Safety Manual

2023

Tokyo University of Agriculture and Technology Koganei Campus

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Issuance of “Safety Manual” 2023 Version

A variety of practical classes and experiments take place at Tokyo University of Agriculture and Technology Koganei Campus every day, including those using drugs, high voltage currents, and heavy machinery. While these have been developed as products of science and technology for our benefit, incorrect use or careless handling results in life-threatening accidents and disasters. In addition to the acquisition of advanced specialist knowledge, the obtainment of knowledge regarding hazards and disaster prevention and the safe handling of substances and equipment that involve risk, while ensuring safety for themselves and those around them, is considered basic common sense and morals for all persons engaging in engineering and is a part of the ability required for high level engineers and researchers in developing new technologies. In addition, major accidents and disasters are often caused by experienced people becoming inflated after familiarizing themselves with the procedures. It is necessary to maintain the attitude of paying attention to every detail, no matter what. All experiments and practical classes are incorporated in the curriculum based on this common understanding.

Since the issuance of the first version in 1989, the “Safety Manual” has been used as a guidance in preventing hazards and disasters in experiments and practical classes conducted by students and faculty and staff members at Tokyo University of Agriculture and Technology Koganei Campus. The details in this manual are not only considered rules within Tokyo University of Agriculture and Technology but the social responsibilities of engineers and researchers. The university has increased responsibilities according to the complex changes in society. Safety management within the university also leads to the prevention of social incidents such as crimes. We aimed to create a safety manual that is more convenient to use through revisions made in response to the changes in the present time. We would like to express our gratitude to the faculty and staff members for their cooperation.

Our earnest desire is that this “Safety Manual” is used by the students and faculty and staff members with profound awareness of the responsibilities as those receiving engineering education and responsibilities in engaging in education and research, while enriching their activities.

Tokyo University of Agriculture and Technology
Koganei Environment, Health, and Safety Committee

University website on “Safety Manual”

The items relating to this “Safety Manual” are published on the website of this university. Laws and regulations relating to environment and safety are revised every year, and this is accompanied by amendments in relevant procedures. Make sure to actively check the following website to obtain the latest information.

- “Center for Environment and Safety” website
- How to access the website
  Access the faculty and staff member website from the Tokyo University of Agriculture and Technology top page to access the “Center for Environment and Safety” website
- Details of each item in the “Center for Environment and Safety” website (partially omitted)

Item name	What information is provided, and when is this necessary?
Safety activities and safety management	・ Safety Manual This is the electronic version of this “Safety Manual”. You will be able to access the Faculty of Agriculture version. ・ Proper control of radioactive substances This is mandatory for laboratories handling radiation. Detailed explanation on various procedures and handling methods are provided. ・ Storage and control of various organisms Mandatory for laboratories conducting experiments on genetically modified organisms, pathogenic microbes, and introduced species. ・ Periodical self-inspection of draft chambers Laboratories with draft chambers will be required to perform self-inspection of air flow according to the Industrial Safety and Health Act. Test tables and manuals for these inspections are provided.
Environmental activities and environmental control	You can access the “Environmental Activity Plan” and “Environmental Report” (which are mandatory for submission every year) for this university.
Disaster prevention activities and crisis management	Disaster prevention requirements Requirements for precautionary and reactive measures for earthquake, fire, etc. ・ Crisis management manual The manuals for handling of “crisis” that are potentially encountered at the university. The manual also provides the response by faculty and staff members and students in case of earthquake, fire, etc.
Laws and regulations relating to environment and safety, university rules, and compliance	You can access the laws and regulations relating to environment and safety control, as well as the internal rules at the university.
Applications and signages	・ Applications Application formats including “Accident/incident/disaster Report” are available. ・ Signages for Ordinance on Prevention of Organic Solvent Poisoning and Ordinance on Prevention of Hazards Due to Specified Chemical Substances Laboratories owning designated “organic solvents” and “specified chemical substances stipulated in the Industrial Safety and Health Act must display signage by the designated method. This section contains the applicable “signages”. ・ Work environment measurements Documents on the measurement of work environment, etc.
Emergency contact for onset/discovery of accidents, incidents, and disasters	Explanation is provided on the contact method within the university, contact details, and rules for reporting in case of accidents and disasters (These rules are common to the entire university.)
Drug management system	All laboratories handling chemical products are required to be registered. Explanations on the operating methods, details of registration, and relevant laws and regulations (PRTR, metropolitan ordinances), etc. are also provided.

Table of Contents

Safety and disaster prevention within the university

Under any circumstances, safety assurance is considered a basic requirement of the university. Unlike those studying humanities at university, the students and faculty and staff members who spend most of the day at Koganei Campus are constantly exposed to the risk of accidents through experiments and practical classes. Accidents may also occur outside experiments and practical classes, for example during practical classes in physical activity and extracurricular activities, however these accidents occur during the activities of education and research as the original purpose of the university and considered to be accident characteristics of the university. The specific details of accidents at the university are reported in the education and student affairs committee hosted by the educational affairs office, however most accidents are thought to have been prevented with sufficient learning and behaviors compliant with the basic precautions for accident prevention. Specific examples of safety measures relating to practical classes in physical activity and extracurricular activities include (1) Self-check and adjustment of physical conditions, (2) Undergoing periodical health checkup, (3) Engaging in preparatory exercises, (4) Confirmation of safety regarding facilities, equipment, and clothes, and (5) Application of fully examined trip schedules to the Student Support Section.

Although accidents may also occur in daily life, for example traffic accidents while commuting, this safety manual has been prepared to prevent accidents that potentially occur in experiments and practical classes at Koganei Campus due to the carelessness of individuals to the highest extent possible. For example, in conducting experiments, items such as (1) appropriate clothing, (2) organization and prior inspection of machineries, and (3) compliance with the basic procedures are basic items that require compliance by individuals. Students and faculty and staff members specializing in engineering must read this “Safety Manual” from the start to the end and conduct examinations themselves on preventive and protection measures to allow response to a wide variety and high level of accidents as a part of the efforts to prevent accidents on daily basis. Also, it is necessary to keep in mind at all times that appropriate decision making and action can be taken in the unfortunate cases where accidents occur, for example first-aid measures and reporting to relevant departments. It is said that looking at things without losing attentiveness to safety provides opportunities for learning on a daily basis. It is important to make sure to maintain a habit of paying attention to safety.

In the present day where there is heightened social interest on safety in accordance with the advancement in scientific technology, it is natural that the entire university takes proactive measures for safety. However, accidents are often caused by the inattention of the individuals. Two basic principles of safety can be described as “disasters occur sometime unless the cause is eliminated” and “safety-related events including disasters, accidents, and malfunctions that are larger scale have a lower likelihood of occurring”. This suggests that near-misses occur in the surroundings at all times, and it is important to not overlook these and make sure that the cause is analyzed constantly to prevent further accidents. We ask that utmost care is taken at all times for details provided in this manual, including basic precautions regarding practice and clothes, and for individuals to make efforts in preventing accidents. Since the causes of accidents become more diverse as current research become more advanced and complex, we recommend that the readers read the entire manual.

While this manual was prepared with investigation centered around committee members of various areas of specialization, there may be a number of insufficiencies. If you have any opinions or criticisms, no matter how small or how harsh, please direct your message to the Environment, Health, and Safety Committee. We hope to make this “Safety Manual” more complete with every revision due to your cooperation.

Emergency measures

I Contact methods

If an accident occurs, call loudly to notify the occurrence of the accident and gather everyone to the area. Notify nearby faculty and staff members. Do not attempt to handle the situation alone. This often leads to irremediable consequences.

1. In case of accidents involving injury or death

Remove the victim from the accident site to a safe location and conduct measures for the accident site to prevent a secondary accident. However, care is required in the case of neck injury as careless transfer without immobilizing the injured area poses a risk of severe quadriplegia. Notify the fire station or the health service center according to the method shown in the table below as suitable for the injury condition. Perform first-aid measures shown in II until treated by a specialist.

Method of notification if there is an injury

Contact details	Phone	Details
(1) Fire station	0-119 (via the university extension telephone) Extension 119	There is an injured person at XX in YY class at Tokyo University of Agriculture and Technology Koganei Campus. Call the ambulance. My name is XX.
(2) Health Service Center	Fuchu 042-367-5548 (Extension 5548) Koganei 042-388-7171 (Extension 7171)	There is an injured person at XX in YY class at Koganei Campus. We would like to call for first-aid.
(3) Guard office (front entrance of Koganei Campus)	042-388-7007 (Extension 7007) Mobile: 070-6474-7007	There is an injured person at XX in YY class at Koganei Campus. We would like to ask for an ambulance.
(4) Staff room (5) Administrative office	For students (Student Affairs Section) 042-388-7011 (Extension 7011) For faculty and staff members (General Affairs Section) 042-388-7003 (Extension 7003)	Situation report

2. In case of fire or explosion

If there are any injured persons, remove from the site to a safe location and perform first aid. Press the button of the fire alarm attached to the fire hydrant located in corridors, etc. Notify the fire station, etc. as shown in the following table. If the name of the substance causing the fire is identified and the quantity is small, and it is confirmed to not pose any imminent hazard to the surrounding area, the fire may be extinguished using an appropriate fire extinguisher (table below). However, no life-endangering actions should be taken. Evacuation of all people in the building to outside the building should be prioritized as saving lives is more important than extinguishing the fire. Since modern buildings made of reinforced concrete do not burn easily, the risk of fire spreading is low, however delay in evacuation may lead to deaths caused by smokes generated during fire.

Method of notification in case of fire

Contact details	Phone	Details
1) Fire station	0-119 (via the university extension telephone) Extension 119	Call 119. ・ There is a fire. 2-24-16 Nakacho, Koganei-shi; Tokyo University of Agriculture and Technology Koganei Campus ・ Room XX on the Xth floor of Building No. XXX is burning.
2) Health Service Center	Fuchu 042-367-5548 (Extension 5548) Koganei 042-388-7171 (Extension 7171)	Fire occurred in XX in YY class at Tokyo University of Agriculture and Technology Koganei Campus, and there are persons injured. We would like to call for first-aid.
3) Guard office (front entrance of Koganei Campus)	042-388-7007 (Extension 7007) Mobile: 070-6474-7007	Fire occurred in XX in YY class at Tokyo University of Agriculture and Technology Koganei Campus We would like to call fire engines.
4) Administrative office (Accounting Office)	Koganei Accounting Office 042-388-7004 (Extension 7004)	Situation report

Type of fire extinguisher and capacity

Type	Type (mechanism of action)	Sample capacity (estimate)	Operable substance
Sprays incombustible gases	Rotary valve Liquefied carbon dioxide gas, trigger type Acid gas, hand-held type	Volume: 2.9 kg Distance: 2 to 3 m Time: 25 sec	Flammable liquid
Sprays powder	Dry chemical extinguisher A/B/C extinguisher Metal fire extinguisher Pressure accumulation type Compressed gas cylinder type	Volume: 7.5 kg Distance: 6 to 8 m Time: 20 sec	Flammable liquid Flammable gas Metal (for metal combustion)
Sprays halides	Carbon tetrachloride Bromochloromethane Dibromofluoroethane Pressure accumulation type, rotary valve Hand-held type	Volume: 31 kg Distance: 6 to 9 m Time: 60 sec	Flammable liquid Electric fire

II First-aid measures

After calling the ambulance, you will be required to wait for its arrival. First-aid measures should be performed during this period.

1. Common procedure

a) The victim must be quickly rescued first and kept at rest in a safe location.

b) Perform a quick check of the victim's symptoms.

- Call out to the victim to check if they are consciousness. If the victim does not respond, the victim is considered to be "unconscious". Call loudly to gather people and issue specific instructions, such as "call 119" and "bring AED".
- If the victim is conscious, explain that the symptoms are mild and ambulance and medical attention will be available shortly to provide the victim with relief from the state of shock.
- Check the pulse with fingers or check the heartbeat by feeling the area of the victim's heart with a hand. If there is no pulse, perform chest compressions. If the victim is not breathing, perform mouth-to-mouth resuscitation.

c) Check if the victim is bleeding. Also check for any lacerations, contusions, or fractures. If bleeding is present, perform hemostasis. If a bone is fractured, apply a splint.

d) Help the victim to breathe easily. Maintain normal body temperature. If the body temperature is decreasing or if the air temperature is low, keep warm by wrapping the victim in a blanket or similar material.

e) If foreign matter or chemical is adhered to the body, remove by rinsing with water.

2. First-aid measures for bleeding

Rupture of superficial artery causes fresh red, pulsating bleeding in a spray, while bleeding from a deep artery causes continuous bleeding in lines. For adults, human body contains an average of 5,700 mL of blood, however the impact of bleeding is considered small if the amount of blood loss is up to 10%. However, bleeding of 10% or more of this amount causes shock, and 50% or more leads to death. Therefore, hemostasis by compression of major blood vessels should be prioritized over treatment of a wound in the case of major bleeding.

a） Hemostasis must be performed by compressing the artery with the ball of the fingers at each pressure point on the heart side of the site of bleeding. Most bleeding can be stopped in this manner. Since this method cannot be used for arms and legs, flow of the blood is reduced by strong binding near the pressure points of the arms and legs using a triangular bandage and dressing.

b） If the tension is too weak, this only causes venous congestions and rather results in increased bleeding.

c） Blood flow should not be reduced using thin strings or other similar materials as this may lead to laceration of muscles, nerves, and tissues. In addition, reduction of blood flow should not be continued for 2 hours or longer as prolonged application causes tissue necrosis.

d） If the skin is wet with blood, a wide cloth should be used for compression as the balls of fingers and rubber tubes will cause slipping. A skinny rod like a vice can be used effectively to tighten. However, tightening should be stopped after hemostasis is achieved.

3. First-aid measures for trauma

a） In the case of trauma accompanying major bleeding, the hemostasis described above should be performed prior to first-aid measures.

b） Observe the wound. For scars beneath the clothes, rip or cut the clothes open to observe the wound.

c） Remove any glass or metal fragments from the wound if they are observed and can be removed easily. If these are found deep in the wound or in a complex manner, leave the treatment to the doctor.

d） If the wound is contaminated with soil, sand, or oil, only rinse with copious amount of water.

e） Apply a disinfected gauze and wrap a dressing around the wound to stop mild bleeding.

4. First-aid measure for bone fracture

a） Check the location of the fracture. Apply a splint to prevent movement in this area and provide pain relief. Leave further treatments to the doctor.

b） A splint must be longer than the area of the fracture. A branch, rod, umbrella, or similar materials with a width of about 19 cm should be applied along the area of the fracture as a first-aid measure, and tied with towel, dressing, or similar materials to prevent movement. Adjacent joints on the upper and lower sides should also be fixed in this procedure.

c） Treatment for shock induced by the severe pain of bone fracture should also be applied. For this reason, a splint should be applied over a towel, cloth, or felt for effective application.

5. First-aid measures for burns

Burns become more severe with higher temperature and longer duration of heat application. Burns are classified from first to third degree depending on the severity.

i. First degree burn: Mild damage is observed on the epidermis only, with dilation of capillaries, red swelling, heat generation, hot sensation, and mild pain.

ii. Second degree burn: Damage extends to dermis underneath the epidermis, with heat generation and redness in the area surrounding the burn, as well as blisters and severe pain.

iii. Third degree burn: Damage extends to epidermis, dermis, and the subcutaneous tissues underneath these layers, resulting in necrosis.

It was previously said that burns affecting 1/3 or more of the body surface is fatal, however in the present time, patients have been able to recover from burns affecting around 80% of the body with appropriate treatment.

a） Cool the burned area as soon as possible using tap water, cold water, or iced water.

b） Cooling is more effective the earlier it is initiated, and should be continued for at least 30 minutes, or for 2 to 3 hours if possible until the victim no longer feels pain.

c） For first degree pain with a small burn area, the affected surface should be disinfected after cooling then covered with a clean gauze or compress. However, treatment of second- or higher-degree burns should be left to the doctor while continuing cooling.

6. First-aid measures for electrocution

Electrocution may induce atrial fibrillation in the heart and cause cardiac arrest, while high voltage current may cause respiratory arrest.

a） Firstly, switch the power off to prevent a secondary disaster. Remove the victim from the power source.

b） If spontaneous breathing or pulse is not present, immediately start mouth-to-mouth resuscitation and chest compression. Since electrocution may cause rigidity of the body, this may be mistaken for rigor mortis and first-aid measures are often abandoned. If an AED (automated external defibrillator) is used, perform treatment by following the audio guidance provided. Continue mouth-to-mouth resuscitation while waiting for the arrival of the emergency services (mouth-to-mouth resuscitation should be continued for 4 to 5 hours, or longer in some cases).

7. Checking for breathing and chest compression

a) If the victim is unconscious, check if the victim is “breathing normally”.
Sit beside the victim and observe the upward movement of the chest and abdomen within 10 seconds to decide if the victim is breathing normally. Following cases are not considered “breathing as per usual”:

i) If there is no movement in the chest or abdomen

ii) If the state of breathing is unclear after observing for about 10 seconds

iii) If intermittent, hiccup-like breathing is observed (victim immediately after cardiac arrest may show unusual movement in the chest or abdomen when breathing, or hiccup-like intermittent breathing)

b) If the victim is not considered to be breathing normally, immediately start chest compression to deliver blood to the whole body.

Chest compression

Position of chest compression

Method of chest compression

Perform “strong, fast, continuous” compression on the center of the chest with two hands placed on top of one another.

i) The site of compression for chest compression is the center of the chest. (Figure 1 below)

ii) Place the base of one hand on top of the compression site (Figure 2 below) and place the other hand on top of the first hand. Interlocking of fingers helps to concentrate the force further (Figure 3 below).

Figure 1

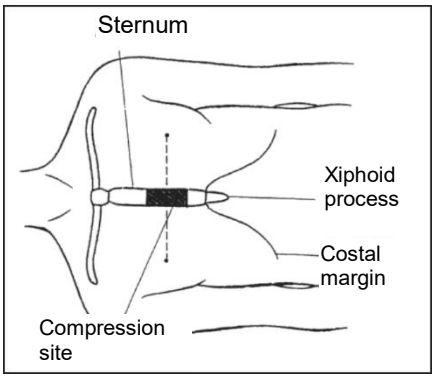


Figure 2

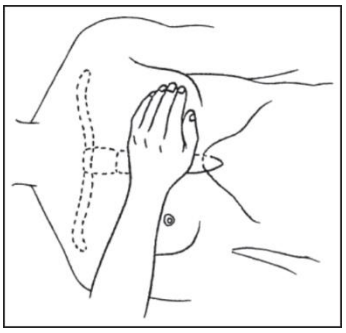
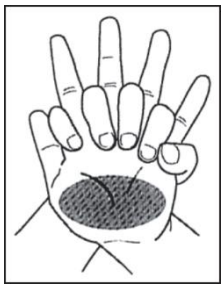


Figure 3



iii) Straighten the elbow and place the weight on the base of the hand, and compress forcefully until the chest of the victim sinks by at least 5 cm.
iv) Compress 30 times continuously at a fast tempo, at least 100 times per minute.

Release the weight fully between compressions (when not compressing) until the chest returns to the original level.

c) After compressing the chest for 30 times, blow breaths into the victim for mouth-to-mouth resuscitation.

*Civil rescuers who are not well-versed in CPR do not have to perform mouth-to-mouth resuscitation.

Even with trained rescuers, interruption of chest compression for mouth-to-mouth resuscitation should be kept to a minimum.

However, mouth-to-mouth resuscitation should be prioritized for children and infants, as these cases often involve suffocation, as well as in drowning victims.

i) Securing airway (head tilt-chin lift maneuver)

Expand the back of the victim's throat to help access of air to the lungs.

Place one hand on the forehead, with the index and middle fingers on the other hand on the tip of the chin (hard area with bone) to tilt the head backwards (head tilt) and lift the chin.

Head tilt-chin lift maneuver

ii) Mouth-to-mouth resuscitation

While securing the airway, hold the victim's nose with the thumb and index finger of the hand placed on the forehead.

Open the mouth widely and cover the mouth of the victim and blow the breath over about 1 second so that the air does not leak out. Check that the victim's chest is raised. Release the mouth, and blow breath into the victim again in the same manner.

Hold the nose and cover the mouth

- Observation of chest raising with each of two breaths is ideal, however blowing should be performed up to twice even if the chest is not raised and proceed immediately to chest compression.

- Chest compression is interrupted while mouth-to-mouth resuscitation is performed, and the period of interruption should be kept as short as possible.

- If the victim is bleeding from the face or mouth, or if there is hesitation in performing mouth-to-mouth resuscitation with direct contact of the mouths, mouth-to-mouth resuscitation may be avoided and proceed with chest compression only.

Check that the chest is raised

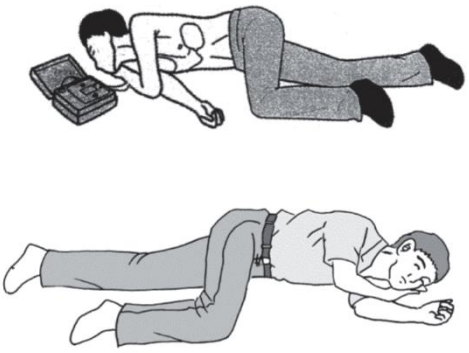
d) Continue cardiopulmonary resuscitation (chest compression and mouth-to-mouth resuscitation)
Perform chest compression 30 times consecutively then perform mouth-to-mouth resuscitation twice. Continue this combination of chest compression and mouth-to-mouth resuscitation (30:2 cycle) without stopping until handover to the emergency service.

・ Since continuous chest compression is tiring, if there are two or more rescuers, they should take turns performing chest compression with an interval of about 1 to 2 minutes.

・ Cardiopulmonary resuscitation should be terminated in the following cases:
i. After handover of cardiopulmonary resuscitation to the emergency services (do not rush to stop the procedure after the arrival of emergency services; follow the instructions of the emergency service)
ii. If the victim opens their eyes or starts breathing normally during cardiopulmonary resuscitation

▼Recovery position

e) Recovery position
i) If the victim is not responsive but breathing normally (as per usual), continue to secure airways and wait for the arrival of the emergency service. If there is a risk of suffocation due to vomited matter, or if the rescuer must leave the side of the victim for an unavoidable reason, place the victim in the recovery position.
ii) Pull the lower jaw to the front and place the victim's face on the back of the upper hand. Following this, bend the knee of the upper leg by about 90 degrees to prevent the victim from falling backwards.



<References>
Procedures for basic life support (BLS): Fire and Disaster Management Agency, Ministry of Internal Affairs and Communications http://www.jlsa.jp/pdf/oukyu2.pdf

8. First-aid measures for acute poisoning caused by chemicals

1) General matter

Acute poisoning caused by chemicals differs in toxicity and irritation depending on the type of chemicals involved. Possible causes include entry to the body, contact with skin or mucosa, or inhalation of volatile chemicals. The basic procedure involves the elimination of the chemical from the body.

2) Skin contamination

Firstly, rinse the substance adhered to the skin with copious amounts of water If the clothes are also contaminated, immediately remove the clothes and rinse the skin with water. Showers are equipped for this purpose in the corridors and bathrooms of chemistry classrooms and use of such showers is recommended.

3) Eye contamination

It is important to quickly rinse off chemicals that came in contact with the eye using copious amount of water. Open the eyelids and rinse carefully with a gentle flow of water from a face washing fountain, hose, or tap. Strong water pressure is not beneficial for the eyes. It is recommended that the victim repeatedly immerse the face into a basin with overflowing clean water, and open and close the eyes repeatedly.

4) Inhalation

Remove the victim to fresh air as soon as possible. Strictly keep the victim at rest and commence oxygen inhalation as soon as possible. If oxygen is not readily available and the victim has difficulty breathing, perform mouth-to-mouth resuscitation. Care must be taken so the rescuer must not also become affected by inhalation of harmful substances adhered to (or inhaled by) the victim. If chemicals are inhaled, seek urgent medical attention.

5) Swallowing

If chemicals are swallowed accidentally, vomiting should be induced in some cases and not induced in other cases. If vomiting should be induced, water, milk, or egg white should be given to induce vomiting. If the identity of the swallowed material is not known, attend a medical institution urgently. Vomiting should not be induced if strong alkaline/acidic stock solutions and powders, concentrated materials, or corrosive substances have been swallowed. Rinse the mouth carefully and give milk, egg white, or egg white in water (white of one egg dissolved in about 1 glass of water) should be given and attend a medical institution immediately. This procedure is a race against time. Damage of the stomach or esophagus may lead to death in a few minutes. Repeat the procedure if vomiting continues. Do not induce vomiting if consciousness is unclear or if convulsions are present as there is a risk of suffocation.

9. Use of AED

1) What is an AED?

An AED (automated external defibrillator) is a medical device used for a heart that has lost its blood-pumping function due to convulsion (atrial fibrillation) to provide electric shock and return the cardiac rhythm to a normal state. Cardiac arrest is primarily caused by atrial fibrillation, and “atrial fibrillation” is the most common type of arrhythmia that results in sudden cardiac death. The actions that should be taken in the few minutes while waiting for the ambulance to arrive decide the life and death of the victim, and electrical defibration at an early stage is essential for life saving. Anyone can perform resuscitation with an AED as audio guidance is provided on how to use the device after the power is turned on. * However, AED cannot be used for infants less than 1 year of age.

2) Location of AED

1. In the guard office of the front entrance
2. Right side of the 1F entrance of the indoor sports complex (outdoor)
3. Right side of the 1F central entrance of BASE main building
4. Front of the 1F entrance of advanced scientific experiment building
5. Right side of the 1F entrance of Nature and Science Museum
6. Left side of the 1F entrance of the lecture building (outdoor)

3) How to use AED

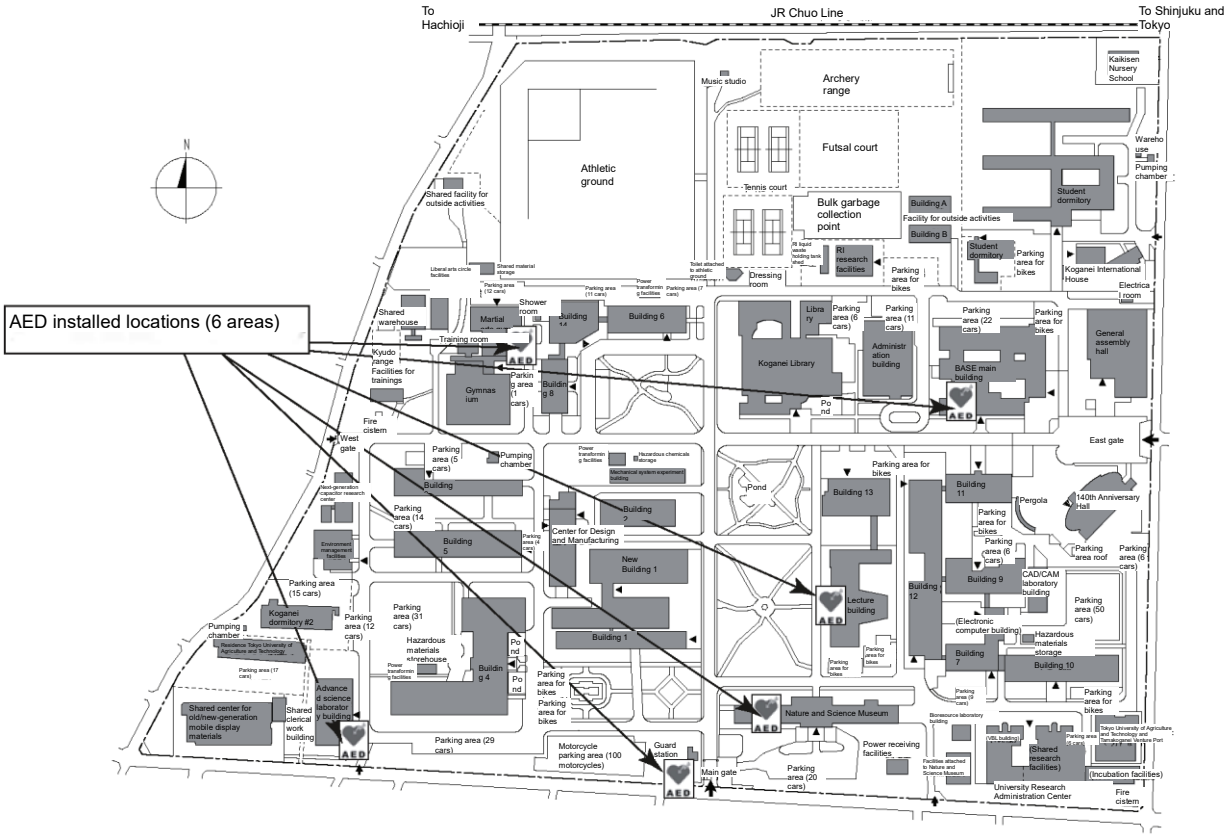
1. Check the consciousness and breathing of the victim. If these are absent, call the ambulance and ask to bring the AED.
2. Perform mouth-to-mouth resuscitation and chest compression until the arrival of AED.
3. Open the cover of AED. (The power is turned on automatically when the cover is opened)
4. Expose the chest of the victim and apply the electrode pads of the AED to the chest.
5. Wait for the result of automatic analysis through the electrode pad. If electric shock is required, press the red flashing button according to the audio guidance.

   *Make sure that no one is in contact with the victim.
6. Continue the first-aid activity from 2 to 5 as necessary until the ambulance arrives.

*See below for details

- Japan Resuscitation Council AED (Japan Emergency Medical Foundation)
- “Do you know about AED?” (Japan Heart Foundation)
- “We can save lives with our actions.” (Nihon Koden Coporation)

<Reference>
AED map for the Center for Environment and Safety, Tokyo University of Agriculture and Technology
http://web.tuat.ac.jp/~kankyou/AED.shtml



Tokyo University of Agriculture and Technology Koganei layout diagram

III Post-treatment

Occurrence of fire, explosion, injury, etc. must be notified to the supervisor. The supervisors and staff members in charge must report this in a timely manner to the responsible persons, including the head of department, and the dean according to the “Rules on Emergency Contact and Reporting of Accidents, Disasters, etc.” In addition, the initial report on accidents and disasters must be prepared as specified separately and submitted to the Center for Environment and Safety. Following the conclusion of the first-aid measures, the responsible persons must promptly prepare “Accident/Incident/Disaster Report (next page)” and submit this to the department in charge as shown follows.

The supervisor must investigate the cause of the accident as soon as possible after its occurrence, then determine the recurrence prevention measures and enforce the details with the students involved or affiliated faculty and staff members.

<Submission of accident report>

For report on students: Koganei Student Support Office
Student Support Section: 042-388-7011

For report on faculty and staff members: Koganei Accounting Office
Accounting Section: 042-388-7004

Accident/incident/disaster Report

(Form 1)

Route of reporting | **Department of occurrence** | **Department in charge within the division** (Name of department) → **Head of General Affairs Section** (Faculty and staff members also affiliated with Center for Environment) → **Vice President in charge of environment and safety** → **(President)**; **Environment, Health, and Safety Committee (chairperson)**; **Vice director of Center for Environment and Safety and other related departments**; **Relevant organizations within the division and other related departments (Note 3)**

Prepared **(MMM DD, YYYY)**
Department/division of occurrence
Title
Name

Classification		Accident/incident/disaster	**Type of accidents, etc.**	Traffic accident/experimental accidents/accidents in extracurricular activities/fire/property damage/suspicious person/crime/others ( )	
Date and time of occurrence		(MMM DD, YYYY) hh:mm am/pm	**Details and circumstances of the accident (work details, collaborators, etc.)**		**Notification and action taken with hospitals/police**
Location					
Victim	Name				
		Student ID			
	Date of birth	MMM DD, YYYY (years old) male/female			
	Affiliation				
	University year	Undergraduate/Master/Doctorate/Other ( )			**State of building/property damage**
	Title				
	Contact details	Current address	**Cause of event**		
		Phone (mobile/extension) / E-mail			
	Circumstances of event	During an experiment or practical class/during other regular classes/during extracurricular activities/during a commute			
		During work/outside work hours/during break/during commute			
	State of injury, etc.	Abrasion/cut/bruising/bites and stings/sprains Contusion/fracture/burn/chemical burn/poisoning Other ( )			**Persons who confirmed the occurrence of the event**
					Affiliation
					Title
		Affected body parts:			Name
		Outpatient/inpatient, days, full recovery expected in days/weeks	**Recurrence prevention measures and actions taken**		**Remarks**
	Insurance coverage, etc.	Coverage by accident insurance for students (yes/no) Eligibility for accident insurance for students (yes/no) Application for industrial accident (yes/no) Necessity for temporary absence from school (yes/no) Necessity for temporary absence from work (yes/no)			*Write any considerations, issues, complaints, or impacts
Hospital or health service center attended for initial consultation					
Name of hospital _____ (designated/not designated for industrial accidents) Address _____ Phone number _____			*If recurrence prevention measures are being examined (write the direction of details being examined and the scheduled date of completion)		

Note 1. Circumstances of the event and recurrence prevention measures must be reported immediately to the head of division according to Paragraphs 1 and 2, Article 4 of the requirements.

2. For accidents involving properties and experimental equipment (for example, injury), photographs showing the properties, etc. must be attached according to Paragraph 3, Article 4 of the requirements.

3. If the accident involves a student, report must also be submitted to the General Student Support Section. Similarly, if faculty and staff members are involved, a report must also be submitted to the Personnel and Labor Section, and if premises and facilities are involved, a report must also be submitted to the Accounting and Purchase Section and the Facility Maintenance Section.

Safety in experiments and practices

I Safety in Student Experiments

1. General Tips

This section presents the general tips for taking these experimental subjects. Note that only the minimum requirements are presented here. Be sure to read the precautions in the relevant sections other than this one.

(1) Attitude toward Experiments

Experiments at the Koganei Campus often use electrical equipment, power tools, chemicals, and the like that may cause a fire or injury if handled incorrectly. These experiments involve risks that may lead to accidents if close attention is not paid. However, these experiments are indispensable to educating you, who will play active parts in various industrial fields as specialists, engineers, or researchers. Besides, experiments are never dangerous if conducted after carefully reading the experimental guidelines and understanding the meanings of individual experimental operations. There is nothing particularly difficult about the precautions for the safe conduct of experiments. It all boils down to faithfully adhering to the following quite common-sense protocols:

1) Attend to keeping clean and orderly the areas around benches or experiment apparatus.

Experiments usually take place on a bench. Hence, the bench and its surroundings must always be kept clean and orderly before, during, or after an experiment. Examples abound of accidents: labware got broken because of unnecessary labware for the experiment being left sitting; or a chemical brought in for use in an experiment failed to be put away and caught fire during the experiment, causing an unexpected accident. Accidents of this sort occur as a result of insufficient housekeeping. Sticking to the basic rule of bringing in nothing other than the items necessary for the experiment is important.

2) Meticulously prepare equipment and materials, reagents, and outfits.

It is essential to fully understand the content of the experiment to be conducted and to obtain prior knowledge of the usage and hazards of the labware, apparatuses, chemicals, and other necessary items for the experiment. Not only does this point matter to safety, but it also matters to the experiment's success. Apparatuses and the like must be checked for normal operation before starting the experiment. Labware must be inspected for safety and suitability for the purpose of the experiment. For reagents, care must be exercised for deterioration or incorrect labeling without blindly accepting what the label on the bottle says.

3) Laboratory wear

Appropriate laboratory wear differs between individual experiments. You are advised to purchase the most appropriate clothes and footwear as instructed by individual instructors. This apparel cost is a small price to pay to prevent accidents.

i. For chemical experiments, you are advised to wear white coats. A white coat prevents chemicals from soiling clothes. Not in close contact with the skin and quickly removable even when heavily exposed to acids, alkalis, or the like, it allows easy escape from damage. However, during experiments involving motors and other power tools, there is a risk of the trouser legs getting caught in the machine. For this reason, wearing work clothing that is not loose is especially preferable.

In a laboratory, specified footwear should be worn. If none have been specified, shoes that allow easy movements and serve as foot protectors should be worn. In the case of a chemical experiment, wear protective goggles to protect the eyes from an explosion or deleterious droplets. When handling deleterious or hot substances, you should preferably wear protective gloves as necessary to protect yourself and ensure safety.

ii. Mechanical system experiments quite often involve using machine tools. On these occasions, wear work clothes that can withstand soiling from contaminants, such as oil or chips, and with no parts lifted free from the body, are unlikely to get the trouser legs or sleeves caught in the machine. Never wear sandals. Leather shoes are desirable to wear. Besides, gloves must not be worn during operations other than special operations (such as welding operations). Moreover, always wear a helmet or working cap for operations that involve the risk of falling heavy objects or head banging.

4) Do not attempt to conduct impossible experiments.

Overexerting oneself must be avoided in experiments. No impossible experiments are assigned as student experiments. However, adding a reagent prematurely in an experiment against the instructions in the hope of completing the experiment sooner may lead to an accident. A failure or an accident often results from experimenting with distracted attention after staying up all night or drinking too much alcohol the day before. The same applies when feverish from sickness. Any experiment demands both physical and mental health that allows concentration on it.

5) Do not experiment alone.

No such case occurs in student experiments. However, when it comes to a graduation or post-graduate research project, it may happen that experiments must be conducted on a one-theme-per-student basis. In such cases, a careful plan should be devised to ensure that two or more people are in the same laboratory. This principle should be strictly followed, especially when remaining until nighttime or conducting an experiment overnight.

6) Plan measures to be implemented in the event of accidents.

It is important to conduct experiments with care not to cause accidents. Still, it is critically essential to know what to do in the event of an accident to minimize damage. If an accident occurs, it is too late to go and ask the advisor what to do, which will only worsen the damage.

Especially for potentially hazardous substances and equipment as mentioned above regarding *meticulous preparations*, it is important that you know what hazards may occur in what situations and what first-aid treatment measures to implement in the event of accidents to protect yourself and ensure safety.

(2) Guidelines for Safety in Experiments

This section presents points to bear in mind during actual experiments. Experiments vary in type, and each consists of a combination of various operations. As such, they also vary in safety precautions and measures, depending on the situation. However, as a general rule, attention should be paid to the following points: These points overlap somewhat with the previous section because what should be prepared before an experiment and what to be careful about during the experiment are common.

1) Know the meaning and nature of the experiment.

Guidelines for student experiments usually lead you to complete your experiment successfully without thinking about the meanings of individual operations if faithfully adhered to. However, each operation of an experiment always has a meaning. For safety's sake, you must know its meaning before doing it.

Several examples from chemical experiments are given here. Assume that a written instruction for a reaction experiment tells you to "slowly add" a reagent. If the reagent is added too quickly, the resulting reaction may become too violent to control, leading to an accident. Assume another written instruction: "Add the reagent while keeping the reaction system at the temperature of 30°C to 40°C." If you perform this operation at a temperature exceeding 40°C, the reaction will become excessively violent, posing a danger. However, suppose you cool the reaction system to 0°C based on a hasty deduction that it would be safe at a low temperature. In that case, the reaction will be too slow, leaving the added reagent to remain unreacted, which may lead to a dangerous situation where the reaction abruptly resumes and rapidly proceeds when you return the reaction system to the ordinary temperature, assuming the completion of the reaction. Again, in a case like this, you can also avoid making a mistake by considering the meaning of the operation before performing it. When a toxic or malodorous gas occurs during an experiment, it is also necessary to be careful enough to experiment in a draft chamber.

Assume that before using a machine tool, an instruction is given to pick up no chips with a bare hand and use a steel brush, chip removal stick, or the like. The reason is that chips and the like become hot from the processing and too dangerous to touch with a bare hand.

2) Carefully assemble labware and apparatuses for use in experiments.

When assembling an apparatus for use in an experiment, (1) carefully check each piece of labware for any defect that may cause trouble in the experiment. (E.g., whether meters operate normally, whether glassware is crack-free, whether ground joints are perfect, whether power cords are discontinuity-free, whether machine tools' cutters are free of chipping or deformities, or whether gas hoses are crack-free.)

