

Chemistry 1105 R11 Fall 2011 Test 2

Friday, October 28, 2011

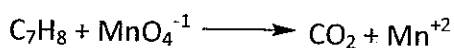
Time: 1 hour 50 minutes

Name: ANSWERS

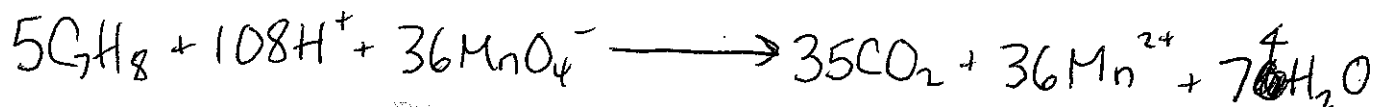
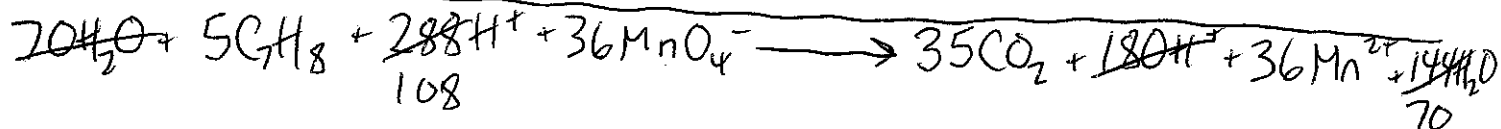
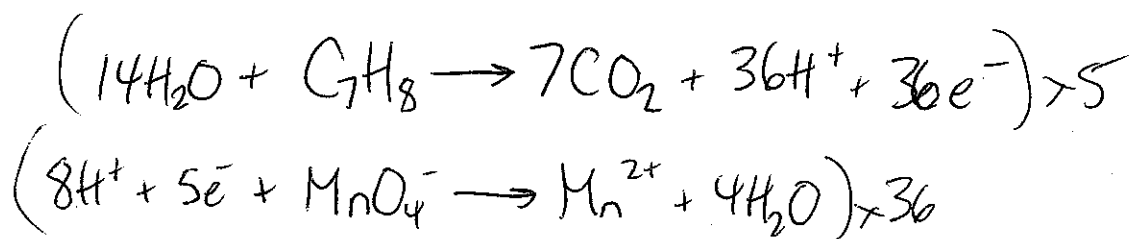
Student Number: _____

This test consists of **seven** pages of questions, a periodic table, and a page of useful constants. Please ensure you have a complete paper and, if you do not, obtain one from me **immediately**. There are **36** marks (and one bonus mark) available. Good luck!

- 1) [6 marks total] Given the following (unbalanced) redox reaction, that occurs in acidic solution:



- a) [3 marks] Balance the reaction.



- b) [1 mark] Which species is the oxidizing agent? MnO_4^-

- c) [1 mark] Which species is reduced? MnO_4^-

- d) [1 mark] How many electrons are in the reduction half-reaction? 5

2) [4 marks] "Compound X" is known to be 2.144 percent hydrogen by mass, 68.062 percent oxygen by mass, and the rest nitrogen.

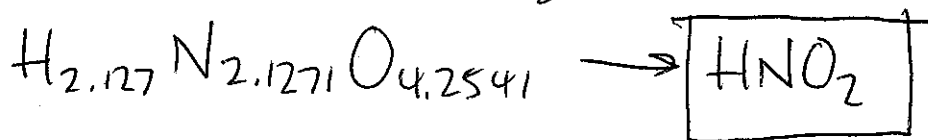
a) [2 marks] What is the empirical formula of "Compound X"?

$$m_{\text{N}} = (100 - 2.144 - 68.062) \text{ g} = 29.794 \text{ g}$$

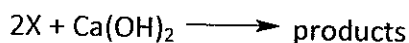
$$n_{\text{H}} = 2.144 \text{ g H} \times \frac{1 \text{ mol}}{1.0079 \text{ g}} = 2.127 \text{ mol}$$

$$n_{\text{O}} = 68.062 \text{ g O} \times \frac{1 \text{ mol}}{15.999 \text{ g}} = 4.2541 \text{ mol}$$

$$n_{\text{N}} = 29.794 \text{ g} \times \frac{1 \text{ mol}}{14.007 \text{ g}} = 2.1271 \text{ mol}$$



b) [2 marks] "Compound X" reacts with calcium hydroxide according to the (balanced) equation



