MATTER & MINERALS

CHEMISTRY HOMEWORK - FALL - WEEK 4

Chapter 3

(59) (a) CH_2O molar mass $= (12.01 + 2(1.008) + 16.00)\ g/mol$

$= 30.026\ g/mol$

mass of C in 1 mol of $CH_2O = 12.01\ g/mol$

mass % of C $= \frac{12.01\ g/mol}{30.026\ g/mol} \times 100\% = \underline{\underline{39.99\%}}$

mass of H in 1 mol of $CH_2O = 2(1.008)\ g/mol$

$= 2.016\ g/mol$

Mass % of H $= \frac{2.016\ g/mol}{30.026\ g/mol} \times 100\% = \underline{\underline{6.71\%}}$

mass of O in 1 mol of $CH_2O = 16.00\ g/mol$

mass % of O $= \frac{16.00\ g/mol}{30.026\ g/mol} \times 100\%$

$= \underline{\underline{53.29\%}}$

(b) molar mass of $C_6H_{12}O_6 = [6(12.01) + 12(1.008) + 6(16.00)]\ g/mol$

$= 180.156\ g/mol$

mass of C in 1 mol of glucose $= 6 \times 12.01\ g/mol = 72.06\ g/mol$

mass % of C $= \frac{72.06\ g/mol}{180.156\ g/mol} \times 100\%$

$= \underline{\underline{39.99\%}}$

mass of H in 1mol of glucose $= (12 \times 1.008)\ g/mol$
$= 12.096\ g/mol$

mass % of H $= \frac{12.096\ g/mol}{180.156\ g/mol} \times 100\%$

$= \underline{\underline{6.71\%}}$

mass of O in 1mol of glucose $= (6 \times 16.00)\ g/mol$
$= 96.00\ g/mol$

mass % of O $= \frac{96.00\ g/mol}{180.156\ g/mol} \times 100\%$

$= \underline{\underline{53.29\%}}$

(c) molar mass of $HC_2H_3O_2$ $= [4(1.008) + 2(12.01) + 2(16.00)]\ g/mol$

$= 60.052\ g/mol$

mass of C in 1mol of $HC_2H_3O_2$ $= 2(12.01)\ g/mol$
$= 24.02\ g/mol$

mass % of C $= \frac{24.02\ g/mol}{60.052\ g/mol} \times 100\%$

$= \underline{\underline{39.99\%}}$

mass of H in 1mol of $HC_2H_3O_2$ $= 4(1.008)\ g/mol$
$= 4.032\ g/mol$

mass % of H $= \frac{4.032\ g/mol}{60.052\ g/mol} \times 100\%$

$= \underline{\underline{6.71\%}}$

mass of O in 1 mol of $HC_2H_3O_2 = 2(16.00)\ g/mol$

$= 32.00\ g/mol$

mass % of O $= \dfrac{32.00\ g/mol}{60.052\ g/mol} \times 100\%$

$= \underline{\underline{53.29\%}}$

(63) Percentage of Ti $= 59.9$

∴ Percentage of O $= 100 - 59.9 = 40.1$

	Ti	O
In 100 g of compound	59.9 g	40.1 g
moles	$\dfrac{59.9g}{47.88\ g/mol}$ $= 1.25\ mol$	$\dfrac{40.1g}{16.00\ g/mol}$ $= 2.51\ mol$
molar ratios	$\dfrac{1.25\ mol}{1.25\ mol} = 1$	$\dfrac{2.51\ mol}{1.25\ mol} = 2$
	1	2

∴ Empirical formula $= \underline{\underline{TiO_2}}$

65 **Compound ①**

mass of compound $= 0.6498\,g$

mass of residue = mass of Hg $= 0.6018\,g$

$\therefore$ mass of O_2 gas $= (0.6498 - 0.6018)\,g$

$= 0.0480\,g$

moles of Hg $= \dfrac{0.6018\,g}{200.6\,g/mol}$

$= 3.000 \times 10^{-3}\,mol$

moles of O_2 $= \dfrac{0.0480\,g}{2(16.00)\,g/mol}$

$= 1.5 \times 10^{-3}\,mol$

$\therefore$ moles of O $= 2(1.5 \times 10^{-3})\,mol$

$= 3.000 \times 10^{-3}\,mol.$

molar ratios

	Hg	O
molar ratios	$\dfrac{3.000 \times 10^{-3}\,mol}{3.000 \times 10^{-3}\,mol}$	$\dfrac{3.000 \times 10^{-3}\,mol}{3.000 \times 10^{-3}\,mol}$
	1 :	1

