IB chem Topic 1 Problems

1) $2VO + 3Fe_2O_3 \rightarrow V_2O_5 + 6FeO$

2.0 g VO
5.75 g Fe_2O_3
? g V_2O_5

(theoretical Yield, Balancing Eqns, Limiting Reagent, Formula Mass, Stoichiometry, mol ratios)

$VO = 50.9415 + 15.9994 = 66.9409$, $V_2O_5 = 2(50.9415) + 5(15.9994) = 181.88$

$$2.0\,g\,VO\left(\frac{1\,mol\,VO}{66.9409\,g\,VO}\right)\left(\frac{1\,mol\,V_2O_5}{2\,mol\,VO}\right)\left(\frac{181.88\,g\,V_2O_5}{1\,mol\,V_2O_5}\right) = 2.7\ g\,V_2O_5$$

$$5.75\,g\,Fe_2O_3\left(\frac{1\,mol\,Fe_2O_3}{159.6922\,g\,Fe_2O_3}\right)\left(\frac{1\,mol\,V_2O_5}{3\,mol\,Fe_2O_3}\right)\left(\frac{181.88\,g\,V_2O_5}{1\,mol\,V_2O_5}\right) = \boxed{2.18\ g\,V_2O_5}$$

$Fe_2O_3 = 2(55.847) + 3(15.9994) = 159.6922$

L.R = Fe_2O_3, Theoretical yield of V_2O_5 = 2.18 g

2) 74.0% C, 8.65% H, 17.3% N ⇒ Empirical formula.

*assume a 100 g sample!

$$74.0\,g\,C\left(\frac{1\,mol\,C}{12.011\,g\,C}\right) = 6.16\,mol\,C \div 1.24 = 4.97 \Rightarrow 5$$

$$8.65\,g\,H\left(\frac{1\,mol\,H}{1.00794\,g\,H}\right) = 8.58\,mol\,H \div 1.24 = 6.92 \Rightarrow 7$$

$$17.3\,g\,N\left(\frac{1\,mol\,N}{14.00674\,g\,N}\right) = 1.24\,mol\,N \div 1.24 = 1 \Rightarrow 1$$

Empirical formula of Nicotine $C_5H_7N_1$

3) $Al_2(SO_4)_3(aq) + 3BaCl_2(aq) \rightarrow 3BaSO_4(s) + 2AlCl_3(aq)$
(Impure)

$1.000\,g\ Al_2(SO_4)_3 + \text{impurity} \rightarrow 2.000\,g\ BaSO_4$

(Balancing Eqns, Stoichiometry, % Composition)

$BaSO_4 = 233.39\ g/mol$ $Al_2(SO_4)_3 = 342.15\ g/mol$

$$2.000\,g\ BaSO_4\left(\frac{1\,mol\ BaSO_4}{233.39\,g\ BaSO_4}\right)\left(\frac{1\,mol\ Al_2(SO_4)_3}{3\,mol\ BaSO_4}\right)\left(\frac{342.15\,g\ Al_2(SO_4)_3}{1\,mol\ Al_2(SO_4)_3}\right) = 0.9773\,g\ Al_2(SO_4)_3$$

$$\left(\frac{0.9773\,g}{1.000\,g}\right)100 = \boxed{97.73\%\ Al_2(SO_4)_3 \text{ in the original sample.}}$$

4) M_3N $\frac{0.673\,g\ N}{1.00\,g\ M}$? atomic Mass of M ? identity of M (molar mass, mol ratios,)

$$0.673\,g\ N\left(\frac{1\,mol\ N}{14.00674\,g}\right)\left(\frac{3\,mol\ M}{1\,mol\ N}\right) = 0.144\ mol\ M$$

$$\text{molar mass} = \frac{g}{mol} \Rightarrow \frac{1.00\,g}{0.144\,mol} = \boxed{6.94\ g/mol = Li}$$

5) $Fe_2(SO_4)_3(aq) + 3BaCl_2(aq) \rightarrow 3BaSO_4(s) + 2FeCl_3$ (same as problem 1)

$$50.0\,g\ Fe_2(SO_4)_3\left(\frac{1\,mol\ Fe_2(SO_4)_3}{399.88\,g\ Fe_2(SO_4)_3}\right)\left(\frac{2\,mol\ FeCl_3}{1\,mol\ Fe_2(SO_4)_3}\right)\left(\frac{162.2\,g\ FeCl_3}{1\,mol\ FeCl_3}\right) = \boxed{40.6\ g\ FeCl_3}$$

$$100.0\,g\ BaCl_2\left(\frac{1\,mol\ BaCl_2}{208.23\,g\ BaCl_2}\right)\left(\frac{2\,mol\ FeCl_3}{3\,mol\ BaCl_2}\right)\left(\frac{162.2\,g\ FeCl_3}{1\,mol\ FeCl_3}\right) = 51.93\ g\ FeCl_3$$

$\boxed{LR = Fe_2(SO_4)_3,\ \text{theoretical yield of } FeCl_3 = 40.6\,g}$

6) $Eu \Rightarrow {}^{151}Eu\ (150.9196\,amu) + {}^{153}Eu\ (152.9209\,amu)$

Avg. Atomic mass Eu = 151.96 amu

? relative abundance of isotopes.