(2) Carefully check the labware to be used for appropriateness. (E.g., the measurable ranges and accuracies of meters, the types and capacities of glass vessels used for reactions and the like, strength under applied force, stirring capacity, the strength of chucks for holding specimens for material tensile strength tests, or whether gas appliances are for city gas or propane gas) (3) Improve the safety of the apparatus as a whole. (4) For experiments that use power supplies, perform the connection between electrical equipment so as to never cause short-circuit accidents and electric shock accidents. For this purpose, comply with the following: (a) To connect two electric wires, solder exposed live parts and cover them completely with insulating tape. Besides, when connecting an electric wire to the connection terminal of a meter, secure the wire firmly with a fastener. (b) When done with the wiring, ensure no short circuit has been formed. Then, finally, connect the power supply. Turn off the power before modifying the wiring during the experiment or before removing it after finishing the experiment.

3) During an experiment, remain calm and act with seriousness.

Needless to say, seriousness, calmness, and utmost care are required during an experiment. Playfulness, corner-cutting, or panicking during an experiment may lead to failure or an accident. You should continuously stay close to the experiment apparatus, especially during the experiment, to observe the progress closely. With this in mind, you would have a good chance of noticing subtle experimental anomalies to prevent or escape accidents.

4) Pay attention to not only your own but others' experiments.

A laboratory is where members jointly pursue their academic interests and conduct research work. The selfish and irresponsible act of one member may not only cause inconveniences to other experimenters but lead to an accident. Cases abound of inadvertently, if not selfishly or irresponsibly, forgetting to pay attention to others' experiments, thereby inviting accidents. You should not unwittingly light a gas burner near someone handling a flammable solvent or use equipment that will likely become a vibration source near someone performing a precision measurement.

5) You should take upon yourself the responsibility of tidying up after your experiment.

It is a matter of course that you tidy up when you have finished an experiment. Tidying up means returning the apparatuses, labware, reagents, and other items used to their original state before use. Tidying up is important not only from the standpoint of *cleanliness* and *orderliness* but also with a view to convenience on the next occasion of use. Let us limit ourselves here to warning from the standpoint of safety. Remember to turn off gas, water, and electricity after use. Dispose of unwanted things with safety in mind.

(3) Measures for Dealing With Accidents

Needless to say, if an accident unfortunately occurs, you should first ensure the safety of human life, minimize human injury and damage, and then implement measures to prevent the spread of damage. At the same time, you should contact a faculty member as soon as possible to seek instructions.

What follows lists the first-aid treatment measures to administer first for likely accidents:

Physics and electrical and electronics engineering

1) The most dangerous accident likely to occur is electric shock. Anyone experimenting with an apparatus with high voltages or large currents should remember to make safety checks to avoid electric shocks.

2) Emergency measures to implement in case of electric shock accidents are presented in another section. Carefully read that section to be prepared to take first-aid actions anytime.

Chemistry and biology

1) In case of skin contact with deleterious or toxic substances, such as acids and alkalis, wash the contaminated part with plenty of water. In case of clothes contamination, immediately remove the contaminated clothing. If, when removed, the clothing may rub the skin festered from exposure to the deleterious substance, cut off the clothing with scissors promptly. If the whole body is contaminated, wash the body with plenty of water. (Use shower facilities, if any, in the laboratory.)

2) Eye contact – Open the eyelids and flush with tap water for approximately 10 minutes. Seek medical diagnosis as soon as possible. The eyes are particularly vulnerable to alkalis. Exercise care accordingly.

3） Toxic/irritant gas inhalation – Immediately remove to fresh air. If the victim cannot walk independently, use a stretcher or the like to save excessive stress.
4） Deleterious or toxic substance ingestion – Repeat gargling if the substance is stopped in the mouth. In case of ingestion, vomiting is recommended but should not be forced. Alternatively, egg white or cow's milk may be given to protect the mucus membrane. Still, the most preferred option is to seek a medical diagnosis as soon as possible.
5） Fire caught due to ignition or the like – Use a loud voice to warn the people around the area. At the same time, contact the advisor. Even if an organic solvent catches fire, it will only lead to a not-so-serious accident unless the vessel gets broken. Remove combustibles around the site, turn off gas and other heat sources, wait until the fire weakens, and then cover the mouth of the vessel with damp dust cloths or the like. Then, the fire is gone. In short, do not panic. If the body catches fire, roll on the floor to kill the fire. Alternatively, get someone else to cover the fire with lab wear to weaken its force. Then, extinguish with plenty of water (use a shower if available). Fire extinguishers should be kept ready for use at any time but should not be unnecessarily used if the above methods work and the fire poses no risk of spreading to other places.
6） Injury − In a laboratory, you may sustain injuries, such as an injury from broken glass or during a manufacturing task. In such cases, it is essential to rinse the wound well with water, then stop the bleeding, and seek medical treatment as soon as possible.
7） Bone breakage − Check the fracture site and keep it still with a splint to reduce the pain. A splint must be longer than the area of the fracture. A branch, rod, umbrella, or similar materials with a width of about 19 cm should be applied along the area of the fracture as a first-aid measure, and tied with towel, dressing, or similar materials to prevent movement. When doing so, you should secure the joints immediately above and below, together with the affected part. Leave the rest of the measure to the surgeon.
8） Burn injury − Cool the affected part with running water or ice water as soon as possible until the pain is gone. It is too soon to stop cooling the affected part if the pain is still felt when the cooling is stopped. A burn injury must be cooled for 30 minutes or more at the minimum, usually two to three hours. For burn injuries up to First Degree (redness) and Second Degree (blisters), perform this measure sufficiently, followed by treatment by a dermatologist. In case of exposure to hot water or heated oil through gloves, socks, or clothes, do not remove them but pour water over them to cool the affected part. The affected skin is prone to peeling during undressing after cooling. Care must be exercised accordingly. When cooling with ice water, exercise care to avoid frostbite. Never rub the affected part. Do not rupture blisters. Do not apply oil, ointment, or powder. This measure will allow considerable recovery if the burn injury is a first- or second-degree burn injury. In the case of third-degree burn injuries that turn the skin white and are not very painful, cooling is not as effective as for first- or second-degree burn injuries. Transporting the victim to the hospital as soon as possible is better. A burn injury with a considerably large area is critically dangerous. Wrap up the victim with a clean bed sheet and transport him/her to a well-equipped hospital as soon as possible.

II Chemical and Biological Experiments

1. General Tips

In these experiments, the so-called chemical experiments have a higher relative importance. It is extremely important to have a full understanding and mastery of safety-minded operating procedures, which provides the foundation for smoothly conducting specialized and graduation experiments. What follows presents precautions specific to chemical experiments. Note that this booklet lists the bare minimum requirements only. The books listed below are relatively inexpensively priced. You are strongly encouraged to purchase them to prevent accidents in experiments.

References

1） *Kagaku-Dojin* (Eds.), *Experiment Safety Manua* (in Japanese) and *Sequel to Experiment Safety Manual* (in Japanese), Kagaku-Dojin Publishing Company, INC.
2） Masahiro YORIZANE (Ed), *Foundations and Tips for Chemical Experiments* (in Japanese), Baifukan Co., Ltd.
3） *Handbook of the Handling of Waste Liquids* (in Japanese) (Environmental Management Facilities, Tokyo University of Agriculture and Technology)

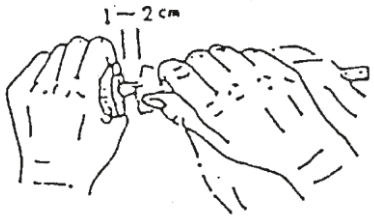
2. Precautions for Preventing Accidents in Basic Operations

(1) Precautions for Glassware Use

a) Check glassware for cracks or scratches before heat application. Besides, thick-walled vessels must not be subjected to heat unless custom-made heat resistant. It is outrageous to do such a thing as heating a vessel containing an organic solvent or the like direct with a gas fire.

b) When cleaning glassware, use an appropriate brush. Clean carefully with a cleaning agent and then rinse with water. If the glassware repels water, the cleaning was insufficient. Redo the cleaning. For viscous stains of fats and oils or mineral oils, dissolve them with an appropriate solvent (be careful when disposing of waste liquids) and then follow the above cleaning method.

c) When using ground-joint ware, do not move the ground part dry. If required to apply lubricant, such as grease, to the ground part, apply it very thinly. After using ground-joint ware, wipe off grease with a solvent, such as hexane or toluene, and clean the glassware immediately. Sticking is likely, especially after use with alkali. Immediately clean after use.



d) When passing a glass tube, a thermometer, or the arm of a side-arm flask through a rubber stopper, push it in gradually by turning it gently while holding a part near the rubber stopper and protecting the hand with a cloth, as shown in the figure to the right. If held by a far part, the glass tube will break, causing a heavy injury. If allowed to use water, apply a small amount for easier insertion (if the experiment does not allow water use, do not use water. Alternatively, dry completely before use).

e) A freshly cut end of a glass tube is sharp and can easily cut a hand. Blunt it by lightly melting it with fire.

f) If any glassware is broken, immediately clean up and collect broken pieces for disposal into a dedicated glass-waste bin.

(2) Handling of chemicals

Frequently used chemicals, such as hydrochloric acid, sulfuric acid, nitric acid, sodium hydrate, potassium hydrate, and the like, are extensively used in experiments in general. As such, their familiarity may lead to inattentiveness, inviting accidents. If used incorrectly, chemicals other than the above will also cause major accidents. Handle with extreme care. Given below are precautions to bear in mind when handling chemicals:

a) When receiving a purchased chemical, check it against the name of the product ordered.

b) Chemicals should be divided into groups with similar hazards, labeled to indicate their hazards, and stored and managed in appropriate safe places, with precautionary measures against loss and theft. Extra care must be exercised for flammable, explosive, corrosive, or toxic dangerous substances.

c) For any bottled chemicals received, their item name, internal capacity, storage site, and other related information must be registered in our institute's chemicals management system (IASO). When storing or retrieving chemicals or disposing of their bottles, update their IASO registration information.

d) Always check the label when using a chemical to avoid confusing it with another chemical.

e) Chemicals must not be mixed unnecessarily, even for reactions. Matters to keep in mind should be researched well. Examples include the dilution of sulfuric acids, mixing of two types of oxidizing agents, and mixing of oxidizing agents and organic solvents.

f) No chemicals should be touched directly with a hand, smelled, or put into the mouth, no matter what they are. Use a hand fan to smell gas.

g) If any chemical falls on the skin or clothes, wash with plenty of water. Some chemicals are extremely dangerous (such as hydrogen fluoride). Research well the matters to keep in mind when using dangerous chemicals. Besides, become well-versed in coping methods.

(3) Precautions for Heating

There are various purposes and methods of heating in chemical experiments. For heat sources, gas and electricity are available. For safety, appliances that use electricity as the heat source are desirable. However, gas can be the only option available in some situations. General precautions for heating operations are as follows:

a) Select appropriate appliances and use them appropriately.
b) Avoid rapid heating.
c) Avoid heating to extremely high temperatures.
d) Stay close to the bench while heating.
e) Keep flammable substances away.
f) Do not construct any apparatus with a closed system that will be internally pressured by heating.

(4) Precautions for Cooling

Even with the same temperature difference, frostbite is more unlikely to occur than a burn injury. Even when cooled to 0°C, cellular tissues at a distal end will not be permanently damaged. However, prolonged cooling will result in the cessation of blood flow and local tissue damage. For example, dry ice (−78.5°C) is dangerous enough to cause blisters when applied directly to the skin.

(5) Precautions for Distillation

1） General precautions

a) Research in advance the boiling, decomposition, and melting points of substances that constitute a sample solution. Distill under atmospheric distillation for distillates that boil at about 150°C or less. Distill under reduced pressure for distillates with a higher boiling point or for compounds that readily polymerize or decompose.
b) Before starting distillation, inspect the apparatus for any signs of damage, such as cracks. Inspect plugs and connections for looseness.
c) Preferably, use electricity as a heat source. Heating from directly below is dangerous. An apparatus must be designed and constructed so the heater can be easily removed (using a tool such as a jack) without moving the still. The aim is to make it possible to stop the heating and let the still and its contents cool down in case of an unexpected situation.
d) A special apparatus and extra care are required if a large amount of crystal precipitation is expected during distillation.
e) Use a water cooler for a running point of 150°C or less. For a running point exceeding 150°C, use an air-cooling tube.
f) Ethers stored for a prolonged period (with peroxide formation) or solutions containing explosive substances, such as peroxides or nitro compounds must not be concentrated until all liquid has disappeared. Failure to comply may result in an explosion.
g) The stoppage of water flow in a water cooler is one of the causes of fire. Ensure that water flows, especially five minutes after water passing (because immediately afterward, the flow is often reduced due to an expanded water plug gasket).
h) Do not fill any sample into a distilling flask exceeding 50% of its capacity.

2） Atmospheric distillation

a) Always add several zeolite pebbles to prevent accidents due to explosive boiling. After interrupting distillation to allow the temperature to drop, add new zeolite pebbles before resuming.
b) If the addition of zeolite is omitted, or if new zeolite pebbles are added during distillation when the zeolite is not very effective, sudden boiling will occur, causing an outburst of liquid or vapor that may result in burns or fire.
c) Use new zeolite pebbles for each distillation.

3） Distillation under reduced pressure

a) Use round bottom flasks. Do not use flat-bottom flasks.

b) In addition to a pressure gauge, remember to install a trap between a still and a vacuum pump or an aspirator.

c) Use wall-thick rubber tubing for connections.

d) Check capillary tubes for any signs of blockage. If the capillary tube is used that does not produce bubbles, explosive boiling will occur during distillation. This phenomenon will cause an accident similar to those in atmospheric distillation.

e) Before starting heating, make sure the pressure has been sufficiently reduced.

4） Steam distillation

a) Steam distillation requires large amounts of steam and hence often uses a burner. Care should be taken not to place combustibles nearby.

b) When steam-distilling a solution containing solid substances, carefully ensure no blockage occurs in the guide tube from the steam generator to the distilling flask.

c) Use a larger cooler with higher efficiency.

d) Handle the steam generator with due care. Use a long safety tube and insert it down to the bottom of the steam generator. When stopping distillation, operate the tap carefully to avoid blocking the steam generator.

(6) Precautions for Filtration

a) Select an appropriate method and labware according to the amount of the crystal to be filtered, its filterability, solubility, and other parameters.

b) Before filtering a flammable solution, ensure that no fire is around. Organic solvent vapors are usually heavier than air. These vapors spread over benches or floors.

c) Toxic solvents should be filtered in a draft chamber.

(7) Precautions for Extraction

a) Use only separating funnels with a capacity one and a half times greater than the total volume of a sample liquid and an extraction solvent.

b) The funnel stand must be large enough to serve as a stable support for a separating funnel filled with a sample solution and a solvent.

c) Cool extracted liquids until room temperature before use. Failure to comply will cause a large amount of vapor, possibly leading to a fire. Remember this point, especially when using a low-boiling-point solvent, such as ether.

d) Even if the same total amount of extraction solvent is used, a higher extraction effect can be achieved by repeating the extraction operation many times in small amounts.

e) If the funnel is shaken vigorously from the beginning, its internal pressure will rise (due to mixing heat), which may cause the contents to blow out from the plug. First, turn the funnel upside down. Then, open the tap to release the pressure. Next, repeat the cycle of light shaking and pressure release. When doing so, you must not point the tip of the funnel at others or yourself. When the pressure stops rising, vigorously shake the funnel, release the pressure once again for the last time, and leave the funnel to stand.

(8) Precautions for Drying

1） Drying liquids

Typically, add a solid desiccant directly to a liquid in an amount of approximately 1/20 to 1/30 of the amount of the liquid. Shake the mixture occasionally and leave it to stand and dry for more than a few hours, preferably overnight. You must select a desiccant that will not react with the sample. For example, basic desiccants cannot be used with acid substances. Doing so is dangerous.

2） Drying solids

a) For a solid that contains much moisture or organic solvent, air-dry it first (natural drying). To dry it completely, use a desiccator or perform baking. When drying solids containing an organic solvent, carefully prevent them from catching fire.

b) Sometimes, an electric oven dryer is used to dry a large amount of solid substance. However, solids that easily decomposition-prone solids, such as peroxides or nitrides, must not be baked. Samples containing flammable organic solvent must not be dried using an electric dryer.

(9) Melting Point Meter Usage

Melting point measurement is a basic and important operation to help you identify the compound you have synthesized. High boiling point oil or concentrated sulfuric acid is used as a medium to heat a capillary tube filled with a sample. They are both hot and can cause serious burn injuries in the case of skin contact. Utmost care is required to heat the apparatus. Because direct fire is used for heating, the burner should be handled with due care.

First, you can heat at the rate of 4ºC to 6°C/min up to 10ºC to 15°C below the expected melting point. Then, heat up to the melting point with care at the rate of 1ºC to 2°C/min and perform the measurement. Adjust the burner flame (without letting in too much air) and perform the heating by moving the burner-holding hand extensively as if trying to heat the whole measuring container. Rapid heating should never be attempted. If the heat medium is at a high temperature after use by someone else, leave it until the temperature becomes 10ºC to 20°C lower than the expected melting point. Then, set the capillary tube filled with the sample, leave it for approximately 5 minutes, and perform the measurement as instructed above when the sample’s temperature equals that of the heat medium.

(10) Precautions for High-Pressure Experiments

1） General precautions

High-pressure experiments take place under severe conditions for chemical experiments and involve relatively high risks. Mishandling of an apparatus may lead to a major accident. Care should be taken accordingly. General precautions are as follows: For the safe handling of autoclaves, pressure-proof glass seal tubes, and the like, refer to lab books and other source materials as necessary.

a) No work shall be carried out that exceeds the performance of the apparatus in terms of pressure resistance or heat resistance (for instance, a high-pressure apparatus should be used with pressure below two-thirds of the test withstanding pressure).

b) Avoid overtightening high-pressure valves.

c) Conduct experiments in the presence of your instructor as much as possible.

d) Ask manufacturers for periodic pressure checks to ensure the safety of high-pressure reaction vessels and other equipment. Besides, make sure that safety measures, such as relief valves, are in place.

e) A high-pressure apparatus should be checked for gas leakage at a pressure equal to or greater than the normal working pressure. In addition, provide indoor ventilation with care so that no gas will build up even in the event of leakage.

f) The apparatus should be installed in a special laboratory rather than a generic laboratory as much as possible. Due consideration should be given to minimizing damage even if an accident occurs.

2） Handling of high-pressure gas containers (cylinders)

Gaseous substances at the ordinary temperature and normal pressure used for experiments are supplied in high-pressure gas containers. They are fed at 150 atm max. and, as such, must be handled with care. Gas cylinders fall into either those with a left-hand thread screw or those with a right-hand thread screw. The former are filled with flammable gas, while the latter are filled with nonflammable or oxidizing gas. For specific details, consult reference books and other sources of information. General precautions are as follows:

a) Be well-versed in the handling of pressure regulators.

b) When transporting a cylinder, firmly tighten the protective cap on the cylinder valve and then place the cylinder on a cylinder transport cart. If the cart is unavailable, tilt the cylinder slightly from its upright position and carry it by rolling it on its bottom edge. Do not handle cylinders with hands in oil-soaked gloves. It is dangerous to transport a cylinder with a pressure regulator on it.
c) Before fitting a pressure regulator, check whether it is for a left or right-hand thread screw. First, check the filling port's valve seat for scratches. If the valve seat is scratched, it is best to replace the whole cylinder. However, if the scratches are shallow, a dedicated gasket may be used to prevent gas leakage. Do not overtighten the gasket.
d) Release any gas only after ensuring that the pressure regulator valve and the outlet-side tap are shut off. Fully open the supply gas valve. Using soapy water, check for any signs of gas leakage from the valve rod part of the supply gas valve and the connection between the filling port and the pressure regulator. Then, slowly turn the pressure regulating valve in the specified direction to adjust to the prescribed pressure. It is dangerous here to look into the pressure gauge. If released rapidly, the gas causes friction with the inner surface of the valve, resulting in static electricity, which is dangerous in the presence of flammable gas.
e) To stop the gas release, shut off the supply gas valve first and then the pressure regulating valve. Next, using soapy water, double-check the seat of the supply gas valve and the connection with the regulator for any signs of gas leakage. Carefully avoid overtightening the supply gas valve.
f) Gas cylinders fall over easily. Take care to prevent them from falling over.

3. Chemical Experiments

These experiments are the first specialized experiments that you will take. Experiments always involve potential risks. You are advised to pay close attention to safety and develop a habit of conducting experiments safely. Eye exposure to chemicals may result in complete blindness. Wear protective goggles as much as possible during experiments.

(1) Analytical Chemistry Experiments

Analytical chemistry experiments involve neutralization titration and instrumental assays. Glassware is often used in these experiments. Handle glassware with care. Do not use damaged glassware that could easily cause injury. When you have damaged or found damaged glassware, always contact the instructor for repair or replacement with new glassware (see “Precautions for glassware use”).

Hydrochloric acid and sodium hydrate are the chemicals that require particular care during handling in these experiments. Read the “Handling of chemicals” section before performing any experiment. Concentrated hydrochloric acid emits irritating fumes that affect the eye and skin and should be weighed out and diluted in a draft chamber.

(2) Organic Chemical Experiments

Organic chemistry experiments involve using glassware and various chemicals and, as such, pose extremely high risks of accidents, such as injuries from accidentally broken glass, burns from leaked flammables catching fire, and skin damage from chemicals, such as acids and alkalis. An uninitiated or unskilled person often breaks a glass tube and gets unexpected deep cuts from broken pieces, especially when connecting a glass tube to a rubber stopper or tube. Carefully read the above tips for chemical experiments to avoid causing these inadvertent accidents with care and perform experiments safely according to the correct methods. You are expected to learn the fundamentals of useful substance synthesis through organic experiments.

1） Before starting experiments

First, arrive in time for the attendance check and report to the instructor that you will surely participate in an experiment. Then, the instructor in charge will provide careful explanations and instructions for the content of the day’s experiment, the reaction mechanism to be covered, specific operations, and expected risks (accidents). Prepare for the class. If in doubt, ask questions during the class and understand the specifics of operations well.

2） Handling of reagents

Reagents for the day’s experiment are made ready for each group in a predetermined place. Weigh out the specified amount into a glass vessel if the reagent is liquid or onto, for example, a piece of drug wrapping paper if it is solid. Be careful not to spill the reagent. For acids, solvents, and the like, weigh out the specified amount using a dedicated pipette without skin contact. In case of inadvertently spilling a reagent, immediately report to the instructor. Then, clean up the spillage as instructed by the instructor. Do not cause inconveniences to the next person. The reagent handling area is used in common by all members and, as such, should always be kept neat and in good order by each member to ensure efficient work.

3） Handling of the labware and tools to be used

These items divide into those consisting mainly of glassware assigned to individual members' experiments and those for shared use in each experiment. Both must be washed clean and kept ready for use. Especially labware lent out for the day must be cleaned after use and returned to the place specified by the instructor.

4） Tips during experiments

Carefully perform experiments according to the general precautions for experiments. Do not leave the bench without putting away dangerous chemicals when heating flammables. When performing a dangerous operation or inadvertently having caused an accident, such as fire, water leakage, or scattering of chemicals, use a loud voice to draw the attention of the people in the surroundings. Then, immediately take action with the help of the instructor and those nearby to avoid getting injured and prevent others from getting injured. When having to leave the laboratory, notify the instructor to that extent. Do not leave the lab without the instructor’s permission.

5） Actions to be taken in case of personal accidents

If, unfortunately, getting injured or finding any nearby person injured, act according to the “Measures for Dealing With Accidents” presented in another section. However, students often fail to implement the appropriate measures for a sudden turn of events. First, use a loud voice to inform the instructor of the injured person and follow the instructor’s instructions.

6） Completion of the day’s experiment

When completing an experiment safely, wash well the glassware you used and prepare for the next day. For any waste from the experiment, always ask the instructor for instructions and perform the disposal with due care accordingly. You are asked to remember that most of the chemicals used in organic experiments and the products obtained cannot be drained untreated to sewerage. If acid and alkali waste liquids are free of substances that cannot be drained to sewerage, neutralize them before disposal. Ether, other organic solvents, chrome wastewater, or the like must be put in a specified reservoir container.

Glassware washing sinks are used in common by everyone. Do not leave any sink cluttered with cleaning liquids, brushes, or any other items on its top.

When you have finished organizing your desk and personal effects, report to the instructor for permission to go home. Never go home without permission. The reason is that there is no asserting that no student is lying unconscious out of the instructor’s sight.

(3) Physical Chemistry Experiments

Before these experiments, each experiment's operating procedure must be carefully read and understood. Before conducting these experiments, you will receive explanations from the instructor. Adhere to the instructions and precautions for each experiment. Contact the instructor immediately whenever any possible anomaly or a safety-threatening situation arises.

1） Precautions for apparatus assembly and handling

i. Any apparatus must be assembled to cope with a contingency that may occur, such as an earthquake, gust, or power outage.

ii. Due consideration must be given to the failsafe to preclude any contingency due to inattentive students other than the parties involved.

iii. Keep floors free of unwanted items to ensure that passages and access openings can be safely secured even in an emergency.

iv. When handling glassware, remember that *glass will always break under excessive force, resulting in injury, and will always break and scatter when subjected to a sharp temperature difference*. When inserting a glass tube or any other glass article into a rubber stopper, rubber tube, pipettor, or the like, hold a part near the insertion hole to allow easy insertion without using excessive force.

v. When using electrical equipment, exercise care to avoid electric shock. Protect the apparatus from exposure to water. Carefully avoid operating it with a wet hand.

2） Handling of chemicals (See “Safe Use of Chemicals”)

i. Exercise extra care when handling toxic and harmful chemicals. Basic precautions must be followed, such as using a draft chamber to avoid inhalation, wearing protective goggles to avoid eye contact, and immediately washing off in case of body contact. Be careful with fire when handling an easily ignitable solvent, even in small amounts. Generally, an organic solvent gas has greater specific gravity than air and may creep along a floor surface to catch fire. Therefore, consideration must be given to the risk of ignition from a distance in a poorly ventilated room. Remember to perform indoor ventilation accordingly.

ii. Adhere to the instructor’s instructions whenever handling particularly toxic chemicals.

iii. Dispose of waste liquids as specified. Be careful not to drain organic solvents, harmful substances, acids, alkalis, or the like, even in small amounts, into the sink.

(4) Computer Experiments

None of the work involved poses a personal safety problem. However, you are asked to be careful and avoid touching various power sources without permission. Security controls are required to prevent data corruption. Follow the instructor’s instructions.

(5) Instrumental Analysis Experiment

1） Infrared absorption spectrum method

Samples are measured in the form of KBr tablets as appropriate. Use a hydraulic press to apply pressure of up to 5 to 8 tons to form tablets. Take care when handling forming equipment, including assembly. Skewed pressing will damage the forming equipment, which is extremely dangerous.

When using solvent casting to form polymer film, do it in the best-ventilated place available to prevent the inhalation of solvent vapors.

2） Nuclear magnetic resonance method

The superconducting magnet used in the apparatus generates an extremely strong magnetic field. Take care to avoid any hazards due to the effects of this magnetic field. Refer also to “Safety in the Use of Common Facilities.”

3） UV-visible absorption spectrum method

A cleaning liquid specified in the JIS and ASTM methods is preferred to clean absorption cells, such as quartz cells. Such cleaning liquids can cause serious damage to the eye and should be used with care.

4） Gas chromatography (GC)

Refer to separate sections for the handling of high-pressure cylinders. Sample inlets are often heated up to accelerate the gasification of the sample. Take care to avoid injuries such as burns.

5） High-speed liquid chromatography

Pay attention to laboratory ventilation and exercise due care with fire when using an organic solvent as a mobile phase. Be particularly careful to prevent liquid spillage.

6） X-ray diffractometry

X-rays, at any dose, cannot be said to be harmless to the human body and must be handled carefully. Refer also to “Safety in the Use of Common Facilities.” Care must be taken to avoid x-ray exposure, especially in student experiments with many students in a small room.

(6) Physical Experiments

Presumably, physics experiments use fewer sets of equipment that can be dangerous than chemistry experiments that use various chemicals and glassware. However, carelessness could cause damage to relatively expensive equipment and injury to the experimenter.

1） Organization of the experiment environment

The basic attitudes toward these experiments are not significantly different from those toward chemistry experiments. Arrange laboratory equipment, including wiring and the like, for easy handling. The measurer should position the chair and the like to allow a comfortable posture for operating the equipment. Placing the equipment in the center of the bench may provide safety at the expense of ease of operation. However, the equipment may fall off if placed too close to either edge of the bench.

2） Precautions for the handling of equipment

i. High-sensitivity or high-precision measuring instruments are often supplied with accessories such as stoppers or fine-tuning screws to ensure the instrument's safety during nonuse. These instruments must be handled with due care. Read the manual and other documents carefully before use. Overexerting oneself must be avoided as it may cause damage or danger to the equipment. Computers, measuring instruments, and the like hate dust and should always be covered when unused.
ii. To use a power source in an experiment, make connections between equipment (make the wiring easy to understand) and then plug the power cord. Turn off the power before modifying the wiring during the experiment or before removing it after finishing the experiment. Even after the power is turned off, a large-capacity capacitor often remains electrically charged and can cause an unexpected electric shock. Be sure to ground the line once and check with a tester.
iii. Needless to say, due care should be taken to avoid the risk of explosion or electric shock when using high pressures or high voltage. A pressure gauge incompatible with a gas cylinder may be blown out when connected. Specific precautions for experiments using high voltage cover a wide range. Separate safety manuals are prepared for each experiment/laboratory.
iv. When experimenting with a laser light source, looking directly at the light with the naked eye is extremely dangerous and must always be avoided. A separate section (Safety Precautions for Laser Light) provides more details on laser light.

(7) Chemical Engineering Experiments

For these experiments, the themes are organized around the premises of the operation of real chemical processes. Therefore, the experiment apparatus will be large and bulky. Their operation requires high volume use of utilities, such as electricity, gas, and water, as shown in the table below for each experiment theme. Accordingly, using these apparatuses requires a thorough understanding of the fundamentals of handling to ensure safety in conducting experiments. This section presents the basic safety knowledge for handling high-pressure gas, city gas, electricity, and water, as well as the precautions to be followed by each of you during experiments.

1) When assembling your experiment apparatus, follow the assembly drawings and guidelines to ensure correct assembly. Try lightly turning stirrers and other moving parts to check whether they move smoothly. Check water flow systems for blockages.

2) For measuring instruments and the like, consult their operating instructions and learn their use and principles, among other things. Be careful not to damage them by improper operation or use beyond their intended use. Conduct preliminary assays as necessary.

3） Hazards from toxic components, flammable or explosive liquids or gases, and heat generation have been mentioned several times earlier. Exercise caution, especially when using them in large quantities in main experiments.
4） At the same time, be aware of mechanical and electrical hazards. Always take protective measures. In many accidents, trouser legs or sleeves have been caught in belts or overcurrent passing through octopus wiring.
5） As regards handling high-pressure gas containers (cylinders), carefully read and follow the instructions in a separate section.

Experiment themes and the main utilities to be used

Experiment theme	High-pressure gas	Electricity	Water	Chemicals
Dimensional analysis			For settlement media	
Flow			For flows	
Fluidized bed	Compressors	For compressors		
Gas absorption	Carbon dioxide gas cylinders	For measuring instruments	Absorbing liquids	NaOH HCl
Distillation		For heating/for measuring instruments		Methanol, ethanol
Drying		For heating/for measuring instruments		
Gas-solid contact reaction		For heating/for measuring instruments		Isopropanol
Heat transfer		For heating/for measuring instruments	For cooling	

4. Biological and Bioengineering Experiments

In biological and bioengineering experiments, you will conduct experiments on such themes as protein separation, purification, and quantification; solid protein structure; enzyme reaction analysis; and microbial cultivation and morphological observation.

These experiments involve the handling of biological samples. Therefore, it is extremely important to take care to prevent both chemical and biological accidents. Safe biological samples are prepared for these student experiments. You will receive specific precautions from the instructor and must follow them and use the utmost care to prevent accidents.

General precautions are as follows:

(1) Segregate areas of potential microbial contamination from clean areas. No smoking, eating, or drinking is allowed in the laboratory.
(2) Inexperienced students often accidentally drop bacterial suspensions on the floor or suck them into pipettes. In such cases, do not attempt any self-invented disposal. Always ask the instructor for appropriate instructions.
(3) Sterilize and disinfect anything suspected of microbial contamination.
(4) For more detailed precautions, refer to “Safety in Biological Experiments.”

5. Staying Safe during Physics Experiments, Engineering Experiments and Practical Training

1. Staying safe during physics experiments

Although few devices used during physics experiments are dangerous, carelessness can cause damage to relatively expensive equipment and injury to the user.

(1) Maintaining the experiment area

The basic attitude toward experiments is not much different from that toward biological or chemistry experiments. Laboratory equipment, including wiring, should be arranged so that it is easy to handle. Position chairs and the like so that the operator can maintain a comfortable posture while manipulating the equipment. Equipment placed in the center of the laboratory table may be safely situated but difficult to handle, and if it is placed too close to the edge it may fall off the table.

(2) Precautions for handling equipment

a) Measuring instruments with high sensitivity and accuracy are often equipped with stoppers and fine-adjustment screws for safety when not in use. Handle these with care and operate them only after carefully reading the instruction manual. If the operation does not go as expected, do not try to force it, since this may damage the equipment. Dust can hinder the operation of computers and measuring instruments, so always

keep them covered when not in use. Always turn off the equipment before covering it, since the cover may heat up if the power is on.
b) For experiments that use a power supply, connect the wires between the equipment (make sure the wiring is organized) before connecting the power supply. Always turn off the power supply first when changing the wiring during an experiment or when disconnecting the wiring after the experiment is over. Large-capacity capacitors may retain an electrical charge even after the power is turned off. This may cause an unexpected electric shock, so always ground the wiring and check the charge with a tester.
c) It goes without saying that you should always take precautions against explosions and electric shock when using high-pressure or high-voltage equipment. A gas cylinder connected to an incompatible pressure gauge can cause them to burst. Specific precautions in experiments involving high voltages vary widely. A safety manual should be prepared for each experiment or research project that considers actual conditions.
d) In experiments that require lasers, keep in mind that looking directly at lasers without protective goggles is dangerous and must be avoided at all costs.

2. Basic Precautions in Electrical Experiments

(1) Always perform start-up checks before starting an experiment.
(2) Until safety is confirmed, never start an experiment. Carefully check the positions of main switches, especially those on switchboards or next to desks.
(3) Ensure the safety of others before turning on the main power. Ensure that the main switch beside the desk is off, especially before turning on any switch on a switchboard.
(4) Assemble your experiment apparatus into a rational setup for experiments. Not only do complicated setups and wiring result in poor-quality data, but they can also lead to laboratory errors, which can result in accidents.
(5) Never touch anyone else's experiment apparatus and the like.
(6) When you have finished an experiment, tie the power cords of electrical equipment into a bundle. Do not leave them hanging down. Otherwise, you may entangle your foot with a power cord, damage the equipment, or injure yourself.
(7) When you have finished an experiment, always turn off all the experiment apparatus, including the main switch next to the desk, and check again before you go home.
(8) When experimenting with high voltage, dry your hands and work as much as possible with one hand.
(9) A power source with a large current-carrying capacity should be used with a limiter set or a resistor inserted to prevent unnecessarily large current flow.
(10) When using a high-capacity capacitor, add a high-impedance resistor of 500 kΩ or more in parallel, unless otherwise prevented, to ensure that the charge does not remain for a long time. Do not touch the capacitor immediately after discharging it.
(11) If someone receives an electric shock, immediately turn off the power or remove the victim from the place with a dried wooden or bamboo stick.
(12) An electric-shock victim may feel strange in the heart after a while. If the victim falls into shock, contact staff immediately and take appropriate action, such as artificial respiration or cardiac massage.

(13) When wiring, check the current-carrying capacity and avoid using old power cords or half-plugged connectors.
(14) When connecting an electrolytic capacitor, check the polarity carefully. If the capacitor is connected with the polarity reversed, it may explode, and the electrolyte or the case may blow out, resulting in personal injury.
(15) If the experiment apparatus fails or a fuse blows, fully understand the cause and avoid repeating the same mistake.
(16) Switch off all apparatuses immediately and turn off the main switch next to your desk in case of a power outage.
(17) A wet-gloved hand is more susceptible to electric shock than a bare hand. Use completely dry gloves.
(18) In the event of a fire or explosion, never attempt to deal with the situation among yourselves, but always contact a faculty member.

IV Mechanical Experiments

While students conduct their experiments primarily in student laboratories, they receive machine tool training at the Center for Design and Manufacturing. Misuse of any machine tool can result in a serious accident. It is extremely important that students fully understand their operating methods and mechanisms, among other things. To prevent accidents, it is important that students carefully read not only this booklet but also the textbooks for the laboratory assignments and fully understand the contents of the experiments, procedures, and precautions. See also “For Safe Operation of Machines” and the section on the Common Facility, the “Center for Design and Manufacturing.”

Safety and notification of experiments, studies, exercises, etc. off campus

1. Prior notification of experiments, studies, exercises, etc. off campus

Notify the University in advance before engaging in activities such as experiments, studies, exercises, laboratory seminars, attendance at academic society meetings, or internships out of doors, at other research institutes, at companies, at general lodging facilities, or elsewhere off the University campus, as part of the University's research and education activities (including classes and research for graduation theses or master's theses). This notification process is necessary both to prevent accidents and to enable the University to respond appropriately and apply for insurance benefits in the unfortunate event of an accident.

Types of notifications

i. Off-Campus Research Notification: Submitted in all cases of experiments, studies, exercises, seminars, academic society meetings, etc. off campus (in Japan).
ii. Tour Notification (page 29): Submitted when touring another facility. Must be guided by a faculty member.
iii. International Travel Notification or International Study Notification (page 30 and later): Submitted for experiments, studies, exercises, seminars, academic society meetings, etc. off campus (overseas). Submit these notifications by the deadline to the Academic Affairs Department through your faculty advisor, referring to the information below for the methods of notification and forms.

■ Students of the Faculty of Engineering and Graduate School of Engineering: Koganei Campus Web Bulletin Board > Academic Information

■ Students of the Graduate School of Bio-Applications and Systems Engineering: Graduate School of Bio-Applications and Systems Engineering Website > List of Application Forms

A student planning to engage in activities such as experiments, exercises, or studies at another institution for a fixed period of time must first make responsibilities clear by submitting a Research Guidance Request and other documents to the other institution. Often, the other institution has established forms that need to be used. Your faculty advisor will fill out those forms and submit them to the University, and then the Faculty of Engineering will issue a Request form.

* The notification above cannot be accepted if no student research/education casualty insurance policy and liability insurance policy (e.g., academic research liability insurance policy) has been taken out.

* For participation in off-campus games or events in extracurricular activities such as those of student clubs or similar organizations, the Notification of Off-Campus Activity must be submitted to the Student Affairs Department in advance. Obtain the form at the Student Affairs Department counter.

2. Traffic safety

Be aware that conditions of University classes conducted off campus may vary considerably. Remember that the trip to and from the location of such exercises is considered a part of the class. While students should behave in ways suited to their surroundings in public areas off campus, they must keep in mind their status as students of the University. In particular, when driving, be considerate of other drivers. However, students are not permitted to drive official vehicles. When traveling on foot, be careful to avoid accidents.

Moving around the city involves interaction with a wide range of vehicles that follow different traffic rules. These include buses, cars, motorcycles, and bicycles. Caution is required because some drivers do not follow the rules. Remember that it is particularly hard to concentrate in situations such as crowded and noisy places. The streets are used by a diverse range of people, including children and seniors, who behave in their own individual ways. It must be noted that dramatic changes in such environments could lead to unforeseen accidents due to misjudgments, even in off-campus places that had seemed safe.

