

Chemistry 1105 Spring 2011 test 2

Friday, February 25, 2011

Time: 1 hour 50 minutes

Name: ANSWERS

Student number: _____

This test consists of **seven** pages of questions, a page of useful constants, and a periodic table. Please ensure you have a complete paper and, if you do not, obtain one from me immediately. There are **30** marks (and four bonus marks) available. Good luck!

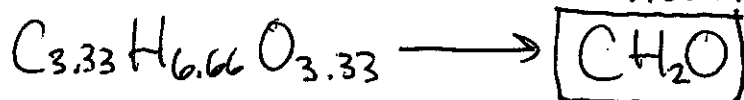
- 1) [5 marks total] "Compound X" is known to be 40.0010 percent carbon by mass, 53.2852 percent oxygen by mass, and the rest hydrogen.

- a) [2 marks] What is the empirical formula of "Compound X"?

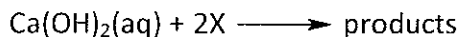
$$40.0010 \text{ g C} \times \frac{1 \text{ mol}}{12.0107 \text{ g}} = 3.33045 \text{ moles C}$$

$$53.2852 \text{ g O} \times \frac{1 \text{ mol}}{15.9994 \text{ g}} = 3.33045 \text{ moles O}$$

$$(100 - 40.0010 - 53.2852) \text{ g H} \times \frac{1 \text{ mol}}{1.00794 \text{ g}} = 6.6609 \text{ moles H}$$



- b) [3 marks] "Compound X" reacts with calcium hydroxide according to the balanced reaction:



A 0.1201-gram sample of "Compound X" required 20.0 mL of 0.0500 M Ca(OH)_2 for complete reaction. What is the molecular formula of "Compound X"?

$$20.0 \text{ mL} \times \frac{0.0500 \text{ moles Ca(OH)}_2}{1000 \text{ mL}} \times \frac{2\text{X}}{1 \text{ Ca(OH)}_2} = 2 \times 10^{-3} \text{ moles X}$$

$$\frac{0.1201 \text{ g}}{2 \times 10^{-3} \text{ moles}} = \frac{60.05 \text{ g}}{\text{mol}}$$

$$\text{EF mass} = 12.0107$$

$$+ 2 \times 1.00794$$

$$+ 15.9994$$

$$\hline 30.0260$$

$$\frac{60.05}{30.026} \approx 2, \text{ so MF is } \boxed{\text{C}_2\text{H}_4\text{O}_2}$$

2) [6 marks] A 0.2763-gram sample of "Compound Y" was burned in excess oxygen and 0.3961 g of CO_2 (44.01 g/mol) and 0.2162 g of H_2O (18.02 g/mol) collected.

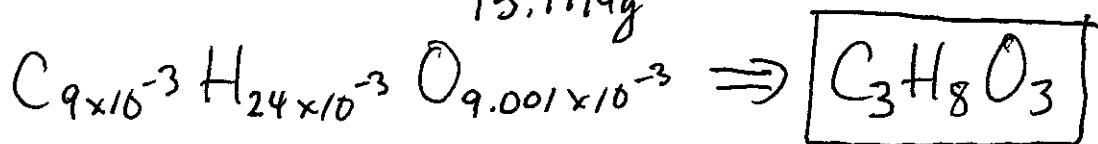
a) What is the empirical formula of "Compound Y"?

$$\text{moles C: } 0.3961 \text{ g } \text{CO}_2 \times \frac{1 \text{ mol}}{44.01 \text{ g}} \times \frac{1 \text{ C}}{1 \text{ CO}_2} = 9.000 \times 10^{-3}$$

$$\text{moles H: } 0.2162 \text{ g } \text{H}_2\text{O} \times \frac{1 \text{ mol}}{18.02 \text{ g}} \times \frac{2 \text{ H}}{1 \text{ H}_2\text{O}} = 24.00 \times 10^{-3}$$

$$\begin{aligned} \text{mass O: } & 0.2763 \text{ g} - 9.000 \times 10^{-3} \text{ moles C} \times \frac{12.0107 \text{ g}}{\text{mol}} - 24.00 \times 10^{-3} \text{ moles H} \\ & \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \times \frac{1.00794 \text{ g}}{\text{mol}} \\ & = 0.1440 \text{ g} \end{aligned}$$

$$\text{moles O: } 0.1440 \text{ g O} \times \frac{1 \text{ mol}}{15.9994 \text{ g}} = 9.001 \times 10^{-3}$$



b) As a gas, "Compound Y" has a density of 1.882 g/L at 25°C and 0.500 atm pressure. What is the molecular formula of "Compound Y"?