$150.9196(X) + 152.9209(1-X) = 151.96$

$150.9196x + 152.9209 - 152.9209x = 151.96$

$-152.9209 \qquad\qquad -152.9209$

$\frac{-2.0013X}{-2.0013} = \frac{-0.9609}{-2.0013} \qquad X = 0.48014$

${}^{151}Eu = 48.014\%$, ${}^{153}Eu = 51.986\%$

7) S_xN_y, $S = 69.6\%$, $S_xN_y = 184\,g/mol$

$N = 100\% - 69.6\% = 30.4\%$

$69.6g\,S\left(\frac{1\,mol\,S}{32.066g}\right) = 2.17\,mol\,S \div 2.17 = 1$

$30.4g\,N\left(\frac{1\,mol\,N}{14.00674g}\right) = 2.17\,mol\,N \div 2.17 = 1$

Empirical formula = SN

$SN = 46.07\,g/mol \qquad \frac{184\,g/mol}{46.07\,g/mol} = 3.994 \Rightarrow 4$

molecular formula = S_4N_4

8) $C_6H_{10}O_4 + 2NH_3 + 4H_2 \rightarrow C_6H_{16}N_2 + 4H_2O$

$C_6H_{10}O_4 = 122.12\ g/mol$, $C_6H_{16}N_2 = 116.21\ g/mol$

a) Theoretical yield

$$1.00\times10^3\ g\ C_6H_{10}O_4\left(\frac{1\ mol\ C_6H_{10}O_4}{146.07\ g}\right)\left(\frac{1\ mol\ C_6H_{16}N_2}{1\ mol\ C_6H_{10}O_4}\right)\left(\frac{116.21\ g}{1\ mol\ C_6H_{16}N_2}\right) = \boxed{7.96\times10^2\ g\ C_6H_{16}N_2}$$

b) % yield $= \left(\frac{\text{actual}}{\text{theoretical}}\right)100$

$$\left(\frac{765\ g}{796\ g}\right)100 = \boxed{96.1\ \%}$$

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9) $Al_2(SO_4)_3 \cdot XH_2O$

$47.64\ g - 39.92\ g = 7.72\ g\ H_2O$

$$7.72\ g\left(\frac{1\ mol\ H_2O}{18.015\ g}\right) = 0.429\ mol\ H_2O \div 0.0330 = 13$$

$39.92\ g - 28.64\ g = 11.28\ g\ Al_2(SO_4)_3$

$$11.28\ g\ Al_2(SO_4)_3\left(\frac{1\ mol\ Al_2(SO_4)_3}{342.15\ g}\right) = 0.0330\ mol\ Al_2(SO_4)_3 \div 0.0330 = 1$$

$\boxed{Al_2(SO_4)_3 \cdot 13H_2O}$

10) $BaX_2 + H_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2HX$

$0.158g\ BaX_2 \rightarrow 0.124g\ BaSO_4$

$0.124g\ BaSO_4\left(\frac{1mol\ BaSO_4}{233.39g}\right)\left(\frac{1mol\ Ba}{1mol\ BaSO_4}\right)\left(\frac{137.327g}{1mol\ Ba}\right) = 0.0730g\ Ba$

$0.158g - 0.0730g = 0.0850g\ X$

$0.124g\ BaSO_4\left(\frac{1mol\ BaSO_4}{233.39g}\right)\left(\frac{2mol\ X}{1mol\ BaSO_4}\right) = 0.00106mol\ X$

$\frac{0.0850g\ X}{0.00106mol\ X} = 80.2\ g/mol \Rightarrow Br$

Formula = $BaBr_2$

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11) $C_xH_yO_z + O_2 \longrightarrow CO_2 + H_2O$

$228.4mg \qquad 627.4mg \qquad 171.2mg$

*all C in $C_xH_yO_z$ comes from CO_2, all H from H_2O.

$0.6274g\left(\frac{1mol\ CO_2}{44.01g}\right)\left(\frac{1mol\ C}{1mol\ CO_2}\right)\left(\frac{12.011g\ C}{1mol\ C}\right) = 0.1712g\ C$

$0.1712g\ H_2O\left(\frac{1mol\ H_2O}{18.015g}\right)\left(\frac{2mol\ H}{1mol\ H_2O}\right)\left(\frac{1.008g\ H}{1mol\ H}\right) = 0.01916g\ H$

%comp: $\frac{0.1712g}{0.2284g}(100) = 74.96\%\ C$, $\frac{0.01916g}{0.2284g}(100) = 8.389\%\ H$

$100\% - 74.96\% - 8.389\% = 16.65\%\ O$

Empirical form.:

$74.96g\ C\left(\frac{1mol\ C}{12.011g}\right) = 6.241mol\ C \div 1.041 = 5.995 \Rightarrow 6$

$8.389g\ H\left(\frac{1mol\ H}{1.00794g}\right) = 8.323mol\ H \div 1.041 = 7.995 \Rightarrow 8$

$16.65g\ O\left(\frac{1mol\ O}{15.9994g}\right) = 1.041mol\ O \div 1.041 = 1$

C_6H_8O