It also must be noticed that driving in places such as the mountains and surrounding areas, which seem peaceful at first glance, could lead to unforeseen accidents due to driving at high speeds.

Date (M/D/Y): / /

Tour Notification

To: Head of the Faculty of Engineering

To: Head of the Graduate School of Engineering

To: Head of the Graduate School of Bio-Applications and Systems Engineering

Faculty advisor

To: Head of Department/Program etc.
or Chair of Education Committee/Academic Affairs Committee

Please be notified of my/our plans for the tour described below:

Details

Purpose of tour					
Class name		Department/program		Student year	
		Subject			
Date (Y/M/D) and time of tour		/ / (____day) - / / (____day) : am/pm - : am/pm			
Destination of tour	Name				
	Address	〒 - ; tel. - -			
Tour participants		Department/program		Student year	Student year
		Student ID		Name	(Number of other participants:)
Guiding faculty member					
Means of transport to the tour destination		To: From:			
Insurance coverage		□ Student research/education casualty insurance □ Academic research liability insurance policy □ Others (insurance policies taken out individually):			For staff use (Coverage verification seal)
Request Form		□ Required □ University form □ Destination form			
Addressee of Request Form	Name				
	Address	〒 - ; tel. - -			
Remarks		1. Meeting date (M/D) and time: / (_____day), : am/pm 2. Meeting place 3. Other information			

(Note 1) ***Submit this Notification at least once week in advance*** of the tour.

(Note 2) ***A tour may not be participated in if not insured.***

(Note 3) If the number of participating students is large, ***attach a separate list and indicate insurance coverage status on it.***

Submit to: Academic Affairs Department

(付表B)
Front Page

渡　航　届
Notification of Going Abroad

Year　Month　Day
令和　　年　　月　　日

工学部長　殿
工学府長　殿
生物システム応用科学府長　殿

下記のとおり、学外（研究・教育）活動について安全管理上の措置を講じたうえ、実施することをお届けします。

学科長または指導教員名
Department Chair or Supervisor

印
Seal

【TEL：　　】

学科 専攻 Affiliation	年次 Grade	学籍番号 Student ID No.	
		氏名 Name	
		国籍 Nationality	

日程 Schedule	令和 From Year	年 Month	月 Day	日 ～	令和 To	年 Year	月 Month	日 Day	
行　先 Destination	名　称 Institution Name								
	渡航先・国 Country			都市名 City					
研究先での指導者 Instructor	□無 No ・ □有 Yes【指導者氏名：Name			所属：Affiliation	】				
同行者 Accompanying instructor	□無 No ・ □有 Yes【同行者氏名：Name			所属：Affiliation	】				
旅費・修学費等の支弁 Financial Support	□ 本学 / 国の公的機関からの支援 【支援元：　　】 From TUAT / Government □ 招へい先の支援 From Partner Institution □ 自費・民間奨学金、その他 【奨学金等名称：　　】 Own Fund / From Private Scholarship / Other								
目的 Purpose	内容・プログラム名 ： Research theme・Program title								
	（関連項目に✔を記入）Please mark ☑ to your purpose.								
	□卒業および修士論文 Research for Thesis				□学会発表 Academic Presentation				
	□インターンシップ Internship				□研修 Training Program				
	□授業科目名 Taking class 【　　】				□他 Other【　　】				
	単位修得の希望 ：□無No ・□有Yes → SPICA登録： □済Done ・ □未登録Not Yet Credit Transfer Request　SPICA Registration								

渡航中の緊急連絡方法（Emergency Contact During Travel）：連絡のとれるTEL、E-mailを記入して下さい。

個人所有の携帯電話 Personal Mobile Phone	TEL:	E-mail:
その他の連絡先 Emergency Contact	□研究先Reserch Inst □宿泊先Accomodation □その他Other （　　）	名称Name：
	TEL※:	E-mail:
	□研究先Reserch Inst □宿泊先Accomodation □その他Other （　　）	名称Name：
	TEL※:	E-mail:

※国番号も入れてください(Please include Country Number)

安全管理チェック（Safety Management Check List）：　確認の上、✔を記入して下さい。

□	参加学生に対し指導教員が講ずるべき事項 Make sure to check by your Supervisor	①災害傷害および賠償責任保険、海外旅行保険の加入確認・指導 Have personal accident insurance, liability insurance, and travel insurance ②連絡方法・救急具の携行等、事前の安全教育の実施 Make sure to comfirm the emergency contact and teach how to live safety overseas
□	渡航届と併せて提出するもの Other documents needed to submit	①海外渡航誓約書 Written pledge regarding international trip (I-R&C Support Service) ②付帯海学被保険者証コピー Copy of travel insurance contract

注　1.学生は、渡航届前に、災害傷害保険、賠償責任保険および海外旅行保険（付帯海学）に加入していること。
　　2.【本届の提出場所】　小金井地区事務部学生支援室　教務係
　　3.【本届の提出期日】　渡航日2週間前迄

（裏面につづく　Continue to back page）

※Please submit to Educational Affairs Office by 2 weeks before your departure※

渡航届(付表B)**裏面** Back Page

国内の緊急連絡先 Emergency Contact in Japan	氏名Name：	続柄Relation：
住所Address：		
TEL:	携帯 Mobile：	
パスポート 氏名(ｱﾙﾌｧﾍﾞｯﾄ表記)： Passport Name in alphabet		No.
海外旅行保険 Travel Insurance	□付帯海学 Futai Kaigaku **≪加入必須≫**	

Attention International Students!! For Temporary Leave, please fill in below. 外国人留学生の一時帰国の場合は下記を記入してください。	
奨学金の種類 Type of scholarship	□国費 Japanese Government Scholarship Student □政府派遣 Foreign Government Sponsored Student □私費 Student at Private Expense（□学習奨励費 Honors Scholarship）
備考 Note	

スケジュール表（別紙可） Itinerary (Please add appendix if necessary)

年月日 Date	発着地名・交通手段(便名)* Departure/Destination	訪問先 Visiting institution	滞在日数 Days	用 務 Business

*発着地名と飛行機(便名）、バス、電車等の移動交通手段を記入して下さい。
*Please input port of departure, destination, and means of transportation including airline (flight No.), bus, and train.

□国内で空港までの往復等に自主運転で自動車を利用する予定がある
I plan to drive myself to and from domestic airports.
□海外で交通手段として、自主運転で自動車を利用する予定がある
I plan to drive myself to and from overseas airports.

【運転歴： 年】
Driving Experience(Year)

Form 1

International Study Notification

To: President of Tokyo University of Agriculture and Technology

Date (M/D/Y): / /

Affiliation: (year:)

Student no.:

Kana
Name:

Joint and several guarantor: Seal
(Relation:)

Address
:

Tel.:

I hereby permission to study abroad as described below:

Details

1. Purpose		Units awarded: □ Y □ N
2. Destination of international study	Name of University Address Tel.	(Country:) Email
3. Period (Y/M/D) of international study	/ / - / /	
4. Provision of travel expenses, attendance expenses, etc.	□ Paid by the University or a national public institution □ Paid by self (private scholarship), etc.	□ Paid by destination
5. Contact while abroad Personal mobile phone	 Tel.	 Email
Place of lodging	Name Tel.	 Email
6. Emergency contact in Japan	Name Tel.	Relation Mobile tel. no.
7. Passport	No.	Name (in Roman alphabet)
8. International travel insurance	□ Covered international study □ Other ( ) * If "other" is checked above, attach documentation of coverage details.	

Head of Department/Program etc.:	Chair of Education Committee:	Academic advisor:
Seal	Seal	Seal

* Attach a travel itinerary (in any format).

. Personal Accident Insurance for Students Pursuing Education and Research and Liability Insurance for Students

I. Personal Accident Insurance for Students Pursuing Education and Research

The Personal Accident Insurance for Students Pursuing Education and Research package provides protection for students who are injured due to disasters or accidents during university classes or extracurricular activities. TUAT requires all students to enroll in this insurance.

1. Enrollment

New students complete membership procedures for the prescribed years of study when they enroll in the university. Students enrolled in the university for more than the prescribed period of study, due to a lack of credits for graduation or the like, must renew membership annually.

2. When insurance benefits are paid

(1) When a student suffers bodily injury as a result of a sudden and accidental external accident during TUAT's educational and research activities.
"Educational and research activities" refers to the following:

1) During regular classes

This refers to lectures, experiments, practical training, exercises, or practical skill courses (hereinafter collectively referred to as "classes"), and also includes the following activities:

a) While engaged in thesis or dissertation research under the direction of an academic advisor. However, this excludes the period when the student is engaged in such activities exclusively at places related to the student's personal life.

b) While preparing for or cleaning up after classes as directed by an academic advisor, or while conducting research activities in the place where the class is held, or at a TUAT library, reference room or language-learning facility.

c) While taking regular courses at other universities in accordance with the provisions of Article 28 of the University Establishment Standards and Article 15 of the Graduate School Establishment Standards.

"Other universities" includes universities in foreign countries.

2) During university events

While participating in university events that are part of educational activities, such as entrance ceremonies, orientations and graduation ceremonies the university organizes.

3) While in a university facility other than 1) or 2) above

While in facilities owned, used or managed by TUAT for educational activities. However, this excludes: accidents that occur while the student is in a university dormitory, that occur at a time or location prohibited by TUAT, or that occur while conducting activities TUAT prohibits.

4) During TUAT-approved extracurricular activities outside university facilities

While engaged in cultural or athletic activities under the supervision of a TUAT-approved TUAT student organization in accordance with the prescribed procedures as stipulated in the university's rules and regulations. (However, the scope of the insurance coverage is limited.)

(2) When a student suffers bodily injury as the result of an accident while commuting to and from the university, or while traveling between university facilities, etc.

1) While commuting to and from the university
While traveling between the student's residence and university facilities by a reasonable route and method (excluding methods TUAT prohibits) for the purpose of participating in university classes, events or extracurricular activities.

2) While traveling between university facilities
While traveling by a reasonable route and method (excluding methods TUAT prohibits) between facilities owned, used or managed by TUAT for education and research, and locations where classes, university events or extracurricular activities are held.

3. Type and amount of insurance benefits

Scope of coverage	Death benefits	Permanent disability benefits	Medical benefits	Additional benefit for hospitalization
During curriculum activities or school events	20 million yen	1.2-30 million yen	Cases involving treatment for one or more days are covered 3,000-300,000 yen	4,000 yen/day
For reasons other than the above, while inside campus facilities	10 million yen	0.6-15 million yen	Cases involving treatment for fourteen or more days are covered 30-300 thousand yen	4,000 yen/day
During extracurricular activities outside of University facilities, of which the University was notified	10 million yen	0.6-15 million yen	Cases involving treatment for fourteen or more days are covered 30-300 thousand yen	4,000 yen/day
While commuting to or from school	10 million yen	0.6-15 million yen	Cases involving treatment for four or more days are covered 6-300 thousand yen	4,000 yen/day
While in transit between University facilities or similar locations	10 million yen	0.6-15 million yen	Cases involving treatment for four or more days are covered 6-300 thousand yen	4,000 yen/day

4. Insurance benefits will not be paid in the following cases:

Intentional acts, fighting, criminal acts, illnesses, earthquakes, volcanic eruptions, tsunamis, wars, civil unrest, damage caused by radioactive waves or radiation, unlicensed driving, drunk driving, dangerous sports during extracurricular activities off campus, etc.

Accidents that do not satisfy the conditions of being due to abrupt, sudden, external causes, such as acute alcohol poisoning caused by consuming alcoholic beverages also are not covered.

5. Insurance premiums and coverage period (limited to designated years of attendance)

Classification	Period of coverage	Premium	Remarks
Undergraduate students	4 years	3,300 yen	
Graduate students	2 years	1,750 yen	Graduate School of Engineering (Master Course, Doctoral Course, Professional Degree Course) Graduate School of Bio-Applications and Systems Engineering (Master Course)
	3 years	2,600 yen	Graduate School of Engineering Doctoral Course Graduate School of Bio-Applications and Systems Engineering (Master Course, Doctoral Course, Consistent Doctoral Program)
	5 years	4,050 yen	Graduate School of Bio-Applications and Systems Engineering (Consistent Doctoral Program)
	For a one-year course	1,000 yen	

6. Notice of accident and claim for insurance benefits

(1) Notice of accident (notify using designated postcard)

The administrative staff responsible in your affiliated section must be notified promptly of the date, time, location, conditions, and degree of injury in the event of an insured accident. Note that insurance benefits cannot be paid if notice is not provided within 30 days after the accident. (Article 18 of the insurance policy)

(2) Claim for insurance benefits (claim benefits using the designated form)

Insurance Benefits Claim Form/Accident Certificate, written diagnosis from a doctor, etc.

7. Transfer

You may apply for a refund of insurance premiums if you withdraw or take a leave of absence exceeding one year during the insurance period.

8. The following section handles administration of this insurance policy. Entrance Examinations Department, Student Affairs Office (ex. 7014)

Associated liability insurance program for student research/education casualty insurance

The student may be liable by law to pay compensation for damages in the event of accidental injury to another or damage to off-campus facilities or property during curriculum activities, off-campus research activities, internships, school events, and travel to and from such activities. The associated liability insurance program for student research/education casualty insurance is intended to cover such legal liability.

1. Eligible for coverage

Students covered by student research/education casualty insurance as of the time the off-campus activity begins.

2. Scope of covered activities

Curriculum activities, school events, extracurricular activities, internships, volunteer activities (only those authorized by the University through the designated procedures), and travel to and from such activities (not including medical-related exercises).

3. Amount of coverage and premium

Insurance premium: 340 yen (for one year)
Limit on coverage per personal injury or property damage incident: 100-million-yen
Deductible: 0 yen
Accidents both inside and outside Japan are covered.

4. Coverage period:

Students entering in April: April 1 – March 31 of the following calendar year
Students entering in October: October 1 – September 30 of the following calendar year

5. The following section handles administration of this insurance policy. Entrance Examinations Department, Student Affairs Office (ex. 7014)

How to use chemicals safely

I General precautions

1. For experiments

When engaging in research activities, such as research for a graduation thesis, master or doctorate research, joint research, and consigned research, chemicals (hazardous substances and poisons) must be handled appropriately with the guidance of a supervisor.

(1) The experiment room must be kept tidy.
(2) Do not place objects in an emergency stairway, in front of a fire door, in front of a fire hydrant, in a corridor, or on a balcony, and ensure that an evacuation route is available.
(3) Check that the experimental apparatuses/devices and electric wiring are in adequate condition.
(4) Check the locations of safety facilities, such as fire extinguishers, and learn how to use these facilities.
(5) Clothes that come into contact with the skin should be made of cotton or wool rather than synthetic fiber or mixed yarn in case they catch fire.
(6) Care must be taken to avoid being alone during an experiment, and do not leave your post.
(7) Wear protective glasses at all times. Use rubber or vinyl gloves as necessary.
(8) Notify the people in the area if a dangerous experiment is to be conducted.
(9) Avoid placing unnecessary drugs on the experiment table. Ensure familiarity with the nature of the chemicals and the handling methods.
(10) Containers must be labelled clearly, and these must be checked before use.
(11) Smoking is prohibited in the experiment room. Be careful of fire (including water heater, burner, and heater) and keep away from substances that are flammable, easily ignited, or combustible.
(12) Gas cylinders must be secured tightly with chains or dedicated belts. Make sure to close the cap when transporting. Leakage of gas lines should be checked using soapy water or a gas leakage detector.
(13) Toxic gases (especially odorless and explosive gases) should be handled in the fume hood. Gas masks should be prepared.
(14) Care must be taken for the flow rate of cooling water, pipe leakage, and stopping of water after use.

2. Measures in the event of an accident and disposal of chemicals (see individual sections for details)

(1) Do not perform experiments in the experiment room alone. If an accident occurs, stay calm and call for people to deal with it.
(2) Make effort in initial firefighting using appropriate fire extinguishers. If clothes catch fire, ask to have the fire extinguished, use the safety shower, or immediately move to the corridor and extinguish the fire by rolling on the floor.
(3) If chemicals (particularly alkalis) get in the eyes, immediately rinse them with running water for at least 10 minutes. Following this, seek medical attention as soon as possible.
(4) If the chemical comes into contact with the skin or causes a burn, this must be washed with water carefully in a similar manner. Avoid applying oil-based drugs.
(5) Following use, hazardous and harmful chemicals must be processed to eliminate danger and stored.
(6) Waste solvents of all types must not be disposed of in the drainage.
(7) Do not dispose of heavy metals and their salts. Different compounds require different processing. Appropriate handling must be applied under the instruction of a faculty member.
(8) Chemical bottles after use must be cleaned of their contents in a safe and appropriate manner and disposed of in the specified methods.

II Classification of hazardous substances

Substances that are easily ignited or combusted are specified as dangerous substances according to the Fire Services Act, and this law also specifies the handling of these substances. The outline of the substances in each category, as well as their properties and precautions of use are provided in this section.

With regards to the storage of hazardous substances, storage in the laboratory must be kept to the minimum required amount, and the remaining amount must be stored in the indoor hazardous substances storage. When storing hazardous substances, measures must be taken to avoid falling and bottle breakage due to earthquakes or other causes. Also, since certain combinations of chemicals are dangerous when mixed, care must be taken for the storage location of each substance to avoid mixing in case the contents leak.

Hazardous substances must be handled under the supervision of a qualified hazardous materials engineer. Each research group (laboratory, division, department, faculty, etc.) in charge of handling the hazardous substances must obtain hazardous material handler qualifications.

According to the Fire Services Act, hazardous substances are classified into the following 6 categories depending on the morphology or hazard level of the substances:

Class1 (Oxidizing solids)

Chlorates, perchlorates, inorganic peroxides, chlorites, bromates, nitrates, iodates, permanganates, dichromates, and other substances stipulated in Cabinet Orders, as well as compounds containing these substances

Class 2 (Flammable solids)

Phosphorus sulfide, red phosphorus, sulfur, iron powder, metal powder, magnesium, and other substances stipulated in Cabinet Orders, as well as compounds containing these substances, and combustible solids

Class 3 (Pyrophoric substances and water-prohibitive substances)

Potassium, sodium alkyl aluminum, alkyl lithium, yellow phosphorus, other alkali metals and alkali earth metals, other organic metal compounds, metal hydrides, metal phosphides, calcium or aluminum carbides, and other substances stipulated in Cabinet Orders, as well as compounds containing these substances

Class 4 (Flammable liquids)

Specified flammable substances, Class 1 petroleum, alcohols, Class 2 petroleum, Class 3 petroleum, Class 4 petroleum, animal and vegetable oils

Class 5 (Self-reactive substances)

Organic peroxides, nitrate esters, nitro compounds, nitroso compounds, azo compounds, diazo compounds, hydrazine derivatives, hydroxylamine, hydroxylamine salts, and other substances stipulated in Cabinet Orders, as well as compounds containing these substances

Class 6 (Oxidizing liquids)

Perchloric acid, hydrogen peroxide, nitric acid, and other substances stipulated in Cabinet Orders, as well as compounds containing these substances

III Properties of the individual hazardous substances and characteristics by item name

1. Class 1 hazardous substance (oxidizing solids) Table 1

Many of the oxidizing solids are prohibited from mixed loading and storage in the same location with other substances due to its nature of oxidizing other substances. Oxidizing solids are classified into Type 1, Type 2, and Type 3.

i. Common characteristics

・ Specific gravity is greater than 1.

・ Soluble in water. Some substances may generate heat in this process.
・ The substance has a strong oxidizing capacity.
・ The substance is highly reactive and undergoes degradation due to heat, shock, friction, etc., with oxygen produced in this process.
・ Some substances are deliquescent and are absorbed by paper and cloth.

ii. Common storage and handling methods

・ Avoid heat, shock, friction, etc.
・ For deliquescent substances, care must be taken for water and moisture.
・ Avoid direct exposure to sunlight and store in a cool, well-ventilated location.
・ Avoid storage and loading mixed with flammable substances.
・ Avoid contact with strong acids.
・ Prevent leakage of hazardous substances associated with container breakage.

iii.Common fire extinguishing method

・ Use water to cool the oxidizer below the degradation temperature or use foam to extinguish fire.
・ Dry chemicals and dry sand should be used for substances degraded by water.

iv.Characteristics by item name

○Type 1 oxidizing solids

・ Chlorates: Potassium chlorate, sodium chlorate, ammonium chlorate, etc. Degrade due to shock, heat, etc. and cause explosion.
・ Perchlorates: Potassium perchlorate, sodium perchlorate, ammonium perchlorate, etc. Similar to chlorates in hazard properties.
・ Inorganic peroxides: Potassium peroxide, sodium peroxide, magnesium peroxide, barium peroxide, etc. Degrades with heat to produce oxygen. Many of these substances react with water to generate heat and therefore fire cannot be extinguished with water unlike other oxidizing solids.

○Type 2 oxidizing solids

・ Nitrates: Deliquescent and readily soluble in water. More stable against shock and heat compared with type 1 oxidizing solids such as chlorates. Potassium nitrate, sodium nitrate, and ammonium nitrate, as well as barium salts, nickel, cobalt, magnesium, and strontium are included in nitrates.
・ Permanganates: Considered to be strong oxidizers, although the extent is less than that of nitrates. Produce oxygen when heated and are deliquescent. Fire should be extinguished by water.
・ Dichromates: Potassium dichromate, sodium dichromate, calcium dichromate, etc. These substances are deliquescent and degrade with heat to produce a large volume of oxygen.

Table 1 Class 1 Hazardous Substances (Oxidizing Solids)

Item name	Chemical formula	Ignition point (℃)	Specific gravity	Melting point (℃)	Solubility in water
<<Type 1 Oxidizing solids>>					
Chlorates					
Potassium chlorate	$KClO_3$	400	2.32	368	Soluble
Sodium chlorate	$NaClO_3$	>50	2.49	255	Soluble
Ammonium chlorate	NH_4ClO_3	About 100	1.8	380	Soluble
Perchlorates					
Potassium perchlorate	$KClO_4$	550	2.52	610	Soluble
Sodium per chlorate	$NaClO_4$	480	2.50	480	Soluble
Ammonium perchlorate	NH_4ClO_4	Thermally degraded	1.95		Soluble
Inorganic peroxides					
Potassium peroxide	K_2O_2	< 308	2.9	490	Degraded
Sodium peroxide	Na_2O_2	< 650	2.81	460	Degraded
Magnesium peroxide	MgO_2	Thermally degraded			Insoluble
Barium peroxide	BaO_2	800	4.96	450	Practically insoluble
Chlorites					
Potassium chlorite	$KClO_2$		2.4		Soluble
Sodium chlorite	$NaClO_2$		2.3		Soluble
Bromates					
Potassium bromate	$KBrO_3$		3.27	350	Practically insoluble
Sodium bromate	$NaBrO_3$		3.34	381	
<<Type 2 Oxidizing solids>>					
Nitrates					
Potassium nitrate	KNO_3	400	2.09	339	Soluble
Sodium nitrate	$NaNO_3$	380	2.26	308	Soluble
Ammonium nitrate	NH_4NO_3	200	1.73	169	Soluble
Iodates					
Potassium iodate	KIO_3		3.89	560	Practically insoluble
Sodium iodate	$NaIO_3$		4.28		Practically insoluble
Permanganates					
Potassium permanganate	$KMnO_4$	Thermally degraded	2.7		Soluble
Sodium permanganate	$NaMnO_4$	Thermally degraded	2.47		Soluble
Dichromates					
Potassium dichromate	$K_2Cr_2O_7$	Thermally degraded	2.67	396	Soluble
Sodium dichromate	$Na_2Cr_2O_7$	Thermally degraded	2.52	356	Soluble

<<Type 3 Oxidizing solids>>					
Periodates					
Sodium periodate	$NaIO_4$		3.87	300	Soluble
Oxidates of chromium, etc.					
Chromic anhydride	CrO_3		2.70	196	Soluble
Lead dioxide	PbO_2		9.375	360, degraded	Insoluble
Nitrites					
Potassium nitrite	KNO_2		1.91	297	Soluble
Sodium nitrite	$NaNO_2$		2.17	270	Soluble
Hypochlorites					
Calcium hypochlorite	$Ca(ClO)_2$				Soluble
(Bleaching powder)					Soluble
Peroxoborates					
Sodium perborate	$NaBO_3$, $4H_2O$		2.1	63	Soluble

2. Class 2 hazardous substance (flammable solids) Table 2

Flammable solids generally have a low ignition temperature and are susceptible to oxidation. Substances such as phosphorus sulfide, red phosphorus, sulfur, aluminum powder, zinc powder, iron powder, and combustible solids are included in this category.

i. Common characteristics

- Ignite at relatively low temperatures.
- Rapid combustion rate is observed when combusted.
- Some substances are toxic.
- Not soluble in water.
- Specific gravity is small but greater than water.
- Oxidized gradually in air. Heat may be generated in this process and may cause spontaneous ignition.

ii. Common storage and handling methods

- Avoid contact with oxidizer.
- Avoid contact with the air.
- Care must be taken in the vicinity of flames, sparks, or high temperature objects.
- Avoid friction and shock.
- Avoid mixed loading with Class 1 hazardous substances. Do not handle these substances together.
- Care must be taken for container breakage and management.
- Store safely in a cool location.
- For iron powder and metal powder, contact with water should be avoided.

iii. Common fire extinguishing method

- Water may not be used to extinguish fire in some cases (metal powder).
- In general, a large amount of water is poured for extinguishment by cooling.

iv. Characteristics by item name

・ Red phosphorus: Less hazardous than Class 3 hazardous substance yellow phosphorus, however those mixed with oxidizers are susceptible to combustion. Keep away from flammable substances.

・ Phosphorus sulfide: Includes phosphorus trisulfide, phosphorus pentasulfide, and phosphorus heptasulfide. Undergo hydrolysis to generate H_2S. This hydrogen sulfide gas is flammable and toxic to the human body, resulting in death by poisoning in a short period of time. P_4S_3 (phosphorus trisulfide) has ignition temperature of 100 ℃. Undergoes spontaneous combustion.

・ Sulfur: There are 3 types of sulfur, namely orthorhombic, monoclinic, and amorphous, depending on the heating temperature, and results in a solid, fluid, or rubber form. Those mixed with oxidizers explode with heat and shock.

・ Metal powder, etc.: Aluminum powder, magnesium powder, zinc powder, iron powder, etc. are dangerous due to the large surface area of powders. Aluminum and magnesium generate hydrogen when in contact with water. These powders cause dust explosion.

・ Combustible solids: This refers to solid alcohol. The hazards involved are similar to those of alcohol.

Table 2 Class 2 Hazardous Substances (Flammable Solids)

Item name	Chemical formula	Ignition point (℃)	Specific gravity	Melting point (℃)	Solubility in water
Phosphorus sulfide					
Phosphorus trisulfide	P_4S_3	100	2.03	173	Insoluble
Phosphorus pentasulfide	P_2S_5	110	2.09	290	Cold water Insoluble
Phosphorus heptasulfide	P_4S_7	110	2.19	310	Cold water Insoluble
Red phosphorus	P	260	2.20	400 (sublimation)	Insoluble
Sulfur	S	232.2	2.07	113	Insoluble
Iron powder	Fe		7.86	1540	Insoluble
Flammable solid					
Solid alcohol	C_2H_5OH	Flash point 13	0.792	-114	Soluble
<<Type 1 flammable solids>>					
Magnesium powder	Mg	520	1.74	650	Insoluble
Zinc powder	Zn		7.14	419	Insoluble

3. Class 3 hazardous substances (pyrophoric substances and water-prohibitive substances) Table 3

Some substances, such as yellow phosphorus and alkyl aluminum, undergo gradual oxidation when left standing in the air and lead to spontaneous combustion when ignition temperature is reached, while other substances, such as potassium and sodium, react violently in the presence of water to cause combustion while degrading water to produce hydrogen.

Other examples of this class include calcium phosphide as metal phosphide, and carbide (calcium carbide) as the carbides of calcium or aluminum.

Alkyl aluminum is a hazardous substance with pyrophoric properties; however it is also a water-prohibitive substance. Yellow phosphorus has an ignition point of around 50℃ and undergoes oxidation in air by combustion generating white smoke. Pyrophoric substances must be stored avoiding contact with air.

Alkali earth metals is a general term for 4 elements in Group II subgroup A of the periodic table, including the 3rd element Ca (calcium, No. 20), Sr (strontium, No. 38), Ba (barium, No. 56), and Ra (radium, No. 88). They have a higher melting point than alkali metals, and the electrical charge of these elements is most positive after alkali metals. This results in the next strongest basicity of hydroxides following alkali metals. Basicity becomes stronger with a greater atomic number. The hazards of these substances should be considered in a similar manner to those of alkali metals.

i.Common characteristics

- Reacts violently with water to generate heat.
- Reacts with water to generate flammable gases.
- Some substances may combust spontaneously. Avoid contact with air.
- Specific gravity is greater than 1.

ii.Common storage and handling methods

- Water-prohibitive substances must avoid contact with water.
- Pyrophoric substances must be kept away from flame, spark, etc. and avoid contact with air. Store and transport these substances in inert gases such as argon.
- Store in small portions.
- When storing these substances in a protective solution, ensure that the substance is not exposed from the solution.

iii.Common fire extinguishing method

- No effective extinguishing media have been found up to present.
- Dry sand. For organic aluminum, covering with expanded vermiculite (vermiculite) or similar materials reduces contact with air and slows the reaction, however care must be taken as the fire is not extinguished by this method. Contact with water in this condition causes an explosion. Dry chemical extinguishers without phosphates should be used.
- Use of water on water-prohibitive substances is strictly prohibited.

Table 3 Class 3 Hazardous Substances (Pyrophoric Substances and Water-prohibitive Substances)

Item name	Chemical formula	Ignition point (℃)	Specific gravity	Melting point (℃)	Solubility in water
Potassium	K		0.86	63.5	Reacts violently
Sodium	Na	587	0.97	97.8	Reacts violently
Alkyl aluminum	$(CnH_{2n+1})3Al$	100℃ ≤	1.2	-58.5	Reacts violently
Alkyl lithium	$CH_3(CH_2)nLi$	100℃ ≤	0.765		Reacts violently
Yellow phosphorus	P	30 to 45	1.82	44	Insoluble
<<Type 1 pyrophoric substances and water-prohibitive substances>> Alkali metals, alkali earth metals, and organic metal compounds					
Lithium	Li		0.53	179	Reacts
Calcium	Ca		1.55	848	Soluble
Alkyl magnesium	$CH_3(CH_2)nMgX$				Degraded
Cesium	Cs		1.9	28.5	

<<Type 2 pyrophoric substances and water-prohibitive substances>> Metal hydrides, phosphides, calcium or aluminum carbides					
Calcium hydride	CaH_2		1.7	817	Soluble
Calcium phosphide	Ca_3P_2	100 to 150	2.52	1600	Reacts
Calcium carbide	CaC_2		2.22	2300	Reacts
<<Type 3 pyrophoric substances and water-prohibitive substances>> Silicon chloride compounds					
Trichlorosilane	$SiHCl_3$	93 to 104	1.34	-134	Degraded

4. Class 4 hazardous substance (flammable liquids) Table 4

These substances are typical examples of hazardous substances, and 90% or more of the hazardous substances actually handled are classified as Class 4. Note that all of these substances are liquids.

i.Common characteristics

- All substances are liquids.
- Majority of the substances are lighter than water and insoluble in water. For this reason, the substances float on the water surface and spread, increasing the risk of combustion.
- Vapor is heavier than air.
- These substances are poor electrical conductors.
- These substances are susceptible to static electricity charges.
- The lower limit of the vapor combustion range is low, resulting in combustion (explosion) when mixed with a slight amount of air.
- Highly flammable.
- Some substances have low combustion temperature.

ii.Common storage and handling methods

- Keep away from fire
- Keep away from Class 1 and Class 5 hazardous substances. Avoid mixed loading.
- Keep the container lid tightly closed.
- Keep the temperature lower than the flash point.
- Avoid leakage of the hazardous substances to the external environment. Also avoid the leakage of vapor.
- Care must be taken for wind-induced ventilation.
- Avoid using instruments that generate sparks.
- Avoid filling the container to full (thermal expansion causes the container to break, resulting in the leakage of hazardous substances to the external environment).
- Store at or below 40℃.
- Care must be taken for static electricity.
- Avoid vigorous stirring and fast flow rate.
- Handle in a high humidity environment.

iii.Common fire extinguishing method

- Water must not be used to extinguish fire.
- Fire should be extinguished by suffocation.

iv.Characteristics by item name

Type 4 hazardous substances are divided into the following 7 categories:

- Specified flammable substances: Diethyl ether, carbon disulfide, and other substances with an ignition point of 100 ℃ or lower, or a flash point of -20 ℃ or lower with a boiling point of 40 ℃ or lower at 1 atmospheric pressure. Examples include collodion, acetaldehyde, and propylene oxide.

Petroleum is divided into the following 4 categories based on the flash point:

- Class 1 petroleum (flash point: < 21 ℃): Gasoline, acetone, benzene, acetate ester, formate ester, etc.
- Class 2 petroleum (flash point: 21 ℃ to < 70 ℃): Kerosene, diesel oil, chlorobenzene, xylene, etc.
- Class 3 petroleum (flash point: 70 ℃ to < 200 ℃): Heavy oil, creosote oil, nitrobenzene, etc.
- Class 4 petroleum (flash point: 200 ℃ to < 250 ℃): Lubricant oil, plasticizer, etc.
- Alcohols: Monosaturated alcohol containing 1 to 3 carbon atoms in each molecule. This is a water-soluble substance and is therefore an exception within Class 4 hazardous substances. Normal foam extinguisher must not be used to extinguish fire. Protein form should be used as alcohol-resistant foam extinguisher.
- Animal and vegetable oils: This refers to the oils extracted from the fat and meat of animals, or seeds and fruits of plants. Animal and vegetable oils are pyrophoric, which is a unique characteristic among Class 4 hazardous substances.

Strict prohibition of fire and avoiding leakage into the air are considered key points in the handling of Class 4 hazardous substances.

Sealable container should be used to avoid leakage into the air, however the container must be filled up to 97.5% rather than full capacity in case the hazardous substances increase in volume due to temperature.

In addition, water must not be used to extinguish fire as these substances are insoluble in water and are lighter than water. Suffocation is the only method available.

According to the Fire Services Act, water-soluble liquid is defined as a liquid mixture, which maintains uniform appearance after stabilization of the flow following gentle stirring with an equal amount of pure water at 20 ℃ at 1 atmospheric pressure, and liquids other than water-soluble liquids are referred to as water-insoluble liquids.

Table 4 Class 4 Hazardous Substances (Flammable Liquids)

Item name	Chemical formula	Flash point (℃)	Ignition point (℃)	Specific gravity	Solubility in water
Specified flammable substances					
Diethyl ether	$C_2H_5OC_2H_5$	-45	180	71	Practically insoluble
Carbon disulfide	CS_2	-30	90	1.3	Insoluble
Collodion	$C_{12}H_{16}O_6(NO_2)_4$	-18			
	$C_{12}H_{17}O_7(NO_2)_3$				
Acetaldehyde	CH_3CHO	-38	175	0.783	Soluble
Propylene oxide	OCH_2CHCH_3	-37	465	0.830	Soluble
Class 1 petroleum (water-insoluble)					
Gasoline	C_5H_{12} to C_9H_{20}	< -40	About 300	0.6 to 0.8	Insoluble
Pentane	$CH_3(CH_2)_3CH_3$	< -40	308	0.631	Insoluble

Normal hexane	$CH_3(CH_2)_4CH_3$	-21.7	225	0.661	Insoluble
Isohexane	$(CH_3)_2CH(CH_2)_2CH_3$	< -29	260	0.669	Insoluble
Octane	$CH_3(CH_2)_6CH_3$	-16	232	0.706	Insoluble
Benzene	C_6H_6	-11	538	0.88	Insoluble
Toluene	$C_6H_5CH_3$	4	480	0.871	Insoluble
Ortho-xylene	$C_6H_4(CH_3)_2$	17	482	0.88	Insoluble
Isoprene	$CH_2C(CH_3)CHCH_2$	-54	220	0.679	Insoluble
Propyl acetate	$CH_3COOC_3H_7$	14	450	0.866	Insoluble
Isobutyl acetate	$CH_3COOCH_2CH(CH_3)_2$	18	423	0.871	Insoluble
Propyl formate	$HCOOC_3H_7$	-3	454.6	0.909	Insoluble
Acrylonitrile	CH_2CHCN	0	481	0.80	Soluble
Vinyl acetate	$CH_3COOCHCH_2$	-8	427	0.93	Soluble
Methyl acetate	CH_3COOCH_3	-10	501	0.925	Soluble
Ethyl acetate	$CH_3COOC_2H_5$	-4	427	0.899	Practically insoluble
Methyl formate	$HCOOCH_3$	-19	449	0.975	Soluble
Ethyl formate	$HCOOC_2H_5$	-20	455	0.922	Practically insoluble
Methyl ethyl ketone	$C_2H_5COCH_3$	-4	516	0.806	Soluble
Class 1 petroleum (water-soluble)					
Acetone	CH_3COCH_3	-18	557.8	0.792	Soluble
Diethylamine	$(C_2H_5)_2NH$	-18	350	0.71	Soluble
Triethylamine	$(C_2H_5)_3N$	-7	384	0.73	Soluble
Acetonitrile	CH_3CN	13	525	0.785	Soluble
Pyridine	$CH<(CHCH)_2>N$	20	482	0.982	Soluble
Class 2 petroleum (water-insoluble)					
Kerosene		30 to 60	254	< 1	Insoluble
Diesel fuel		50 to 70	257	< 1	Insoluble
Chlorobenzene	C_6H_5Cl	30	638	1.11	Insoluble
Amyl ether	$C_5H_{11}OC_5H_{11}$	57		0.78 to 0.80	Insoluble
Meta-xylene	$C_6H_4(CH_3)_2$	25	527	0.864	Insoluble
Paraxylene	$C_6H_4(CH_3)_2$	25	528	0.861	Insoluble
Coal tar (diesel fuel)		< 27		< 1	Insoluble
n-butyl acetate	$CH_3COOC_4H_9$	22	421	0.88	Practically insoluble
Hexyl acetate	$CH_3COO(CH_2)_5CH_3$	45		0.855	Insoluble
Cellosolve acetate	CH_3COOCH_2, $CH_2OC_2H_5$	51	380	0.975	Practically insoluble
Ethyl silicate	$(C_2H_5)_4SiO_4$	52		0.936	Degraded
Methyl cellosolve acetate	$CH_3OCH_2CH_2$	55	380	1.005	Soluble

	$OCOCH_3$				
n-butyl alcohol	$CH_3(CH_2)_2CH_2OH$	11.1 to 39	343 to 477	0.806	Soluble
Isobutyl alcohol	$(CH_3)_2CHCH_2OH$	28	427	0.805	Soluble
Sec-butyl alcohol	$CH_3CH_2CHOHCH_3$	24	414	0.808 to 0.812	Soluble
n-amyl alcohol	$CH_3(CH_2)_3CH_2OH$	38	371	0.817	Practically insoluble
Fusel oil		42		0.814	Practically insoluble
Stylene	$C_6H_5CHCH_2$	32	490	0.907	Insoluble
Naphtha (coal tar)		30 to 44	482 to 510	< 1	Insoluble
Turpentine oil (α-pinene)	$C_{10}H_{16}$	35	240	< 1	Insoluble
Camphor oil		47		0.87 to 0.96	Insoluble
Pine oil		54 to 78		0.86 to 0.87	Insoluble
Class 2 petroleum (water-soluble)					
Formic acid	HCOOH	69	601	1.218	Soluble
Cellosolve	$C_2H_5O(CH_2)_2OH$	40	238	0.931	Soluble
Glacial acetic acid	CH_3COOH	40	427	1.05	Soluble
Class 3 petroleum (water-insoluble)					
Heavy oil		60 to 150	254 to 263	0.9 to 1	Insoluble
Creosote oil		74	336	> 1	Insoluble
Spindle oil		76	247.4	< 1	Insoluble
Aniline	$C_6H_5NH_2$	75	770	1.022	Practically insoluble
Nitrobenzene	$C_6H_5NO_2$	88	482	1.2	Insoluble
Dibutyl phthalate (ortho)	$C_6H_4(CO_2C_4H_9)_2$	157 or higher	403	1.045	Insoluble
Dibutyl phthalate (meta)	$C_6H_4(CO_2C_4H_9)_2$	161 or higher			Insoluble
Class 3 petroleum (water-soluble)					
Glycerin	$HOCH_2CHOHCH_2OH$	160	370	1.26	Soluble
Class 4 petroleum					
Turbine oil		204	371	< 1	Insoluble
Transformer oil		200 or higher		0.9	Insoluble
Dioctyl phthalate	$C_6H_4[CO_2CH_2-CH(C_2H_5)C_4H_9]_2$	219	241	0.986	Insoluble
Alcohols					
Methyl alcohol	CH_3OH	11	385	0.792	Soluble
Ethyl alcohol	C_2H_5OH	13	423	0.79	Soluble
N-propyl alcohol	$CH_3CH_2CH_2OH$	15	371	0.804	Soluble
Isopropyl alcohol	$(CH_3)_2CHOH$	12	460	0.789	Soluble

Animal and vegetable oils					
Coconut oil		216	320	0.91	Insoluble
Linseed oil		222	343	0.93	Insoluble
Castor oil		230	449	0.96 to 0.97	Insoluble
Olive oil		225	343	0.91	Insoluble

5. Class 5 hazardous substance (self-reactive substances) Table 5

These hazardous substances include gunpowders and explosives and are divided into Type 1 and Type 2 self-reactive substances with similar hazards to these.

i.Common characteristics

・ These substances are explosives.
・ Explodes violently with heat, shock, and friction.
・ Some substances contain oxygen.
・ The substances catch fire easily.
・ Combustion velocity is extremely fast.
・ Prolonged oxidation results in degradation and spontaneous combustion.

ii.Common storage and handling methods

・ Avoid heat, shock, and friction.
・ Keep away from flammable substances.
・ Avoid contact with other chemicals.
・ Store in a cool location.
・ Take care to avoid container breakage when handling.
・ Be careful of room temperature, humidity, and ventilation.

iii.Common fire extinguishing method

・ Cool with copious amount of water.
・ It is difficult to extinguish the fire on the most part.
・ Fire cannot be extinguished by suffocation.

iv.Characteristics by item name

○Type 1 self-reactive substances

・ Organic peroxides: Unlike inorganic peroxides in Class 1, ketone peroxides and benzoyl peroxides are flammable and explode with shock, etc. They also combust suddenly. Organic peroxides are used as polymerization initiators and catalysts in synthetic chemistry, particularly in polymer chemistry.

