

IB Chem Topic 1 Problems



2.0g VO

5.75g Fe₂O₃

? g V₂O₅

(theoretical yield, Balancing Equations
Limiting Reagent, Formula Mass
Stoichiometry, mol ratios)

$\text{VO} = 50.9415 + 15.9994 = 66.9409$, $\text{V}_2\text{O}_5 = 2(50.9415) + 5(15.9994) = 181.88$

$2.0\text{g VO} \left(\frac{1\text{mol VO}}{66.9409\text{g VO}} \right) \left(\frac{1\text{mol V}_2\text{O}_5}{2\text{mol VO}} \right) \left(\frac{181.88\text{g V}_2\text{O}_5}{1\text{mol V}_2\text{O}_5} \right) = 2.7\text{g V}_2\text{O}_5$

$5.75\text{g Fe}_2\text{O}_3 \left(\frac{1\text{mol Fe}_2\text{O}_3}{159.6922\text{g Fe}_2\text{O}_3} \right) \left(\frac{1\text{mol V}_2\text{O}_5}{3\text{mol Fe}_2\text{O}_3} \right) \left(\frac{181.88\text{g V}_2\text{O}_5}{1\text{mol V}_2\text{O}_5} \right) = \boxed{2.18\text{g V}_2\text{O}_5}$

$\text{Fe}_2\text{O}_3 = 2(55.847) + 3(15.9994) = 159.6922$

LR = Fe₂O₃, Theoretical yield of V₂O₅ = 2.18g

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

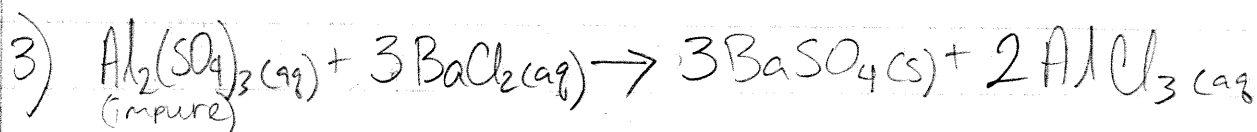
*assume a 100g sample!

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

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

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

Empirical formula of Nicotine C₅H₇N₁

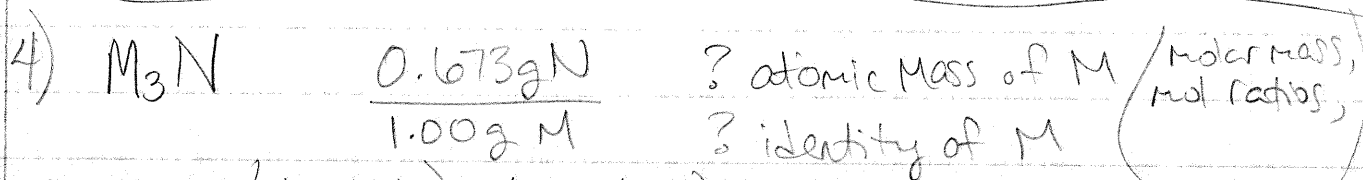


(Balancing Eqns, Stoichiometry, % Composition)

$$\text{BaSO}_4 = 233.39 \text{ g/mol} \quad \text{Al}_2(\text{SO}_4)_3 = 342.15 \text{ g/mol}$$

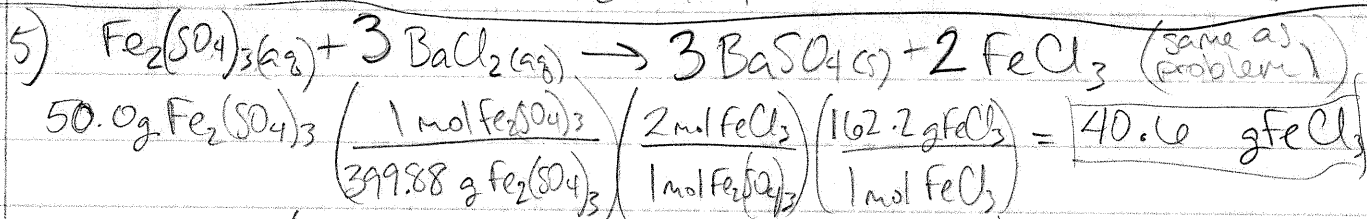
$$2.000 \text{ g BaSO}_4 \left(\frac{1 \text{ mol BaSO}_4}{233.39 \text{ g BaSO}_4} \right) \left(\frac{1 \text{ mol Al}_2(\text{SO}_4)_3}{3 \text{ mol BaSO}_4} \right) \left(\frac{342.15 \text{ g Al}_2(\text{SO}_4)_3}{1 \text{ mol Al}_2(\text{SO}_4)_3} \right) = 0.9773 \text{ g Al}_2(\text{SO}_4)_3$$