$\therefore$ empirical formula $= \underline{\underline{HgO}}$

Compound ②

mass of compound $= 0.4172\,g$

mass loss = mass of O_2 gas $= 0.016\,g$

$\therefore$ mass of mercury $= (0.4172 - 0.016\cancel{3})\,g$

$= 0.4612\,g$

moles of mercury $= \dfrac{0.4012\ g}{200.6\ g/mol}$

$= 2.000 \times 10^{-3}$ mol

moles of O_2 $= \dfrac{0.016\ g}{2(16.00\ g/mol)}$

$= 5.000 \times 10^{-4}$ mol

moles of O $= 2(5.000 \times 10^{-4})$ mol

$= 1.000 \times 10^{-3}$ mol

	Hg	O
molar ratios	$\dfrac{2.000 \times 10^{-3}\ mol}{1.000 \times 10^{-3}\ mol}$	$\dfrac{1.000 \times 10^{-3}\ mol}{1.000 \times 10^{-3}\ mol}$
	= 2	: 1

empirical formula = $\underline{\underline{Hg_2O}}$

(74) mass of compound heated = 10.68 mg

mass of CO_2 produced = 16.01 mg

moles of CO_2 produced $= 16.01\ mg \times \left(\dfrac{g}{10^3\ mg}\right)\left(\dfrac{mol}{44.01\ g}\right)$

$= 3.638 \times 10^{-4}$ mol

moles of C $= 3.638 \times 10^{-4}\ mol\ CO_2 \times \dfrac{1\ mol\ C}{1\ mol\ CO_2}$

$= 3.638 \times 10^{-4}$ mol C

Mass of H_2O produced = 4.37 mg

moles of H_2O $= 4.37\,mg \times \frac{g}{10^3\,mg} \times \frac{1\ mol}{18.016\,g}$

$= 2.426 \times 10^{-4}\ mol$

mol of H $= 2.426 \times 10^{-4}\ mol\ H_2O \times \frac{2\ mol\ H}{1\ mol\ H_2O}$

$= 4.852 \times 10^{-4}\ mol$

mass of C $= 3.638 \times 10^{-4}\ mol \times \left(\frac{12.01\,g}{1\ mol}\right)$

$= 4.369 \times 10^{-3}\ g$

mass of H $= 4.852 \times 10^{-4}\ mol \times \left(\frac{1.008\ g}{1\ mol\ H}\right)$

$= 4.890 \times 10^{-4}\ g$

$\therefore$ mass of O in the compound $= 10.68 \times 10^{-3}\ g - \left[4.369 \times 10^{-3}\,g + 4.890 \times 10^{-4}\,g\right]$

$= 5.822 \times 10^{-3}\ g$

moles of O $= 5.822 \times 10^{-3}\ g \times \frac{mol}{16.00\,g}$

$= 3.639 \times 10^{-4}\ mol$

$$\text{molar ratios} \quad \begin{array}{ccccc} C & & H & & O \\ \dfrac{3.638\times10^{-4}\,\text{mol}}{3.638\times10^{-4}\,\text{mol}} & : & \dfrac{4.852\times10^{-4}\,\text{mol}}{3.638\times10^{-4}\,\text{mol}} & : & \dfrac{3.639\times10^{-4}\,\text{mol}}{3.638\times10^{-4}\,\text{mol}} \end{array}$$

$$1 \quad : \quad 1.33 \quad : \quad 1$$

$$3 \quad : \quad 4 \quad : \quad 3$$

$\therefore$ empirical formula $= \underline{\underline{C_3H_4O_3}}$

empirical formula mass $= [3(12.01) + 4(1.008) + 3(16.00)]$ g

$= 88.062$ g

molar mass $= 176.1$ g/mol

$$\left.\begin{array}{l}\text{\# of empirical formula units} \\ \text{in one molecular formula}\end{array}\right\} = \frac{176.1\ \text{g/mol}}{88.062\ \text{g}}$$

$= 2$ /mol.