Ketone peroxides are represented by R-CO-R'-O_2, and those with methyl group at R and ethyl group at R' are referred to as methyl ethyl ketone peroxides (MEKPO). These substances have a strong oxidizing capacity; however, they combust spontaneously at the temperature of 40°C or higher. Meanwhile, they also degrade at ordinary temperature when in contact with waste cloths or other materials, with heat generation followed by ignition.

Benzoyl peroxides are white granular crystals. They degrade in an explosive manner due to heat, shock and friction and show strong oxidizing effect. Explosion may occur in such cases.

・ Nitrate esters: Nitrocellulose and ethyl nitrates fall under this category. Nitrocellulose is produced by the reaction of cellulose with nitric acid, and different properties can be obtained with different types of cellulose (fibrin) used as the raw material. In addition, various properties can be obtained by the degree of nitrification. The substances explode with fire, heat, and shock. Nitrocellulose is an ingredient in gunpowder as well as collodion listed as specific flammable substances in Class 4 hazardous substances.

Ethyl nitrate is liquid and has a high risk of catching fire. Cautions equivalent to the precautions for handling specified for Class 1 petroleum are necessary.

・ Nitro compounds: This includes picric acid, nitroglycerin, and trinitrotoluene (TNT).

Picric acid is trinitrophenol and explodes violently with impact and friction when mixed with alcohol. It is used as explosive in a similar manner to nitroglycerin and TNT.

・ Nitroso compounds: Hazardous substances include paradinitrosobenzene and nitrosamine. These compounds include -NO groups, which are different to the nitro compounds that contain nitro group($-NO_2$). Both of these types of compounds are organic compounds.

・ Azo compounds: These substances include azo group (-N=N-) bound to the C element on hydrocarbon and refers to RN=NR'. If R and R' are identical, the compounds are named "azo-", and if R and R' are different, the compounds are named " -azo- ".

・ Diazo compounds: There are two types of diazo compounds. One of these is open chain compounds that include the diazo group (=N2) bound to the C element. The other type is aromatic compounds with the H atom on the benzene ring replaced with ($-N_2$). Reaction of aromatic primary amine with nitrous acid results in diazotization.

・ Hydroxylamine: White crystals. These are unstable at room temperature and undergo degradation and explosion by heat. Even the 85% aqueous solution presents the descriptions of Type 1 self-reactive substances.

○Type 2 self-reactive substances

・ Hydrazine derivatives: Reaction with gelatin, dilute ammonia water, and sodium hypochlorite solution results in N_2H_4, NaCl, H_2O, and hydrazine N_2H_4 produced in this process creates acids and salts. Sulfate salt (N_2H_4, H_2SO_4) is a hydrazine salt with relatively low solubility. Hydrazines are generally toxic, and their derivatives are used as agricultural chemicals and catalysts.

・ Hydroxylamine salts: These substances are synthesized by the neutralization reaction between hydroxylamine and acids. Sulfate salts and hydrochloride salts are available. Aqueous solutions are strongly acidic and corrosive to metals.

・ Azo compounds of metals: Metal compounds containing N_3. These are compounds with direct combination of metal and N_3. Metals include Pb and Na, however the binding is unstable and are used as detonators.

Table 5 Class 5 Hazardous Substances (Self-reactive Substances)

Item name	Chemical formula	Ignition point (°C)	Specific gravity	Melting point (°C)	Solubility in water
<<Type 1 self-reactive substances>>					
Organic peroxides					
Methyl ethyl ketone peroxide	R-CO-R-O_2	205	1.13	-20	Partially soluble
Benzoyl peroxide	$(H_6H_5CO)_2O_2$	Thermally degraded	1.334	103.5	Insoluble
Nitrate esters					
Nitrocellulose	$[C_6H_7O_2(ONO_2)_3]n$	160 to 170	1.35 to 1.40		Insoluble
Ethyl nitrate	$C_2H_5ONO_2$	Flash point 10	1.11		Insoluble
Nitro compounds					
Picric acid	$C_6H_2(OH)(NO_2)_3$	300	1.77	122.5	Soluble
Trinitrotoluene (TNT)	$C_6H_2(NO_2)_3CH_3$	230	1.65	81	Insoluble
Nitroso compounds					
Nitroso naphthol	$C_{10}H_7NO_2$			164	Insoluble
Azo compounds					
Azobisisobutyronitrile	$C_8H_{12}N_4$		1.64	106	Practically insoluble
Diazo compounds					
Diazodinitrophenol	$C_6H_2N_4O_5$	180	1.63	169	Practically insoluble
Hydroxylamine	NH_2OH	130	1.20	33	Soluble
<<Type 2 self-reactive substances>>					
Hydrazine derivatives					
Hydrazine sulfate	N_2H_2-H_2SO_4		1.37	254 (degraded)	Practically insoluble
Hydroxylamine salts					
Hydroxylamine sulfate	H_2SO_4, $(NH_2OH)_2$		1.90	120	Soluble
Hydroxylamine hydrochloride	HCl, $(NH_2OH)_2$		1.67	152	Soluble
Azi compounds of metal					
Zinc azide	$Pb(N_3)_2$	330	4.71		
Sodium azide	NaN_3		1.85	300 (degraded)	Soluble
Guanidine nitrate	$HN=C(NH_2)_2$, HNO_3		1.44	215	Soluble

6. Class 6 hazardous substance (oxidizing liquids) Table 6

Liquids with a strong oxidizing capacity. Oxidizing liquids themselves are noncombustible, however they cause combustion when in contact with flammable substances. They also often generate toxic gases. Care is required in handling as they corrode skin and metals. Note that hydrochloric acid and sulfuric acid are not included in this category.

i. Common characteristics

- Do not combust on their own but help the combustion of other materials.
- Cause oxidation when mixed with flammable substances. Generate toxic gases.
- Harmful to the human body.
- Generate heat when in contact with water.
- React violently with metals and generate heat in this process.

ii. Common storage and handling methods

- Avoid contact with the human body.
- Wear protective clothes when handling these substances.
- Keep away from other flammable substances and metals.
- Containers resistant to breakage must be used.
- Glass containers or similar must be used.
- Avoid water and moisture in the air from entering the container.

iii. Common fire extinguishing method

- Use dry sand, dry chemicals, etc.
- Water must not be used.
- Water in mist form may be used.

iv. Characteristics by item name

- Perchloric acid: Colorless liquid obtained by vacuum distillation of the mixture of potassium perchlorate and concentrated sulfuric acid. Generates smoke in air with moisture. Explodes when in contact with organic compounds.
- Hydrogen peroxide: Colorless liquid that generates oxygen when in contact with manganese dioxide. It is used as an oxidizer to oxidize ferrous ion and is also used as a reducing agent. Purposes of use include bleach and rocket fuel.
- Interhalogen compounds: Compounds produced between 5 halogen elements in Group VIIB of the periodic table, namely fluorine (F), chlorine (Cl), bromine (Br), iodine (I), and astatine (At).

Oxidation reaction refers to the reaction with oxygen, however reactions, which involve the removal of hydrogen at the same time, are also regarded as oxidation. Interhalogen compounds are oxidizing liquids of the latter type.

Table 6 Class 6 Hazardous Substances (Oxidizing Liquids)

Item name	Chemical formula	Ignition point (°C)	Specific gravity	Melting point (°C)	Solubility in water
Perchloric acid	$HClO_4$		1.76	-112	Soluble
Hydrogen peroxide	H_2O_2		1.46	-0.89	Soluble
Nitric acid	HNO_3		1.53	-42	Soluble
Interhalogen compounds					
Iodine pentafluoride	IF_5	40	3.75	9.6	Soluble

III Combination of Substances are Hazardous in Mixture

Hazardous substances may cause fire or explosion when mixed, and therefore require caution in handling and storage. Combination of substances that are hazardous when mixed are shown as follow.

	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
Class 1		×	×	×	×	○
Class 2	×		×	○	○	×
Class 3	×	×		○	×	×
Class 4	×	○	○		○	×
Class 5	×	○	×	○		×
Class 6	○	×	×	×	×	

Remarks

1. Substances prohibited from mixed loading are shown with ×.
2. Substances acceptable for mixed loading are shown with ○.

IV Indoor hazardous substances storage

With regards to the storage of hazardous substances designated in the Fire Services Act, stock in the laboratory must be kept to the minimum required amount (check the maximum quantity specified for each building, floor, etc.) and the remaining amount must be stored in the indoor hazardous substances storage.
Note: For the maximum quantity, refer to Center for Environment and Safety website, Safety activities and management > Fire Services Act and hazardous substances “Storage of Hazardous Substances”.

There are 4 hazardous substance storage locations at Koganei Campus as permitted by the fire department, and this is referred to as “indoor hazardous substance storage”. If large amounts of hazardous substances are available, they must be stored in this storage location. In order to use the storage location, application must be submitted to the head of the respective department and facility, and the substance must be stored in a specified location according to the rule of storage use (hazardous substances for storage and the maximum storage quantity applicable are specified for each storage, and these must be checked with the manager and used in accordance with the instructions provided). Also, entry and removal of hazardous substances in these storages must be conducted with a qualified hazardous materials handler or a person designated as hazardous materials security supervisor.

The substances to be stored in each storage and the limits of storage quantity are shown in Tables 7 to 10. Substances that are not designated as hazardous substances in the Fire Services Acts must not be stored in the indoor hazardous substances storage.

Table 7 Mechanical and System Engineering Experiment Building, North Side

Class	Property	Category	Item name (solvent name)		Designated quantity (liter)	Maximum storage quantity (liter)	Factor
Class 4	Flammable liquid	Specified flammable substances	Ether		50	160	3.20
		Class 1 petroleum	Hexane	Water-insoluble	200	600	3.00
			Heptane	"	"		
			Ethyl acetate	"	"		
			Petroleum ether	"	"		
			Benzene	"	"		
			Toluene	"	"		
			Cyclohexane	"	"		
			Acetone	Water-soluble	400	360	0.90
			Tetrahydrofuran	"	"		
			Dioxane	"	"		
		Alcohols	Methanol		400	250	0.63
			Ethanol		"		
			Propanol		"		
		Class 2 petroleum	Kerosene		1,000	100	0.10
			Xylene		"		
			Dibutyl ether		"		
		Class 3 petroleum	Liquid paraffin	Water-insoluble	2,000	100	0.05
			Ethylene glycol	Water-soluble	4,000		0.03
		Class 4 petroleum	Polyethylene glycol		6,000	100	0.02
			Silicon oil		"		
			Vacuum pump oil		"		
		Animal and vegetable oils	Soybean oil		10,000	100	0.01
					Total factor		7.94

Table 8 Building No. 4 North Side Courtyard

Class	Property	Category	Item name (solvent name)		Designated quantity (liter)	Maximum storage quantity (liter)	Factor
Class 4	Flammable liquid	Specified flammable substances	Ether		50	160	3.2000
		Class 1 petroleum	Hexane	Water-insoluble	200	162	0.8100
			Ethyl acetate	"	200	126	0.6300
			Benzene	"	200	72	0.3600
			Toluene	"	200	72	0.3600
			Petroleum ether, gasoline, heptane, cyclohexane, acrylonitrile	"	200	405	2.0250
			Acetone	Water-soluble	400	216	0.5400
			Dioxan, tetrahydrofuran, acetonitrile	"	400	216	0.5400
		Alcohols	Ethanol, methanol, 1- and 2-propanol		400	300	0.7500
		Class 2 petroleum	Xylene, kerosene, dibutyl ether, dimethylformamide, acetic acid		1,000	94	0.0940
		Class 3 petroleum	Liquid paraffin, glycerin, ethylene glycol		2,000	72	0.0360
		Class 4 petroleum	Silicon oil, vacuum pump oil, polyethylene glycol		6,000	90	0.0150
		Animal and vegetable oils	Soybean oil		10,000	72	0.0072
					Total factor		9.3672

Table 9 Building No. 10 North Courtyard

Class	Property	Category	Item name (solvent name)		Designated quantity (liter)	Maximum storage quantity (liter)	Factor
Room No. 1, Class 3, 1.35	Pyrophoric substances and water-prohibitive solids/liquids	Potassium	Potassium		10	1	0.1
		Sodium	Sodium		10	2	0.2
		Alkyl aluminum	Trimethylaluminum		10	2	2
			Triethylaluminum		10	2	0.2
			Diethyl ethoxy aluminum		10	4	0.4
		Organic metal compounds	Sodium naphthalene		10	1	0.1
		Yellow phosphorus	Yellow phosphorus		20	2	0.1
		Metal hydrides	Lithium aluminum hydride		50	2	0.04
		Calcium/aluminum carbides	Calcium carbide		50	0.5	0.01
Room No. 2, Class 4, 1.44	Flammable liquid	Specified flammable substances	Diethyl ether		50	18	0.36
		Class 1 petroleum	Benzene	Water-insoluble	200	18	0.09
			Toluene		200	18	0.09
			Hexane		200	18	0.09
			Ethyl acetate		200	18	0.09
			Tetrahydrofuran	Water-soluble	400	72	0.18
			Acetone		400	72	0.18
		Alcohols	Methanol		400	72	0.18
			Ethanol		400	72	0.18
Room No. 3, Class 4, 1.44	Flammable liquid	Specified flammable substances	Diethyl ether		50	18	0.36
		Class 1 petroleum	Benzene	Water-insoluble	200	18	0.09
			Toluene		200	18	0.09
			Hexane		200	18	0.09
			Ethyl acetate		200	18	0.09
			Tetrahydrofuran	Water-soluble	400	72	0.18
			Acetone		400	72	0.18
		Alcohols	Methanol		400	72	0.18
			Ethanol		400	72	0.18

Room No. 4, Class 4, 5.76	Flammable liquid	Specified flammable substances	Diethyl ether		50	72	1.44
		Class 1 petroleum	Benzene	Water-insoluble	200	72	0.36
			Toluene		200	90	0.45
			Hexane		200	72	0.36
			Ethyl acetate		200	90	0.45
			Tetrahydrofuran	Water-soluble	400	90	0.225
			Acetone		400	450	1.125
		Alcohols	Methanol		400	270	0.675
			Ethanol		400	270	0.675
					Total factor		9.99

Table 10 Building No. 1 Indoors

Class	Property	Category	Item name (solvent name)		Designated quantity (liter)	Maximum storage quantity (liters)	Factor
Class 4	Flammable liquid	Specified flammable substances	Diethyl ether		50	220	4.40
			Pentane		50	18	0.36
		Class 1 petroleum	Hexane	Water-insoluble	200	270	1.35
			Heptane	Water-insoluble	200	20	0.10
			Benzol (benzene)	Water-insoluble	200	40	0.20
			Toluol (toluene)	Water-insoluble	200	40	0.20
			Ethyl acetate	Water-insoluble	200	180	0.90
			Gasoline	Water-insoluble	200	50	0.25
			Acetonitrile	Water-soluble	200	18	0.09
			Tetrahydrofuran	Water-soluble	400	40	0.10
			Acetone	Water-soluble	400	240	0.60
		Alcohols	Methanol		400	180	0.45
			Ethanol		400	270	0.675
			n-Propanol		400	36	0.09
			Isopropanol		400	36	0.09
		Class 2 petroleum	Acetic acid	Water-insoluble	1000	18	0.018
			Xylene		1000	18	0.018
			Dimethylformamide		1000	18	0.018
			Kerosene		1000	18	0.018
		Class 3 petroleum	Methylglutaronitrile	Water-insoluble	2000	36	0.018
			Glycerin	Water-soluble	4000	54	0.0135
			Ethylene glycol	Water-soluble	4000	36	0.009
		Class 4 petroleum	Polyethylene glycol		6000	36	0.006
			Silicon oil		6000	30	0.005
			Vacuum pump oil		6000	30	0.005
		Animal and vegetable oils	Soybean oil		10000	72	0.0072
					Total factor		9.99

Handling of poisons and deleterious substances

Poisons and deleterious substances must be managed with appropriate handling as stipulated in the Poisonous and Deleterious Substances Control Act (Act No. 303, 1950). However, due to the frequent occurrence of incidents involving poison contamination, the Ministry of Education, Culture, Sports, Science and Technology and relevant authorities decided to further enforce the “appropriate management of poisons and deleterious substances”.

Management of poisons and deleterious substances at this university is implemented according to the “Rules on the Handling of Poisons and Deleterious Substances at Tokyo University of Agriculture and Technology” established on April 1, 2004. In this section, the key points implemented at Koganei Campus will be explained.

1. With regards to the handling of poisons and deleterious substances, a control manager and a handling manager are appointed at Koganei Campus.

The control manager is appointed by the dean of the Graduate School of Engineering or director of BASE. Control manager provides information, education, and training on the handling to those involved in experiments that use poisons and deleterious substances, as well as to direct and supervise the control of poisons and deleterious substances. At present, the chairperson of Koganei Environment, Health, and Safety Committee is in charge of this role.

The handling manager is a faculty member in charge of providing guidance or conducting experiments that use poisons and deleterious substances and refers to the person who submits the “Application for Permission to Use Poisons and Deleterious Substances” (Attachment 1) and receives the “Approval for the use of Poisons and Deleterious Substances and Notification on the Designation of a Handling Manager” (Attachment 2). In cases where there are risks of poisons and deleterious substances being stolen, misplaced, or cause scattering, leakage, spillage, or seepage, and absorption poses a risk to public health, the handling managers must conduct the necessary actions to prevent harm and submit a notification to the control manager.

2. Storage cabinets for poisons and deleterious substances must be separate storage from general reagents and must be robust. The cabinets must be locked to prevent theft, with the keys controlled by the handling manager. If poisons and deleterious substances are stored in a refrigerator, the entire refrigerator must be locked. In addition, the storage cabinet must display the text “Poisons” in white text over a red background for poisons, or the text “Deleterious substances” in red text over a white background for deleterious substances. Ensure that poisons and deleterious substances purchased are registered to the drug control system (IASO). IASO(URL) https://web.tuat.ac.jp/~kankyou/IASO/IASOindex.htm

3. The handling manager must have the usage register available to keep track of the amount in the inventory and the amount used, and periodically check the quantity of poisons and deleterious substances in storage (poisons managed by the amount used and remaining amount, and deleterious substances controlled by number of bottles) against the usage register. It is possible to record the apparent remaining amounts of poisons and deleterious substances in IASO, however there is difficulty in recording the information required for the usage register (date of use, person used, purpose of use, etc.). For this reason, the handling manager must separately prepare a usage register. If poisons and deleterious substances are stolen or misplaced, this must be notified immediately to the control manager and the provided instructions must be followed. Furthermore, poisons and deleterious substances that are stored over prolonged periods, which are not expected to be used in the future, must be discarded promptly.

*What are poisons and deleterious substances?

Extremely large numbers of chemicals are used at the university, and the laws relating to individual chemicals are diverse, including the “Poisonous and Deleterious Substances Control Act”, “Pharmaceutical Affairs Law”, “Narcotics and Psychotropics Control Law”, “Fire Services Act hazardous substances classification”, and “Industrial Safety and Health Law”. While poisons and deleterious substances can be simply defined as chemicals stipulated in the “Poisonous and Deleterious Substances Control Act”, it is meaningless to list the individual chemicals. Therefore, in this section, explanation will be provided on how to distinguish the types of chemicals involved.

All chemicals have labels that display the legally appropriate information on each product as well as specification values and precautions for handling (Figure 2). In addition to this, recent product labels include symbols indicating the hazard associated with the product for safety in handling (Figure 2). The meaning of each symbol is shown in Table 11. With regards to the poisons and deleterious substances mentioned

previously, “highly toxic” shown with a skeleton is generally applicable to poisons, and “toxic” marked with a cross is generally applicable to deleterious substances.

The display and other information provided above must be used as a reference for safe handling in the use and disposal of poisons and deleterious substances.

Displayed according to the Industrial Safety and Health Act

Symbol

Displayed according to the Poisonous and Deleterious Substances Control Act

Displayed according to the Fire Services Act

Figure 2 Chemical Labels

Table 11 Symbols Displayed on Chemical Labels

Symbol (including the signal words for details of hazards)	Details of hazards	Applicable items in the domestic laws and regulations
 Explosive	Explosion occurs with shock, friction, heat, etc.	(1) Gunpowder and explosives in Paragraph 1, Article 2 of the Explosives Control Act (2) High pressure gas stipulated in Article 2 of the High-Pressure Gas Safety Act
 Extremely flammable	Extremely flammable liquids [liquids with flash point of < -20°C and boiling point of ≤ 40°C, or ignition point of ≤ 100°C]	(1) Type 4 specified flammable substances in the Fire Services Act
 Flammable	Flammable liquid [liquids with flash point of < 70°C]	(1) Class 4 petroleum No. 1, alcohols, and Class 2 petroleum in the Fire Services Act

 Flammability	Solids that easily catch fire or are flammable at low temperatures, as well as flammable gases.	(1) Class 2 flammable solids in the Fire Services Act (2) Flammable gases stipulated in Attached Table 1 No. 5 of the Order for Enforcement of the Industrial Safety and Health Act
 Pyrophoric	The substances combust spontaneously in air.	(1) Class 3 pyrophoric substances in the Fire Services Act (2) Substances listed in the item name column of the section of pyrophoric substances in Attached Table 6 of the Notification of the Regulations for the Carriage and Storage of Dangerous Goods in Ship (excluding pyrogenic substances and other pyrophoric substances)
 Water-prohibitive	The substances combust when in contact with water or may generate flammable gases.	(1) Class 3 water-prohibitive substances in the Fire Services Act (2) Substances listed in the item name column of the section of other flammable substances in Attached Table 6 of the Notification of the Regulations for the Carriage and Storage of Dangerous Goods in Ship (excluding other flammable substances)
 Oxidizing	Causes combustion or explosion when mixed with flammable substances.	(1) Class 1 oxidizing solids and Class 6 oxidizing liquids in the Fire Services Act (2) Substances listed in the item name column of the oxidizers section in Attached Table 7 of the Notification of the Regulations for the Carriage and Storage of Dangerous Goods in Ship (excluding other oxidizers)
 Self-reactive	Generates large amount of heat or causes explosive progression of reaction due to heat, shock, etc.	(1) Class 5 self-reactive substances in the Fire Services Act
 Highly toxic	Highly harmful and may result in death when swallowed, inhaled, or in contact with the skin. [Reference] LD_{50}: ≤ 30 mg/kg (rat, oral)	(1) Poisons in the Poisonous and Deleterious Substances Control Act (2) Substances not applicable to the Poisonous and Deleterious Substances Control Act but are listed in the item name column of Attached Table 4 of the Notification of the Regulations for the Carriage and Storage of Dangerous Goods in Ship (excluding other poisons) that are regarded as highly toxic(*)
 Toxicity	Harmful when swallowed, inhaled, or contact with the skin. [Reference] LD_{50}: 30 to ≤ 300 mg/kg (rat, oral)	(1) Poisons in the Poisonous and Deleterious Substances Control Act (2) Substances not applicable to the Poisonous and Deleterious Substances Control Act but are listed in the item name column of Attached Table 4 of the Notification of the Regulations for the Carriage and Storage of Dangerous Goods in Ship (excluding other poisons) that are regarded as toxic(*)

 Hazardous	May be harmful when swallowed, inhaled, or in contact with the skin. [Reference] LD_{50}: 200 to ≤ 2000 mg/kg (rat, oral)	(1) Substances not applicable to the Poisonous and Deleterious Substances Control Act but are listed in the item name column of Attached Table 4 of the Notification of the Regulations for the Carriage and Storage of Dangerous Goods in Ship (excluding other poisons) that are regarded as hazardous (2) Existing chemical substances with confirmed mutagenicity as announced in the Labour Standards Bureau Notification No. 51 dated February 10, 1992 (3) New chemical substances with confirmed mutagenicity as announced in the Labour Standards Bureau Notification No. 414-3 dated June 25, 1991 (4) Type 2 specified chemical substances and designated chemical substances stipulated in Article 2 of the Chemical Substance Control Law
 Irritation	May cause irritation such as pain in the skin, eye, respiratory organs, etc.	No relevant laws and regulations
 Corrosivity	The substances corrode the skin, devices, etc.	(1) Substances listed in the item name column of Attached Table 3 of the Notification of the Regulations for the Carriage and Storage of Dangerous Goods in Ship (excluding other corrosive substances)

Attachment 1

Date (M/D/Y): / /

Application for Permission to Use Poisons and Deleterious Substances

To: Koganei Control Manager

We hereby submit an application for permission to use poisons and deleterious substances at the laboratory.

The following precautions will be adhered to strictly for the use of these substances, and efforts will be made to prevent the misplacement and theft of the substances.

*Precautions

1. The substances will be stored in a secure, dedicated storage cabinet fitted with devices to prevent falling, and displays warning of poisons and deleterious substances will be made.

2. A register for incoming/outgoing poisons and deleterious substances will be made available, and periodic confirmation of quantity will be conducted for purchase and use of the substances, as well as those not in use.

3. Strict control system will be implemented to prevent the misplacement and theft of the substances, and if the substances are stolen or misplaced, this will be reported immediately to the control manager.

4. If accidents or disasters occur and the scattering, leakage, spillage or seepage, and absorption of the substances pose a risk to public health, necessary actions to prevent the harm will be implemented and the incident will be reported immediately to the control manager.

Name of department or specialization Applicant Seal

Attachment 2

DD/MM/YYYY

To: Poisons and Deleterious Substances Handling Manager

Koganei Control Manager

Approval for the use of Poisons and Deleterious Substances and Notification on the Designation of Handling Manager

The use of poisons and deleterious substances at the laboratory will be approved, and the poisons and deleterious substance handling manager will be designated as shown below. The precautions provided in the Application for Permission to Use Poisons and Deleterious Substances must be strictly adhered to, and any incidents must be reported immediately.

Name of department or specialization Handling manager

Handling of experimental wastes and waste liquids

Conduct of experiments always involves the generation of a certain amount of experimental wastes and waste liquids to be discharged. These often contain toxic or hazardous substances, and leaving the wastes standing, disposing of these wastes with general wastes, and release into sewage lead to environmental contamination or harm to humans. For this reason, individual persons must take the utmost care in the handling of experimental wastes and waste liquids. The handling of experimental wastes and waste liquids will be explained in this section.

1. Handling of experimental wastes

(1) Injection needles, etc.

Injection needles and syringes used for experiments must not be discarded together with general waste. Disposal should be consigned to the specified contractor after a certain amount has been accumulated.

(2) Experimental animals.

Disposal of experimental animals should be consigned to the specified contractor.

(3) Check with the Accounting Section (7004) for information on the contractors in (1) and (2).

(4) Reagent bottles

Remove the labels and clean the contents, then dispose of at the time of collection performed a few times every year. Care must be taken as these cannot be disposed of in general non-combustible waste boxes. (Depending on the type of content, the washing should be retrieved and disposed of as experimental waste liquid as explained in “Handling of waste liquids” below) Disposal of the reagents themselves should be consigned to the specified contractor.

(5) Fluorescent lamps and dry batteries

Used fluorescent lamps and dry batteries should be disposed of separately in a dedicated box in the temporary waste storage on the north side of the radiation laboratory.

2. Handling of waste liquids

Waste liquids generated at the university are collected into polyethylene tanks at each campus, then the disposal is consigned to the external waste liquid processing contractor for incineration or water treatment at specialized plants. For this reason, the handling of waste liquids is specified as follows.

Guide for the handling of waste liquids, etc.

1) Treatment of waste liquids, etc.

Waste liquids, etc. must be stored separately according to detailed classifications as suitable for the processing device of each liquid and for the purpose of safety in storage. Classified storage of waste liquids is the minimum responsibility of the persons involved in waste discharge. It is important to fully recognize this as the starting point of the processing operation and store the liquids separately without error.

2) Classified storage of waste liquids, etc.

(1) Category for classified storage

Categories of waste liquids are shown in (Table 12). Waste liquids, etc. must be stored separately in the designated container as shown in the classification.

Containers of flammable organic waste liquids and inorganic waste liquids must be filled up to 2/3 capacity, and other waste liquids and wastewater must be filled up to 3/4 capacity. The liquids must be stored with the lid closed.

(2) Inorganic waste liquids

A. Inorganic mercury waste liquids

Note: Only inorganic mercury is applicable to this storage classification. Organic mercury must be made inorganic by oxidation treatment at the source (treatment for 2 to 3 days in the mixture with chromic acid) before storage. Metal mercury (generated by the breakage of fluorescent lamp, germicidal lamp, thermometer, etc.) must be stored separately by immersing in water, etc. to prevent loss through volatilization. See (6). Utmost care must be taken for storage in the laboratory.

B. Heavy metal and chromium waste liquids (acidic)

Note: Heavy metal waste liquids and chromium waste liquids must be stored together. However, mixed chromic acid waste liquids and permanganate waste liquids in large quantities must be stored separately.

Heavy metals refer to Cd, Pb, Cr, Cu, Zn, Fe, Mn, and other toxic heavy metals. If the content of organic matter is 10% or higher, this will be handled as water-mixed organic waste liquids (Q). Substances that form complexes with metals, such as ammonia and amine, and liquid containing chelating agents will also be handled as water-mixed organic waste liquids (Q). (See (7)-C for content less than 10%)

Table 12 Table of the Category for Classified Storage of Waste Liquids

Treatment category	Classification	Category for classified storage		Category code	Details	Container color classification
Coprecipitation and electrolytic floatation treatment	Inorganic	Mercury		A	Aqueous solution containing mercury salt	Yellow
		Heavy metals and chromium		B	Aqueous solution containing toxic metals including cadmium, lead, chromium, copper, zinc, iron, and manganese, chromic acid waste liquids, nitric acid, sulfuric acid, etc.	Green
		Cyanide		C	Alkaline (pH > 10) aqueous solution containing cyanide compounds	Blue
		Arsenic		D	Alkaline (pH > 10) aqueous solution containing arsenic compounds	Gray
		Cyanide complex		E	Alkaline (pH > 10) aqueous solution containing cyanide complex (excluding persistent cyanide complex)	Black
		Fluorine		F	Aqueous solution of fluoride compounds that can be precipitated as calcium salt, phosphoric acid	Purple
Combustion treatment	Organic	Flammability	General waste organic solvent	L	Hydrocarbon, ester, ketone, alcohol, organic acid (to be neutralized), etc.	Red
			Waste oil	M	Kerosene, heavy oil, machine oil, liquid paraffin, grease, animal and vegetable oils, etc.	Orange
			Nitrogen-containing waste solutions	N	Pyridine, aniline, acetonitrile, formamide, etc.	Brown
			Sulfur- and phosphorus-containing waste solvents	O	Sulfolane, dimethyl sulfoxide, hexamethyl phosphamide, etc.	Pink

		Fire resistant	Halogen-containing waste solvents	P	Chloroform, etc.	Yellow green
			Water-mixed organic waste liquids	Q	Aqueous solutions of organic compounds, organic solvents containing water, etc.	White
			Photographic waste liquids	R	Waste liquids from development and stopping (excluding fixing solution)	
		Specified hazardous substances		Z	Solutions containing specified hazardous substances including benzene, methylene chloride, carbon tetrachloride	Blue and red (two colors)
Others		Scrubber waste liquid		U	Excluding those allowed for discharge after neutralization treatment	Yellow and black (two colors)

C. Cyanide (alkaline)
Alkaline aqueous solution (pH > 10) containing cyanide compounds
D. Arsenic (alkaline)
Alkaline aqueous solution (pH > 10) containing arsenic compounds
E. Cyan complex (alkaline)
Alkaline (pH > 10) aqueous solution containing cyanide complex (excluding persistent cyanide complex)
F. Fluorine waste water (alkaline)
Note: Aqueous solution of fluorine compounds that can be precipitated as calcium salt

(3) Flammable organic waste liquids

L. General organic waste solvents
i) Aliphatic hydrocarbon: Petroleum ether, cyclohexane, etc.
ii) Aliphatic oxygen-containing compounds: Alcohol, ketone, ester, etc.
iii) Aromatic compounds: Toluene, xylene, etc.
Note: Benzene must be stored separately as it is applicable to (5) specified hazardous substances.
iv) Organic acid (to be neutralized): Acetic acid, formic acid, etc.
v) Phenols: Phenol, cresol, etc.
Note: Substances with a low flash point, such as diethyl ether, peroxides, and compounds that readily produce peroxides must be stored separately. See (6).

M. Waste oils
i) Kerosene, disease fuel, turpentine oil, etc.
ii) Heavy oil, vacuum pump oil, lubricant oil, grease, motor oil, liquid paraffin, etc.
iii) Animal and vegetable oils
Note: Substances with high viscosity should be diluted with kerosene or waste solvent (50 c.p. or lower). Those containing solid matter (such as metal shavings) should be filtered through a 100-mesh wire mesh to remove the solid matter before storage.

N. Nitrogen-containing waste solvents
i) Aliphatic and aromatic nitrogen compounds: Acetonitrile, amine, amide, pyridine, aniline, etc.
Note: Explosive compounds such as nitrate ester, poly-nitro compounds, and organic azides must be stored separately. See (6).
Note: Excludes substances that are harmful to health, such as benzidine. Utmost care must be taken to avoid mixing with halogen-containing waste solvents (P).

O. Sulfur- and phosphorus-containing waste solvents
i) Sulfur-containing waste solvents: Mercaptan, sulfolane, dimethyl sulfoxide, etc.
ii) Phosphorus-containing waste solvents: Hexamethyl phosphamide, etc.
Note: Utmost care must be taken to avoid mixing with halogen-containing waste solvents (P).
(4) Fire resistant organic waste liquids
P. Halogen-containing waste solvents
i) Aliphatic halogen compounds: Chloroform, etc.
Note: Methylene chlorides, carbon tetrachloride, etc. must be stored separately as it is applicable to (5) specified hazardous substances.
ii) Aromatic halogen compounds: Chlorobenzene, benzyl chloride, etc.
Note: PCB and substances containing PCB must be stored separately. Dichloroacetic acid and trifluoroacetic acid must be neutralized before storage. Mixture of halide solvents and other organic solvents is classified as this category for storage.
Q. Water-mixed organic waste liquids
i) Aqueous solutions of organic compounds
ii) Organic solvents with high water content
Note: This includes waste liquids of persistent cyan complex and organic metals (chelate, etc.) (excluding organic mercury) Solvent that does not mix with water must be separated and stored separately under the applicable categories.
R. Photographic waste liquids
i) Waste liquids in development
ii) Waste liquids in stopping
Note: Waste fixing solution must be stored separately for the collection of silver.
(5) Specified hazardous substances
Z. Specified hazardous substances
Organic waste liquids with high content of the following specified hazardous substances must be stored separately from (3) and (4) above.

- Trichlorethylene
- Tetrachlorethylene
- Methylene chloride (dichloromethane)
- Carbon tetrachloride
- 1,2-dichloroethane
- 1,1-dichloroethylene
- Cis-1,2-dichlorethylene
- 1,1,1-trichloroethane
- 1,1,2-trichloroethane
- 1,3-dichloropropene
- Benzene
- Organic phosphorus (agricultural chemical)

(6) Scrubber waste liquid
U. Scrubber waste liquid
Note: If strong acids or strong alkali are contained, pH must be measured beforehand and notified at the time of collection.
(Strong acids and strong alkali may cause chemical reactions in a large tank)
(7) Excluded wastes
Substances that are highly toxic, hazardous, or dangerous as shown in [Table 13] and the waste liquids containing these substances are excluded from uniform processing at the facility. These substances must be disposed of separately under the responsibility of the generating department in accordance with laws and regulations.

Table 13 Excluded Wastes (for Separate Treatment)

Specified hazardous and toxic substances	Metal mercury and amalgam; osmium, beryllium, thallium, selenium, and their compounds, nickel carbonyl, alkyl aluminum, PCB, simazine, thiobencarb, thiuram, etc.
Highly flammable, combustible, or explosive substances	Diethyl ether and other highly flammable or combustible substances equivalent to specified flammable substances; explosive substances including poly-nitro compounds, organic peroxides, and organic azides
Radioactive substances	Radioactive substances and radioactive contaminants

The following waste must be handled as explained below.

(i) Mercury (excluding inorganic mercury): Notify the Accounting Section when a certain amount of waste has accumulated. The waste will be gathered and processed for the entire department.

(ii) PCB: If waste is generated, notify the Accounting Section and ask for the instructions regarding the method of treatment.

(8) General precautions for the classified storage of waste liquids

(Inorganic)

a) Solid matter (crystals, deposits, glass fragments, metal fragments, paper fragments, etc.) in the waste liquid may cause a malfunction in the heavy metal treatment device. Filter with a 50 to 60 mesh wire mesh or 4 to 5 layers of gauze or equivalent before storage.

b) Do not mix the following substances for transfer to the storage container.