$$\left(\frac{0.9773 \text{ g}}{1.000 \text{ g}} \right) 100 = \boxed{97.73\% \text{ Al}_2(\text{SO}_4)_3 \text{ in the original sample.}}$$



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

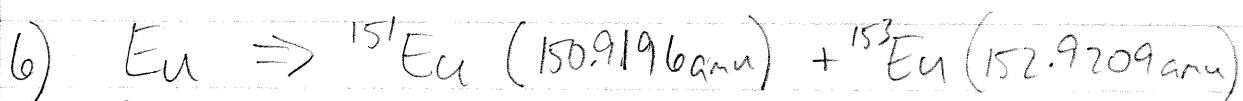
$$\text{molar mass} = \frac{\text{g}}{\text{mol}} \Rightarrow \frac{1.00 \text{ g}}{0.144 \text{ mol}} = \boxed{6.94 \text{ g/mol} = \text{Li}}$$



$$50.0 \text{ g Fe}_2(\text{SO}_4)_3 \left(\frac{1 \text{ mol Fe}_2(\text{SO}_4)_3}{399.88 \text{ g Fe}_2(\text{SO}_4)_3} \right) \left(\frac{2 \text{ mol FeCl}_3}{1 \text{ mol Fe}_2(\text{SO}_4)_3} \right) \left(\frac{162.2 \text{ g FeCl}_3}{1 \text{ mol FeCl}_3} \right) = \boxed{40.6 \text{ g FeCl}_3}$$

$$100.0 \text{ g BaCl}_2 \left(\frac{1 \text{ mol BaCl}_2}{208.23 \text{ g BaCl}_2} \right) \left(\frac{2 \text{ mol FeCl}_3}{3 \text{ mol BaCl}_2} \right) \left(\frac{162.2 \text{ g FeCl}_3}{1 \text{ mol FeCl}_3} \right) = 51.93 \text{ g FeCl}_3$$

$$\boxed{\text{LR} = \text{Fe}_2(\text{SO}_4)_3, \text{ theoretical yield of FeCl}_3 = 40.6 \text{ g}}$$



Avg. Atomic mass Eu = 151.96 amu

? relative abundance of isotopes.

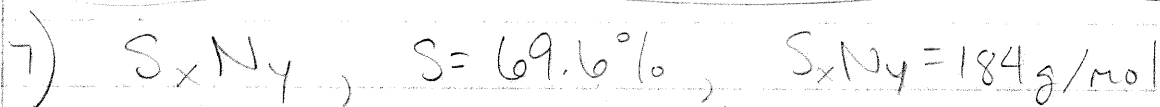
$$150.9196(x) + 152.9209(1-x) = 151.96$$

$$150.9196x + 152.9209 - 152.9209x = 151.96$$

$-152.9209 \qquad \qquad \qquad -152.9209$

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

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



$$\text{N} = 100\% - 69.6\% = 30.4\%$$

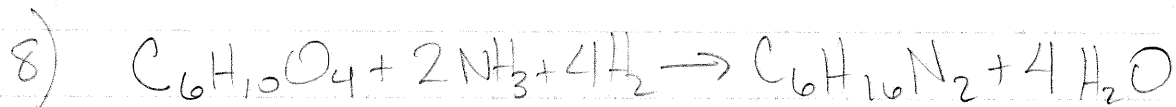
$$69.6 \text{ g S} \left(\frac{1 \text{ mol S}}{32.066 \text{ g}} \right) = 2.17 \text{ mol S} \div 2.17 = 1$$