$\therefore$ Molecular formula $= \underline{\underline{C_6H_8O_6}}$

(77) (a) $Cu(s) + 2AgNO_3(aq) \rightarrow 2Ag(s) + Cu(NO_3)_2(aq)$

(b) $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

(c) $Au_2S_3(s) + 3H_2(g) \rightarrow 2Au(s) + 3H_2S(g)$

(78) (a) $3Ca(OH)_2(aq) + 2H_3PO_4(aq) \rightarrow 6H_2O(l) + Ca_3(PO_4)_2(s)$

(b) $Al(OH)_3(s) + 3HCl(aq) \rightarrow AlCl_3(aq) + 3H_2O(l)$

(c) $2AgNO_3(aq) + H_2SO_4(aq) \rightarrow Ag_2SO_4(s) + 2HNO_3(aq)$

(80) (a) $16Cr(s) + 3S_8(s) \rightarrow 8Cr_2S_3(s)$

(b) $2NaHCO_3(s) \xrightarrow{heat} Na_2CO_3(s) + CO_2(g) + H_2O(g)$

(c) $2KClO_3(s) \xrightarrow{heat} 2KCl(s) + 3O_2(g)$

(d) $2Eu(s) + 6HF(g) \rightarrow 2EuF_3(s) + 3H_2(g)$

(86)

$$Fe_2O_3(s) + 2Al(s) \rightarrow \underset{15.0\,g}{2Fe(l)} + Al_2O_3(s)$$

$$15.0\,g\ Fe \times \frac{1\,mol\ Fe}{55.85\,g\ Fe} = 0.269\ mol\ Fe$$

$$0.269\ mol\ Fe \times \frac{1\,mol\ Fe_2O_3}{2\,mol\ Fe} = 0.134\ mol\ Fe_2O_3$$

$$0.134 \text{ mol } Fe_2O_3 \times \frac{[2(55.85) + 3(16.00)]\text{g}}{1 \text{mol } Fe_2O_3}$$

$$= 21.39 \text{ g } Fe_2O_3 = \underline{\underline{21.4 \text{ g } Fe_2O_3}}$$

$$0.269 \text{ mol Fe} \times \frac{1 \text{ mol } Al_2O_3}{2 \text{ mol Fe}} = 0.1345 \text{ mol } Al_2O_3$$

$$0.1345 \text{ mol } Al_2O_3 \times \frac{[2(26.98) + 3(16.00)]\text{g}}{1 \text{mol } Al_2O_3} = 13.71 \text{ g}$$

$$= \underline{\underline{13.7 \text{ g } Al_2O_3}}$$

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$$Ba(OH)_2 \cdot 8H_2O(s) + 2NH_4SCN(s) \longrightarrow Ba(SCN)_2(s) + 10H_2O(l) + 2NH_3(g)$$

6.5 g

Molar mass of $Ba(OH)_2 \cdot 8H_2O = [137.3 + 10(16.00) + 18(1.008)]$ g/mol

$= 315.444$ g/mol

number of moles of $Ba(OH)_2 \cdot 8H_2O = 6.5\text{g} \times \frac{\text{mol}}{315.444\text{g}}$

$= 2.061 \times 10^{-2}$ mol

$$2.061 \times 10^{-2} \text{ mol } Ba(OH)_2 \cdot 8H_2O \times \frac{2 \text{ mol } NH_4SCN}{1 \text{mol } Ba(OH)_2 \cdot 8H_2O} = 4.121 \times 10^{-2} \text{ mol } NH_4SCN$$

Molar mass of $NH_4SCN = [2(14.01) + 4(1.008) + 32.07 + 12.01]$ g/mol

$= 76.132$ g/mol

4.121×10^{-2} mol $NH_4SCN \times \frac{76.132 g}{mol} = 3.137 g$

$= \underline{\underline{3.1 g}}$

(92) $C_7H_6O_3(aq) + C_4H_6O_3(aq) \longrightarrow C_9H_8O_4(s) + HC_2H_3O_2(aq)$

(a) Molar mass of salicilic acid $= [7(12.01) + 6(1.008) + 3(16.00)]$ g/mol

$= 138.118$ g/mol

# of moles of salicilic acid $= 1.00 \times 10^2 g \times \left(\frac{mol}{138.118 g}\right)$

$= 0.724$ mol

0.724 mol salicilic acid $\times \left(\frac{1 \text{ mol acetic anhydride}}{1 \text{ mol salicilic acid}}\right) =$ 0.724 mol acetic anhydride

Molar mass of acetic anhydride $= [4(12.01) + 6(1.008) + 3(16.00)]$ g/mol

$= 102.088$ g/mol

Mass of acetic anhydride $= 0.724 \text{ mol} \times \left(\frac{102.088 \text{ g}}{\text{mol}}\right)$