(A) Peroxides and organic matter

(B) Cyanide compounds, sulfides, and hypochlorites with acids

(C) Volatile acids such as hydrochloric acid and hydrofluoric acid

With non-volatile acids

(D) Ammonium salt and volatile amine salt with alkali

c) Waste liquids containing heavy metals and organic waste solution must be handled as waste liquids containing heavy metals as a general rule. However, since a high content of organic waste solution causes problem in wastewater processing, waste liquid with 10% or higher concentration of organic waste solution must be stored in the storage container for flammable or fire-resistant organic waste solvents. If the concentration of organic waste solution is low, adsorb in advance by adding activate charcoal, then remove the activated charcoal and transfer to a heavy metal storage container.

d) The device pipeline is made of vinyl chloride, therefore organic solvents that do not mix with water (chloroform, carbon tetrachloride, etc.), which may damage the pipeline, must be prevented from entering the pipeline.

(Organic)

a) Solid matter (deposits, floating materials) in the waste liquids causes clogging of the strainer during the combustion treatment. All waste liquids containing solid matter must be filtered with 80 to 100 wire mesh (wire mesh available at the facility at all times may be used. Mesh size must be 0.147 mm) before storage.

b) Acidic waste liquids containing inorganic and organic acids must be neutralized with sodium carbonate or similar materials and filtered before storage as these cause corrosion in the device.

c) Waste liquids separated into two phases must be isolated and stored separately.

d) Highly viscous waste liquids must be diluted with kerosene or waste solvents so that the viscosity is not more than 30 to 50 c.p.

Consult the Accounting Section if there are any questions regarding the classified storage of waste liquids, etc.

(9) Concentration of waste liquids for storage and storage limits

・ Storage is required for waste liquids and at least the first washings of the containers. Second and subsequent washings must be stored for substances with particularly high toxicity and substances with strict wastewater standards (see Table 14).

・ Containers of organic waste liquids that are insoluble in water and highly toxic must be cleaned with solvents such as alcohol and acetone before washing with water.

・ Dilute aqueous solutions of biodegradable substances such as alcohol, glycerin, acetone, fatty acids, and amino acids that do not contain other organic substances may be discharged in the sewer.

・ Dilute solutions of acids and alkali such as hydrochloric acid, sulfuric acid, sodium hydroxide, potassium hydroxides that do not contain other hazardous substance may be discharged in the sewer after adjusting the pH to 5.8 to 8.6 under the responsibility of the persons involved.

(10) Storage container and display for waste liquids, etc.

For safety and convenience in transportation and treatment of waste liquids, designated polyethylene containers such as that shown below must be used (for provisional measures, large polyethylene containers with chemical resistance equivalent to the designated container with high mechanical strength may be used), and the necessary items must be displayed on the container.

a) Container

Waste liquids: White polyethylene tank (10 L or 20 L in volume, with inner lid and packings intact)

b) Display (see Figure 3)

The following display must be made on the container for storage and transportation.

i) Display for classified storage and color label of the category according to Table 12.

ii) Display of faculty, department, laboratory name, etc.

iii) Attachment of waste liquid treatment slip (B) with the necessary items recorded

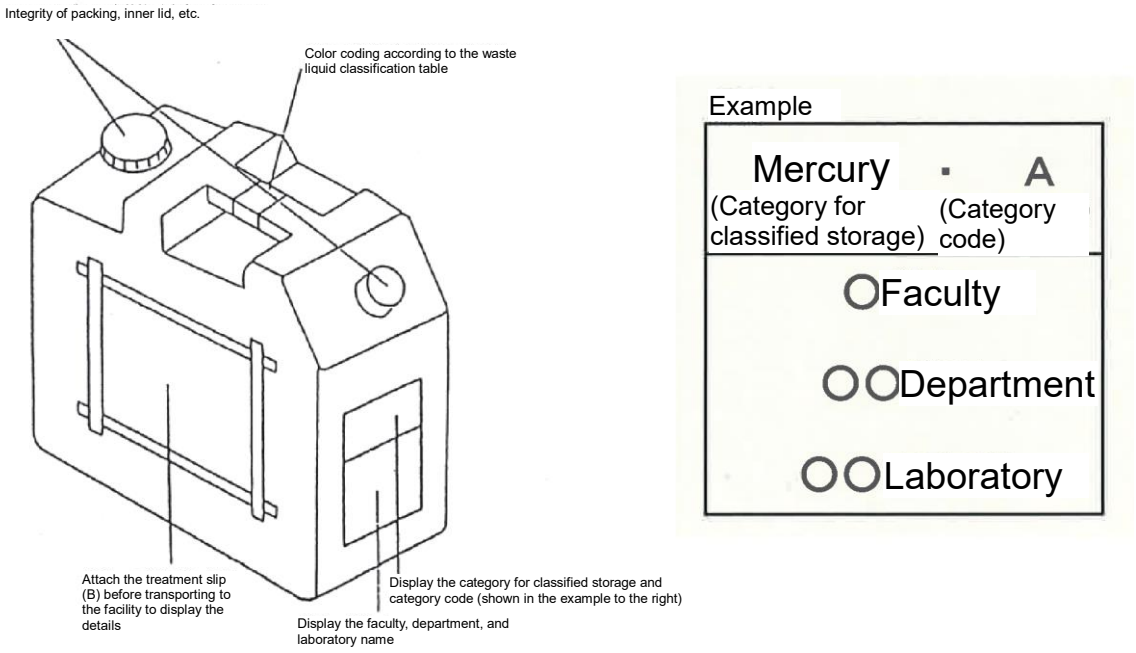


Figure 3 Container for Classified Storage

Note: Tapes for display must be prepared under the responsibility of the persons involved, and the required form (slip) will be made available at all times at the Koganei Accounting Office.

3. Transfer to the facility and handover

(1) Receipt

Waste liquids, etc. after storage must be transported in the polyethylene tank at the designated date, time, and location. Waste liquids handling manager must be in attendance for collection.

(2) Handover

・ For scrubber waste liquids, the laboratory name and number of tanks must be declared to the person in charge of administration.

・ Care must be taken as waste liquids may not be collected if there are deficiencies in category, lack of clarity in the contents, or if the waste liquids cannot be processed.

Table 14 Sewage Discharge Standards at the University

Applicable substance or item		
Hazardous substances	Cadmium	0.1
	Cyanide	1
	Organic phosphorus	1
	Lead	0.1
	Hexavalent chromium	0.5
	Arsenic	0.1
	Total mercury	0.005
	Alkyl mercury	Not detected
	PCB	0.003

Applicable substance or item			
Environmental items, etc.	Total chromium		2
	Copper		3
	Zinc		2
	Phenols		5
	Iron		10
	Manganese		10
	Fluoride		15
	Biological oxygen demand (BOD)		600
	Suspended solids (SS)		600
	Normal hexane	Mineral oil	5
		Animal and vegetable oils	30
	Hydrogen ion concentration (pH)		5 to 9
	Temperature		< 45°C
	Iodine consumption		220

Safety in biological experiments

The precautions in biological experiments are similar to those in chemistry experiments but include several others specific to biology experiments. The main precautions are as follows:

I Precautions for Preventing Accidents in Basic Operations

Biology experiments rarely use strong oxidizing agents, pyrophoric substances, or the like but often use substances toxic to living organisms, including humans. It is important to check in advance with the “Merck Index” and other sources for the toxicity of reagents. Engineering research institutes are allowed to conduct experiments using radioisotopes (RIs) only in their radiation laboratories, which are joint-use facilities. Refer to the section on our radiation laboratory on page 121 onwards.

(1) Precautions for the use of centrifuges

Centrifuges are used to perform rapid separations of difficult-to-separate liquids and solids or between liquids different in specific gravity. Centrifuges vary in revolving speed, ranging from 1,000 rpm to several thousand rpm. An operational anomaly in high-speed revolving equipment with a large mass, such as centrifuges, would lead to a major accident. Any parts of such equipment, if scattered with bullet-like force, would cause personal and property damage. Therefore, the following precautions should be kept in mind:

Carefully read the operating manual before starting the machine.
Be sure to ground the main unit of the centrifuge before use.
Perform start-up operation of the machine and safety devices.
Before turning the swing rotor, always remove the rotor for operation.
Check the rotor for any signs of corrosion or scratches.
Be sure to adjust the balancing.
Do not operate the rotor beyond its allowable revolving speed.
Stay close to the machine during work.
Do not touch the machine when it is revolving.
Do not attempt to stop the machine with your hands.
Immediately stop operation and contact the person responsible for the machine or the manufacturer for instructions if any anomaly (such as abnormal noise) occurs during the operation of the machine.
Keep operation logs without fail.
Be sure to avoid unbalanced operations.

Maintenance and inspection of the rotor

Especially where a supercentrifuge is used, you must be aware that failure to perform maintenance work on it will lead to a broken rotor during centrifuge operation.

Service life: A rotor gradually loses strength due to material fatigue and friction during repetitive use. Therefore, it has a predetermined service life. Typically, the number of revolutions used, and the number of hours turned are added up, respectively. If either of these numbers reaches the numerical value (primary life) given in the manual, the rotor is operated at a revolving speed 10% below the maximum revolving speed. When the rotor goes further and reaches the predetermined numerical value (secondary life), no further use of it is allowed. Be careful that some rotors (titanium alloy-made) have only the primary life.

An aluminum rotor will corrode if not sufficiently maintained. A corroded tube insertion hole, in particular, will cause damage to the rotor and should be paid attention to.

A rotor requires a check every 100 hours of use. A rotor’s holes, especially tube holes and tapered bottom holes, show a large decrease in strength when corroded and must be carefully checked. Discolorations, dents, cracks, and other anomalies on the surface serve as signs of corrosion. Do not use a rotor if it is found to be corroded.

・ For more details, refer to the machine’s manual.

(2) Precautions for the use of UV irradiation devices

・ Ultraviolet (UV) irradiation devices are used mainly to detect ethidium bromide-stained DNAs. Direct eye exposure to ultraviolet (UV) may cause eye watering or temporary or permanent blindness. Skin exposure may also result in sunburns or blisters. Always wear protective goggles and carefully avoid exposing the skin directly to ultraviolet.

(3) Precautions for the use of freezers and deep freezers

・ Wear hand protection, such as cotton work gloves, to avoid the risk of cold burns when taking samples in and out. Besides, wear a white coat or jacket to protect exposed arms from cold burns when wearing half-sleeved clothing.

(4) Precautions for the use of hot air oven sterilizers

・ Install on a flame-resistant bench and leave no flammable substances sitting nearby.

・ Sealed containers may explode and must not be put inside.

・ Avoid use for flammable and combustible substances.

・ When taking in and out sterile glassware or the like, wear heat-resistant gloves or similar hand protection as a precaution to avoid burns.

・ In case of an abnormal temperature rise due to an accident, stay calm, turn off the main switch, and leave until cool. Never open the pneumatic open/close lid to lower the temperature. Failure to comply may lead to fire breaking out.

・ Take safety measures for the wiring, switches, or the like. Preferably install an earth leakage breaker.

(5) Precautions for the use of clean benches

・ Turn off germicidal lamps before use.

・ Adjust the flame intensity to an appropriate level when using a gas burner.

・ Avoid handling flammable substances.

・ Do not use an airflow clean bench to work with harmful substances, pathogenic bacteria, or the like (use a circulation clean bench or a biosafety cabinet).

・ Be careful with the airflow rate. HEPA filter replacement is required depending on the frequency of use.

(6) Precautions for the use of autoclaves

・ Use within the stamped ranges of pneumatic test pressure, normal working pressure, and maximum working temperature.

・ Fill samples up to one-third or less of the container’s inner capacity.

・ When closing the lid, inspect the packing with care. If the lid is flanged, avoid overtightening or uneven tightening. Tighten diagonally opposite pairs of bolts evenly and in sequence several times.

・ Monitor and occasionally inspect the safety valve for normal operation.

・ Wait until the internal pressure has reached atmospheric pressure and the internal temperature has cooled sufficiently. Wear hand protection, such as heat-resistant gloves, to remove the samples inside.

・ Refer to the machine’s manual for details.

(7) Precautions for the use of power sources

If you are involved in protein or DNA research, you routinely use electrophoresis for separation and purification. Then, you use direct current, which is extremely dangerous, especially when your hands are wet. Handle the connection cords or the like with due care.

II Precautions for Using Mutagens

In genetic experiments with microbes, etc., chemical mutagens, such as MNNG (1-methyl-3-nitro-1-nitrosoguanidine) or EMS (ethyl methanesulfonate), are often used to induce mutations. These mutagens affect DNA and are, of course, carcinogenic. Besides, EB (ethidium bromide) and other DNA-staining reagents are also often used. These substances are also carcinogenic. Therefore, ask the instructor for instructions and exercise due care when using or disposing of these mutagens.

III Precautions in Microbiology Experiments

Microbes exist everywhere. When experimenting with microbes, take great care to avoid contamination with microbes or fungi other than those intended. There is nothing special about microbiology experiments that makes them different from general chemistry experiments. However, you must remember that microbes are "living organisms." General precautions for experiments with microbes are as follows:

(1) Keep the laboratory and equipment clean.

Microbes are all around you. To avoid contamination with them, keep the laboratory and equipment clean at all times. If bacterial culture is accidentally spilled, wipe it off using a sterile liquid such as inverted soap.

(2) Sterilize all used items before disposal.

Cultures, microbes, or the like used in experiments must be sterilized by autoclaving before disposal to prevent biocontamination. Autoclave and sterilize pipettes or the like before disposal or cleaning.

Without fail, you should wear a white coat while in the lab. However, do not wear a white coat to and from, especially in the cafeteria or restrooms.

(3) Always work with aseptic techniques.

For basic operations such as microbial separation or inoculation, nothing is more important than working aseptically at all times. Depending on the microbe used in the experiment, limit microbe handling to a location such as a sterile cabinet, clean bench, or safety cabinet. Carefully select the location for culturing and storage to prevent contamination with unwanted bacteria or fungi.

IV Precautions for Animal Experiments

Carefully read the "Guidelines and Handbook for Animal Experiments."

To conduct an animal experiment, you must submit the specified documents for approval to the General Affairs Section, Fuchu General Affairs Division (extension number: 5070).

V Precautions in Gene Recombination Experiments

Gene recombination experiments are performed with Type 1, Etc., or 2 Use, Etc., of Living Modified Organisms. One of the standards for ensuring safety during gene recombination experiments is the "Law on the Conservation and Sustainable Use of Biological Diversity through Regulations on the Use of Living Modified Organisms" based on a MEXT Public Notice (in effect since Feb. 2004). Based on this law and related laws and regulations, the "National University Corporation Tokyo University of Agriculture and Technology Safety Management Rules for Genetically Modified Organisms" has been enforced at our institute (since Apr. 2004). For all gene recombination experiments conducted at our institute, an application must be submitted for approval to the "Tokyo University of Agriculture and Technology Biosafety Management Subcommittee on Specific Organisms." The website below contains links to the above law and related laws and regulations, the application form, and the form-filling instructions. Carefully read all these documents.

Relevant laws and regulations	https://web.tuat.ac.jp/~kankyou/05/03_specific_organisms.shtml	
Application form	https://web.tuat.ac.jp/~kankyou/02/lifescience/form.htm	(Access limited to relevant parties)

Besides, an easy-to-understand explanatory document on the "Law on the Conservation and Sustainable Use of Biological Diversity through Regulations on the Use of Living Modified Organisms" is available from the MEXT website (http://www.biodic.go.jp/bch/download/law/070401law_manual_ver5.pdf). Be sure to download and carefully read this document.

When conducting a real experiment, consult well with your advisor based on the above laws and regulations, etc., and experiment according to a reasonable experiment plan, paying due attention to safety care.

<Reference>

The forms of the Use, Etc., of Living Modified Organisms is divided into “Type 1 Use, Etc.,” and “Type 2 Use, Etc.” Whichever the case may be, you must take appropriate measures beforehand.

(1) Type 1 Use, Etc.

The Use, Etc., of Living Modified Organisms without measures to prevent their dispersal into the environment. Examples include cultivation in farm fields, use as livestock feed, and transportation, etc., without using containers.

(2) Type 2 Use, Etc.

The Use, Etc., of Living Modified Organisms with measures taken to prevent their dispersal into the environment. Examples include use, etc., with laboratories, culturing/fermentation facilities, and the like or transportation, etc., using sealed containers.

The use, etc., practiced in universities generally corresponds to Type 2 Use, Etc. Dispersal prevention and other measures to be taken are specified for experiments, storage, and transportation, respectively.

“Gene recombination experiments” fall into the following four types of experiments: “experiments using microbes,” “mass culturing experiments,” “experiments using animals,” and “experiments using plants.”

Gene recombination experiments

Experiments with the use, etc., of genetically modified organisms or the like having nucleic acids or copies thereof (recombined nucleic acids) obtained by extracellular nucleic acid processing techniques. Note that the storage and transportation performed as part of such use, etc., are also included.

a) Experiments using microbes
The use, etc., of genetically modified organisms, which does not fall into any of b) to d) below:

b) Mass culturing experiments
The use, etc., of genetically modified organisms, in which culturing equipment (with a capacity exceeding 20 liters) is used.

c) Experiments using animals
Divided into “animal development experiments,” which is the use, etc., of recombinant animals, and “animal inoculation experiments,” which is the use, etc., of recombinant organisms harbored by animals.

d) Experiments using plants
Divided into “plant development experiments,” which is the use, etc., of recombinant plants, “plant inoculation experiments,” which is the use, etc., of recombinant organisms harbored by plants, and “mushroom development experiments,” which is the use, etc. of recombinant mushrooms.

How to handle electricity safely

I Introduction

An ELECTRIC SHOCK is the most serious electrical accident encountered in laboratories and experimental laboratories of universities. Since it is difficult to estimate the severity of electrical danger, any assumption that “It’s not serious” will result in a very serious situation. You must be careful not to approach within the safety distance according to the level of applied voltage, especially for high voltage. In electrical experiments, there could be fires and explosive accidents caused by electric sparks or overcurrent, and mechanical accidents caused by the rotational operation of devices such as motors and electric generators.

In this chapter, the outline and causes of electric shocks, which most likely result in severe situations, are described, as well as the measures for them.

II What is an electric shock?

An electric shock is a type of shock encountered when the human body makes contact with electricity. It is caused by direct contact of the human body on a charged part or by an electrical leak. The human body consists of the parenchyma, which is composed by conductive electrolytes, and the skin that is slightly insulated and wrapping the parenchyma. Thus, the electrical resistance of the human body depends on that of the skin, determining electric current upon an electric shock. Dry skin has a resistance of from several dozens of kiloohms to about 1 MΩ while skin wet with water or sweat has a lower resistance of about several hundred ohms. In other words, even a voltage of 100 V will make the human body conduct a current of 100 mA or more. This “100 mA” means the current will be harmful to life. Then, you may think dry skin is always safe; however, this is not true for a high voltage of 3000 V or more, for example. Supposing dry skin is an insulated object with a resistance of 1 MΩ, applying high voltage to the thin skin will produce a very high electric field in the skin layer. This will result in dielectric breakdown to make the skin layer conductive, passing a high electric current.

Influences on the human body are roughly estimated as follows:

0-less than 3 mA: Makes a slight stimulus.

3-less than10 mA: Causes a pulled away from.

10-less than 30 mA: Stiffens the muscles and cannot be pulled away from. Causes shortness of breath and is life threatening after a few minutes.

30 mA or more: Causes cessation of respiration and is fatal.

III Causes of electric shocks

Not a few electric shock accidents are caused by artificial reasons such as carelessness of testers; in this section, however, causes of electric shocks in terms of electrical equipment are described.

(1) Defects of wiring materials, systems, and devices

Functional and mechanical defects of wiring materials and devices, such as loosened screws on plugs and switches and poorly tightened terminals, cause electric shocks. The following cords and cables are used for wiring and are required to be checked for their allowable currents:

1) VFF cords: Have a rated current of 7 A (for a core wire of 0.75 mm²). Be careful when you wire them to a power strip with other plugs connected.

2) Cabtyre cables: Used as movable wires and typically have an allowable current of 15-25 A.

3) VVF cables (F cables): Used for outdoor wiring and have a thickness of 1.5 mm and an allowable current of 19 A.

(2) Insulation failure

The failure of insulation performance will be a decisive defect for electrical safety. Poorly insulated parts cause electric shock if the human body or other objects directly contact them. These parts also cause an electrical leak and severe accidents such as electrical fires. Insulation resistance is reduced by various causes such as aged insulation materials, moisture absorption, and wetting and contamination on surfaces of insulation materials.

(3) Grounding failure

"Grounding" means connecting a certain part of an electrical circuit or system to the ground in order to maintain the electric potential of the part to the ground potential (0 V). If grounding is poor, unexpectedly high voltage will be produced on unintended places, causing electric shocks and electrical leaks. In fact, grounding the case of a device is a safety measure for insulation failure of the device and other similar situations.

(4) Electrical leak

An "electrical leak" is a situation where electric current leaks through an unintended part. The types of electrical leaks are classified as follows: resistive leaks caused by the deterioration in the insulation performance, grounding failure, circuit mixing, and other reasons, and capacitive leaks passing between lines of a circuit or through a stray capacity between insulated conductors.

Since leakage current flows to the ground through a grounding wire if grounding is performed correctly, touching a leaking part rarely results in an electric shock.

(5) Shortage of rated performance of systems and devices

If you conduct experiments while not paying attention to the rated currents and energy capacitance of resistors and wiring devices, and the rated withstand voltages of capacitors, such experiments will cause circuit damage due to a fire and dielectric breakdown, resulting in accidents such as electrical fires, electrical leaks, and electric shocks.

(6) Unfamiliarity with handling capacitors

Though the terminals of a high voltage capacitor are once short-circuited and discharged, high voltage is produced again because absorbed charges are generated from its internal dielectric substance when the terminals are left open. If you accidentally touch the terminals of a capacitor, you will get an electric shock.

(7) High voltage

When the grounded human body touches a conductor with high voltage applied, an electric shock will occur due to dielectric breakdown even though the skin is dry. High voltage also generates a spark even when the human body just approaches; such a spark may then change into an arc, resulting in an electric shock as well as severe burns.

(8) Static electricity

When a human, who is insulated from the ground by their shoes or by standing on a mat, walks in a dry room, static electricity is charged in their body. The human then gets the same electric shock as one mentioned above if they touch grounded metals such as the knob of a door and a keyhole. In this case, the human feels almost no shock if the potential of the body is 1 kV or less but a slight shock if the potential is about 1.5 kV. When the potential is 1.5-2.5 kV, the human feels a very serious shock. There have been no electrostatic deaths reported, but many secondary disasters including injuries from falls due to electrostatic shocks have been reported. In addition, electrostatic sparks may cause an explosion of a mixed gas.

IV Measures against electric shocks

First, accident preventive measures are required to be taken sufficiently for systems and devices themselves. In addition to this, testers using them must receive safety education for some purposes such as the promotion of safety awareness and the completion of safety precautions.

The principal preventive measures for electric shocks, corresponding to the causes of electric shocks, are described below:

(1) Use strong grounding wires when grounding all systems and devices.

(2) Periodically check the insulation and electrical leaks of the system and device wiring.
Testers must keep in mind that they make a habit of checking grounding, insulation, electrical leaks, and other conditions.

(3) Check the rated performance of systems, devices, and fuses.

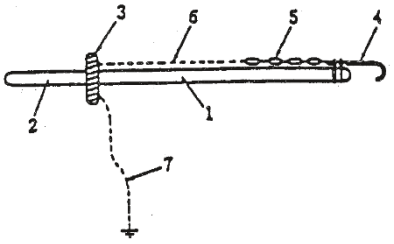
(4) To ease an electrostatic shock, hold a metal piece (such as a key) and put it to a grounded metal to discharge; by doing this, you do not need to directly touch an electric spark with your fingertips. Other measures are also taken by discharging static electricity with conductive substances in order to prevent electrostatic hazards and accidents.

(5) To prevent direct contact with a charged part accidentally during an experiment, apply insulation tape, covers, and other items over as many experimental circuits and charged parts of systems as possible to avoid exposure. If a charged part cannot be covered, after applying a caution sign on the part, support it with insulated stands such as insulators and place it so that the human body and other objects cannot make contact with it easily during an experiment.
(6) A proper distance must be ensured between experimental circuits, between systems, and between a tester and them to conduct experiments safely with the consideration of workability and unexpected situations such as falls during experiments.

V Precautions for high voltage experiments

(1) Ensuring grounding for high voltage, insulation, and a proper safety distance is the key to preventing electric shocks. In addition, an experiment team for high voltage experiments must consist of two or more members. One of them is a safety checker, who must grasp the members' progress of an experiment and ambient conditions and establish a system where proper instructions can be provided immediately if necessary. Before beginning an experiment, make a habit of checking where the power switch of the room is, where the switches of systems and devices are, whether fuses and grounding wires are installed correctly, and other conditions. If terminals and conductors of high voltage parts are exposed, cover all of them with grounded wire nets and other similar materials to prevent contact with hands and the human body. In some cases, install warning lamps to prevent unauthorized persons from approaching an experiment area. Testers shall also wear insulated shoes and gloves if necessary.
(2) When you suspend an experiment with high voltage capacitors and approach or touch conductors with high voltage applied, follow the procedure below: turn off the power supply; put the end of a grounding bar (Note) to places with high voltage applied to lower their potential to zero; and approach or touch the conductors. Repeat grounding with a grounding bar at least several times in this procedure because high voltage is produced again due to absorbed charges of a capacitor even though it has been grounded once and discharged. Then, put the end hook of a grounding bar to a high voltage part to ensure the part is always kept being grounded before starting operation.

(Note) An example of the structure of a grounding bar is shown in the figure below.



Example of structure of grounding bar

Rods 1 and 2 are made of insulated materials (ferrule resin or wood), and rod 2 is a grip (about 30 cm in length). Rod 1 is typically 1-2 m in length (according to the level of voltage) and about 3 cm in diameter. Conductive guard 3 (about 10 cm in diameter) placed on the opposite side of the grip is grounded. Conductive hook 4 placed on the end is used for touching a high voltage part. Resistor chain 5 consisting of about 10 connected resistors, each of which has a resistance of about 100 kΩ, is inserted between hook 4 and conductive guard 3. If resistor chain 5 is not inserted, a large spark and a very loud sound are generated when a capacitor or another device is touched with hook 4. If resistor chain 5 is inserted, no sparks are generated and only a soft sound is heard. In other words, resistor chain 5 plays a safety role, protecting a capacitor by gradually releasing the accumulated energy of the capacitor. Conductor 6 is thick. Grounding wire 7 combines a knitted organization and lead wires composed by thick strands.
(3) To approach a failed part, turn off all the power switches including the base knife switch and disconnecting switches. Ground all high voltage parts. Next, check that a voltage is zero with a voltmeter. Then, ground the failed part and all high voltage parts through which the failed part is grounded with grounding bars. For this reason, you need two or more grounding bars. If sparks and discharging sounds are still generated after a high voltage part is grounded several times, lines of resistors and other devices of a discharging circuit are supposed to be broken; pay great attention to this. After performing the above-mentioned grounding, conduct operations carefully while grounding bars are kept on places where failures are expected.

(4) Check the difference between live and dead wires. Middle voltage live wires with a voltage of several hundred volts tend to be handled carelessly as if these have no dangerous voltage, especially for experiments with a high voltage of several dozens of kilovolts or more; pay great attention to this.
(5) Check safety distances from systems, devices, and experimental samples carefully. The following table shows some relations between circuit voltages and safety distances. Note that these values are only estimations, and greatly depend on factors such as the inequality of an electric field due to the shape of a charged part of systems and devices and waveforms of applied voltage.

Circuit voltages and safety distances

Circuit voltage (kV)	Safety distance (cm)	Circuit voltage (kV)	Safety distance (cm)
11 to 22	70	77 to 88	110
33 to 44	80	110 to 154	200
55 to 66	90	187 to 275	300

(6) Prepare high voltage rubber gloves and insulation protectors such as insulated stands for some types of experiments. However, you must be careful as such protectors often cannot work in wet situations such as highly humid or rainy weather.

VI Measures and precautions for electric shocks

If a victim cannot get away, another person must immediately help them get away from the situation or interrupt the power supply. For this reason, all large-scale electrical experiments must be conducted by multiple members. A rescuer must pay great attention to the prevention of a secondary electric shock to themself and secondary disasters such as burns during escape rescue and power supply interruption.

(1) Precautions for helping a victim get away and interrupting power supply

A victim who cannot get away by themself must be helped immediately to get away from a charged part. However, a rescuer may get a secondary electric shock through the victim by carelessly touching them if the rescuer is in a hurry. A rescuer must be insulated from the ground by wearing insulated shoes or standing on an insulated stand. If a rescuer is not insulated from the ground, they must turn off the power supply and ground charged parts before touching the victim.

To take a safe and proper course of immediate action, including getting the victim away, interrupting the power supply, and grounding, it is essential to place experimental equipment and devices, receive training, and completely develop awareness with the consideration of emergency situations at all times.

(2) Emergency treatment for a victim

When an accident occurs, help the victim escape from a charged part firstly in the way above, and then interrupt and ground the power supply. If the victim is unconscious, check their breathing and pulse and then immediately call an emergency physician while also taking relief action including artificial respiration and cardiac massage. Note that artificial respiration and cardiac massage can be conducted at the same time by two members and are highly effective for relief.

Artificial respiration is conducted as follows: keep pinching the victim’s nose; breathe deeply; and breathe into the victim’s mouth (mouth-to-mouth). Repeat this course of action slowly. Cardiac massage is conducted as follows: expose the victim’s chest; straddle the victim; put your both palms on the victim’s heart region; and place your whole weight on the region and release it. Repeat this course of action.

Though the victim is not unconscious, they may have burns and their mind and body may be deeply impacted. The victim must be examined by a physician, or an electrocardiogram taken in some serious cases. In the case of a minor accident, the victim also needs to rest sufficiently after the accident.

An electric shock often makes burns on the skin and in subdermal tissues. Electrical burns in subdermal tissues particularly require long-term treatment. Carefully check whether or not there are burns and get treatment from a physician immediately if necessary.

A fall and plunge due to the impact of an electric shock are recognized as secondary disasters, often resulting in external injuries and bruises. In some cases, stop the bleeding and take emergency treatment for broken bones.

Laser safety

I Introduction

Laser safety was discussed relatively early, mainly in the U.S., from the 1960s. In Japan, the Ministry of Labour and the Ministry of Health and Welfare issued notices such as “Preventive Measures for Laser Beam Injuries” and “Laser Surgical Devices” from their points of view, specifying detailed precautions for using laser light. The Japanese laser safety standard was established as “Safety Standard of Laser Product Radiation” (JIS C 6802) on November 1, 1988, after various discussions had been held.

II Laser classification

Laser radiation is produced by exciting specific matters artificially with immense energy and amplifying electromagnetic waves generated in the return of the matters to the original state through controlled stimulated radiation. It has a wavelength ranging from about 200 nm to 10 μm, generating a highly directive beam with a single-wavelength and an even phase (see the table below).

Principal laser types

	Type	Wavelength (μm)	Power	
		Continuous	pulse	
Gas laser	He-Ne	0.63	1-50 mW	
	CO_2	10.6	10-5000 W	300 J or less
	Ar ion	0.51	0.5-5 W	
	Excimer	8.48	5-20 mW	2 J or less
Solid-state laser	YAG	0.2 to 0.4	—	50 J or less
	Ruby	1.06	10-500 W	20 J or less
	Glass	0.69	—	100 kJ or less
Liquid laser	Colored paper	1.06	—	
	Rhodamine 6G	0.5 to 0.65	0.1-10 W	
Semiconductor laser	Ca As series	0.64 to 3.1	1-1 mW	

As shown above, laser products have a wide range of radiation wavelengths, waveforms, powers, structures, and other factors. In addition, in the case of the eye, which is the most sensitive, the area subjected to photochemical and thermal effects depends on wavelengths, and a laser intensity per area of visible light or near-infrared light (400-1200 nm) on the fundus can reach 10^4 times as much as one on the corneal surface through the condensation of the crystalline lens. Thus, the severity of laser hazards to the human body greatly depends on the conditions, thus common safety standards cannot be established. The JIS standard then classifies lasers into four classes from essentially safe lasers to harmful ones. The classes are generally described below while the details of them are shown in the JIS standard. The Accessible Emission Limits (AEL) allowable for the eyes and the skin are also specified. Since laser systems have complicated structures and oscillation styles, classification must be determined on the basis of advice from manufacturers’ and other institutes’ specialists.

Class 1	Has a low power (about 0.39 μW or less) not injuring the human body.
Class 2	Visible light (with a wavelength of 400-700 nm) having a power (about 1 mW or less) equal to or lower than one that the human body can avoid by defensive reactions (during a blinking period).
Class 3A	Harmful for interbeam observation with optical means and has an emission level (about 5 mW or less) equal to or lower than five times the power of class 2.
Class 3B	Has a power (about 0.5 W or less) that may injure the eyes exposed to a laser beam either directly or reflected but will not injure the eyes exposed to one from diffused reflection.
Class 4	Has a power (over about 0.5 W) that may injure the eyes exposed to a laser beam even from diffused reflection.

III Influences on the human body

Influences on the human body depend on the wavelengths, powers, output waveforms, and other factors of the laser beams; however, the eyes typically tend to be seriously injured and changed irreversibly rather than the skin.

(1) Eye injuries

The absorption of the cornea and the crystalline lens depends on wavelengths, and conditions of injuries also vary according to the following table.

(2) Skin injuries

When the skin is excessively exposed to a high-power laser beam, changes on the skin range from minor red spots to blister formation, thermocoagulation, and carbonization.

Biological disorders for excessive exposure to laser light

CIE wavelength range*	Eye	Skin
Ultraviolet C (UV-C)	Corneal disorder	Red spot (sunburn)
(100-280 nm)		Acceleration of skin aging
Ultraviolet B (UV-B)		Pigment increase
(280-315 nm)		
Ultraviolet A (UV-A)	Corneal disorder, cataract	
(315-400 nm)		Blackening pigment
Visible	Retinal injury	Optical reaction
(400-780 nm)		
Infrared A (IR-A)	Retinal injury, cataract	
(780-1400 nm)		
Infrared B (IR-B)	Corneal disorder, cataract	Burn
(1.4-3 μm)		
Infrared C (IR-C)		
(3 μm-1 mm)		

* The wavelength range that is defined by the International Science Council (CIE) and used for describing somatological influences.

IV Safety prevention measures

Since safety measures for lasers are taken by their manufacturers according to the classification in the safety standard, injury prevention measures taken by users are described here.

(1) Use of remote interlock protection connectors

Remote interlock protection connectors are installed on laser products of class 3B or higher (except for class 3B with a power of 5 mW or less in the visible range). Users of such products must link these connectors to emergency interruption interlocks, room locks, door interlocks, and other interlocks.

(2) Control with keys

Lasers of class 3B or higher (except for class 3B with a power of 5 mW or less in the visible range) are specified to be equipped with main controls with keys. Users must use these keys and remove them when laser products are not used to prevent unauthorized operation.

(3) Beam breakers and attenuators

Users of laser products of class 3B or higher must recognize that beam breakers and attenuators are in principle closed to prevent accidental laser radiation and careless exposure.

(4) Warning signs

Users must post proper warning signs on places, entrances to rooms, and protective enclosures where laser products of class 3B or higher are installed. The laser safety officer is responsible for taking safety prevention measures in areas where laser exposure could exceed the Maximum Permissible Exposure (MPE), a controlled value of laser exposure to the human body; such areas are called laser-controlled areas.

(5) Beams

Beams emitted from laser products of class 2 or higher must be terminated. For termination, use diffusion reflectors or absorbers with proper reflectance and heat characteristics. Do not use mirror reflectors. If laser beams are required to be used without enclosures, position the beams at a height below eye level or much higher than it. When a fundamental wave is infrared light and its optical path cannot be checked visually, you should pass a type of visible light beams such as Ar ion laser beams through the completely same path, enabling the entire optical path and reflected or diffused light to be tracked.

(6) Mirror reflection

Since laser beams from laser products of class 3B or higher could be harmful to the eyes even though they pass instantaneously, you must ensure mirrors, lenses, beam splitters, and other optical elements are installed on holders. If optical elements are moved without laser beams, a beam will be radiated in an unintended direction and result in a harmful situation; thus, optical elements should be moved only when a laser beam is radiated.

(7) Eye protection

Eye protection is the most important measure of safety prevention and conducted by wearing proper safety glasses. Though laser safety glasses are not specified by the JIS standards, these glasses should be selected as follows.

No safety glasses can be applied to all wavelength ranges. Some lasers can oscillate multiple wavelengths simultaneously (Ar lasers) and can radiate both a fundamental wave (1064 nm) and a secondary high-frequency wave (532 nm) (YAG lasers). For this reason, safety glasses should be selected by considering both applied and unapplied wavelengths and check the optical density of each wavelength from the characteristics graphs and other materials of a product. If you do not care about the transparency of safety glasses, it could affect workability and safety. From this point of view, the use of safety glasses separately for routine operation and alignment purposes helps risk prevention.

The types of safety glasses are divided into an absorption type that are made by adding absorbents into the plastic or glass base and a reflection type that has a derivative multilayer thin film on the base surface. For the plastic-made absorption type, a surface should be coated for damage prevention. Note that the transparency of the reflection type is seriously affected by damages, as well as its performance is changed by the incidence angle of a beam.

(8) Protective clothing

You must wear protective clothing when you could be exposed to a radiation level obviously exceeding the MPE for the skin and when you operate class 4 lasers because such lasers could cause fires.

Safe work with hazardous gases

I Introduction

As the semiconductor industry developed, hazardous/harmful gases (high-pressure specialty gases), such as silane or arsine, have also come into use for university research activities. Many of these gases are often so violently explosive as to lead to a serious accident or so toxic as to lead to death. Therefore, any process that uses a semiconductor gas must be conducted under strict supervision and guidance by the Principal Investigator. Utmost care must be exercised to prevent accidents, and:

i. Never let harmful gases leak out;
ii. Do not discharge untreated harmful gases; and
iii. Provide a failsafe setup that always prevents inhalation, even in the event of leakage.

Rules above must be meticulously complied with to proceed with experiments. Additionally, in semiconductor process-related experiments, all staff must comply at least with the following general precautions.

i. Have basic knowledge about semiconductor gases and conduct experiments with full awareness of the properties of the gases.
ii. Whenever using a new semiconductor gas with no previously reported cases, gather materials about its safety before starting experiments.
iii. Accidents tend to occur at the startup of equipment. Run a thoroughgoing leak check by vacuum drawing before flowing the gas for the first time. Pressurized parts, in particular, require a careful leak check.
iv. A typical semiconductor process involves quite a few valve operations. Always prepare a valve operation manual. Do not omit the task of checking with the manual even after getting used to the experiment.
v. It is desired that experiments using a dangerous gas be conducted by two or more persons. No one should conduct such an experiment alone, especially late at night.
vi. Perform periodic safety checks. Especially for apparatuses and the like requiring periodic maintenance (e.g., a waste gas treatment system), always keep work records and prevent failure to perform maintenance.
vii. Conduct periodic emergency fire drills besides being fully prepared for the above. Do not fail to conduct routine drills with firefighting equipment, especially fire extinguishers and gas masks, to ensure readiness in using them. It is also important that the staff discuss emergency measures against earthquakes, fires, gas leaks, and the like on a routine basis. In particular, the following two kinds of chemicals have a high frequency of use and pose an extreme danger. It is advised to take due care.

1) Trichloroethylene (trichlene)

There are reported cases of decreased white blood cell counts in trichlene users. Due care must be taken to avoid inhaling its vapor.

2) Hydrofluoric acid (HF)

Even a tiny droplet on the skin will cause injury down to the bone. Exercise the strictest care. Due caution must also be exercised against its vapor. Always wear gloves, protective goggles, and gas masks when using HF.

viii. Poisoning by inhalation needs immediate life-saving treatment, which, however, is unavailable at most hospitals and therefore requires direct transportation to a special emergency medical service facility. Therefore, it is necessary to know the contact information at emergency medical service facilities beforehand.