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

Empirical formula = SN

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

molecular formula = S_4N_4



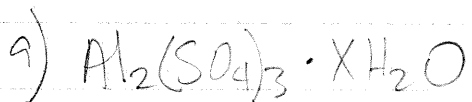
$$\text{C}_6\text{H}_{10}\text{O}_4 = 146.07 \text{ g/mol}, \text{C}_6\text{H}_{16}\text{N}_2 = 116.21 \text{ g/mol}$$

a) Theoretical yield

$$1.00 \times 10^3 \text{ g C}_6\text{H}_{10}\text{O}_4 \left(\frac{1 \text{ mol C}_6\text{H}_{10}\text{O}_4}{146.07 \text{ g}} \right) \left(\frac{1 \text{ mol C}_6\text{H}_{16}\text{N}_2}{1 \text{ mol C}_6\text{H}_{10}\text{O}_4} \right) \left(\frac{116.21 \text{ g}}{1 \text{ mol C}_6\text{H}_{16}\text{N}_2} \right) = \boxed{7.96 \times 10^2 \text{ g C}_6\text{H}_{16}\text{N}_2}$$

b) % Yield = $\frac{\text{actual}}{\text{theoretical}} \times 100$

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

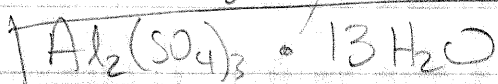


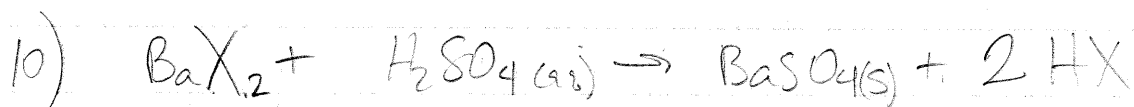
$$47.64 \text{ g} - 39.92 \text{ g} = 7.72 \text{ g H}_2\text{O}$$

$$7.72 \text{ g} \left(\frac{1 \text{ mol H}_2\text{O}}{18.015 \text{ g}} \right) = 0.429 \text{ mol H}_2\text{O} \div 0.0330 = 13$$

$$39.92 \text{ g} - 28.64 \text{ g} = 11.28 \text{ g Al}_2(\text{SO}_4)_3$$

$$11.28 \text{ g Al}_2(\text{SO}_4)_3 \left(\frac{1 \text{ mol Al}_2(\text{SO}_4)_3}{342.15 \text{ g}} \right) = 0.0330 \text{ mol Al}_2(\text{SO}_4)_3 \div 0.0330 = 1$$





$$0.124\text{g BaSO}_4 \left(\frac{1\text{mol BaSO}_4}{233.39\text{g}} \right) \left(\frac{1\text{mol Ba}}{1\text{mol BaSO}_4} \right) \left(\frac{137.327\text{g}}{1\text{mol Ba}} \right) = 0.0730\text{g Ba}$$

$$0.158\text{g} - 0.0730\text{g} = 0.0850\text{g X}$$

$$0.124\text{g BaSO}_4 \left(\frac{1\text{mol BaSO}_4}{233.39\text{g}} \right) \left(\frac{2\text{mol X}}{1\text{mol BaSO}_4} \right) = 0.00106\text{mol X}$$

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

Formula = BaBr₂



228.4mg

627.4mg

171.2mg

*all C in C_xH_yO_z comes from CO₂, all H from H₂O.

$$0.6274\text{g} \left(\frac{1\text{mol CO}_2}{44.01\text{g}} \right) \left(\frac{1\text{mol C}}{1\text{mol CO}_2} \right) \left(\frac{12.011\text{g C}}{1\text{mol C}} \right) = 0.1712\text{g C}$$

$$0.1712\text{g H}_2\text{O} \left(\frac{1\text{mol H}_2\text{O}}{18.015\text{g}} \right) \left(\frac{2\text{mol H}}{1\text{mol H}_2\text{O}} \right) \left(\frac{1.008\text{g H}}{1\text{mol H}} \right) = 0.01916\text{g H}$$

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

$$100\% - 74.96\% - 8.389\% = 16.65\% \text{ O}$$

Empirical
form.

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

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

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

C₆H₈O