Chem 1A

Answers - Exam 1 - Review Problems

1. $2\,AlCl_3 + 3\,Mg \rightarrow 2\,Al + 3\,MgCl_2$

a. $(5.0\text{ mol }AlCl_3)\left(\frac{3\text{ mol Mg}}{2\text{ mol }AlCl_3}\right) = 7.5\text{ mol Mg}$

b. $(50.0\text{ mg Mg})\left(\frac{1\text{ g Mg}}{1000\text{ mg}}\right)\left(\frac{1\text{ mol Mg}}{24.31\text{ g Mg}}\right)\left(\frac{2\text{ mol Al}}{3\text{ mol Mg}}\right) = 0.00137\text{ mol Al}$

or 1.37×10^{-3} mol Al

c. $(3.00\text{ g }AlCl_3)\left(\frac{1\text{ mol }AlCl_3}{133.33\text{ g }AlCl_3}\right)\left(\frac{3\text{ mol Mg}}{2\text{ mol }AlCl_3}\right)\left(\frac{24.31\text{ g Mg}}{1\text{ mol Mg}}\right) = 0.820\text{ g Mg}$

d. $(5.0\times10^{24}\text{ atoms Al})\left(\frac{1\text{ mol Al}}{6.022\times10^{23}\text{ atoms}}\right)\left(\frac{3\text{ mol Mg}}{2\text{ mol Al}}\right)\left(\frac{24.31\text{ g Mg}}{1\text{ mol Mg}}\right)\left(\frac{1\text{ cm}^3}{1.738\text{ g}}\right) =$

$= 174\text{ cm}^3\text{ Mg}$

$1.7\times10^2\text{ cm}^3$

2. $\%Fe = \frac{g\ Fe}{g\ total}\times 100$ $\quad MM = 2(55.85) + 6(12.01) + 12(16.00) = 375.76$ g/mol

$\%Fe = \frac{2(55.85)\text{ g Fe}}{375.76\text{ g total}}\times 100 = 29.73\%\text{ Fe}$

$\%C = \frac{6(12.01)\text{ g C}}{375.76\text{ g total}}\times 100 = 19.18\%\text{ C}$

$\%O = \frac{12(16.00)\text{ g O}}{375.76\text{ g total}}\times 100 = 51.096 \rightarrow 51.10\%\text{ O}$

3. $2\,Al_{(s)} + 3\,F_{2(g)} \longrightarrow 2\,AlF_{3(s)}$ $\quad (Al^{3+}, F^-)$

4. $S_8 + 4\,Cl_2 \longrightarrow 4\,S_2Cl_2$

a) LR problem

$(20.0\text{ g }S_8)\left(\frac{1\text{ mol }S_8}{256.56\text{ g }S_8}\right) = 0.07795\text{ mol }S_8$

$$(10.0\,g\,Cl_2)\left(\frac{1\,mol\,Cl_2}{70.90\,g}\right) = 0.1410\,mol\,Cl_2$$

need: $\frac{4\,Cl_2}{1\,S_8}$ have $\frac{0.1410\,mol\,Cl_2}{0.07795\,mol\,S_8} = \frac{1.809\,mol\,Cl_2}{1\,mol\,S_8}$

not enough Cl_2. so Cl_2 is LR.

$$(0.1410\,mol\,Cl_2)\left(\frac{4\,mol\,S_2Cl_2}{4\,mol\,Cl_2}\right)\left(\frac{135.04\,g\,S_2Cl_2}{1\,mol\,S_2Cl_2}\right) = 19.0\,g\,S_2Cl_2$$

4.b. $$(85.0\,kg\,S_2Cl_2)\left(\frac{1000\,g\,S_2Cl_2}{1\,kg}\right)\left(\frac{1\,mol\,S_2Cl_2}{135.04\,g\,S_2Cl_2}\right)\left(\frac{4\,mol\,Cl_2}{4\,mol\,S_2Cl_2}\right)$$

$$\times\left(\frac{70.90\,g\,Cl_2}{1\,mol\,Cl_2}\right) = 44627.5\,g\,Cl_2 \quad \div 1000$$

$\Rightarrow$ 44.6 kg Cl_2

4c. $\frac{86.5\,g\ \text{actual}}{100\,g\ \text{theoretical}}$

we want to actually get 25.0 g S_2Cl_2.