$$\text{MM} = \frac{DRT}{P} = \frac{1.882 \frac{\text{g}}{\text{L}} \times 0.0820575 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}} \times 298.15 \text{ K}}{0.500 \text{ atm}}$$

$$0.500 \text{ atm}$$

$$= 92.09 \frac{\text{g}}{\text{mol}}$$

$$3 \times 12.0107$$

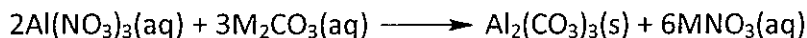
$$+ 8 \times 1.00794$$

$$+ 3 \times 15.9994$$

$$\hline 92.0938$$

$$\frac{92.09}{92.0938} \approx 1, \text{ so MF is } \boxed{\text{C}_3\text{H}_8\text{O}_3}$$

- 3) [3 marks] A 0.6359-gram sample of M_2CO_3 (where "M" is an unknown metal) gave 0.4680 grams of $Al_2(CO_3)_3$ (234.0 g/mol) when reacted with excess $Al(NO_3)_3$:



What is the metal, M?

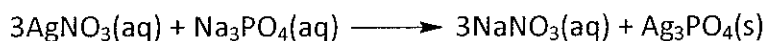
$$0.4680 \text{ g } Al_2(CO_3)_3 \times \frac{1 \text{ mol}}{234.0 \text{ g}} \times \frac{3M_2CO_3}{1Al_2(CO_3)_3} = 6.000 \times 10^{-3} \text{ moles } M_2CO_3$$

$$\frac{0.6359 \text{ g}}{6.000 \times 10^{-3} \text{ moles}} = 106.0 \frac{\text{g}}{\text{mol}}$$

$$\text{So: } 2M + 12.0107 + 3 \times 15.9994 = 106.0$$

$$\Rightarrow M = 23.0 \frac{\text{g}}{\text{mol}}, \text{ which is } \boxed{\text{Na}}$$

- 4) [3 marks] How many grams of 80.0-percent pure $AgNO_3$ (pure $AgNO_3$ molar mass 169.9 g/mol) are necessary to prepare 41.86 grams of Ag_3PO_4 (418.6 g/mol) if the reaction



is known to proceed with a 62.5 percent yield?

$$41.86 \text{ g} \times \frac{100}{62.5} \times \frac{1 \text{ mol}}{418.6 \text{ g}} \times \frac{3AgNO_3}{1Ag_3PO_4} \times \frac{169.9 \text{ g}}{\text{mol}} \times \frac{100}{80.0}$$

$$= \boxed{102 \text{ g}}$$

- 5) [2 marks] A 10.00-mL aliquot of solution A was diluted to 100.0 mL to form solution B. If solution B had an $[\text{NaCl}] = 1.0 \times 10^{-3} \text{ M}$, what was the $[\text{NaCl}]$ in solution A?

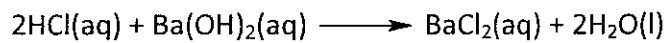
$$\frac{1.0 \times 10^{-3} \frac{\text{moles}}{\text{L}} \times 100.0 \text{ mL}}{10.00 \text{ mL}} = \boxed{1.0 \times 10^{-2} \text{ M}}$$

- 6) [3 marks] A solution of HX (where "X" is some unknown element) has a concentration of 12.39 M, a density of 1.189 g/cm^3 , and is 38 percent HX by mass. What is the element, X?

$$1.189 \frac{\text{g}}{\text{cm}^3} \times \frac{1000 \text{ cm}^3}{\text{L}} \times \frac{38 \text{ g HX}}{100 \text{ g sol'n}} \times \frac{1 \text{ L}}{12.39 \text{ moles}} = 36 \frac{\text{g}}{\text{mol}}$$