II Hazardous/Harmful Chemicals for Semiconductors

1. General Knowledge of Semiconductor Gases

Semiconductor processes use various ignitable and toxic gases. To conduct research using these hazardous/harmful chemicals, one must get accustomed to handling gases while developing the basic knowledge on them and providing sufficient safety measures. This section first overviews the basic properties of these gases, waste gas treatment methods, first-aid treatment methods, and so on. The table below summarizes the general properties of various gases used for semiconductors:

(1) Combustibility

Silane and other hydrides easily hydrolyze and have properties to be particularly wary of, including combustibility and explosibility. All hydrides are flammable, explosively combust in air, and, as such, must be handled with extreme care. Chlorsilane (SiH_3F, Cl, SiH_2Cl, $SiHCl_3$) and fluorosilanes (SiH_3F, SiH_2, F_2, $SiHF_3$) also easily ignite in air and catch fire from static electricity.

Organic metal compounds (trimethylgallium, trimethyl aluminum, etc.) are thermally unstable at high temperatures, violently react with air and water, and, as such, must be handled with due care. When in contact with air, they spontaneously ignite, producing a white smoke of oxides. The gas thus generated is extremely toxic, so provide sufficient ventilation. Additionally, even a mere leak of these organic metal compounds may result in a fire and must not be left sitting. Wiping off the leakage with an absorbent, such as cloth or paper, may result in a secondary fire.

(2) Corrosivity

Hydrides attack rubber, grease, and lube oil. Saran, polyester, quartz glass, nylon, Teflon, asbestos, paraffin, and the like remain unaffected. Among metals, aluminum gets attacked. H_2S and NH_3 have particularly strong corrosivity and violently corrode Cu, Al, and their alloys, respectively, particularly when there is moisture present.

Halogenides easily hydrolyze almost completely and produce highly corrosive acids, such as hydrochloric acid or hydrofluoric acid. At the same time, an accompanying white smoke and pungent odor are generated. These acids violently corrode most metals.

(3) Toxicity

Many of the gases used in the semiconductor film formation process have strong toxicity, seriously affect the human body even in an extremely trace amount, and, as such, must be handled with extreme care. Hydrides have particularly strong toxicity and cause acute symptoms, such as headache, dizziness, nausea, or breathing difficulty if inhaled even in a trace amount. AsH_3 and the like, in particular, have a strong hemolytic action. Their inhalation at high concentrations results in instantaneous death. Even at low concentrations, their inhalation leads to death in several hours. Additionally, many irritate the mucous membranes of the eye, throat, and the like and, if repeatedly inhaled, even in extremely trace amounts, cause similar chronic symptoms.

(4) Waste gas treatment methods

After hydrolysis, hydrides should be treated by methods such as neutralization with alkali or adsorption using an oxidation adsorbent. Silanes can be treated by combustion using an incinerator. Halogenides are to be treated by neutralization with alkali after hydrolysis. These must not be loaded into an incinerator. Organic metal compounds are to be eliminated using an adsorbent, such as Toxoclean. It is very dangerous to treat these gases in a large amount at a time, regardless of the method used. The gases must be flow-controlled for gradual treatment. Additionally, when different kinds of gases are used simultaneously, due consideration must be given to the configurations of their treatment systems to ensure safety.

(5) First-aid treatment

In case of highly toxic gas inhalation, immediately remove the affected person to fresh air for oxygen inhalation. In the event of a respiratory arrest, take appropriate measures, such as artificial respiration. Keep the affected person at rest and immediately call a medical specialist. In case of contact with the skin, eye, nose, or the like, immediately flush with plenty of running water for a long time. When a medical specialist is called, keep flushing until the doctor arrives. In most cases, chemical neutralizers must not be used. In many cases, ointments and the like must also not be applied. Care must be taken accordingly. In cases of organic metals, a burn is especially likely to be involved. Hence, the injury should be rinsed and cooled sufficiently. In case of accidental ingestion, the appropriate measure may vary: the affected person may be given plenty of water for dilution, may be allowed to vomit, or may not. Care must be taken accordingly.

General properties of various semiconductor gases

Category	Gas name	Appearance	Boiling point (°C)	Specific gravity (Air = 1)	Vapor pressure (0°C)	Allowable concentration (ppm)	Hazards: Toxicity	Hazards: Flammability	Hazards: Spontaneity	Hazards: Corrosivity
Hydrides	AsH_3	Colorless gas with a garlic odor	-62.5	2.695	8.58 K	0.05	◎	○		
	B_2H_6	Colorless, nauseous gas	-92.8	0.965	28.10 K	0.1	◎	○	○	
	PH_3	Colorless gas with a rotten-fish odor	-87.7	1.184	22.43 K	0.3	◎	○	○	
	H_2S	Colorless gas with a rotten-egg odor	-60.7	1.189	10.33 K	10	○	○		◎
	H_2Se	Colorless gas with a garlic odor	-41.4	2.08	5.12 K	0.05	◎	○	○	
(Silanes)	SiH_4	Colorless gas with an unpleasant odor	-111.5	1.114	24.2 K	5	○	◎	◎	
	Si_2H_6	Colorless gas with an unpleasant odor	-14.5	2.3	1.86 K		○	◎	◎	
	GeH_4	Colorless gas with a distinctive choking odor	-88.4	2.654	25.11 K	0.2	◎	◎	○	
Chlorides	$SiCl_4$	Colorless, fuming liquid with a choking odor	59	5.90 (gas)	100 m (5.4°C)	Unknown	○			○
	CCl_4	Colorless liquid with a peculiar odor	76.8	5.32 (gas)	33 m	5	○			○
	BCl_3	Colorless, fuming liquid with a pungent odor/colorless gas with a hay-like odor	12.5	4.03 (gas)	470 m	Unknown	○			○
	HCl	Colorless gas with a pungent odor	-85	1.268	26.55 K	5	○	Oxidizing		○
	Cl_2	Yellowish-green gas with a choking, pungent odor	-34.1	2.49	3.8 K	1	○	Oxidizing		◎
Fluorides	SiF_4	Colorless gas with a pungent odor	-95.5	3.57	103.5 K	0.5*	○			○
	GeF_4	—								
	CF_4	Colorless, odorless gas	-128	3.05	798.9 m (-127.3)					
	BF_3	Colorless gas with a pungent, choking odor	-99.8	2.380	760 m (-99.9°C)	1	○			○
	HF	Colorless gas or liquid with a unique, pungent odor	19.5	1.27	360 m	(3asF)	○			○
	F_2		-187	1.311		1	○	Oxidizing		◎
	TMG	Yellowish-green gas with a chlorine-like odor	55.8		64.5 m		○	◎	◎	
Organic metals	TEG	Colorless, transparent liquid	143		16 m (43°C)		○	◎	◎	
	TEAL	Colorless, transparent liquid	186		1 m (62°C)	(2 mg/m^3)	○	◎	◎	
	CH_4	Colorless, transparent liquid	-161.5	0.555	87.4 m (-182°C)			○		
Others	NH_3	Colorless, odorless gas	-33.4	0.597	4.55 K	25	○	○		○
	H_2	Colorless gas with a stifling, pungent odor Colorless, odorless gas	-252.8	0.2695				○		

[Remarks] Vapor pressure: K … kg/cm2; m … mmHg Allowable concentration: Value specified by ACGIH, * … Unapproved Flammability: Oxidizing … Oxidizing

2. Various Semiconductor Gases

For high-risk chemicals frequently used as semiconductor gases, their danger, effects on the human body, emergency processing method, and so on can be detailed as follows:

1) AsH_3 (arseniureted hydrogen/arsine)

i.Hazards

Combustibility: Positive

Explosive range: 0.8 to 98 vol%

Incompatible materials: Cl_2, strong oxidizing agents, nitric acid

Autocatalyticity: Extremely strong

ii.Emergency measures

Leakage: Evacuate personnel and provide emergency ventilation. Exhaust the gas through a purifier.

Fire: Use dry chemical fire extinguishers and CO_2 fire extinguishers.

Handling: Wear self-contained breathing apparatus, gloves, mittens, or the like, and eye protection. After handling, wash hands and face well.

iii.Effects on the human body

Acute (inhalation): High in affinity for hemoglobin and with hemolytic action. Anemia, jaundice, and edema manifest themselves. Even cutaneous respiration causes these impacts, which means they cannot be completely prevented by holding a breath or wearing a gas mask. 250 ppm … Instantaneous death. 25 to 50 ppm … Death within one and half an hour. 3 to 10 ppm … Manifestation of poisoning symptoms within several hours. Fatal over a long time. 0.5 ppm … Manifestation of acute poisoning. Dizziness, headache, throat irritation, and pulmonary edema.

Chronic: Red blood cell destruction. Protein in urine.

Carcinogenicity: Likely.

iv.First-aid treatment

Oxygen inhalation. Seek immediate medical diagnosis. In the event of respiratory arrest, perform artificial respiration.

v.Waste gas treatment methods

Adsorption reaction treatment using a solid oxidation absorbent (based on $FeCl_3$) and its combined use with a combustor.

2) PH_3 (hydrogen phosphide/phosphine)

i.Hazards

Explosive range: 1.32 to 9.8 vol%

Pyrophoricity: Pyrophoric because of the trace amount of P_2H_6 contained.

Hypergolic materials: $AgNO_3$, $Hg(NO_3)_2$, N_2O, HNO_3, HNO_2, Cl_2, NO, NCl_3, Cl_2O, and Br_2

Incompatible materials: Air, BCl_3, Br_2, Cl_2, Cl_2O, $Hg(NO_3)_2$, HNO_3, NO, NCl_3, NO_2, N_2O, HNO_2, O_2, $(K + NH_3)$, $AgNO_3$, and $AgNO_3$

ii.Emergency measures

Leakage/scattering: Keep fire away. Stop leakage. Reduce vapor by water spraying and ventilation.

Minor fire: Powder or CO_2 fire extinguishers

Major fire: Water spraying, mist, or foam. In this case, take care to avoid contaminating water.

iii.Effects on the human body

Acute (inhalation): Within a few minutes, signs occur of breathing difficulty, cyanosis, fainting, asphyxial convulsions, and so on, leading to death.

Subacute (inhalation): Extreme fatigue feeling, headache, chest pain, stomachache, persistent nausea, and diarrhea. Further inhalation causes pulmonary edema, ataxia, excitation, drowsiness, and the like, leading to death within 48 hours. Even if overcome, this phase is followed by fatal liver and kidney disorders. The breath smells like garlic. Jaundice, azotemia, and retention of urine occur. Cardiac disorders also occur. 2000 ppm … Death occurs within several minutes. 300 ppm … Death is likely within one hour. Asymptomatic maximum allowable concentration … 1.4 to 2.8 ppm.

iv.First-aid treatment
Perform oxygen inhalation as soon as possible. In the event of a respiratory arrest, perform artificial respiration. Keep warm and at rest. Seek immediate medical diagnosis.
v.Waste gas treatment methods
Elimination using an adsorbent (sulfuric acid aqueous solution of potassium permanganate, ferric chloride solution, or sodium hypobromite solution), followed by waste gas scrubbing before discharge into the atmosphere.
3) B_2H_6 (borohydride/diborane)
i.Hazards
Combustibility: Flammable
Explosive range: 0.9 to 98.0 vol%
Pyrophoricity: Pyrophoric in humid air.
Hypergolic ignitability: Heat, flame, air, HNO_3, and O_2
Incompatible materials: CO_2, oxidizing agents, aluminum, and lithium
ii.Emergency equipment
Leakage/fire: Spray water to reduce vapor. If the gas is on fire and cannot be stopped from leaking, allow the fire to continue burning. Isolate for at least 800 meters in all directions from the tank where the fire occurred.
Firefighting: Minor fire … Powder or CO_2 fire extinguishers; Major fire … Water spraying, mist, or foam is effective.
iii.Effects on the human body
Acute (inhalation): Highly irritant to mucous membranes. Headache, nausea, weakness, convulsive fits, tightness in the chest, coughing, breathing difficulty, pulmonary edema, and hemolytic action. If inhaled, B_2H_6 dulls the sense of smell. Eye … Irritant at high concentration. Skin … Inflammatory at high concentration.
Chronic: Wheezy breathing, dry coughing, breathing difficulty, persistent hyperpnea for a few years, headache, fatigue, and convulsions manifest themselves, among others.
iv.First-aid treatment
Inhalation: Immediately remove to fresh air, keep warm and at rest, and give pure oxygen inhalation. In the event of respiratory arrest, perform artificial respiration and immediately call a physician. Eye: Lift the upper and lower eyelids and rinse for 15 minutes. Seek immediate medical attention from a specialist. Do not wear contact lenses when handling this substance.
Skin: Flush with plenty of water for 15 minutes and treat the heat burn.
v.Waste gas treatment methods
Burn while eliminating B_2O_3 in the waste gas using a liquid dispersion-type gas absorber.
4) H_2Se (hydrogen selenide)
i.Hazards
Combustibility: Flammable. When ignited, H_2Se burns with blue flames.
Explosibility: Risk of fire and explosion.
Hypergolic ignitability: Together with air, H_2Se forms an explosive mixture.
Incompatible hazardous substances: Oxidizing agents (H_2O_2, HNO_3, etc.), acids, water, and hydrocarbon chlorides.

ii.Emergency measures
Leakage/scattering: Keep fire away. Stop the leakage. Spray water to reduce vapor.
Minor fire: Powder or CO_2 fire extinguishers
Major fire: Water spraying, mist, or foam. If a gas leakage is unstoppable, allow the fire to continue burning. Isolate for at least 800 meters in all directions from the tank where the fire occurred.
iii.Effects on the human body
Acute (inhalation): After prolonged exposure at or below 0.2 ppm, breath with a garlic odor, nausea, dizziness, and malaise. Harmful to the liver and spleen. Hemolytic. Dimethyl selenide resulting from selenium detoxification … Pneumonia and sore throat. Eye/skin … Irritant to mucous membranes. At 1 ppm, unbearably irritant to the eye, nose, and throat.
iv.First-aid treatment
Inhalation: Immediately remove to fresh air and keep warm and at rest. Oxygen inhalation and artificial respiration. Closely observe for any sign of pulmonary edema.
Eye: Rinse well with water for at least 15 minutes.
Pain reduction method … A drop of olive oil, three or four drops of 0.1% epinephrine sulfate, local anesthesia, and hot and cold compress. Seek examination by a medical specialist as soon as possible.
v.Waste gas treatment methods
Absorption by an alkaline aqueous solution, such as KOH. A highly toxic substance, unabsorbed gas, which is dangerous even in a trace amount. Due care must be taken accordingly.
5) SiH_4 (silane/monosilane)
i.Hazards
Flammable range: 0.8 to 98%
Explosive range: 1.37 vol% (1 atm), 1.65 vol% (4.84 atm), 1 vol% (1 atm, O_2 concentration 0.2 vol%), 0.64% (1 atm, O_2 concentration 0.8 vol%). The lower limit decreases due to the ignition of the diluent. Care must be taken accordingly. At 5%, silane has an explosion pressure nine times the initial pressure and a maximum pressure rise rate of 2,168 atm/s.
Pyrophoricity: Pyrophoric in air.
Incompatible materials: Halogen (explosion), oxidizing agents, air, heavy metal chlorides, O_2 (explosive substance production), NO, NO_2, and N_2O
ii.Emergency measures
Leakage/scattering: Detectable by flames in most cases. If a leak occurs in the middle of the piping, stop the supply, evacuate, and burn any remaining silane.
Minor fire: Powder or CO_2 fire extinguishers
Major fire: Water spraying, mist, or foam is effective.
iii.Effects on the human body
Acute (inhalation): Almost nothing is known except that upper airway irritation, headache, and nausea occur.
Eye/skin … Irritant.
Chronic: Unknown
iv.First-aid treatment
Immediately remove to an uncontaminated atmosphere and keep at rest and warm. 100% oxygen inhalation. In the event of respiratory arrest, perform artificial respiration and immediately call a physician.

v.Waste gas treatment methods
Burn (at or above 1,000°C), absorb into an alkaline aqueous solution (hydrolysis), or treat with an oxidizing agent.
6) GeH_4 (germane/germanium hydride)
i.Hazards
Combustibility: Flammable
Explosive range: 0.8 to 98%. Risk of explosive decomposition.
Pyrophoricity: Spontaneously ignitable in air due to decomposition reaction.
Incompatible materials: Halogen
ii.Emergency measures
Leakage/scattering: No open fire or smoking. Stop the leakage. Spray water to reduce vapor. If leakage is unstoppable, allow the fire to continue burning.
Minor fire: Powder or CO_2 fire extinguishers
Major fire: Water spraying, mist, or foam is effective.
iii.Effects on the human body
Acute (inhalation): Similarly, to arsine, high in affinity for hemoglobin and with hemolytic action. While exposure is expected to cause hemolytic phenomena and kidney disorders, accurate toxicity information is currently scarce.
iv.First-aid treatment
No treatment method is known. The first-aid treatment for arsine should be consulted. Perform oxygen inhalation and other general auxiliary methods as soon as possible. Seek immediate medical attention.
v.Waste gas treatment methods
Incineration in an incinerator. This incineration is to be performed according to the treatment method for silanes.
7) SiF_4 (silicon tetrafluoride)
i.Hazards
Combustibility: Non-combustible
Chemical reactivity: Hydrolytically productive of fluorides, hydrogen fluoride, and hydrofluoric acid and thermolytically generative of fluorine ion vapor.
ii.Emergency measures
Leakage/scattering: Stop the leakage. Spray water to reduce evaporation. However, avoid the spilled area. Note that any leakage would cause white smoke, allowing easy detection.
Minor fire: Powder or CO_2 fire extinguishers
Major fire: Water spraying, mist, or foam is effective.
iii.Effects on the human body
Acute (inhalation): 50 ppm. Death within 30 to 60 minutes. Respiratory organ irritation, pulmonary inflammation and congestion, circulatory organ debility, pulmonary edema, and osteosclerosis. Eye … Irritation. Skin … Pain and severe burn.
iv.First-aid treatment
Inhalation: Immediately remove to fresh air. 100% oxygen inhalation (pressurized oxygen inhalation in case of a serious case). Keep warm and at rest. An analgesic/sedative agent with mild action (such as aspirin) may be administered. In the event of respiratory arrest, perform artificial respiration and seek immediate medical attention.

Eye … Flush with water for 15 minutes. Repeat this several times. Apply an ice poultice. Seek immediate ophthalmologic attention.

v.Waste gas treatment methods

Perform hydrolysis and neutralization with plenty of water or an alkaline aqueous solution of KOH or the like. Alternatively, perform absorption by an adsorbent.

8) BCl_3 (boron trichloride)

i.Hazards

Incompatible materials: Water, aniline, hexafluoroisopropylidene, aminolithium, nitrogen dioxide, phosphine, grease, organic matter, and oxygen.

Corrosivity: Corrosive of most metals under the presence of water.

ii.Emergency measures

Leakage/scattering: Stop the leakage. Spray water to reduce vapor. However, avoid the spilled area. Isolate the area until the gas is dispersed. Note that any leakage would cause white smoke and could be easily detected.

Minor fire: Powder or CO_2 fire extinguishers

Major fire: Water spraying, mist, or foam is effective.

iii.Effects on the human body

Acute (inhalation): Causative of upper airway irritation, edema, and a highly pungent odor, allowing easy detection.

Eye/skin … Tissue irritation. If severely attacked, the skin becomes feverish and weakened.

iv.First-aid treatment

In any case, immediately call a physician.

Inhalation: Immediately remove to fresh air. In the event of respiratory arrest, perform artificial respiration. In case of breathing difficulty, perform oxygen inhalation. The affected person must be kept warm and at rest.

Skin: Immediately rinse with running water. Chemical neutralizers are unacceptable. In a serious case, the affected person must be kept at rest and warm.

Nose: Flush with water for at least 15 minutes.

Eye: Immediately flush with water for at least 15 minutes with the eyelids lifted.

v.Waste gas treatment methods

Perform hydrolysis and neutralization with plenty of water or an alkaline aqueous solution of KOH or the like. Alternatively, perform absorption by an adsorbent.

9) $Ga(CH_3)_3$ (TMG/trimethylgallium)

i. General properties

Molecular weight: 114.82	Melting point: -15.8℃
Boiling point: 55.8℃	Density: 1.151 g/ml (15°C)
Appearance: Colorless, transparent liquid	
Vapor pressure: Temperature (°C)	Vapor pressure (mmHg)
0.0	64.5
25.0	226.5
55.8	760

ii. Hazards

Easily oxidized in air. Spontaneously ignitable if leaked in a large amount. Violently reactive with water, generating methane gas and producing Me_2GaOH or $[[Me_2Ga]_2O]x$. Formative of a stable complex with AsH_3, PH_3, or the like. Violently reactive with substances containing active hydrogens, such as alcohols and acids.

iii. Emergency measures
Leakage: Highly ignitable. Do not attempt removal with an absorbent, such as cloth or paper. Oxidizable in contact with air, generating toxic gas. Provide sufficient ventilation.
Fire: Localize the fire to prevent its spread to other areas. Isolate other combustibles. Let the fire slowly burn while controlling its force using firefighting methods, such as powder fire extinguishers (dry chemical) or dry sand. Never use anything other than the above, such as water, foam fire-extinguishing agents, or carbon tetrachloride.

iv. Effects on the human body
Acute (inhalation): Inhalation of the white fumes generated during burning causes damage to the windpipes and lungs. Inhalation at a high concentration (15 mg/m^3) may cause a severe, flu-like fume fever, recovery from which normally takes several days. Skin/eye … Inflammatory, irritant to mucous membranes. Destructive to tissues. A delay in treatment will result in a severe burn scar.

v. First-aid treatment
Skin: Remove with plenty of water while cooling the affected part to protect the skin tissue.
Eye: Holding the eyelids open, flush the eye gently with water for 15 minutes. For subsequent treatment, follow the instructions of the doctor.
Inhalation: Keep at rest and follow the instructions of the doctor.

vi. Storage stability: Stable if stored at room temperature in an inert gas atmosphere (N_2, Ar, or the like).

10) $Ga(C_2H_5)_3$ (TEG/triethylgallium)

i. General properties

Molecular weight: 156.91	Melting point: -82.3°C
Boiling point: 143°C	Density: 0.06 g/ml
Appearance: Colorless, transparent liquid	
Vapor pressure: Temperature (℃)	Vapor pressure (mmHg)
43	16
47	18
143	760

ii. Hazards
Violently reactive with water, generating ethane gas and producing Et2GaOH. Others: Equivalent to those of TMG.

iii. Emergency measures, effects on the human body, first-aid treatment, and storage stability: Equivalent to those of TMG.

11) $Al(C_2H_5)_3$ (TEA1/triethyl aluminum)

i. General properties

Molecular weight: 114.17	Melting point: -52.5°C
Boiling point: 186°C	Density: 0.835 g/ml
Appearance: Colorless, transparent liquid	
Vapor pressure: Temperature (°C)	Vapor pressure (mmHg)
62	1.0
98	10.0
136	760

ii. Hazards

Possibility of violently reacting with water and igniting hydrocarbon gas. Others: Equivalent to those of TMG.

iii. Emergency measures, effects on the human body, first-aid treatment, and storage stability: Equivalent to those of TMG.

III Containers

Containers filled with semiconductor material gas have an elevated internal pressure and, as such, must be handled with particularly great care. Note that it is prohibited to use these containers when alone. Always use them held in a sealable explosion-proof storage cabinet. Additionally, treat and detoxify waste gases according to a prescribed method before discharging them. Before handling new containers for the first time, consult with specialist dealers and establish safe use methods and facilities beforehand. (Also refer to (V) below.)

1. Containers

Semiconductor manufacturing gas-filled containers largely fall into two types. The first types are containers filled at high pressure, as with nitrogen, hydrogen, silane, or the like, and fitted with a pressure regulator to take out the gas. The second types contain a liquid inside, as with triethylgallium and other organic metals, and rely on a gasification method, such as carrier gas bubbling, to take out the gas. Containers for high pressure are provided with a pressure regulator mounting screw. On the other hand, those for organic metals are provided with a fitting for flowing a carrier gas, such as hydrogen gas.

2. Valves for Cylinders - Pressure Regulators

Valves mainly used for semiconductor manufacturing gas-filled containers fall into two types: (1) valves for compressed gas containers and (2) valves for liquefied gas containers. Their materials are yellow steel, yellow steel nickel-plated, stainless steel, and the like, selectively used to suit the nature of the gas. The most important point of caution about valves for cylinders is whether the connection screw is a right-hand or left-hand thread screw. Those for flammable gases are left-hand thread screws. Others are right-hand thread screws.

IV Liquid Nitrogen

Liquid nitrogen is used by many laboratories of various departments, whether their specialty is physics-, chemistry-, or biology-related. Nitrogen gas itself is harmless. However, due care must be taken against frostbite or oxygen deficiency when handling liquid nitrogen.

Handling of Liquid Nitrogen (Warning)

1. Overview

Nitrogen gas is inexpensive and readily available. Additionally, the gas itself is harmless. As such, it tends to be handled offhandedly. However, due care must be taken against frostbite or oxygen deficiency when handling liquid nitrogen.

On March 6, 2018, an accident occurred in which liquid nitrogen spilled over the right knee of a student transferring liquid nitrogen from a storage tank to a carrier container. Its usage has been made known through chemical experiment workshops and safety manuals, but this section serves as a renewed call for attention.

2. Usage of Liquid Nitrogen

◎ Liquid nitrogen storage equipment and method of use of containers

The job of filling liquid nitrogen from a storage tank to another container (liquid transfer) is only one mistake away from frostbite from exposure to liquid nitrogen. Hence, this task demands extreme care.

Always wear safety goggles and cold-temperature work gloves when performing liquid nitrogen pumping work. Cotton work gloves and the like are undesirable. Do not perform pumping work in outfits such as short pants and sandals that leave the legs exposed. Do not touch low-temperature liquefied gas directly with a hand, finger, foot, or any other part of the body.

Additionally, a storage tank is under high pressure (035 to 0.95 Mpa), and a careless valve operation will lead to an outburst of high-pressure nitrogen gas, which can be extremely dangerous. In liquid transfer to a liquid nitrogen dewar vessel, insert the saber deep into the mouth of the dewar vessel and slowly open the pumping valve while watching out to ensure the saber is not floated up by the force of re-gasified nitrogen gas. When the flexible hose and the dewar vessel become sufficiently cooled inside, further open the pumping valve. Take care not to open it too much. When the dewar vessel is filled with liquid nitrogen, liquid nitrogen hits the guard part of the saber and starts to be scattered to the surroundings. Immediately shut off the pumping valve. After pumping, the flexible hose is frozen. Take care to avoid forcedly bending the saber when inserting the saber back into the tube.

A liquid nitrogen dewar features a dual-wall structure with a vacuum section between the two walls. The safety valve is the part that seals off the vacuum and hence must not be fiddled with by, e.g., unwittingly removing its cap. When transporting a filled dewar vessel, always tighten the cap on it. Otherwise, if the dewar vessel is jolted at bumps and dips in the floor, the liquid nitrogen inside may burst out, which can be dangerous. Serious cases of personal accidents have been reported, including liquid nitrogen splashed on the face.

Additionally, transport dewar vessels by two or more people as much as possible. Do not ride on an elevator with dewar vessels. Put signs stating “Transporting Liquid Nitrogen” in place when transporting dewar vessels on an elevator.

A hand pump is often used to draw liquid nitrogen from a dewar vessel. This procedure is designed to raise the pressure inside the container to push liquid nitrogen out. For the suck-up pump, it is important that it is dry. With water droplets on it, the pump will become frozen and malfunction. Additionally, applying excessive pressure to the hand pump will cause the hose part to be overpressured to burst, which can be dangerous. Always try to apply appropriate pressure.

◎ Usage of liquid nitrogen

i. An improvement must be devised to prevent liquid nitrogen from “leaking” when feeding liquid nitrogen from a storage container to a laboratory apparatus. Liquid nitrogen evaporates quickly. Hence, exposure to small droplets does not affect the human body. However, if exposed to a certain amount for a certain period, human body tissue will be instantaneously frozen (frostbitten). In the event of frostbite, warm the affected part with warm water (which must not exceed 42°C). Then, take appropriate measures. Do not massage or rub the affected part. When a fingertip or the like is frozen, keep it as is and seek immediate medical treatment.

ii. Ensure proper ventilation when using in large amounts. Any waste gas due to surplus pressure from laboratory equipment must be exhausted to a ventilation fan. Staying too long in a laboratory stagnant with gas re-gasified during use poses the risk of suffocation (oxygen deficiency). Caution is required for use in a particularly tightly sealed room, such as a clean room. Oxygen sensors and other alarm devices are desired to be installed. When the oxygen concentration in air lowers to or below 15%, oxygen deficiency occurs, causing unconsciousness, which poses an extreme danger. In the state of oxygen shortage with an oxygen concentration of 15% to 20%, symptoms such as headache and dizziness will manifest. Note that a single inhalation of nitrogen gas with an oxygen concentration of 0% results in unconsciousness.
In the event of coming across someone feeling sick or falling unconscious in an oxygen-poor condition, it is necessary to ventilate the room well, then take the affected person (with an oxygen mask on as necessary) outside of the room and loosen the collar of the clothes to perform oxygen inhalation.

iii. Any room-temperature object must be put slowly into liquid nitrogen. Otherwise, violent boiling will occur, causing the liquid to overflow, which can be dangerous. Additionally, the increased internal pressure due to re-gasification must be considered when feeding liquid nitrogen to a trap or shroud. Feeding ignoring the increased pressure may cause mechanically weak points to rupture or become detached, scattering liquid nitrogen, which can be extremely dangerous.

V Safety Measures for Equipment and Directions for Operation

Sites for handling semiconductor manufacturing gases require safety measures for equipment. Semiconductor processes must be designed with a particular focus on safety to use large amounts of highly dangerous gases. Additionally, accidents tend to occur mainly during gas cylinder replacement or when a chamber is opened. Purging and other necessary operations must never be omitted.

1. Workrooms and Container Storage Sites

For experiments that use ignitable or toxic gases, the following safety measures for equipment are desired:

(1) A laboratory must be built to be fire-resistant and stagnant gas-free and to maintain an appropriate indoor temperature.

(2) A safe distance must be provided from places constantly accessed by those other than the staff. Provide a structure and measures that preclude access by anyone other than the staff. Install a lock to the toxic gas container storage site.

(3) Considering airflow/ventilation against toxic gases, establish a safety-first work environment.
(4) Keep fire away.
(5) Considering the workability and the emergency evacuation route, conduct experiments in as wide a place as possible. Be sure to secure escape routes to be used during an unexpected evacuation.
(6) As a rule, electric equipment for workrooms and container storage sites for flammable gases must be built to be explosion-proof.

2. Residual Gas Removal by Purging

When installing an ignitable or highly toxic semiconductor gas container on the laboratory apparatus or removing part of the piping, even a trace of residual gas can be dangerous. Then, the job of flowing a harmless gas, such as nitrogen or argon, becomes necessary to prevent any hazardous gas from remaining. This operation is called purging. In practice, it is impossible to perform precise gas analysis every time. Hence, it is necessary to have the basic knowledge for performing effective purging.

The fundamental rule for piping purge is to carefully avoid ending up with gas stagnation points from the piping design stage. The reference equations for determining the optimum number of purges are shown below. The following two equations were derived from the premise that the purge and component gases are mixed instantaneously in the system. Therefore, this aspect must be taken into consideration when applying the equations.

1) Continuous purging

Continuous purging is a method that flows purge gas at a constant flow rate to replace the content of the system of a container. The following equation holds among the initial concentration (Xo) of the reactant gas of interest, the concentration (Xn) after the elapse of time t, the internal volume (V), and the purge gas flowrate (Q):

$Xn/Xo = \exp(-Qt/V)$

2) Cycle purging

Cycle purging is a method that repeats the cycle of pressure application and release by pressurizing the inside of the system up to a predetermined pressure with purge gas and then releasing the internal pressure or drawing a vacuum before repeating pressurization.

In this case, the following equation holds among the initial concentration (Xo), the concentration (Xn) after the n-th purge, the initial pressure (pressure after release, Po), the pressure after pressurization (P), and the number of purges (n):

$Xn/Xo = (Po/P)^n$

When continuous and cycle purging are compared, the latter is usually more effective. Cycle purging becomes more advantageous in proportion to the complexity of especially the piping or the system configuration.

3. Waste Gas Treatment and Ventilation Equipment

Gas exhaust treatment very often involves danger. Therefore, it is necessary to dispose of the gas after processing it into a safe state free of toxicity or ignitability with a familiar knowledge of the gas, including its characteristics and hazards.

(1) After detoxification, waste gas must go to an exhaust vent via an exhaust fan. Detoxification methods include chemical reactions, chemical adsorption, physical adsorption, combustion, and dilution. Among these methods, physical adsorption is based on the affinity that enables porous solids to adsorb specific substances. Adsorbents such as activated charcoal, silica gels, alumina gels, and molecular sieves are commercially available. Among these options, the one generally adopted is the harmful gas removal method based on activated charcoal. For hydride gases, such as AsH_3, PH_3, and H_2S, treatment methods based on oxidation adsorption with a high detoxification ability are used. The oxidizing agent in use consists of ferric chloride ($FeCl_3$) being the primary ingredient and porous powder impregnated into the carrier.
(2) The materials used for flammable/spontaneous gas exhaust systems must be non-combustible. Additionally, the materials used for non-combustible gas exhaust systems must be corrosion resistant.
(3) If deemed necessary, use a local exhaust ventilation system with an appropriate hood to ensure worker safety.
(4) Constant ventilation must be equipped, considering the possibility of indoor dispersion of leaked gas.
(5) Operate exhaust fans continuously, e.g., during work. Install alarms that immediately report any fan failure that may occur.

4. Gas Leak Detection/Alarming Equipment

Flammable gas leakage will cause an explosion or fire. Toxic gas leakage will pose a hazard to human health and life. Therefore, it is indispensable to install leak detector alarms for the purpose of identifying the occurrence and location of leakage as early as possible. Currently, however, these leak detector alarms are available in various types but are still new to the market and yet to have an established reputation. Hence, it is advisable to consult with their manufacturers to make a selection that suits the type and purpose of each gas used.

It is desirable to monitor particularly highly toxic gases all the time with two or more types of detectors based on different principles.

5. Firefighting and Protective Equipment

In workrooms, container storage sites, and the like for flammable and toxic gases, fire extinguishers and gas masks must be regularly stocked with their installed locations identifiably indicated.

(1) Fire extinguishers

Fire extinguishers include those for special fires (such as metal fires), besides carbon dioxide gas, powder, liquid, and foam fire extinguishers. Each has its own features and should be selected according to the type of dangerous substance. It is important to keep the most suitable ones handy all the time and maintain them with their service life in mind.

(2) Gas masks

Gas masks include ones that use absorbents, besides the air-supplied respirators shown in the table below. For absorbent gas masks, the absorbent must be changed according to the type of toxic gas and prepared to suit the gas used. Airline masks have a positive internal pressure and show resistance to small internal leaks. However, they have the drawback of a user's movable range limited by the hose length. SCBAs equipped with a portable cylinder have no restrictions regarding the user's movable range but have drawbacks, such as a short continuous operation time because of a limited cylinder volume.

(3) Others

Other protective equipment includes various types, such as protective clothing, gloves, safety helmets, protective goggles, and stretchers, and must be kept handy to suit gas usage. Additionally, it is also important to conduct drills to ensure correct use at any time.

Gas masks

Item name	Details
Airline mask (compressed-air mask)	・ Reliant on a compressed-air line, a compressed air container, and an air compressor to supply compressed air. ・ Equipped with a flowrate device and a filtration device midway to control the air supply rate appropriately to minimize the burden. ・ Appropriate air supply rate ranging from 100 to 1,501/min.
Self-contained breathing apparatus	・ Air sucked in just by breathing in. ・ Reliant on a cylinder with a limited amount of breathable air supply. Refilling work required. ・ Complete with a cylinder carried on the back and free of restrictions regarding the user's movable range.

VI General Emergency Measures

Anyone handling hazardous gases must understand well the properties of each gas and the work environment, among other matters, and must always be prepared to take appropriate measures flexibly in an emergency. In an emergency, efforts must be made to minimize damage. However, affected parties must not take risky actions without regard for their own lives.

1. Fire Emergency Response Measures

Fire emergency measures are explained elsewhere. This section describes emergency measures specifically related to semiconductor processes.

(1) General precautions

(a) In the event of a fire, it is necessary to grasp the degree of the fire and the situation near the site. With
i. Ignition sources
ii. Poisoning from toxic gas leakage
iii. Breakage of containers
iv. Gas explosion due to flammable gas leakage
in mind, among other factors, flexible measures must be taken to prevent personal accidents. In any case, affected parties must make an appropriate estimate of their required evacuation time and take safe actions accordingly.

(b) In the event of a fire that requires calling the fire department for help, the fire station personnel to be engaged in firefighting must be informed of the presence of toxic and flammable gases and that of high-pressure containers that may be broken.

(c) If poisonous or deleterious substances may leak due to a fire or other causes, leading to causing damage to the surroundings, it is mandatory to make an immediate report to the nearest public health center, police station, or fire service organization (while the legal reporting obligation applies to arsine, phosphine, stibine, hydrogen selenide, hydrogen chloride, ammonia, arsenic trichloride, and antimony pentachloride, other gases also have an equivalent or higher toxicity and should be reported according to the procedures described above).

(2) Measures for fires in the surrounding areas

(a) Move containers to as safe a place as possible.

(b) For containers unable to be moved, keep cooling them with water injection.

(c) If the rise in container temperature is found to be inevitable, expect toxic gas leakage and, with a gas mask on, evacuate the workers near the site and the people in likely affected areas to the windward side.

(d) Additionally, in the event of container breakage, scattering of their contents, and damage to flammable gas containers, expect a gas explosion and evacuate people near the site.

(3) Measures for fires on containers/manufacturing facilities

(a) Decide that leakage of toxic or flammable gas has occurred, immediately evacuate to the windward side, and warn loudly of toxic gas leakage many times to prompt the workers near the site to evacuate.

(b) Then, with a gas mask on, move the transportable containers in the surroundings to a safe place. Where containers cannot be transported out, keep cooling all the containers by injecting water from as far a distance on the windward side as possible.

(c) At the same time, when firefighting is possible depending on the fire situation and causes no leakage of toxic or flammable gas, or when leakage poses no risk of damage or injury, perform first-aid firefighting. Use firefighting methods, such as water throwing, dry chemical fire extinguishers, foam fire extinguishers, and halon fire extinguishers, depending on the situation.

(d) In the event of a manufacturing machinery fire, shut off the valves of gas sources as much as possible.

(e) When a fire spreads and is expected to cause the temperature of other containers or machines to rise, expect a gas explosion and evacuate the people near the site.

2. Leakage Emergency Measures

In the event of a gas leak from a container or the like, its handling very often involves danger. Therefore, in case of gas leakage, all necessary measures must be taken promptly, considering factors such as the type and characteristics of the leaked gas and the situation near the site, to minimize the disaster.

(1) Minor leakage

(a) When leakage occurs from the mouth of a cylinder valve, stand on the windward side and firmly tighten the cylinder valve. In this case, wear protective gear as necessary. If the leakage persists with the cylinder valve closed, be sure to wear a gas mask, fit the outlet cap in place, and then move the leaky container to a safe place as instructed by the safety officer.

(b) When leakage occurs from somewhere other than the mouth of the cylinder valve, be sure to wear a gas mask and move the leaky container to a safe place as instructed by the safety management supervisor.

(c) Take appropriate measures when leakage occurs from equipment or a piping system.