$= \underline{\underline{73.9 \text{ g}}}$

(b) $0.724 \text{ mol salicilic acid} \times \left(\frac{1 \text{ mol aspirin}}{1 \text{ mol salicilic acid}}\right)$

$= 0.724 \text{ mol aspirin}$

Molar mass of aspirin $= [9(12.01) + 8(1.008) + 4(16.00)] \text{ g/mol}$

$= 180.154 \text{ g/mol}$

$0.724 \text{ mol aspirin} \times \left(\frac{180.154}{1 \text{ mol}}\right) = 130.43 \text{ g}$

$= \underline{\underline{130 \text{ g aspirin}}}$

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$Ca_3(PO_4)_2(s) + 3H_2SO_4(aq) \rightarrow 3CaSO_4(s) + 2H_3PO_4(aq)$

1.0 kg $= 10^3$ g | $1.0 \text{ kg} = 10^3 \text{ g}$ 98% | ? g | ? g

Molar mass of $Ca_3(PO_4)_2 = [3(40.08) + 2(30.97) + 8(16.00)] \text{ g/mol}$

$= 310.18 \text{ g/mol}$

Molar mass of $H_2SO_4 = [2(1.008) + 32.07 + 4(16.00)] \text{ g/mol}$

$= 98.086 \text{ g/mol}$

\# of moles of $Ca_3(PO_4)_2 = 10^3 g \times \dfrac{mol}{310.18 g}$

$= 3.223 \, mol$

\# of grams of $H_2SO_4 = 10^3 g \times \dfrac{98}{100} = 980 g$

\# of moles of $H_2SO_4 = 980 g \times \dfrac{mol}{98.086 g} = 9.99 \, mol$

$\left.\begin{array}{l}\text{\# of moles of } H_2SO_4 \text{ required} \\ \text{to react with } 3.223 \text{ mol} \\ \text{of } Ca_3(PO_4)_2\end{array}\right\} = 3.223 \, mol \; Ca_3(PO_4)_2 \times \left(\dfrac{3 \, mol \; H_2SO_4}{1 \, mol \; Ca_3PO_4}\right)$

$= 9.672 \, mol \; H_2SO_4$

Since there are 9.99 mol H_2SO_4, there is excess H_2SO_4. Therefore the limiting reagent is $Ca_3(PO_4)_2$.

$3.223 \, mol \; Ca_3(PO_4)_2 \times \left(\dfrac{3 \, mol \; CaSO_4}{1 \, mol \; Ca_3(PO_4)_2}\right) = 9.669 \, mol \; CaSO_4$

$3.223 \, mol \; Ca_3(PO_4)_2 \times \left(\dfrac{2 \, mol \; H_3PO_4}{1 \, mol \; Ca_3(PO_4)_2}\right) = 6.446 \, mol \; H_3PO_4$

Molar mass of $CaSO_4 = [40.08 + 32.07 + 4(16.00)] \, g/mol$

$= 136.15 \, g/mol$

Molar mass of $H_3PO_4 = [3(1.008) + 30.97 + 4(16.00)]$ g/mol

$= 97.994$ g/mol

$$9.669 \text{ mol } CaSO_4 \times \left(\frac{136.15 \text{ g}}{1 \text{ mol } CaSO_4}\right) = 1316.43 \text{ g } CaSO_4$$

$$= \underline{\underline{1.3 \text{ kg } CaSO_4}}$$

$$6.446 \text{ mol } H_3PO_4 \times \left(\frac{97.994 \text{ g}}{1 \text{ mol } H_3PO_4}\right) = 631.67 \text{ g } H_3PO_4$$

$$= \underline{\underline{6.3 \times 10^2 \text{ g } H_3PO_4}}$$

100

$$C_7H_6O_3(aq) + C_4H_6O_3(aq) \rightarrow C_9H_8O_4(s) + HC_2H_3O_2(aq)$$

salicilic acid — acetic anhydride — aspirin

1.50g — 2.00g — (1.50g yield)

$$\#\text{ of moles of salicilic acid} = 1.50\text{g} \times \left(\frac{\text{mol}}{138.118\text{g}}\right)$$

$$= 1.086 \times 10^{-2} \text{ mol salicilic acid}$$

$$\#\text{ of moles of acetic anhydride} = 2.00\text{g} \times \left(\frac{\text{mol}}{102.088\text{g}}\right)$$