so $$(25.0\,g\,S_2Cl_2\ \text{actual})\left(\frac{100\,g\ \text{theoretical}}{86.5\,g\ \text{actual}}\right) = 28.9\,g\ \text{theoretical}\ S_2Cl_2$$

$$(28.9\,g\,S_2Cl_2)\left(\frac{1\,mol\,S_2Cl_2}{135.04\,g\,S_2Cl_2}\right)\left(\frac{1\,mol\,S_8}{4\,mol\,S_2Cl_2}\right)\left(\frac{256.56\,g\,S_8}{1\,mol\,S_8}\right) = 13.7\,g\,S_8$$

5. Wt-ave atomic mass on per table = 85.49 amu

closer to 85 than 87. ^{85}Rb is more abundant.

6. $$(2.0\,ng\,C_5H_{12})\left(\frac{1\,g}{10^9\,ng}\right)\left(\frac{1\,mol\,C_5H_{12}}{72.146\,g}\right)\left(\frac{12\,mol\,H}{1\,mol\,C_5H_{12}}\right)\left(\frac{6.022\times10^{23}\,atoms\,H}{1\,mol\,H}\right)$$

$= 2.0\times10^{15}$ H atoms

7. $(6.111\text{ g }CO_2)\left(\frac{1\text{ mol }CO_2}{44.01\text{ g }CO_2}\right)\left(\frac{1\text{ mol C}}{1\text{ mol }CO_2}\right)\left(\frac{12.01\text{ g C}}{1\text{ mol C}}\right) = 1.66\bar{7}6\text{ g C}$

$(1.390\text{ g }H_2O)\left(\frac{1\text{ mol }H_2O}{18.016\text{ g }H_2O}\right)\left(\frac{2\text{ mol H}}{1\text{ mol }H_2O}\right)\left(\frac{1.008\text{ g H}}{1\text{ mol H}}\right) = 0.155\bar{5}4\text{ g H}$

$2.317\text{ g comp.} - 1.66\bar{7}6\text{ g C} - 0.155\bar{5}4\text{ g H} = 0.49\bar{3}86\text{ g O}$

$(1.66\bar{7}6\text{ g C})\left(\frac{1\text{ mol C}}{12.01\text{ g C}}\right) = 0.138\bar{8}5\text{ mol C}$

$(0.155\bar{5}4\text{ g H})\left(\frac{1\text{ mol H}}{1.008\text{ g H}}\right) = 0.1543\text{ mol H}$

$(0.49\bar{3}86\text{ g O})\left(\frac{1\text{ mol O}}{16.00\text{ g O}}\right) = 0.030\bar{8}7\text{ mol O}$

$\frac{0.138\bar{8}5\text{ mol C}}{0.030\bar{8}7\text{ mol O}} = \frac{4.5\text{ C}}{1\text{ O}}$ $\quad \frac{0.1543\text{ mol H}}{0.030\bar{8}7\text{ mol O}} = \frac{5\text{ H}}{1\text{ O}}$

$C_{4.5}H_5O \quad \times 2 \Rightarrow \boxed{C_9H_{10}O_2}$

8.a. $Al(OH)_3 + 3HCl \rightarrow AlCl_3 + 3H_2O$

b. LR problem.

$(5.00\text{ g }Al(OH)_3)\left(\frac{1\text{ mol }Al(OH)_3}{78.004\text{ g}}\right) = 0.064\bar{0}99\text{ mol }Al(OH)_3$

$(8.00\text{ g HCl})\left(\frac{1\text{ mol HCl}}{36.458\text{ g HCl}}\right) = 0.21\bar{9}43\text{ mol HCl}$

needed: $\frac{3\text{ mol HCl}}{1\text{ mol }Al(OH)_3}$ have: $\frac{0.21\bar{9}43\text{ mol HCl}}{0.064\bar{0}99\text{ mol }Al(OH)_3} = \frac{3.42\text{ HCl}}{1\text{ }Al(OH)_3}$

have extra HCl, so $Al(OH)_3$ is LR.