Therefore the molar mass of X must be 35 g,
which is $\boxed{\text{Cl}}$

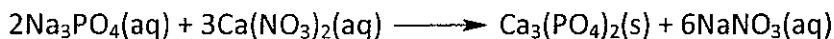
- 7) [2 marks] How many millilitres of 0.0500 M Ba(OH)₂ are needed to react with 40.00 mL of 0.0750 M HCl?



$$40.00\text{ mL} \times \frac{0.0750\text{ moles HCl}}{1000\text{ mL}} \times \frac{1\text{ Ba}(\text{OH})_2}{2\text{ HCl}} \times \frac{1000\text{ mL}}{0.0500\text{ moles}}$$

$$= \boxed{30.0\text{ mL}}$$

- 8) [6 marks] A 20.0-mL aliquot of 0.200 M Na_3PO_4 was mixed with 27.0 mL of 0.200 M $\text{Ca}(\text{NO}_3)_2$:



- a) How many grams of $\text{Ca}_3(\text{PO}_4)_2$ (310.2 g/mol) should be collected, assuming 100 percent yield?

$$20.0 \text{ mL} \times \frac{0.200 \text{ moles Na}_3\text{PO}_4}{1000 \text{ mL}} \times \frac{1 \text{ Ca}_3(\text{PO}_4)_2}{2 \text{ Na}_3\text{PO}_4} = \cancel{2.00 \times 10^{-3}} \text{ moles Ca}_3(\text{PO}_4)_2$$

$$27.0 \text{ mL} \times \frac{0.200 \text{ moles Ca}(\text{NO}_3)_2}{1000 \text{ mL}} \times \frac{1 \text{ Ca}_3(\text{PO}_4)_2}{3 \text{ Ca}(\text{NO}_3)_2} = 1.80 \times 10^{-3} \text{ moles Ca}_3(\text{PO}_4)_2$$

$$\therefore \text{ get } 1.80 \times 10^{-3} \text{ moles Ca}_3(\text{PO}_4)_2 \times \frac{310.2 \text{ g}}{\text{mol}} = \boxed{0.558 \text{ g}}$$

- b) What is the excess reagent, and what should its concentration be after reaction?

ER is Na_3PO_4 :

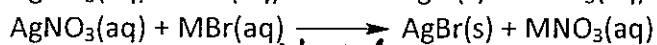
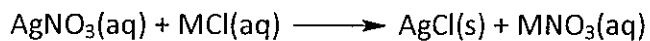
$$\left(2.00 \times 10^{-3} \text{ moles Ca}_3(\text{PO}_4)_2 - 1.80 \times 10^{-3} \text{ moles Ca}_3(\text{PO}_4)_2 \right) \times \frac{2 \text{ Na}_3\text{PO}_4}{1 \text{ Ca}_3(\text{PO}_4)_2}$$

0.0470 L

$$= \boxed{8.5 \times 10^{-3} \frac{\text{moles}}{\text{L}}}$$

Bonus question

[4 marks] When a certain mass of MCl ("M" is an unknown metal) is reacted with excess AgNO₃, 1.4332 grams of AgCl (143.32 g/mol) are collected. When the exact same mass of MBr ("M" is the same unknown metal) is used, 0.9165 grams of AgBr (187.77 g/mol) are collected. What is the unknown metal, M?



Let mass ^{metal halide} used be "m" grams, and let ^{the molar mass of "M" be} ~~this molar mass be~~ "M" g.

Then:

$$m \text{ g MCl} \times \frac{1 \text{ mol}}{(M + 35.4527) \text{ g}} \times \frac{1 \text{ AgCl}}{1 \text{ MCl}} \times \frac{143.32 \text{ g}}{1 \text{ mol}} = 1.4332 \text{ g AgCl}$$

$$\text{or: } \frac{m \times 143.32}{M + 35.4527} = 1.4332$$

which rearranges to:

$$\frac{1.4332(M + 35.4527)}{143.32} = m$$

For MBr, we get:

$$\frac{0.9165(M + 79.904)}{187.77} = m$$

$$\text{So that } \frac{1.4332(M + 35.4527)}{143.32} = \frac{0.9165(M + 79.904)}{187.77}$$

Which gives $M = 6.93$, which is Li (or very close to it)