$$= 1.959 \times 10^{-2} \text{ mol acetic anhydride}$$

$$\left.\begin{array}{l}\#\text{ of moles of salicilic acid} \\ \text{needed to react with } 1.959 \times 10^{-2} \\ \text{mol acetic anhydride}\end{array}\right\} = 1.959 \times 10^{-2} \text{ mol acetic anhydride} \times \left(\frac{1 \text{ mol salicilic acid}}{1 \text{ mol acetic anhydride}}\right)$$

$$= 1.959 \times 10^{-2} \text{ mol salicilic acid}$$

There is only 1.086×10^{-2} mol salicilic acid.
Therefore salicilic acid is the limiting reagent.

$$\left.\begin{array}{l}\text{Amount of aspirin that can}\\ \text{be made from } 1.086\times10^{-2}\text{ mol}\\ \text{of salicilic acid}\end{array}\right\} = 1.086\times10^{-2}\text{ mol salicilic acid} \times \left(\frac{1\text{ mol aspirin}}{1\text{ mol salicilic acid}}\right)$$

$$= 1.086\times10^{-2}\text{ mol aspirin}$$

$$= 1.086\times10^{-2}\text{ mol aspirin} \times \left(\frac{180.15\text{ g}}{1\text{ mol aspirin}}\right)$$

theoretical yield $= \underline{\underline{1.96\text{ g aspirin}}}$

Percentage yields $= \dfrac{\text{actual yield}}{\text{theoretical yield}} \times 100\%$

$= \dfrac{1.50\text{ g}}{1.96\text{ g}} \times 100\%$

$= 76.67\ \%$

$= \underline{\underline{76.7\%}}$

(101) $2\,Cu_3FeS_3(s) + 7O_2(g) \longrightarrow 6\,Cu(s) + 2\,FeO(s) + 6\,SO_2(g)$

2.50 metric ton

$= 2.50 \times 1000$ kg

$= 2.50 \times 10^6$ g

$$\left.\begin{array}{l}\text{Molar mass of}\\ Cu_3FeS_3\end{array}\right\} = [3(63.55) + 55.85 + 3(32.07)]\text{ g/mol} = 342.71\text{ g/mol}$$

$$2.50 \times 10^6 \text{ g } Cu_3FeS_3 \times \left(\frac{\text{mol}}{342.71 \text{ g}}\right) = 7294.797 \text{ mol}$$

$$\left(\begin{array}{c}7294.797 \text{ mol} \\ Cu_3FeS_3\end{array}\right) \times \left(\frac{6 \text{ mol } Cu}{2 \text{ mol } Cu_3FeS_3}\right) = 21884.39 \text{ mol } Cu$$

$$= 2.1884 \times 10^4 \text{ mol } Cu$$

$$= 2.1884 \times 10^4 \text{ mol} \times \left(\frac{63.55 \text{ g } Cu}{1 \text{ mol } Cu}\right)$$

$$= 1.3908 \times 10^6 \text{ g } Cu$$

= theoretical yield.

actual yield = 86.3% of theoretical yield

$$= \frac{86.3}{100} \times 1.3908 \times 10^6 \text{ g } Cu$$

$$= 1.2002 \times 10^6 \text{ g } Cu$$

$$= 1.20 \times 10^6 \text{ g } Cu = \underline{\underline{1.20 \text{ metric tons of } Cu}}$$

(102) $P_4(s) + 6F_2(g) \longrightarrow 4PF_3(g)$

120. g

78.1% yield.

actual yield = 120. g PF_3

percentage yield = 78.1%.

78.1

$= 153.6\ g\ PF_3$

Molar mass of PF_3 $= [30.97 + 3(19.00)]\ g/mol$

$= 87.97\ g/mol$

\# of moles of PF_3 $= 153.6\ g \times \left(\frac{mol}{87.97\ g}\right)$

$= 1.746\ mol\ PF_3$.

$$1.746\ mol\ PF_3 \times \frac{6\ mol\ F_2}{4\ mol\ PF_3} = 2.619\ mol\ F_2$$

molar mass of F_2 $= 2(19.00)\ g/mol$

$= 38.00\ g/mol$

$$2.619\ mol\ F_2 \times \left(\frac{38.00\ g\ F_2}{1\ mol\ F_2}\right) = 99.525\ g\ F_2$$

$$= \underline{\underline{99.5\ g\ F_2}}$$