$(0.064\bar{0}99\text{ mol }Al(OH)_3)\left(\frac{3\text{ mol }H_2O}{1\text{ mol }Al(OH)_3}\right)\left(\frac{18.016\text{ g }H_2O}{1\text{ mol }H_2O}\right) = \boxed{3.46\text{ g }H_2O}$

(c) how much HCl used?

$$(0.064\bar{0}99 \text{ mol } Al(OH)_3)\left(\frac{3 \text{ mol HCl}}{1 \text{ mol } Al(OH)_3}\right)\left(\frac{36.458 \text{ g HCl}}{1 \text{ mol HCl}}\right) = 7.01 \text{ g HCl used}$$

8.00 g HCl − 7.01 g used = 0.99 g HCl left over

9. $2\,C_8H_{18} + 25\,O_2 \longrightarrow 16\,CO_2 + 18\,H_2O$

$$(50.0\text{ g } C_8H_{18})\left(\frac{1 \text{ mol } C_8H_{18}}{114.224\text{ g}}\right)\left(\frac{16 \text{ mol } CO_2}{2 \text{ mol } C_8H_{18}}\right)\left(\frac{44.01\text{ g } CO_2}{1 \text{ mol } CO_2}\right) = 154\text{ g } CO_2$$

$$(50.0\text{ g } C_8H_{18})\left(\frac{1 \text{ mol } C_8H_{18}}{114.224\text{ g}}\right)\left(\frac{18 \text{ mol } H_2O}{2 \text{ mol } C_8H_{18}}\right)\left(\frac{18.016\text{ g } H_2O}{1 \text{ mol } H_2O}\right) = 71.0\text{ g } H_2O$$

10. $\frac{1.80\text{ g } CO_2}{1\text{ L}}$ want: $\frac{\#\text{ molecules}}{in^3}$

$$\left(\frac{1.80\text{ g } CO_2}{1\text{ L}}\right)\left(\frac{1 \text{ mol } CO_2}{44.01\text{ g } CO_2}\right)\left(\frac{6.022\times10^{23}\text{ molecules}}{1 \text{ mol } CO_2}\right)\left(\frac{1\text{ L}}{1000\text{ mL}}\right)\left(\frac{1\text{ mL}}{1\text{ cm}^3}\right)\left(\frac{2.54\text{ cm}}{1\text{ in}}\right)^3$$

$$= \frac{4.04\times10^{20}\text{ molecules } CO_2}{in^3}$$

11. wt ave mass = $(0.9223)(27.97693\text{ amu}) + (0.0467)(28.97649) + (0.0310)\times(29.97376)$

$= 25.8\bar{0}3$ amu + $1.3\bar{5}32$ amu + $0.92\bar{9}19$ amu

$= 28.0\bar{8}539 \Rightarrow$ 28.09 amu

12. a. $CuSO_4 + Na_3PO_4$

$Cu^{2+}, SO_4^{2-}, Na^+, PO_4^{3-}$

sol (Na⁺, SO₄²⁻); insol (Cu²⁺, PO₄³⁻)

$3\,Cu^{2+} + 2\,PO_4^{3-} \rightarrow Cu_3(PO_4)_{2(s)}$

net

molec: $3CuSO_{4(aq)} + 2Na_3PO_{4(aq)} \rightarrow Cu_3(PO_4)_{2(s)} + 3Na_2SO_{4(aq)}$

total: $3Cu^{2+} + 3SO_4^{2-} + 6Na^+ + 2PO_4^{3-} \rightarrow Cu_3(PO_4)_{2(s)} + 6Na^+ + 3SO_4^{2-}$

b. $Ba(OH)_2 + HC_2H_3O_2$ ← weak acid

Ba^{2+}, OH^- H^+ $C_2H_3O_2^-$ (water)

net:

$HC_2H_3O_2 + OH^- \rightarrow H_2O + C_2H_3O_2^-$

molec

$Ba(OH)_{2(aq)} + 2HC_2H_3O_{2(aq)} \rightarrow 2H_2O_{(l)} + Ba(C_2H_3O_2)_{2(aq)}$

total: $Ba^{2+} + 2OH^- + 2HC_2H_3O_{2(aq)} \rightarrow 2H_2O_{(l)} + Ba^{2+} + 2C_2H_3O_2^-$

c. $Na_2S + AgNO_3$

$Na^+, S^{2-}, Ag^+, NO_3^-$ (insol) (sol)

$2Ag^+ + S^{2-} \rightarrow Ag_2S_{(s)}$

molec: $Na_2S_{(aq)} + 2AgNO_{3(aq)} \rightarrow Ag_2S_{(s)} + 2NaNO_{3(aq)}$

total: $2Na^+ + S^{2-} + 2Ag^+ + 2NO_3^- \rightarrow Ag_2S_{(s)} + 2Na^+ + 2NO_3^-$

d. $HI + Li_2CO_3$

$H^+ \; I^- \; Li^+ \; CO_3^{2-}$ (gas)

