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Chemistry 1094 Spring 2018 Test 3

Wednesday, March 21, 2018 Time: 1 hour 50 minutes

Name: ANSWERS Student Number: _____

*This test consists of **six** pages of questions and a periodic table. Please ensure that you have a complete paper and, if you do not, obtain one from me **immediately**. There are **36** marks available. Good luck!*

1) **[3 marks]** A compound has been found to have the empirical formula C_2HNO_2. If the molar mass of the compound is known to be between 170 and 240 grams, what is the molecular formula of the compound?

C_2HNO_2 MM is ~ $2\times12+1+14+2\times16 = 71$ g

So "n" Falls in the range

$\frac{170}{71} = 2.4$ to $\frac{240}{71} = 3.4$ The only whole # in this range is 3, so MF must be $\boxed{C_6H_3N_3O_6}$

2) **[3 marks]** If you react 20.0 grams of $CaCl_2$ (111.0 g/mol) with excess K_3P, how many grams of Ca_3P_2 (182.2 g/mol) should you collect?

$3CaCl_2(aq) + 2K_3P(aq) \longrightarrow Ca_3P_2(s) + 6KCl(aq)$

$20.0\text{g } CaCl_2 \times \frac{1\text{mol}}{111.0\text{g}} \times \frac{1\ Ca_3P_2}{3\ CaCl_2} \times 182.2\frac{\text{g}}{\text{mol}}$

$= \boxed{10.94\text{ g}}$

3) **[4 marks]** A 701.4-mg sample of a compound of formula $M_2(SO_4)_3$ was reacted with excess $BaCl_2$:

$M_2(SO_4)_3(aq) + 3BaCl_2(aq) \longrightarrow 3BaSO_4(s) + 2MCl_3(aq)$

A total of 1435.3 mg of $BaSO_4$ (233.38 g/mol) was collected. What is the metal, M?

$1435.3\times10^{-3}\,g\,BaSO_4 \times \frac{1\,mol}{233.38\,g} \times \frac{1\,M_2(SO_4)_3}{3\,BaSO_4} = 2.05\times10^{-3}\,mol\,M_2(SO_4)_3$

$\therefore\ 2.05\times10^{-3}\,mol\,M_2(SO_4)_3 = 701.4\,mg\,M_2(SO_4)_3$

$+\ 1\,mol\,M_2(SO_4)_3 = 342.1\,g$

So $2M + 3\times32.065 + 12\times15.999 = 342.1\,g$

$\Rightarrow M = 26.98$, which is **Al**

4) **[4 marks]** How many grams of 80.0-percent pure $AgNO_3$ (169.9 g/mol) are necessary to produce 3.546 grams of Ag_3P (354.6 g/mol)?

$3AgNO_3(aq) + Na_3P(aq) \longrightarrow Ag_3P(s) + 3NaNO_3(aq)$

If the mass of impure $AgNO_3$ is X g, then...

$X\,g \times \frac{80\,g\,AgNO_3}{100\,g} \times \frac{1\,mol}{169.9\,g} \times \frac{1\,Ag_3P}{3\,AgNO_3} \times \frac{354.6\,g}{1\,mol} = 3.546\,g\,Ag_3P$

Solving for X gives...

$X =$ **6.37125 g**

5) **[3 marks]** If you made a solution using 30.0 grams of ethanol (molar mass 46.07 grams) and 12.0 grams of water (molar mass 18.02 grams), which compound would be the solute, and which the solvent? *(Note: Show all your work and reasoning to receive any credit for your answer.)*

$30\,g \times \frac{1\,mol}{46.07\,g} = 0.651\ mol\ eth.$

$12\,g \times \frac{1\,mol}{18.02\,g} = 0.666\ mol\ H_2O$

Solvent: water (greater # of moles)

Solute: ethanol (smaller # of moles)