(2) Major leakage

(a) Immediately evacuate to the windward side and warn loudly of toxic gas leakage many times to prompt the people near the site to evacuate.

At the same time, wear protective gear and take flexible measures as the safety management supervisor instructs.

(b) Keep people away from the leakage site by such a method as roping off its vicinity.

(c) Turn off all fire sources around the leakage site.

(d) If a poisonous or deleterious substance leakage may cause damage to the surroundings, it is mandatory to report immediately to the nearest public health center, police station, or fire service organization.

(e) In the case of gases for which water spraying is effective, turn on sprinklers.

For the safe operation of machines

Refer to “Safety in the Use of Common Facilities” in addition to what follows. Note that the second and third-year undergraduate experiments offer many opportunities to use machines in the Centre for Design and Manufacturing or individual laboratories. Carefully read and fully understand the textbooks in advance. On experiment days, listen attentively to the instructor’s instructions. Do not hesitate to ask questions if in doubt.

I Safety Precautions to Take Before Machine Operation

(1) Preview the design and operation of the machine.

It is important to listen to the instructor or senior students. Before doing so, read the operating manual of the machine carefully. Remember that the laboratory contains various types of machinery and equipment from different periods, each of which operates differently. The same applies to disassembly and maintenance.

(2) Do not press switches just for the kick of it.

A serious accident can occur when a student, unprepared for class, walks up to a classmate’s machine and half-jokingly turns on the switch.

(3) Operation during holidays or late-night hours

Do not operate any dangerous machine when alone in the lab. Nobody will come to the rescue in the event of an emergency.

(4) Be wise and never court danger.

Install safety fencing or protective shelving around hazardous no-go areas to prevent accidental approaches.

(5) Install anti-scatter protection barriers.

Before operating a machine, place strong protective barriers (steel plates, thick wooden boards, plastic boards, fine-mesh wire screens, etc.) around the area likely to be sprayed with flying debris. Safety goggles are effective against fine flying chips.

(6) Clearing of obstacles

Obstacles at the foot or head level can fall over a machine when hit. Do not leave any object in the operating area of any machine. Otherwise, the object will be knocked flying by the machine during operation. Inspect with due care.

(7) Clothing precautions

Unbound long hair, long sleeves, oversized gloves, or anything that could be pulled into moving machine parts must be tied, bound, removed, or otherwise properly handled. Avoid wearing shoes with soles that slip easily on an oil-stained floor. Wear, preferably, JIS-compliant safety shoes or hard-toed leather shoes that prevent injury from falling heavy objects or tripping.

(8) Mounting of tools and specimens

Tools and specimens may become loose and fly out even if they appear firmly seated. Tighten them carefully. Check for tightness as you tighten. Chips or debris between mounting surfaces may pose a hazard. Clean the surfaces before mounting. An improperly mounted workpiece, especially in a cutting operation, could result in a serious accident. Therefore, always follow the instructor’s instructions for workpiece mounting in any cutting operation.

(9) Heavy object fixation

Elevated or tall heavy objects must be secured to prevent accidental falling or tipping.

II After Machine Startup

(1) Call out.

All machine operations must be performed by one person, even when working in a team of two or more. Before pressing any button, call out to the others to keep them out of harm's way. Even when working alone, call out to reduce the chance of making mistakes (like train drivers do). Double-check emergency stop switch locations.

(2) Be wise and never court danger again.

While a machine is running, stay clear and keep your hands away from any moving part or area likely to be sprayed with flying debris. If a machine needs monitoring, monitor it through a thick plastic plate.

(3) Be all eyes and ears.

Do not just stand around a machine after turning it on. Be all eyes, ears, and nose. An anomaly is undoubtedly underway if anything unusual is seen, heard, or smelled. Stop the machine immediately.

(4) Turn off the main switch.

When the experiment is finished, turn off the main switch of the power source. Let us say you do not. Imagine what would happen if someone accidentally pressed the start button on the machine.

(5) Tidy up.

Put tools and other items away after use. This is not only to avoid losing them. It is also to prevent possible dangers to the next user of the machine. Also, be sure to disable auto-feeding or the like.

III On the Use of Hoist Cranes

(1) Hoist cranes and other powered lifting equipment can be used only by qualified persons (who have completed a skill training course in slinging and the special training specified by the relevant MHLW Ordinance). Note that this limitation does not apply to load lifting using a hoist crane or chain block with a capacity of 0.5 tons or less. However, obtain permission and instructions for use from the person in charge of equipment management.

(2) Stay away from immediately below a hoist crane or other lifting equipment. Wear a helmet. Wear safety shoes.

Fire prevention and earthquake countermeasures

I Fire prevention countermeasures

The occurrence of a fire carries a high risk of leading to bodily injury. In addition, there are also unfortunate cases where a fire causes heavy damage to buildings and facilities, as well as where data created with effort are destroyed. The causes of a fire include gases, chemicals, and electricity, and general precautions are described in this document. For details, refer to the precautions of each item.

1. Fire prevention

Observe the following precautions:

(1) Never use fires in places where an indication that the “use of fire is strictly prohibited” is provided.
(2) Do not place hazardous materials whose quantities exceed the specified level in laboratories.
(3) In laboratories, a means for escape shall always be secured considering the layout of equipment so that everyone can evacuate to corridors no matter where an accident occurs.
(4) Use complete rubber and vinyl chloride pipes and pay attention to the falling or contact with electric cords.
(5) Use standardized switches, fuses, and electric cords, and avoid overloading electrical circuits and falling wires over floors.
(6) Place devices that use fire on nonflammable stands and be sure to inspect the breakage of such devices and scratches on glassware prior to experiments.
(7) Not only avoid placing flammable and combustible substances near heat sources but also always keep the rooms well-organized.
(8) When using flammable solvents, dispense only the amount needed.
(9) In case of experiments that are not known well and carry risks, avoid conducting them during night-time hours and alone.
(10) Avoid leaving workplaces unmanned while equipment that consumes a large amount of power such as electric furnaces is energized. Or an unexpected fire may occur. Each person shall make a habit to become familiar with the locations and usage of fire extinguishers and hydrants.
(11) For smoking, note the following:

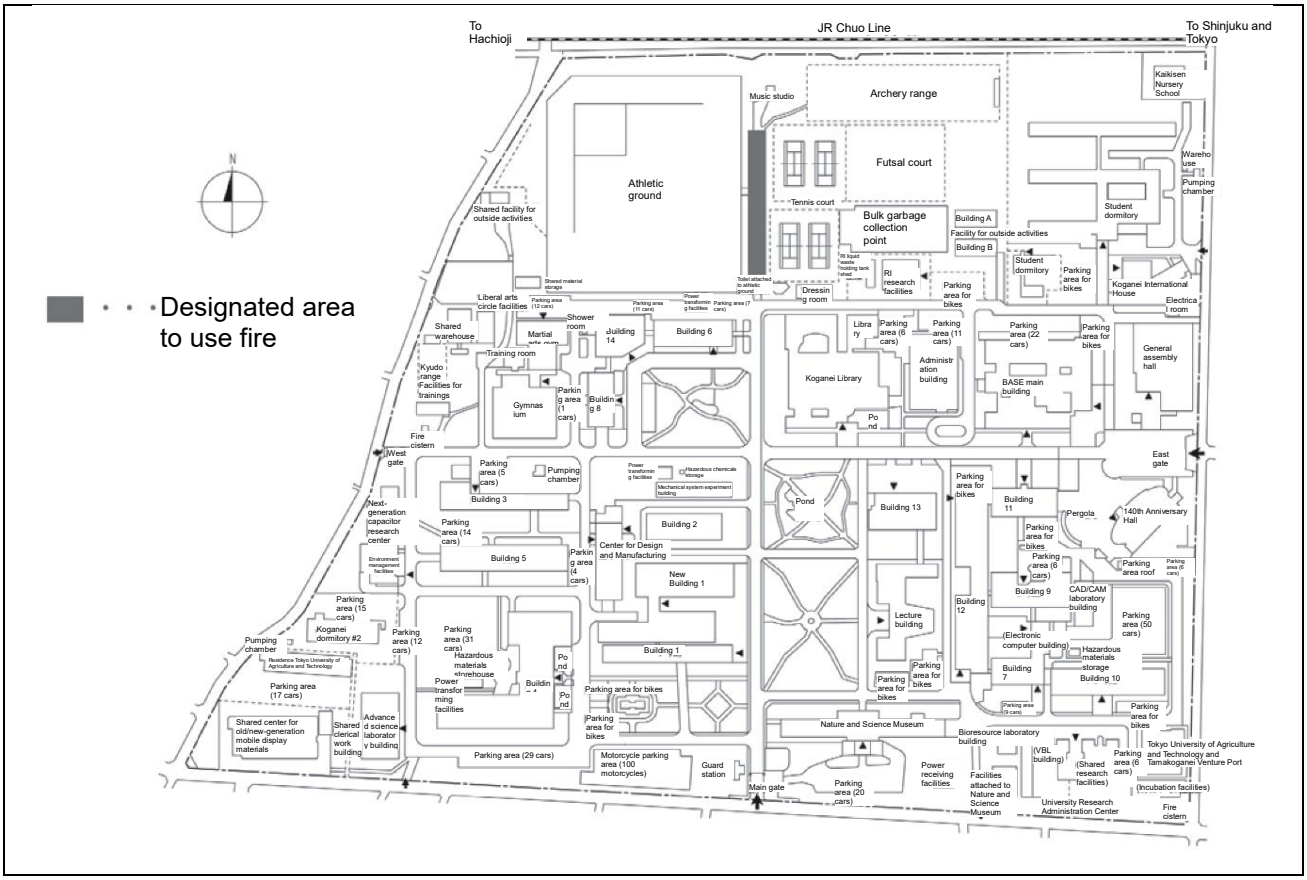
1) Smoking is allowed only in several smoking areas located in the campus. Smoke in places equipped with ashtrays. Smoking in other places and while walking or riding a bicycle is prohibited.
2) Do not leave burning cigarettes.
3) Do not put burnables, such as paper waste, in the ashtrays.
4) Avoid scattering things that can burn easily, such as paper, around the ashtrays.
5) When cleaning up cigarette butts, confirm that they are completely extinguished such as by pouring water over them.
6) Those who smoke shall be sure to read the section “Antismoking Measures at This University” described later.

2. Actions to be taken in the event of a fire

(1) Check the state of occurrence of a fire and let those around know the occurrence of the fire.
(2) Extinguish a fire using appropriate fire extinguishers. Early fire can be extinguished easily by releasing appropriate fire extinguishing agents without mishandling fire extinguishers. In such a case, do not panic. (For details on fire extinguishers, refer to the table on page 102)
(3) Depending on the situation, one of the workers in the workplace shall push the alarm button and then notify the fire department of the place and status of the fire on the phone. (Refer to the action items in an emergency.)
(4) Turn off power and gas sources to prevent secondary disasters. Eliminate items that can burn easily around the fire immediately.
(5) If clothes catch fire, smother the fire with the hands or items available immediately or pour nearby water over the head. Furthermore, rolling on the floor or ground to smother the fire is also recommended.

(6) In the event of a fire in a draft, stopping the ventilation is recommended considering the spread of the fire in the upward direction and the effect of fire extinction.
However, depending on the situation, such as where smoke or toxic gas is generated, it is better to continue the ventilation. The determination of it shall be made after carefully verifying explosive materials and the situation.
(7) If ignition occurs from the blowout of flammable gas from the cylinder, try to eliminate as many combustibles as possible around the fire without extinguishing the fire.
(8) In the event of a blowout of flammable gas without causing ignition, eliminate the ignition source by turning off the power at the furthest place possible from the blowout. Then, open the window for ventilation, and try to block the blowout port if possible.
(9) If there is a risk of generation of toxic gas, wear gas protection equipment when fighting a fire or at least try to extinguish the fire from the upwind side.

*For outdoor places on the Koganei Campus where fires are used, refer to the figure below.



Map of outdoor places where fires are used

3. Evacuation

(1) If it is determined that the occurrence of a fire or the generation of gas cannot be controlled by the means of initial firefighting, evacuate to safer places immediately.
(2) Fires that can be extinguished with fire extinguishers are generally limited to the combustion of interior wall materials, although it depends on the situation. Since it is difficult to extinguish the fire if the ceiling starts to combust, evacuate immediately in such a case.
(3) When leaving a room, handle gas sources, power sources, and hazardous materials, and then close the exit door after confirming that there is no one inside.
(4) If no information on the selection of evacuation routes in corridors is available through announcements, escape to the windward side while watching the movement of smoke.
(5) Do not use elevators because they may stop even if the electricity is not off.
(6) Stairs are dangerous because they become the path of smoke. It is necessary to consider escape routes and the construction of buildings and know where emergency exits are on a routine basis.
(7) If there is a lot of smoke, put a hand towel over the mouth and keep a low posture while evacuating. It takes much time until the smoke moves down to the floor.
(8) In case of urgency where emergency stairs and ladders cannot be used, open the window and call for help in a loud voice.
(9) Rooftops are considered to be relatively safer places for evacuation.

Types and characteristics of fire extinguishers

Types of fire extinguishers	Components	Characteristics	Applicable to	Not applicable to	Principle of fire extinction
Water fire extinguisher	Water		General and electric fires*	Oil fire	Cooling action
Carbon dioxide fire extinguisher	Carbon dioxide	Suitable for laboratories because of less dirt after fire extinction, short firing distance, and weak against wind	Oil and electric fires	General fire	Smothering and cooling actions
Dry chemical fire extinguisher (A, B, and C)	Ammonium phosphate	Profound fire extinction effect Short radiative time Significant influence on chemicals and equipment	General and oil fires* Electric fire		Smothering and inhibiting actions
Reinforced liquid fire extinguisher (A, B, and C)	Potassium carbonate	Long firing distance Effective against fires that are likely to persist	General and oil fires* Electric fire*		Cooling and inhibiting* actions
Mechanical foam fire extinguisher	Surface active agent	Combines the immediate effectivity of dry chemicals and the reliability of water-based substances	General and oil fires	Electric fire	Smothering and cooling actions
Chemical foam fire extinguisher	Sodium hydrogen carbonate and aluminum sulphate	Effective for fire extinction on vertical surfaces Heavy dirt after fire extinction	General and oil fires	Electric fire	Smothering and cooling actions
Halon 1301 fire extinguisher	Bromotrifluoromethane	Does not contaminate affected properties Suitable for computer fire	Oil and electric fires	General fire	Smothering and inhibiting actions*
Fire extinguisher for metal fire	Salt and sugar		Metal and steric fires		Smothering and inhibiting actions

*If radiated in the form of a mist

II Earthquake countermeasures

(1) Because tall objects fall, the upper parts of bookshelves, steel shelves, and lockers shall be fixed to the wall with anchor bolts.

(2) Even heavy loads that are normally difficult to move start to move under even acceleration in the event of an earthquake. Because there are cases where people may be injured by getting caught between heavy loads, attach them securely to the floor with anchor bolts. In addition, the legs of adjacent desks shall be bound with wire.

(3) Gas cylinders shall be attached to the wall with thick chains to prevent them from falling.

(4) Chemicals and hazardous materials shall be stored in the low position in refrigerators. In additions, computers, measuring instruments, and other devices that are used on desks or in racks shall be secured to prevent them from slipping.

(5) In the event of an earthquake, turn the stove off immediately to prevent a fire. Rooms in which fires are used on a routine basis shall not be left unmanned.

(6) Be always careful to put things straight and keep the areas that are used as evacuation passages clear. In addition, check the locations of evacuation passages, evacuation ladders, and emergency exits.

(7) In the event of an earthquake, evacuate to predetermined places without panic depending on the situation. The places of evacuation shall be discussed and determined in each department on a routine basis.

(8) If riding on an elevator, immediately get off at the next floor. (Read the notes posted in the elevators on a routine basis.)

(9) Read the *Manual on the Initial Response to an Earthquake* that is prepared for the case where an earthquake measuring upper 5 or more occurs in the Tama area.

Safety in laboratories

I General precautions

(1) For safety, be fully aware of the structures and usage conditions of the buildings that are used daily. In particular, the locations of escape doors (emergency exits), fire extinguishers, fire hydrants, and fire alarms shall always be remembered just in case. (Check their locations that are described in the drawing of each building.) In addition, because of the equipment related to fire alarms, fire detectors are placed on the ceiling of each room, and fire shutters, fire hydrants, and emergency stairs are provided on each floor. The methods for handling them shall be disseminated by holding a periodic explanatory meeting in each building every year.

(2) The locking of the windows and doors in each laboratory and the handling and management of water, gas, electricity, and other fires and hazardous materials are conducted under the responsibilities of the management representatives (educators) of each laboratory. Those who have become the members of the laboratories as postgraduates, graduates, and research students shall get used to the safety management system as soon as possible according to the instructions of educators and shall observe the rules. The last persons leaving each laboratory shall confirm that the windows/doors are closed, and the water/gas valves and power sources are closed according to the safety checklist, sign the list, and confirm that the entrances and windows are locked before leaving. If there are pieces of equipment that are in operation all night for accomplishing the research, inspect them and confirm that they are operating with no problem.

(3) The last persons leaving each floor shall confirm that the lights of corridors and rest rooms are switched off and the emergency doors on each floor are locked. Emergency doors shall be locked ordinarily without using them.

II Countermeasures against earthquakes and fires

There are lots of earthquakes in the Kanto area. On upper floors, earthquake vibrations may be more than double that on the ground. Therefore, it is necessary to consider minimal earthquake countermeasures in advance. For details, refer to the “Fire Prevention and Earthquake Countermeasures.”

III Safe handling of chemicals

For details, refer to the section “How to Use Chemicals Safely.” Here, only basic precautions are described.

(1) When handling reagents, check the physical properties and the existence of applicable laws and regulations in advance. In particular, carefully do this for the reagents that are handled for the first time and ask for instructions from faculty members if it is difficult to make a determination.

(2) Be sure to separate flammable/explosive substances from ignition sources, water reactive substances from water, and materials that are hazardous to mix from each other, and implement countermeasures to prevent them from influencing each other carelessly.

(3) A wide variety of chemicals are handled in the laboratories. Some of them have strong corrosive and toxic properties, and mixing them may react explosively, ignite, or generate toxic gases. Therefore, it is necessary to handle them after carefully examining the properties of the chemicals to be used.

(4) Each chemical shall be stored in predetermined places.

(5) Experiments using chemicals shall be performed in a draft chamber with a white coat and protective plastic gloves, as well as a gas mask as needed and protective goggles for those who do not ordinarily wear glasses.

(6) When handling chemicals at risk of causing an explosion, ignition, or acute toxicity, experiments shall not be performed alone. In addition, regardless of chemicals, experiments shall not be performed late at night.

(7) When storing reagents that need to be refrigerated, the temperature inside the refrigerator storing such reagents may rise from a power outage. Therefore, implement measures considering such possibilities.

(8) If a chemical is subdivided into different containers, attach labels to them immediately to prevent the mix-up of the contents.

(9) For the treatment and disposal of chemicals, carefully read the *Guidelines for Handling Liquid Waste* issued by the environment management facility of this university and follow the instructions.

(10) Wash the instruments used carefully and dispose of liquid waste into predetermined containers.

IV Prevention of hazards due to gases

Perform the following in advance before handling gases in the laboratories. In addition, also refer to the section “Safety Works for Hazardous Gases.”

(1) Before performing experiments using gases, carefully investigate and fully know the properties of the gas to be used or generated (in particular, specific gravity, explosion limit, ignition point, etc.) in advance.
(2) In order to take immediate action in the event of a gas leakage, check the locations of the fire extinguishers and protective equipment that are applicable to the type of the gas and contents of the reactant.

1. Flammable gas

Handling of flammable gases used in laboratories

(1) Do not use close to fire. In case of an unexpected fire, check the locations of fire extinguishers.
(2) Consider that there is always an ignition source and be careful not to create a gas state that may cause a combustion.
(3) In the event of a leakage of a large amount of gas, report it to nearby people and evacuate immediately. If there is time to spare, turn off the gas to stop the fire and open windows.
(4) To detect a leakage under pressure, using foam made with soap solution is easy. At normal pressures, a leakage can be detected only by checking the decrease in the gas burette.
(5) Handle gases with wide explosive range (For example, hydrogen: 4.00% to 74.20%, carbon monoxide: 12.50% to 74.20%, hydrogen sulfide: 4.30% to 45.50%, acetylene: 2.50% to 80.00%) with great care.

2. Handling of city and propane gases

Recognize the properties of gases and functions of devices well, and observe the followings:

(1) Do not use any other gases than the ones indicated on the gas appliances.
(2) Supply enough air and always provide adequate ventilation in order to prevent incomplete combustion.
(3) Become familiar with the properties of city gas and pay the greatest attention to gas leakage. When connecting a gas main and a combustion device with a rubber pipe, use a designated band to ensure reliability, and it is necessary to pay constant attention to the damage and deterioration of the rubber pipe. If there is no other choice but to lay the rubber pipe on the floor, be sure to apply a robust protective pipe.
(4) In the event of a gas leakage, turn off the gas at the main and then open the windows to ventilate by allowing the breeze to pass through the room. Do not use ventilating fans because the sparks that are generated at the moment when the fans are turned on may cause an explosion.
(5) In principle, do not leave the place unmanned while gases are used.
(6) When turning off the gas at the main, be sure to check if the gas is not used by others. Turning off the gas at the main without noticing the use by others is very dangerous because the gas leaks when the gas is turned on at the main the next day.

3. High-pressure gas

Because high pressure gases are high in pressure and leakage or breakage may lead to the serious hazards of explosions, fires, toxication, and injuries, observe the following:

(1) A container certificate is attached to each high-pressure gas container, and the shoulder of each container has engraved marks. Check them before use.

(2) High-pressure gases shall be handled by those who have adequate knowledge and experience.
(3) When the containers are set up vertically for storage, secure them to the wall or pillar with a chain to prevent them from falling. There was a case where the valve of a fallen container broke and the container was blown as far as 600 meters.
(4) When the containers are placed horizontally, secure them in a reliable manner to prevent them from rolling.
(5) After replacing a container, check for any leakage from the intake of a pressure regulator using soapy solution or other means. In addition, provide adequate indoor ventilation.
(6) Use pressure regulators that are suitable for the types of gases used. In particular, use the dedicated ones for oxygen because it may react with oils or fats to catch fire.
(7) In the event of a leakage of a toxic gas, immediately evacuate to the windward side and shout repeatedly that a toxic gas is leaking to evacuate nearby people. For subsequent actions, follow the instructions from faculty members.
(8) During transportation, wearing safety shoes and gloves, applying a valve protection cap, and using a dedicated hand truck for gas cylinders are preferred. In places where hand trucks cannot be used or if they are not available, inclining a cylinder slightly and transporting it by rolling at the edge of its bottom are recommended. In such a case, pay attention to slippery floors. Do not drag gas cylinders, slip them down over stairs, and roll them in a horizontal position.
(9) Be sure to use liquefied gases and acetylene with the cylinders set up vertically.

4. Low-temperature liquefied gases

(1) Pay attention to prevent low-temperature liquefied gases, such as liquid nitrogen and oxygen, from contacting the skin directly because they may cause cold injuries. In particular, wearing goggles and a face shield is recommended to protect the eyes.
(2) Gasifying low-temperature liquefied gases rapidly in containers with a small opening may cause an explosion. In addition, provide adequate ventilation because gasifying a large amount of liquid nitrogen in a small space may cause oxygen deficiency.
(3) Do not store combustibles near liquid nitrogen. At another university, there was an accident where a researcher who was carrying liquid nitrogen stumbled and fell, the liquid nitrogen spilled over the asphalt pavement in front of the researcher, a metallic ballpoint pen dropped out of the pocket and generated sparks, and the asphalt burst into flames, resulting in the loss of vision in both eyes.

V Countermeasures against electric injuries and hazards

In many laboratories, experiments are performed using equipment that employs high voltage or large current. Associated accidents are electric shock, short circuits, and electric leakage. These are the most dangerous among accidents. Failure to confirm safety may lead to the loss of human life. The safety measures against electric shock are described in “For Safe Handling of Electricity” in detail. Read this section thoroughly and acquire the knowledge about electric shock prevention to learn how to protect oneself from accidents.

VI Precautions for using large-sized equipment and machines

In some laboratories, large-sized advanced equipment is used frequently. In addition, there are cases where prefabricated equipment is used or where it is necessary to design and fabricate equipment intended for experiment by ourselves. In such cases, machine tools, such as a lathe, need to be operated by ourselves. Because using such equipment and machines in the wrong manner could lead to a serious accident, it is inevitable to understand the operation method and mechanism fully.
(1) When using dangerous equipment and facilities that are shared among courses or located in laboratories, apply to the persons responsible for the handling of such equipment/facilities and strictly observe the precautions.
(2) To use shared workshops, apply to the persons in charge of the management of such workshops and observe predetermined rules.
(3) In many experiments, various types of measuring devices are used in combination. In such cases, power lines, pipes, and hoses are likely to be laid on the floor in a messy manner. It is very dangerous if anyone trips over them during an experiment. Always keep the experiment environment well-organized and secure safety over the head and at the foot.

(4) Experiments shall be performed by two or more people. If an experimenter has an accident, another co-experimenter can conduct the appropriate rescue work.
(5) Although measuring systems are increasingly automated recently, it is very dangerous to rely too heavily on machines and to leave everything to them. In particular, leaving before confirming the function is working adequately or going to a far place that prevents you from coping with unexpected abnormalities immediately at an early stage shall be avoided.
(6) When thinking about the layout of equipment, make considerations in order to ensure safety even in the event of a mis operation or component failure from the viewpoint that humans make mistakes and equipment fails (failproof and fail-safe).

VII Prevention of injuries caused by rotating machines

(1) Electric motors are used in vacuum devices and drilling machines. When operating a rotating machine with large machine energy like this, attention needs to be paid to the clothes to prevent them from getting caught in the machine. Avoid wearing work clothes with long hems or a tie, and do not put the head close to the rotating part more than necessary. Experimenters may also get injured if other instruments or nearby objects are caught in the machine. Give consideration to the layout of experimental equipment and organizing of belongings such as writing utensils.
(2) When performing an experiment jointly with several experimenters, the switch-on operation as well as activation of equipment shall be performed while giving the signals loudly among the members and after getting confirmation from all members.
(3) Open and close switches completely. There is a concern that half-open switch may be turned on by a vibration or contact.

VIII Prevention of injuries caused by light beams, radiation, and strong magnetic fields.

(1) Laser light beams, infrared rays, ultraviolet rays, and microwaves could cause damage to the eyes and skin. Take care so that the laser light does not get into the eyes. Wear safety goggles because the optical paths of infrared rays are invisible. Do not look straight at ultraviolet rays and intense lights associated with arc discharge. If there is no other choice but to look straight at them, wear safety goggles. Provide adequate blocking because intense microwaves could cause burn injuries or eye disorders.
(2) The use of radiation sources is strictly regulated by the Act on Prevention of Radiation Hazards due to Radioisotopes. Therefore, the experimenters who use radiation sources are required to perform radiation experiments under the supervision and direction of a radiation protection supervisor. Refer to III “Radiation Laboratories” in “Safety in the Use of Shared Facilities.”
(3) In experiments that use various types of radiation, such as X-rays, and strong magnetic fields, such as nuclear magnetic resonators, they are not visible, and adverse effects on the body surely exist. Therefore, take all precautions for protection from them. For the experiments using them, refer to I “Shared Equipment” in “Safety in the Use of Shared Facilities.”

IX Staying Safe during Experiments at Night and on Saturdays, Sundays and Holidays

In principle, you should conduct experiments and practical training at the university during the daytime on weekdays. This includes student experiments as well as research for theses, dissertations, etc. One reason is that the concentration needed to conduct experiments at night is often lacking due to fatigue or drowsiness. This can result in the loss of valuable samples and time due to failed experiments and presents a high possibility of accidents and injuries.
It is also difficult to take appropriate measures if an accident occurs when you are conducting an experiment alone at night and/or on a holiday. If you lack experience, conduct experiments under the guidance of someone familiar with the procedure, such as an academic advisor. Plan your schedule so that you can receive instruction during the daytime on weekdays between lectures and other activities. There have also been reports that suspicious persons and thefts occur on campus at night and on holidays. From a crime prevention standpoint, it is not safe to be in unpopulated places, especially at night.
If you must conduct an experiment at night or at any time on a Saturday, Sunday or holiday for an unavoidable reason, always ask for instructions from your academic advisor. Please refer to the following instructions to ensure that your experiment is carried out safely:
1) Wear safe and appropriate clothing. Wear a lab coat made of flame-retardant materials and avoid exposing your skin whenever possible. Wear gloves and protective equipment as necessary.
2) Secure sufficient experiment space and organize and clean the area. Keep laboratory tables, instruments and equipment clean. Secure sufficient space for your experiment to avoid causing an accident.

3) In addition to having a thorough understanding of the principles of the experiment and the operations necessary, you should know the procedures for aftertreatments. When your experiment may produce unknown reactions or when you conduct unfamiliar tests, be cautious, including conducting preliminary experiments with small amounts of samples first.
4) Assume that accidents may occur and be prepared to handle them. Check whether the laboratory has gas valves, switches, fire extinguishers and emergency safety showers, and secure emergency evacuation routes. Take all possible precautions, such as checking the posted emergency contact chart in laboratories, etc. and confirming that first-aid kits and emergency medical treatment are available.
5) Never conduct experiments alone. This is extremely dangerous if an accident should occur. This is especially true at night and on Saturdays, Sundays and holidays, when few people are around to help.

The above items are not necessarily limited to securing safety during night and holidays. However, since it is difficult to obtain the assistance and advice of others during these hours, if you must conduct experiments do so with particular care. In addition, when operating experimental equipment continuously over a holiday or overnight, thoroughly consider in advance whether there is any risk of fire, explosion or other hazards.

X Other precautions
(1) Perform experiments in the daytime if possible. If there is no other choice but to operate an experiment device all night, an operator shall stay near the device in order to cope with electric outage or water outage.
(2) If there is no other choice but to get away from the device in operation, ask someone near the device to monitor it. Also disseminate the dangerousness of the relevant device to the people around it.
(3) Do not contact directly to furnaces in the experiments that use high temperatures.
(4) If water contacts a hot section, it gasifies rapidly to cause a vapor explosion.
(5) Inspect glassware carefully before use and avoid using the one with scratches. Pay attention this particularly in cases where depressurization, pressurization, and heating are performed.
(6) Because the water pressure in the water system varies significantly and rises between midnight and early morning. Therefore, in the equipment in which water is flown during the night, use a dedicated rubber hose or plastic pipe and fasten the connection with a band or wire. Because the floor is aging, a water leakage could cause tremendous damage to the equipment on the lower floor and could cause an electric leakage.
(7) The electrical wiring allowed in laboratories is the wiring from a distribution board or power strip to the relevant equipment; therefore, wires shall not be attached to buildings without permission. Semi-permanent wiring shall be requested to qualified people, such as the staff of the Facility Maintenance Section.
(8) Select cords, power strips, and sockets compliant with appropriate standards, considering the properties of electrical equipment used such as voltage and allowable current as well as usage environment. The allowable current limit of general sockets and power strips of 100 V AC is 10 A.
Stay alert to gas leakage, generation of hazardous and toxic gases, spontaneous ignition, heating, inadvertent fire and water leakage. Fully understand the properties of gases (correct knowledge on physical properties) and the method for handling gas cylinders properly.

XI In the laboratories where hazardous chemicals are handled, each member shall particularly be aware of the safe handling method and the measures to be taken in the event of an accident.

(9) Pay attention to the falling prevention for chemical shelves and gas cylinders due to an earthquake.

(10) Organic solvent waste, photo-processing waste, and other waste shall undergo treatment such as neutralization according to the descriptions *Guidelines for Handling Liquid Waste* (Environment Management Facilities of the Tokyo University of Agriculture and Technology) and shall be stored in a safe manner until the day of collection and treatment according to the segregation and storage category table. The date of collection and treatment is notified to each laboratory in each case in writing. Liquid waste containing biological samples, such as microorganisms, shall be disposed of after they are sterilized.

(11) Pay as much attention as possible to inadvertent injuries and the prevention of bodily injuries in the event of a hazard. Educators shall confirm that students have casualty insurance and implement the appropriate measures.

(12) When leaving laboratories, confirm that the power source is turned off and the gas and water valves are closed in each laboratory. Also confirm that hazardous chemicals and cylinders are properly treated and that the windows and entrance of each laboratory are locked.

(13) In case of an emergency, contact the department head and educators of the laboratory immediately. For this purpose, an emergency contact list shall be posted in a conspicuous place such as a wall in a laboratory. (Refer to page 111.)

(14) When using dangerous equipment and facilities that are shared among courses or located in laboratories, apply to the persons responsible for the handling of such equipment/facilities and strictly observe the precautions.

(15) To use shared workshops, apply to the persons in charge of the management of such workshops and observe predetermined rules.

EMERGENCY CONTACT INFORMATION

In case of accidents or disasters, do as follows:

① Notify the occurrence of the accident to your surroundings.

② Either putting out fires or helping others, act prioritizing safety.

③ Press the fire alarm button according to the situation. If you need an ambulance/fire engine, call 119.

④ Call a "24-HOUR EMERGENCY CONTACT".

※ If there are people who speak Japanese around you please ask them to help you call.

24-HOUR EMERGENCY CONTACT:

The Guardhouse at the main gate
【Only available in Japanese】

Ext: 7007
Tel: 042-388-7007
Mobile: 070-6474-7007

Address:
Tokyo University of Agriculture and Technology
Koganei Campus 2-24-16, Naka-cho, Koganei-shi

Building: _____ Room: _____

Do not forget to report to related faculty members!

Name: _____ Tel: _____

Safety for common use facilities

I Common use systems

At the Koganei Campus, you can use the following systems:

Common use system name	Installed in	Supplement (described later)
Transmission electron microscope	Instrumentation Analysis Center	1
Scanning electron microscope	Instrumentation Analysis Center	1
Single crystal X-ray automatic analyzer	Instrumentation Analysis Center	2
Multipurpose X-ray diffractometer	Instrumentation Analysis Center	2
Nuclear magnetic resonance systems (300, 400, 500 MHz)	Instrumentation Analysis Center	3
X-ray photoelectron spectrometer	Instrumentation Analysis Center	4
Thin-film material crystalline analysis X-ray diffractometer	Instrumentation Analysis Center	2
Solid-state NMR system	Instrumentation Analysis Center	3
Mass spectrometers (EI, FAB, ESI, MALDI)	Instrumentation Analysis Center	
Atomic force microscope	Instrumentation Analysis Center	
X-ray microanalyzer	Instrumentation Analysis Center	5
Powder X-ray analyzer	Instrumentation Analysis Center	5
Tensile tester	Building 4	6
Various machining tools	Center for Design and Manufacturing	See “II. Center for Design and Manufacturing.”
Liquid nitrogen storage tank	On the side of the Main Gate Guardhouse	7

To use the systems, take the necessary steps by referencing the website of the Research Center for Science and Technology (Instrumentation Analysis Center) (http://web.tuat.ac.jp/~kiki/instrument/index.html). The systems described below, among others, require careful attention to safety.

1. Electron microscopes

These systems are commonly used in TUAT and kept safe in normal operation though they are operated with high voltage of 120 kV. However, these systems may be still harmful so users must pay close attention to the following points:

i. Register yourself as an X-ray system user to use the transmission electron microscope.
ii. Receive a lecture from the facility administrator before using the systems.
iii. Do not touch unnecessary parts for normal observation, such as the back and the high voltage power supply of a system.
iv. Pay close attention to the operation of a system because the equipment room is darkened during observation.
v. Suspend the operation of a system and contact the person in charge immediately in case of an unusual or emergency situation.

2. Single crystal X-ray automatic analyzer and thin-film material crystalline analysis X-ray diffractometer

Pay particularly careful attention to X-ray exposure during the use of these systems. For this reason, precautions for X-ray exposure are described below. These systems include the following five X-ray generators:

1. Rotating anode X-ray generator (Rigaku ultraX18)
Rated output: 18 kW (60 kV, 300 mA)
2. Multipurpose X-ray diffractometer (Rigaku SmartLab)
Rated output: 9 kW (45 kV, 200 mA)
3. Encapsulated tube X-ray generator (Spectris X'Pert-MRD)
Rated output: 3 kW (60 kV, 50 mA)
4. Multipurpose thin-film X-ray diffractometer (Bruker AXS D8 Discover)
Rated output: 6 kW (50 kV, 120 mA)
5. Single crystal X-ray diffractometer (Rigaku XtaLABmini)
Rated output: 0.6 kW (50 kV, 12 mA)

Since both the X-ray generators and X-ray diffractometers are shielded with X-ray preventive covers, no X-ray exposure will occur in normal diffraction experiments. In fact, all accidents occur unexpectedly. To prevent them, it is essential to be aware of safety at all times and to be familiar with X-ray generators and their operation mechanisms. The detailed precautions are described below:

i. Consult the equipment administrator about the use of the systems and receive a lecture before using them.
ii. Conduct an experiment under an expert's guidance if you are unfamiliar with a system.
iii. Register yourself as an X-ray system user to use the X-ray systems.
iv. To change an optical system, obtain the equipment administrator's approval and receive a lecture on how to change it before doing so. In addition to this, restore the optical system to the original state and adjust it after the completion of measurement.
v. Conduct measurements according to the manuals distributed in a lecture. Do not operate a system in ways other than those described in the manuals, in principle.
vi. Do not open the X-ray preventive cover during X-ray radiation (during measurement), in principle. When you unavoidably open the X-ray preventive cover, close the X-ray radiation window (shutter) (i.e., suspend measurement).
vii. The X-ray preventive cover has a warning buzzer that sounds upon the opening of the cover, so do not turn on/off this circuit.
viii. In addition, follow the Radiation Damage Preventive Regulations of TUAT.

3. Nuclear magnetic resonance systems

The common use nuclear magnetic resonance (NMR) systems (AL-300, ECX-400, ECA-500, and ECX-400 Solid-state) apply superconducting magnets (SCM) to achieve high resolution. The current systems have lower stray magnetic fields; however, you must be aware of the following points to correctly to use the systems safely.

(1) Care for wide magnetic fields

An SCM generates a very high magnetic field, which expands widely up and down, left and right. Pay close attention to this magnetic field to prevent it from being harmful.

i. Care for the influences of static or variable magnetic fields on medical electronic devices

Precision medical electronic devices, such as cardiac pacemakers could be inoperative when they are exposed to a magnetic field of 5 gausses or more. Blood vessels, artificial organs, and surgical implants are subject to a strong force near an SCM because they include highly magnetic field substances. If a person with implants suddenly moves in a magnetic field area, in addition, an eddy current is induced by these implants and may result in severe damage, such as heat generation.

ii.Care for strong magnetic pull force

A small device attracted to a magnet may be a projectile that can harm people while a large device (such as gas cylinders and power supplies) attracted to a magnet may catch the human body or the limbs between them. The closer to the magnet and the heavier thew device is, the stronger this pull force becomes. For this reason, do not put a side cutting plier, a driver, staples, a steel chair, and other devices within 1.5 m of the magnet. To store and transfer compressed gas and cryogenic liquids, in addition, you must use nonmagnetic cylinders and dewars, as well as nonmagnetic tools for transfer.

iii.Care for direct influences of high magnetic fields on devices

Watches, tape recorders, cameras, and other devices will be magnetized and irreparably damaged if they are exposed to a magnetic field of 10 gausses or more. In addition to this, magnetically written data in credit cards and magnetic tape could be disordered. A transformer will be inoperative due to magnetic saturation when it is exposed to a magnetic field of 50 gausses or more. Safety functions of devices may be also inoperative. Since magnetic levels in which a device safely operates depend on a type of the device, you must contact the device's manufacturer to check them.