$2H^+ + CO_3^{2-} \rightarrow H_2O_{(l)} + CO_{2(g)}$

molec.: $2HI_{(aq)} + Li_2CO_{3(aq)} \rightarrow H_2O_{(l)} + CO_{2(g)} + 2LiI_{(aq)}$

total: $2H^+ + 2I^- + 2Li^+ + CO_3^{2-} \rightarrow H_2O_{(l)} + CO_{2(g)} + 2Li^+ + 2I^-$

e. $H_2SO_3 + KOH$ ABrxn

WA

H^+, SO_3^{2-} K^+ OH^- (H_2O)

$H_2SO_{3(aq)} + 2OH^- \rightarrow 2H_2O_{(l)} + SO_3^{2-}$

molec: $H_2SO_{3(aq)} + 2KOH_{(aq)} \rightarrow 2H_2O_{(l)} + K_2SO_{3(aq)}$

total:

$H_2SO_{3(aq)} + 2K^+ + 2OH^- \rightarrow 2H_2O_{(l)} + 2K^+ + SO_3^{2-}$

assume a 100g sample

13. $(54.5\,g\,C)\left(\frac{1\ mol\ C}{12.01\,g\,C}\right) = 4.5\bar{3}8\ mol\ C$

$(13.7\,g\,H)\left(\frac{1\ mol\ H}{1.008\,g\,H}\right) = 13.\bar{5}9\ mol\ H$

$(31.8\,g\,N)\left(\frac{1\ mol\ N}{14.01\,g\,N}\right) = 2.2\bar{6}98\ mol\ N$

$\frac{4.5\bar{3}8\ mol\ C}{2.2698\ mol\ N} = \frac{2\ C}{1\ N}$ $\frac{13.\bar{5}9\ mol\ H}{2.2\bar{6}98\ mol\ N} = \frac{6\ H}{1\ N}$

ef = C_2H_6N

mf ... molar mass of ef = ~~appr~~ $2(12.01) + 6(1.008) + 14.01$
$= 44.0\bar{7}8\ g/mol$

$\frac{MM}{EFM} = \frac{90\ g/mol}{44.078\ g/mol} = 2.04 \Rightarrow 2$

so MF = $C_4H_{12}N_2$

15. a. H_2SO_4 MM = 98.086 g/mol

$(50.0\,mL)\left(\frac{1\,L}{1000\,mL}\right)\left(\frac{6.0\,mol\,H_2SO_4}{1\,L\,solution}\right)\left(\frac{98.086\,g\,H_2SO_4}{1\,mol\,H_2SO_4}\right) = 29.4\,g\,H_2SO_4$

24 g H_2SO_4

b. NaOH MM = 39.998 g/mol

$(5.00\,g\,NaOH)\left(\frac{1\,mol\,NaOH}{39.998\,g}\right)\left(\frac{1\,L\,solution}{2.35\,mol\,NaOH}\right) = 0.0532\,L$ or 53.2 mL solution

c. Na_2SO_4 MM = 142.05 g/mol

$(35.0\,g\,Na_2SO_4)\left(\frac{1\,mol}{142.05\,g}\right) = 0.24639\,mol\,Na_2SO_4$

$\frac{0.24639\,mol\,Na_2SO_4}{0.253\,L\,soln.} = 0.974\,M\,Na_2SO_4$

16. a. $Mn^{2+} + H_2O_2 + 2OH^- \rightarrow MnO_2 + 2H_2O$

(+2) (+1) (−1) (−2) (+1) (+4) (−2) (+1) (−2)

Mn +2 → +4 oxidized O −1 → −2 reduced

b. $Cr_2O_7^{2-} + 6Cl^- + 14H^+ \rightarrow 2Cr^{3+} + 3Cl_2 + 7H_2O$

(+6) (−2) (−1) (+1) (+3) (0) (+1) (−2)

Cr +6 → +3 reduced Cl −1 → 0 oxidized

17. a. Al is more active than H, so Al will replace H.

$2Al_{(s)} + 3H_2SO_{4\,(aq)} \rightarrow Al_2(SO_4)_{3\,(aq)} + 3H_{2\,(g)}$

b. lead is less active than tin, so it won't replace tin. NR.

c. tin is more active than lead. It will replace lead.