6) **[4 marks]** A 15.00-mL aliquot of 0.500 M NaCl was taken and diluted to 200.0 mL to form solution **A**. A 25.00-mL aliquot of solution **A** was taken and diluted to 250.0 mL to form solution **B**. If you had 1.00 litres of solution **B**, how many **grams** of NaCl (58.44 g/mol) would it contain?

$$\frac{15.00\times10^{-3}\,L \times 0.5\,\frac{moles\ NaCl}{L}}{200\times10^{-3}\,L} = 0.0375\ M\ NaCl$$

$$\frac{25.00\times10^{-3}\,L \times 0.0375\,\frac{moles\ NaCl}{L}}{250.0\times10^{-3}\,L} = 3.75\times10^{-3}\ M\ NaCl$$

$$3.75\times10^{-3}\,\frac{moles\ NaCl}{L} \times 1\,L \times 58.44\,\frac{g}{mol} = \boxed{0.21915\,g\ NaCl}$$

7) **[3 marks]** A 25.00-mL aliquot of H_3PO_4 was taken and titrated with 45.00 mL of 0.01000 M NaOH:

$3NaOH(aq) + H_3PO_4(aq) \longrightarrow Na_3PO_4(aq) + 3H_2O(l)$

What was the concentration of the H_3PO_4?

$45.00 \times 10^{-3}\,L \times 0.01 \frac{moles}{L} NaOH \times \frac{1\,H_3PO_4}{3\,NaOH} = 1.5 \times 10^{-4}\,moles\ H_3PO_4$

$[H_3PO_4] = \frac{1.5 \times 10^{-4}\,moles}{25.00 \times 10^{-3}\,L} = \boxed{6 \times 10^{-3}\,M\ H_3PO_4}$

8) **[8 marks total]** A 50.97-gram sample of $AgNO_3$ (169.9 g/mol) was reacted with 20.00 grams of Na_3P (100.0 g/mol).

$3AgNO_3(aq) + Na_3P(aq) \longrightarrow Ag_3P(s) + 3NaNO_3(aq)$

a) **[3 marks]** Identify the limiting reagent.

$$50.97\,g\ AgNO_3 \times \frac{1\ mol}{169.9\,g} \times \frac{1\ Ag_3P}{3\ AgNO_3} = 0.1\ moles\ Ag_3P$$

$$20.00\,g\ Na_3P \times \frac{1\ mol}{100.0\,g} \times \frac{1\ Ag_3P}{1\ Na_3P} = 0.2\ moles\ Ag_3P$$

$\therefore$ $AgNO_3$ is LR

b) **[2 marks]** How many grams of Ag_3P (354.6 g/mol) should be collected?

$$0.1\ moles\ Ag_3P \times \frac{354.6\,g}{1\ mol} = 35.46\,g$$

c) **[3 marks]** How many grams of which reagent will remain unreacted after the reaction is complete?

$$20.g\ Na_3P - 50.97\,g\ AgNO_3 \times \frac{1\ mol}{169.9\,g} \times \frac{1\ Na_3P}{3\ AgNO_3} \times \frac{100\,g}{mol}$$

$= 10\,g\ Na_3P$

9) **[4 marks]** How many grams of $AgNO_3$ (169.9 g/mol) are necessary to produce 3.1914 grams of Ag_3P (354.6 g/mol) if the reaction

$3AgNO_3(aq) + Na_3P(aq) \longrightarrow Ag_3P(s) + 3NaNO_3(aq)$

is known to proceed with a 90.00 percent yield?

Let mass of $AgNO_3$ be X g;

then...

$$X\text{ g } AgNO_3 \times \frac{1\text{ mol}}{169.9\text{ g}} \times \frac{1\,Ag_3P}{3\,AgNO_3} \times \frac{354.6\text{ g}}{1\text{ mol}} \times \frac{90\text{ g}}{100\text{ g}} = 3.1914\text{ g}$$

Solving for X gives...

$X = \boxed{5.097\text{ g } AgNO_3}$