The upper limits of magnetic fields and which devices can operate normally under them are shown below:

1 gauss	…	Photomultiplier tubes, gamma cameras, electron microscopes, precision measuring apparatus
5 gausses	…	Automobiles, cathode-ray tubes, cardiac pacemakers, neurostimulators, living body stimulators
10 gausses	…	Computers, X-ray tubes, watches, credit cards
20 gausses	…	Magnetic recorders
50 gausses	…	Magnet power supplies, sim power supplies, RF power amplifiers

(2) Safe handling of cryogenic liquids (helium and nitrogen)

Cryogenic liquids present at their boiling points though they are stored in heat-insulated containers, such as dewars. The volumes of such liquids are drastically increased, about 700 times for helium and nitrogen, through natural evaporation. To prevent the risk of container explosion, thus, you must not seal containers of cryogenic liquids (except for those equipped with a check valve to prevent air from flowing backward into the container). Store cryogenic liquids in well-ventilated places. If the ventilation of a room is poor, the gas concentration in the room unusually increases when a large volume of liquid is spilled (or a liquid is used in a closed room); this will likely result in a lack of oxygen and could be harmful to the human body. In case of unusual gas concentration, warn the people around you.

i.Handling of cryogenic liquids

When you handle cryogenic liquids, wear a protective cloth with long sleeves (except for sweaters and other similar clothing that are easily permeating liquid) and dry Southern or PVC-made gloves to prevent frostbite. Wear gloves loosely in order to take off them easily when a cryogenic liquid is spilled onto the gloves.

When a cryogenic liquid is transferred to another container or an object (such as pipes) with normal temperature is inserted into a cryogenic liquid container, the liquid first boils violently and then splashes. Metal pipes should be used for passing liquid because rubber and vinyl pipes could be broken from the impact of frostbite. When you handle a pipe, do not direct the outlet of it to another person.

Since liquid nitrogen and helium have lower temperature than liquid oxygen, oxygen in the ambient air is in contact with these liquids for a long time to be condensed, increasing the condensation of oxygen excessively. For this reason, flammable materials on a cooled surface could cause a fire; keep flammable materials and fire away.

ii.Frostbite

The skin suffers from frostbite when it touches a cryogenic liquid or a vapored cold gas. If a poorly protected part of the body touches pipes and containers for cryogenic liquids that are not heat-insulated, the skin could be stuck and damaged.

iii.First aid

If the eye or the skin is affected by a cryogenic liquid, pour a large volume of cool or lukewarm water to the affected part immediately and apply a cold compress to it. Do not use hot water and hot air. Consult a physician immediately.

iv.Containers

Use only nonmagnetic containers dedicated for cryogenic liquids. To attempt to prevent cryogenic liquids from touching air, attach check valves or dedicated lids to containers.

(3) Environmental safety check

i.Emergency measures

Ensure that external emergency rescuers completely understand and follow the precautions below in case of fire and other accidents:

○ There are very strong magnets in the room.

○ Do not use water for extinguishing fires on magnets and electrical equipment.

○ Use nonmagnetic extinguishers (made of aluminum or stainless) in a high magnetic field area.

In case of fire, activate a fire alarm and evacuate people other than emergency rescuers from the area. When you extinguish a fire, use an electrical equipment fire extinguisher (powder fire extinguisher). If you cannot prepare nonmagnetic fire extinguishers, extinguish a fire at a distance of at least 2 m from the magnet.

*Note: If you extinguish a fire with water, the drain of a cryostat is frozen by water, the cryostat could then explode in the worst case.

ii.Emergency measures for earthquake

In case of an earthquake, an SCM could experience a quench (the loss of superconductivity) or fall down. Ensure an evacuation route immediately and evacuate to a safe place.

iii.Measures for SCM quench

A quench of an SCM could occur when the degree of vacuum of a cryostat drops or when the cryostat is impacted strongly. Such a quench of an SCM evaporates a large amount of liquid helium and pressure in a cryostat suddenly increases, resulting in the risk of explosion. Escape to a safe place through an evacuation route immediately.

4. X-ray photoelectron spectrometer

This system always keeps a vacuum state with the ultra-high vacuum device, so you must be familiar with handling the vacuum device. Measurement with the system requires X-rays and the high voltage power supply for it, and you must pay great attention to this. To use this system, follow the precautions below:

<Precautions>

i. Receive a lecture to be familiar with safe operation and obtain an operation permission before using the system.
ii. Appoint the system in advance and record it on a user book before using the system.
iii. Check an operating manual kept near the system before using it.
iv. Check the conditions of the power supply, water supply, and gas cylinders carefully before using the system.
v. Check the conditions of the system body before using it.
vi. If you have any questions, contact the person in charge of administration.
vii. Register yourself as an X-ray system user to use the system.

vii. Check the system finally after completing measurement and turning off the system.
viii. In the case of a power failure, the system will be turned off by the automatic stop device. Restore the system after it is energized again. In this case, contact the person in charge of administration.
ix. Contact the person in charge of administration immediately in case of an unusual or emergency situation.

5. X-ray microanalyzer

(1) X-ray microanalyzer (JEOL JXA-8900R)

[X-ray] X-rays are generated around the electron gun or from the lens-barrel and the material surface receiving electron beams because a voltage of 10-30 kV is applied and a current of 200 μA or less flows during operation. However, these X-rays have slight intensities, and the whole electron beam system is contained in a metal container that has lead glass windows; thus, leaks can be actually ignored. (Actual measured leakages are equal to or less than 0.01 mR/hr, the detection limit of a survey meter.)

[High voltage] High voltage parts (from several thousand to several tens of thousands of volts) of this system include the electron gun, the X-ray detector, and the photomultiplier tube (in the body); the acceleration voltage power supply (in the power console); high voltage cables (between the body and the power console); the attenuator, the oscilloscope with its power supply, power supplies for the X-ray detector and the photomultiplier tube (in the EBS console); and cables.

Though the protective circuit will be activated during a filament change, a user must turn off the acceleration voltage power supply and open the cover of the electron gun personally.

[Vacuum] The atmospheric pressure is always applied to glass windows of the vacuum vessel in the body. If an object accidentally collides with the window, the vacuum suddenly decays to seriously affect the system; this could scatter pieces of glass and unexpectedly injure people. Be careful not to impact on the glass windows.

[High temperature] When you change a broken filament, you could be burned by directly touching the Wehnelt electrode if the filament were lit at that time. Allow it to be cooled sufficiently or wear gloves (note that it is slippery).

(2) Vacuum evaporation system (JEOL)

[Vacuum] The atmospheric force applied to the entire bell jar is very strong if the system contains a vacuum. When the glass of the bell jar has damage and cannot withstand the atmospheric pressure, pieces of the glass on all sides are brought into the inside to collide with each other and then harmfully scatter. Be careful not to impact the glass bell jar. Cover it with a protection net before creating a vacuum.

(3) Cutter (Buehler)

[High-speed rotation] Keep your hands away from the blade of the cutter rotating at a high speed in operation. If a sample is fixed poorly or the feed rate is excessively high, broken blades could scatter with cut pieces of the sample. Fix a sample and a blade completely and set a feed rate with a margin. In addition, attach a plastic cover before starting the motor.

(4) X-ray diffractometer (Rigaku RAD-II C)

[X-ray] The X-ray generator can be controlled easily because X-rays from it can be interrupted by turning off the power source in contrast to radio isotopes constantly emitting radiation. However, the dose rate of the activated system is not much lower than that of a sealed small radioactive source. The intensity of primary X-rays (a direct beam) emitted from a Cu tube operating with 40 kV in voltage and 30 mA in current, for example, reaches 3.8×10^5 R/hr or less on a sample at a distance of 185 mm. Supposing that a human is exposed to the whole of these rays for one second, the exposure dosage will reach 100 rem or less. So, pay close attention to this.

You can recognize that X-rays will not leak when the shutter is closed. Though the shutter is opened, in addition, leaks of X-rays from the X-ray protection plastic door can be actually ignored if protectors around slits and a sample are properly fixed.

(Actual measurements with a survey meter: for a voltage of 30 kV, a current of 40 mA, and a D.S. angle of 1° , a maximum of 0.2 mR/hr (model SG-9) and 0.16 mR/hr (model RAD-II C) near the protector around a sample in the door, and all measurements outside the door are equal to or less than the detection limit of 0.01 mR/hr. In addition, measurements of both models are equal to or less than the detection limit near the protector in the door under conditions of the adjusted goniometer.)

However, you must follow the steps below before turning on the X-Ray switch:

i. Attach slits (and a slit cover for a D.S.) properly.
ii. Fix a sample and then cover it with a lid.
iii. Close the X-ray protection plastic door.
iv. Set the right shutter SW to “Closed” (manually) or “Neutral” (controlled by a PC).
v. Check the left shutter SW is set to “Closed.” Do not open the left shutter.

You can open the X-ray protection door only when you adjust the goniometer.

<Health care for X-ray operators>

A person who intends to use X-ray systems (an X-ray operator) must make an application for registration with the prescribed form and obtain permission from the applicable person in charge of use and approval from the applicable department head according to the Radiation Damage Preventive Regulations of TUAT. X-ray operators have semiannual health examinations, which are announced by the person in charge of it.

<Maximum permissible exposure dosage of radiation>

The Radiation Injury Prevention Law and the National Personnel Authority Rules (Prevention of Personnel Radiation Injury) specifies the dosage as 3 rem per three months, except for the following special cases where part of the body is exposed:

i. Only the skin: 8 rem per three months.
ii. Only the hands, forearms, feet, or foot joints: 20 rem per three months.
iii. The abdomen of a woman that could be pregnant: 1.3 rem per three months.
iv. The abdomen of a pregnant woman: 1 rem for the pregnancy period.

Of course, the permissible dosage means an “endurance value” in exchange for “returns” from the use of radiation. Since the occurrence rate of tardive diseases, such as leukemia and cancer, is proportional to an exposure dosage, and no thresholds are thought to exist, you must avoid unnecessary exposure at all times.

6. Liquid nitrogen storage facility

This tank facility supplies liquid nitrogen to users. The tank is model CE-5S made by Nippon Sanso Holdings Corporation and has a capacity of 4482 liters. Safety precautions and measures for the pump and the use of liquid nitrogen are the same as general precautions for cryogenic gases, such as liquid nitrogen, being described below.

(1) General precautions for cryogenic gases

i. Wear safety goggles and cryogenic gloves when you handle cryogenic gases or cooled parts due to these gases. Cotton work gloves and the like are undesirable. In addition, wear safety glasses during pump operation.
ii. Do not perform pumping work in outfits such as short pants and sandals that leave the legs exposed. Do not touch low-temperature liquefied gas directly with a hand, finger, foot, or any other part of the body.
iii. Inserting hoses and pipes into the cryogenic gas in an opened vacuum flask is harmful. Liquid could be spouted through a pipe and splashed onto the eyes or other body parts.
iv. Do not leave a container sealed without authorized control.
v. Pay close attention to the pipes used for transferring and topping up liquid because these pipes likely seal it.
vi. Do not spill liquid carelessly or leave it leaking. When a cryogenic liquid is spilled onto steel, it becomes breakable, and the coatings and concrete are damaged.
vii. Cryogenic gases are contained in portable small containers, such as vacuum flasks, which are likely broken due to impacts. Be careful not to hit or bring down them.

viii. Carry a dewar by two or more members if possible. Do not ride on an elevator with dewar vessels. Put signs stating “Transporting Liquid Nitrogen” in place when transporting dewar vessels on an elevator.
ix. Since a cryogenic gas is evaporated into a large volume of gas though it leaks a little, transfer or top up the gas in a well-ventilated place if possible.
x. Operating valves carelessly results in the high risk of the sudden release of high-pressure nitrogen gas because the storage tank is subject to a high pressure (0.35-0.95 MPa).

II Center for Design and Manufac

(1) Work wear

Use work wear that may be contaminated by oil and cutting chips and can prevent its hems and sleeves from being caught in a machine. Since cutting chips enter during machining, do not wear cloth with a largely opened collar. If you have long hair, wear a cap.

(2) Hard hat or work hat

Wear a hard hat or a work hat if your work has risks of heavy objects falling and head injuries.

(3) Work shoes

You should wear safety shoes specified by JIS or work shoes according to it, especially those with steel toes because foot injuries often occur due to carelessness.

(4) Gloves

Wear specified gloves in welding. In contrast to this, you must not wear gloves in machining with machine tools, such as drilling machines and lathes.

(5) Safety glasses

Wear dustproof glasses for grinder operation and deburring, and wear light shielding glasses for welding. In addition, you should wear safety glasses for lathe and milling operation because cutting chips scatter; if you have your own everyday use glasses, however, you can use them instead of safety glasses.

(6) Precautions for handling machine tools

You must follow the explanations and instructions on machine tools from personnel or school staff of the Center for Design and Manufacturing and keep the following points in mind at all times:

i. Secure a workpiece firmly and not by force. (Follow instructions on how to secure it from personnel or school staff of the Center for Design and Manufacturing.)
ii. Grease the parts of a machine every time before using it.
iii. Understand how to use a machine before operating it. Especially, you must be able to conduct an emergency stop.
iv. Conduct processing under proper processing conditions. For processing conditions, consult personnel or school staff of the Center for Design and Manufacturing.
v. Operate levers and switches certainly. In addition, do not stop machine operation with a fed workpiece.
vi. In the case of violent vibration and/or unusual sounds, turn off the machine immediately and notify personnel or school staff of the Center for Design and Manufacturing for instructions.
vii. If the machine and tools are broken, notify personnel or school staff of the Center for Design and Manufacturing immediately.
viii. After completing your work, clean up, sort and return tools, and maintain and clean the machine. Then, report to personnel or school staff of the Center for Design and Manufacturing.

(7) Precautions for machine tools

1） Lathe

i. Fix a bite with a proper length.
ii. Do not turn off the lathe with the bite cut into the workpiece.
iii. Keep your hands away from the rotating chuck and workpiece.
iv. Remove cutting chips with a raking stick or a small broom after turning off the machine.
v. Do not touch a roughly cut surface carelessly.
vi. Do not use gloves.

2) Drilling machine

i. Secure the drill firmly.
ii. Secure the workpiece on the table with a vice or clamps.
iii. Do not sweep cutting chips away with your bare hands while processing the workpiece.
iv. Since drilling a workpiece generates high torque, slow down the feed rate sufficiently and drill the workpiece carefully.
v. Do not use gloves.

3) Milling machine

i. Do not put unnecessary objects on the bed.
ii. Use a waste rag to hold the blade of a milling cutter or an end mill at all times.
iii. Remove cutting chips with a raking stick or a small broom after turning off the machine.
iv. Keep your hands away from the rotating tool.
v. Pay close attention to the direction the cutting chips might scatter to prevent injuries.
vi. Do not use gloves.

4) Surface grinder

i. Do not hit the grindstone with a workpiece when you secure the workpiece.
ii. Follow the instructions on how to secure a workpiece from personnel or school staff of the Center for Design and Manufacturing. Be careful to secure the workpiece to prevent it from falling down in processing, especially for a tall workpiece.
iii. Do not stand in front of the direction of rotation of the grindstone.
iv. In the case of vibration, suspend the work immediately and follow instructions from personnel or school staff of the Center for Design and Manufacturing.
v. Do not use gloves.

5. Electrical discharge machine

i. Do not touch the electrodes while the machine performs spark machining.

6) NC machine tool

i. Check the directions of movement of the X-, Y-, and Z-axes (which direction is positive/negative) carefully when you move the tools and the table. Pay attention to this especially when you move the tools away from the workpiece.
ii. Close the safety door before starting processing.
iii. Check a created program carefully before starting processing with it.
iv. After completing the work, discharge air from the compressor to lower the pressure to atmospheric pressure.
v. For the use of it, consult personnel or school staff of the Center for Design and Manufacturing sufficiently.

7) Grinder

i. Wear safety glasses to prevent grinding powder.
ii. Since a small workpiece is heated to a relatively high temperature by friction and is easily caught in the grinding wheel, pay close attention to this.
iii. Be careful not to impact the grinding wheel because it is vulnerable to impacts.

8) Electric metal shear

i. Secure the workpiece firmly in consideration of its thickness and material because a poorly fixed workpiece could jump or deform.
ii. Keep your fingertips away from the underside of the blade.
iii. Do not touch the cut edge of a plate with bare hands carelessly. Conduct the work with gloves if necessary.

9) High speed cutter

i. Keep your hands away from the rotating blade.
ii. Pay attention to the surrounding conditions because the cutter generates sparks backwards.

10） Band saw

i. Idle the machine to check normal operation before starting the work.
ii. Use a guide in order to prevent cutting accidents of your fingertips.
iii. Pay attention to the strong vibration and/or unusual sounds of the saw at all times in your work.
iv. Do not use gloves.

11） Welding

i. Wear a cloth, shoes, and other protective equipment carefully in order to prevent electric shocks and burns.
ii. Keep flammable materials away from the welding area.
iii. Do not conduct welding while touching metals connected to grounded objects and/or return wires. Otherwise, very harmful accidents will occur.

12） Transportation

i. Clean up any unnecessary objects in the passages in advance to ensure safety and available spaces when you carry workpieces and materials with a platform truck and other devices.
ii. In addition to loads, pay close attention to the people around you.
iii. Pile heavy loads first and light ones next. Be careful not to pile loads excessively or unevenly.
iv. When you carry loads manually, do not lift or carry a heavy load carelessly or in a poor position. Otherwise, you will likely suffer from a backache.
v. When a heavy load is carried by multiple members, arrange the transportation among the members and actually achieve good teamwork. It is important to cooperate with each other.
vi. Transportation requires the consideration of the shape, dimensions, weight, quantity, and other conditions of a load and a method adapted to them.

13） Lifting

i. You can use a hoist or a chain block with a capacity of 0.5 t or less without user qualifications. Since accidents often occur, however, obtain permission from personnel or school staff of the Center for Design and Manufacturing and follow instructions on how to use it from them.
ii. Check the weight of a load is within the allowable lifting range of the equipment you intend to use.
iii. Consider how to lift a load in advance.
iv. Follow instructions from the responsible person and completely give signals and signs during operation.
v. When lifting/lowering and transporting a load, keep yourself away from under or around the load. In addition, be careful that people other than the operator do not approach it carelessly.

14） Keeping things tidy and in order

i. After finishing your work and turning off the power supply, clean up completely.
ii. Remove cutting chips from machine tools as carefully as possible.
iii. Mixing cutting chips could result in explosive accidents. Sort these chips into types because they are reused later.
iv. Check automatic feed is released.
v. Maintain tools and other devices and return them to the original places.

III Radiation Laboratory

1. Introduction

A radioisotope (RI) represents an unstable isotope emitting radiation from the decay of the nucleus. Since contamination and radiation exposure due to RIs result in fatal accidents, the use of RIs is restricted by law on the restriction of radioactive isotopes. At the Koganei Campus of TUAT, you are allowed to use non-sealed RIs only in the Radiation Laboratory, a common use facility.

You can handle both non-sealed and sealed RIs in this laboratory. The outline of the laboratory and the general precautions for the use of RIs are described below.

2. About Radiation Laboratory

At the Koganei Campus of TUAT, you are allowed to use non-sealed RIs only in the Radiation Laboratory, a common use facility. This laboratory contains a radiation-controlled area. The radiation-controlled area can be accessed by those having permission from a radiation worker or the radiation protection supervisor. Currently, 13 nuclides of non-sealed RIs (including H-3 (gas)) are allowed to be used and the maximum quantities per year, three months, and day for each nuclide are specified. In addition, the storage capacity of a non-sealed RI is determined for each nuclide. The RI stock control system, the air discharge equipment, the drainage equipment, and other facilities are provided to control and use RIs safely. In addition to them, radiation is monitored by the air discharge and water monitors. The laboratory also has a survey meter, a room gas monitor, and other devices to check contamination and monitor radiation in the room. Note that users, other than the laboratory members, of the internal apparatus loaded with radioactive materials (sealed RIs) and those handling external radiation facilities can also be registered as a radiation worker of TUAT.

3. Safety control of RIs and radiation workers in Radiation Laboratory

The laboratory assumes accidents, which could cause radiation damage, including the contamination of the facility caused by the accidental scattering of RIs due to broken devices and misoperated experiments, and the ingestion of RIs. So, it is essential to prevent unplanned and unnecessary exposure. To prevent such accidents, radiation and RIs are allowed to be used in the laboratory only by a person that has received training and ionizing radiation health care examinations specified by the Radiation Damage Preventive Regulations of the Faculty of Engineering of TUAT and has been registered as a radiation worker. A radiation worker who actually hopes to use the Radiation Laboratory must prepare an experiment plan in advance and obtain approvals from the Radiation Laboratory Director and the radiation protection supervisor. In addition, facilities and equipment in the Radiation Laboratory are serviced regularly for maintenance and repaired if necessary.

IV Handling of hazardous materials and Chemical Storehouses

1. Overview

The Koganei Campus has four hazardous materials indoor storehouses that are permitted by the fire station. Hazardous materials are classified into some storage types according to the Fire Service Law.

“Hazardous materials” described here mean combustible or flammable materials limited to those specified by the Fire Service Law. Thus, materials not specified by the Fire Service Law, such as organic solvents, cannot be stored in the hazardous materials indoor storehouses. Hazardous materials are classified according to how to handle and extinguish them, as described in the “Classification of hazardous materials” section. Storage quantities of hazardous materials are determined by limiting a quantity to a multiple of the specified one according to the severity of hazards. In fact, the contents of a hazardous materials indoor storehouse are limited in quantity for each of hazardous materials as shown on the board at an entrance to the storehouse. Since the storehouses contain classified hazardous materials, their entrances are also classified and marked with the east/west side. Be careful not to mistake classifications.

These chemicals are essential for experiments and studies at the Koganei Campus though they have harmful characteristics. For this reason, the handling of them is restricted by the Fire Service Law and requires special precautions. To handle the specified quantity or more of hazardous materials, you must have a hazardous materials officer’s license or ask another person with a hazardous materials officer’s license to attend in the same way as a driver’s license to drive a car.

The number of cases of fires due to hazardous materials is not much higher than that of common fires because the Fire Service Law works effectively. However, the former results in three times as many fatal cases as those of the latter statistically. Fires from hazardous materials cannot be extinguished in most cases, except for initial fire extinguishing. Thus, *No Fire* is essential in the hazardous materials indoor storehouses.

Read the following description of hazardous materials carefully to prevent accidents by yourself when you conduct experiments with such materials.

2. Handling of hazardous materials

Hazardous materials should not be stored in an experiment room except for those required for experiments because of their harmful characteristics, and this is essential for safety. The quantity of hazardous materials that can be stored in an experiment room without legal restrictions is up to the specified quantity in the Fire Service Law, while limited to one fifth of the specified quantity in the Fire Prevention Ordinance of Tokyo. If an experiment room has hazardous materials with the quantity equal to or more than one-fifth and below the specified one, the Tokyo Metropolitan Ordinance imposes posted notifications and restricts the handling of them.

To avoid such restrictions, you should purchase and use only the proper quantities of the necessary materials. In some cases, however, you need to store hazardous materials. You must not store them in an experiment room but in a chemical storehouse, legally called a hazardous materials indoor storehouse, in such case. And you should take only the proper quantities of hazardous materials at a time into an experiment room; this may bother you but can maintain safety. Not everyone can take hazardous materials in/out. Hazardous materials must be taken in/out according to “How to use Chemical Storehouses” below.

3. Hazardous materials

Types and characteristics of hazardous materials are described in the “Classification of hazardous materials” and “Features and characteristics of hazardous materials” sections in detail, so refer to them.

4. How to use Chemical Storehouses

If you want to store chemicals that are supposed to be hazardous in the chemical storehouses, check whether or not these chemicals are hazardous materials with tables first. If you have any questions, consult a hazardous materials engineer without hesitation to check on the type the hazardous materials.

After clarifying the type of the hazardous materials, check which room of the chemical storehouses these materials can be stored in. Be careful that hazardous materials other than those specified by the Fire Service Law cannot be stored in the chemical storehouses though you think they are hazardous. For example, cylinders of propane gas, halogenides, toxic substances, and hydrochloric acids cannot be stored.

After deciding a room where hazardous materials are stored, submit an application to the school staff of your assigned laboratory. Then, inform the staff of the names and quantities of chemicals you want to store in the chemical storehouses (because each of these storehouses has limitations of both types and quantities of hazardous materials to be stored). When you obtain permission, hazardous materials can be taken into a chemical storehouse by a person who are familiar with laws and regulations and chemical knowledge on hazardous materials and:

1) Has a hazardous materials engineer’s license; or
2) Designated as a hazardous materials security supervisor; or
3) By yourself with a person who has a hazardous materials engineer’s license.

When you take out chemicals from a chemical storehouse in the same way as taking in them, submit an application to the school staff of your assigned laboratory and do so with an assigned hazardous materials security supervisor.

For the storage and handling of hazardous materials, you must be familiar with characteristics of these materials and common precautions for careful handling, as well as completely follow hazardous materials laws and regulations specified by the Fire Service Law and the Fire Prevention Ordinance of Tokyo.

V Waste separation and disposal

1. Introduction

The effective utilization of resources and the prevention of the global warming are urgent problems. The global warming is mainly caused by carbon dioxide, which is partly discharged from waste incineration. For this reason, as well as non-burnable garbage, burnable garbage should be recycled if possible. Everyone including students and school staff must try to reduce the amount of waste.

2. Burnable garbage

At the Koganei Campus, burnable garbage (including leftover food, kitchen waste, used dispensable chopsticks, and wastepaper) is collected in a temporary waste storage area on the north side of the Radiation Laboratory. Note that sheets of wastepaper are recycled except for those dampened with chemicals and oil or coated with water repellent. Take them into separation baskets provided on buildings.

3. Non-burnable garbage

If plastic tools and vinyl gloves as well as lunch boxes and food containers are mixed with burnable garbage, the incineration of them generates hazardous substances such as dioxin and damage the inner wall of an incinerator. Thus, they are processed as non-burnable garbage. Metals and mixture of metal and plastic such as electronics, electric wires, and ceramics are finally processed by crushing and burying them. Such types of waste are collected in a temporary waste storage area on the north side of the Radiation Laboratory.

Note that broken glassware in a box will be harmful in collection work. Thus, carry broken glassware into a temporary waste storage area on the north side of the RI facility, separating it from the above-mentioned garbage to be buried. Do not carry laboratory glassware, such as beakers and reagent bottles, 18-liter drums, and plastic containers into a temporary waste storage area but dispose of them during the garbage collection conducted several times in a year.

4. Bulky waste

Carry bulky waste into a temporary waste storage area on the north side of the Radiation Laboratory. You can carry such waste into a temporary waste storage area basically in the lunch hour (12:00-13:00) on Tuesday and Thursday, but when you cannot do so and unavoidably carry it at other time in the case of a large amount of waste, for example, contact the Accounting Section, Koganei Accounting Office (ext. 7004) in advance. If a regular carrying-in day is a holiday, it is changed to the next day (next business day) so pay attention to this.

In addition to this, you can carry both burnable and non-burnable garbage into a temporary waste storage area. Such garbage can also be carried in the lunch hour (12:00-13:00) on Tuesday and Thursday.

5. Handling of experimental wastes

(1) Injection needles, etc.

Injection needles and syringes used for experiments must not be discarded together with general waste. Disposal should be consigned to the specified contractor after a certain amount has been accumulated.

(2) Experimental animals.

Disposal of experimental animals should be consigned to the specified contractor.

(3) Check with the Accounting Section (7004) for information on the contractors in (1) and (2).

(4) Reagent bottles

Remove the labels and clean the contents, then dispose of at the time of collection performed a few times every year. Care must be taken as these cannot be disposed of in general non-combustible waste boxes. (Collect the cleaner depending on types of contents and dispose of it as an experimental waste fluid according to “Waste Disposal” below.) Request a prescribed disposal company to dispose of a reagent itself.

(5) Fluorescent lamps and dry batteries

Used fluorescent lamps and dry batteries should be disposed of separately in a dedicated box in the temporary waste storage on the north side of the radiation laboratory.

Waste disposal

At the Koganei Campus, experimental studies use various materials and chemicals and generate many types of used waste. These wastes include many types of toxic or hazardous wastes that, if handled improperly, can cause not only hazards to the handlers themselves but also widespread environmental contamination and harm to non-direct stakeholders. Therefore, various laws and regulations regulate the disposal of these wastes.

While there are a variety of wastes, this section limits itself to presenting precautions for experimental waste liquids, empty bottles of experimental chemicals, articles containing polychlorinated biphenyl (PCB), and asbestos products.

i. Experimental waste liquids are usually toxic and must not be disposed of by drainage like general wastewater. Waste liquids from experiments must be stored in holding tanks prepared in individual laboratories. Stored waste liquids are outsourced to waste-liquid disposal specialists for treatment in dedicated plants.

Waste liquids are divided into organic and inorganic waste liquids, respectively subdivided into waste liquids with different characteristics and requiring different treatments. Therefore, waste liquids must be sorted and stored by type according to a prescribed classification table and delivered to environmental management facilities on designated days by the persons in charge. (Refer to “Handling of Experimental Waste Materials and Waste Liquids” in this booklet.)

Many chemical substances react rapidly and explode when mixed. Many examples of explosions have been known to occur when waste liquids, sorted and stored by type, have been mixed with other waste liquids simply because of the small quantities involved. Special caution must be exercised. The table below shows typical combinations of chemicals that may explode when mixed.

ii. Disposal of chemical bottles is only allowed at a few annual collection events to prevent disposal with dangerous chemicals still inside. Empty chemical bottles must not be mixed with general non-flammable waste for disposal.

Note that collected bottles not meeting any one of the following requirements will not be accepted for disposal:

(1) Only glass and plastic bottles or cans washed and dried clean at least twice (note that solvents, water, or other liquids used in the washing process must also be sorted and stored by type).
(2) No caps/lids.
(3) No odors.
(4) Bottles, etc., with labels removed as long as possible.
(5) Eighteen-liter drums cut open and flattened.
(6) Bottles or cans deemed acceptable by the witness in charge.

iii. Articles containing polychlorinated biphenyl (PCB) are subject to strict storage and reporting requirements under the “Law on Special Measures concerning Promotion of Proper Treatment of PCB Wastes.” Be aware that mixed disposal with general waste results in punishment. If articles containing PCB have turned up in laboratories, etc., immediately contact the Contract and Purchase Section, Koganei Accounting Office (extension 7004), and follow their instructions.

iv. Disposal of asbestos products is subject to the provisions under the “Waste Disposal and Public Cleansing Law.” Scatterable asbestos must be treated as specially controlled industrial waste. If any asbestos product is found, contact the Contract and Purchase Section, Koganei Accounting Office, and follow their instructions. Note that if inhaled, scattered asbestos may cause serious health disorders. Therefore, in case of finding any asbestos product that may scatter asbestos, never touch it and immediately inform a faculty member to that effect.

Combinations of chemicals that may explode when mixed (A+B)

Chemical A	Chemical B		Chemical A	Chemical B
Alkali metals, powdered aluminum or magnesium, etc. (reaction)	Carbon tetrachloride/other chlorohydrocarbons, carbon disulfide, and halogen		Hydrogen peroxide (rapid decomposition reaction)	Copper, chromium, iron, many metals or their salts, alcohol, acetone, organic matter, aniline, combustibles, flammable liquids, nitromethane
Potassium, sodium (reaction)	Carbon tetrachloride, carbon dioxide, water		Ammonia (anhydrous) (mercury/silver azide formation/violent exothermic reaction/product decomposition)	Mercury (e.g., mercury in manometers), chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid, silver compounds
Copper (acetylide formation/decomposition reaction)	Acetylene, hydrogen peroxide		Chromium trioxide (oxidation reaction/oxygen generation)	Acetic acid, naphthalene, camphor, glycerin, turpentine oil, alcohols
Silver (acetylide formation/decomposition reaction/silver fulminate/silver azide formation)	Acetylene, oxalic acid, tartaric oxidation, fulminic acid, ammonium compounds		Hydrofluoric acid (concentrated) (violent exothermic reaction)	Ammonia (hydrous or anhydrous)
Mercury (acetylide/mercury fulminate/azide formation)	Acetylene, fulminic acid, ammonia		Nitric acid (concentrated) (oxidation reaction/exothermic heat)	Acetic acid, aniline, chromic acid, cyanic acid, hydrogen sulfide, flammable liquids, flammable gases
Chlorine (violent exothermic reaction/product decomposition)	Ammonia, acetylene, butadiene, butane, methane, propane (other petroleum gases), hydrogen, sodium, carbide, turpentine oil, benzene, pulverized metals		Sulfuric acid (free chloric acid, permanganic acid formation/decomposition and oxidation reaction)	Potassium chlorate, potassium perchlorate, potassium permanganate (or permanganates of light metals such as sodium or lithium)
Bromine (ditto)	Same as with chlorine		Hydrocarbons (butane, propane, benzene, gasoline, turpentine oil, etc.)	Fluorine, bromine, chromium trioxide, sodium peroxide (violent exothermic reaction/oxidation reaction and peroxide formation)
Iodine (ditto)	Acetylene, ammonia (solution or anhydrous)/hydrogen		Acetylene (violent exothermic reaction and product decomposition/acetylide formation), aniline (oxidation reaction)	Chlorine, bromine, copper, fluorine, silver, mercury

(high energy and hence high exothermic heat)	Extremely high reactivity			
Chlorine dioxide (violent exothermic reaction/product decomposition)	Ammonia, methane, phosphine, hydrogen sulfide		Oxalic acid (rapid decomposition)	Silver, mercury
Chlorate (rapid oxidation reaction)	Ammonium salts, acids, metal powders, sulfur, generally pulverized organic matter or combustible substances		Cumene hydroperoxide (rapid decomposition)	Acids (organic or inorganic)
Perchloric acid (rapid oxidation reaction)	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood		Flammable liquid (oxidation reaction/peroxide formation/rapid reaction)	Ammonium nitrate, chromium trioxide, hydrogen peroxide, nitric acid, sodium peroxide, and halogen
Potassium permanganate (rapid oxidation reaction)	Ethanol or methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural			

Note: The (round parentheses) in the table contain the causes.

Nonsmoking measures at the University

In accordance with the intents of the Health Promotion Act amended in July 2018 and the Tokyo Metropolitan Ordinance to Prevent Exposure to Second-Hand Smoke, established in June 2018, and in light of increasing demand from students for measures to improve the situation regarding secondhand smoke on campus, the University has prohibited smoking indoors in all University facilities. This is intended to enhance the University's measures to separate smoking and nonsmoking areas completely, in line with its emphasis on environmental considerations.

1. Actual measures to separate smoking and nonsmoking areas on campus

i. Smoking is prohibited indoors in all campus facilities, including research laboratories and student dormitories. (As a result, smoking is prohibited indoors even if other measures have been taken to prevent secondhand smoke.)
ii. Smoking is prohibited outdoors as well in places where the smoke could spread to indoors.
iii. Smoking is prohibited outside of designated areas on campus. This means that smoking is prohibited while walking on campus as well.

2. Campus beautification and smoking etiquette

The University is enhancing its efforts to separate smoking and nonsmoking areas and promoting sound smoking etiquette in consideration of the negative effects of smoking on the appearance of the campus environment, such as discarded cigarette butts, and failure to comply with smoking etiquette as commonly accepted in today's society, for example not smoking while walking around.

3. Smoking rules

i. Smoking is permitted only in designated smoking areas on campus. Do not smoke in other places.
ii. Place cigarette butts and ashes in ashtrays. Do not throw them on the ground or elsewhere.
iii. Smoking is prohibited while walking or riding a bicycle.
iv. Do not dispose of empty cans or plastic bottles in ashtrays. Do not use them as trash receptables.
v. Extinguish cigarettes in the ashtrays, never on the walls or elsewhere.
vi. Smoke or flame in ashtrays is a fire hazard. If you see smoke or flame in an ashtray, immediately extinguish it with water.
vii. Smokers should encourage each other to follow these rules as necessary.
viii. Even in smoking areas, try to prevent exposure to secondhand smoke through means such as extinguishing cigarettes and refraining from smoking while passersby are present.

Reference: Article 25-5 of the Health Promotion Act (Prevention of Exposure to Secondhand Smoke in Facilities Used by Numerous Users)

Managers of facilities used by numerous users, such as schools, gymnasiums, hospitals, theaters, meeting halls, exhibition halls, department stores, offices, public facilities, and restaurants and bars must strive to take measures as necessary to prevent unwanted exposure of users to secondhand smoke.

Appendix

Reference materials

1. References for each chapter

"*Safety Manual*" *2001*, Safety Committee for Faculty of Agriculture, Tokyo University of Agriculture and Technology
"*Animal Experiment Guidelines and Animal Experiment Guide*" 2001, Animal Care and Use Committee for Tokyo University of Agriculture and Technology
"*Safety Guide*" 1994, Student Life Committee for Osaka University
"*Safety Handbook (4th edition)*" 1993, Safety Management Committee for Tokyo Institute of Technology
"*Safety Guide for Experiments and Practices (Revised edition)*", Yokohama National University in 1988, Safety Committee for the College of Engineering Science, Yokohama National University
"*Health Guide*" 2005, Health Management Center for Tokyo University of Agriculture and Technology

Reference materials on chemical system

"*Accident Prevention Guide*", 1987, Edition by Department of Industrial Chemistry and Department of Synthetic Chemistry, Faculty of Engineering, Chiba University
"*To Conduct Experiments Safely (Revised Edition)*", Kagakudojin, 1977, Editorial Desk of Kagakudojin
"*To Conduct Experiments Safely (Sequal New Edition)*", Kagakudojin, 1987, Editorial Desk of Kagakudojin
"*Basics and Understanding of Chemical Experiments*" by Masahiro Yorizane, Baifukan
Handbook of the Handling of Waste Liquids (in Japanese) (Environmental Management Facilities, Tokyo University of Agriculture and Technology)

Reference materials on biological system

"*Microbiological Experimental Techniques*" Kodansha
"*Microorganism Experiment Manuals*" Kodansha
"*Biology Handbook*" Maruzen
"*Recombinant DNA Experiment Guidelines*" Life Science Planning Room Edition, Planning Bureau, Science and Technology Agency
"Explanatory Material on Laws Related to Ensuring of Biotic Diversity Due to Regulations on Use of Genetically Modified Organism (Version on November 1, 2005)" Ministry of Education, Culture, Sports, Science and Technology

2. Regulations on Safety Management at Tokyo University of Agriculture and Technology

Regulations on Safety and Health Management at Tokyo University of Agriculture and Technology, National University (April 7, 2004)
Detailed Rules of Radiation Damage Prevention at Tokyo University of Agriculture and Technology, National University (April 7, 2004)
Regulations on Safety Management of Genetically Modified Organism at Tokyo University of Agriculture and Technology, National University (April 1, 2004)
Regulations on Handling of Poisonous and Deleterious Substances at Tokyo University of Agriculture and Technology, National University (April 1, 2004)
Regulations on Security of Electrical Facilities for Private Use at Tokyo University of Agriculture and Technology, National University (April 1, 2004)
Fire Protection Control Outlines at Tokyo University of Agriculture and Technology, National University (December 2005)
Earthquake Disaster Countermeasures Outlines at Tokyo University of Agriculture and Technology, National University (December 2005)
Health and Safety Management Regulations at Tokyo University of Agriculture and Technology (March 1975)
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Outlines of Usage of Incineration Equipment for Radioactive Organic Wastewater at Tokyo University of Agriculture and Technology (July 1983)

Regulations on Management of Wastewater at Tokyo University of Agriculture and Technology (July 1983)
Outlines of Handling of Wastewater at Tokyo University of Agriculture and Technology (July 1983)
Regulations for Animal Care and Use Committee (February 1998)
Fire Protection Control Regulations at Tokyo University of Agriculture and Technology (April 1981)
Outlines of Implementation of Check and Inspection of Fire Equipment at Tokyo University of Agriculture and Technology (September 1975)
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