$Sn_{(s)} + Pb(NO_3)_{2\,(aq)} \rightarrow Pb_{(s)} + Sn(NO_3)_{2\,(aq)}$

18. Wt. ave mass Ag (from per table in book) = 107.8682 amu ← this 1 is exact by definition.

let abundance of $^{107}Ag = x$ abundance of $^{109}Ag = 1 - x$

107.8682 amu = x(106.90509 amu) + (1 − x)(108.9047 amu)

107.8682 = 106.90509 x + 108.9047 − 108.9047 x

−108.9047 −108.9047

$\frac{-1.0365}{-1.99961} = \frac{-1.99961x}{-1.99961}$

x = 0.51835 5sf 1 − x = 0.48165

^{107}Ag 51.835% ^{109}Ag 48.165%

19. ammonium sulfite
tin (II) chloride
oxalic acid
phosphorus triiodide
gold (I) periodate
copper (I) chromate

20. $Ba(C_2H_3O_2)_2$
H_2SO_4
$Pb(BrO)_4$
~~Ag_2O~~ CS_2
Ag_2O
$Al_2(CO_3)_2$

21. $47 p^+$, $47 n^0$ $109 - 47 = 62\ n^0$

22. a. Ce, Pr, Nd, Th, Pa, U etc
b. F, Cl, Br, I
c. Rb, Sr, Y, Zr, Sn, Sb, I etc.
d. H, Li, Mg, Al, P, O etc

23. a. $2N_2O \rightarrow 2N_2 + O_2$ decomposition
b. $2C_7H_4O_2 + 19\,O_2 \rightarrow 14\,H_2O + 14\,CO_2$ combustion

24. $6K_{(s)} + N_{2(g)} \rightarrow 2K_3N_{(s)}$
K^+, N^{3-}

25. $(2.00\,kg)\left(\frac{1000\,g}{1\,kg}\right)\left(\frac{1\,cm^3}{4.51\,g}\right)\left(\frac{1\ inch}{2.54\,cm}\right)^3 = 27.1\ in^3$

26. $6HBr + 2Al \rightarrow 3H_2 + 2AlBr_3$

a. $(0.500\,g\,Al)\left(\frac{1\,mol\,Al}{26.98\,g\,Al}\right)\left(\frac{6\,mol\,HBr}{2\,mol\,Al}\right)\left(\frac{80.908\,g\,HBr}{1\,mol\,HBr}\right) = 4.4982\,g\,HBr$ (4.50 g HBr)

b. $(0.500\,g\,Al)\left(\frac{1\,mol\,Al}{26.98\,g\,Al}\right)\left(\frac{3\,mol\,H_2}{2\,mol\,Al}\right)\left(\frac{6.022\times10^{23}\,molecules\,H_2}{1\,mol\,H_2}\right) = 1.67\times10^{22}\ H_2$ molecules

27. $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

a. $(50.0\,g\,Fe)\left(\frac{1\,mol\,Fe}{55.85\,g\,Fe}\right) = 0.89526\,mol\,Fe$ need $\frac{4H_2O}{3Fe} = \frac{1.33\,H_2O}{1\,Fe}$

$(30.0\,g\,H_2O)\left(\frac{1\,mol\,H_2O}{18.016\,g\,H_2O}\right) = 1.665\,mol\,H_2O$ have $\frac{1.665\,H_2O}{0.89526\,Fe} = \frac{1.85\,H_2O}{1\,Fe}$

have more than enough H_2O, so Fe is LR.

$(0.89526\,mol\,Fe)\left(\frac{1\,mol\,Fe_3O_4}{3\,mol\,Fe}\right)\left(\frac{231.55\,g\,Fe_3O_4}{1\,mol\,Fe_3O_4}\right) = 69.1\,g\,Fe_3O_4$

c. % yield $= \frac{60.2\,g\ actual}{69.099\,g\ theor.} \times 100 = 87.1\%$ yield.

b) $(0.89526\,mol\,Fe)\left(\frac{4\,mol\,H_2O}{3\,mol\,Fe}\right)\left(\frac{18.016\,g\,H_2O}{1\,mol\,H_2O}\right) = 21.5\,g\,H_2O$ used

30.0 g start
−21.5 g used
8.5 g H_2O left