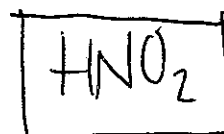
It took 20.00 mL of 0.05000 M $\text{Ca}(\text{OH})_2$ to titrate 94.0 mg of "Compound X." What is the molecular formula of "Compound X"?

$$n_{\text{X}} = 20.00 \text{ mL} \times 0.05000 \frac{\text{moles}}{\text{L}} \times \frac{2\text{X}}{1 \text{ Ca}(\text{OH})_2} = 2.000 \text{ mmol X}$$

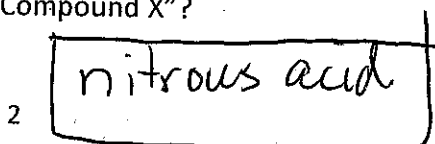
$$\frac{94.0 \text{ mg}}{2 \text{ mmol}} = 47.0 \frac{\text{g}}{\text{mol}}$$

$$\left. \begin{array}{l} \text{H} \quad 1 \\ \text{N} \quad 14 \\ 2 \times \text{Oxy} \quad 32 \end{array} \right\} 47 \frac{\text{g}}{\text{mol}}$$

MM = EFM, so MF is



c) [bonus - 1 mark] What is the name of "Compound X"?



- 3) [5 marks total] "Compound Y" is known to contain carbon, hydrogen, and oxygen. A 1761-mg sample of "Compound Y" was burned and 720.6 mg of H_2O (18.015 g/mol) and 2640.54 mg of CO_2 (44.009 g/mol) collected.

a) [3 marks] What is the empirical formula of "Compound Y"?

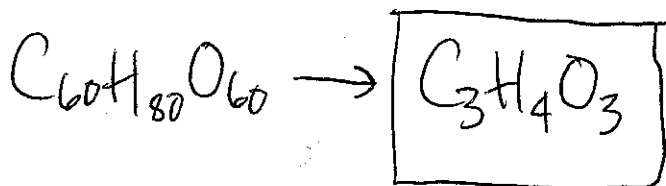
$$n_{\text{C}}: 2640.54 \text{ mg} \overset{\text{CO}_2}{\underset{\text{g}}{\times}} \frac{1 \text{ mol}}{44.009 \text{ g}} \times \frac{1 \text{ C}}{1 \text{ CO}_2} = 60 \text{ mmol C}$$

$$n_{\text{H}}: 720.6 \text{ mg} \text{H}_2\text{O} \times \frac{1 \text{ mol}}{18.015 \text{ g}} \times \frac{2 \text{ H}}{1 \text{ H}_2\text{O}} = 80 \text{ mmol H}$$

$$m_{\text{Ox}}: 1761 \text{ mg} - 60 \text{ mmol C} \times \frac{12.011 \text{ g}}{\text{mol}} - 80 \text{ mmol H} \times \frac{1.0079 \text{ g}}{\text{mol}}$$

$$= 959.708 \text{ mg O}$$

$$n_{\text{Ox}} = 959.708 \text{ mg O} \times \frac{1 \text{ mol}}{15.999 \text{ g}} = 60. \text{ mmol O}$$



- b) [2 marks] As a gas, "Compound Y" has a density of 1.761 g/L at 336.18°C and 0.500 atm pressure. What is the molecular formula of "Compound Y"?

$$\text{MM} = \frac{DRT}{P} = \frac{1.761 \frac{\text{g}}{\text{L}} \times 0.0820575 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \times 609.33 \text{ K}}{0.500 \text{ atm}}$$

$$= 176.1 \frac{\text{g}}{\text{mol}}$$

$$\frac{3 \times 12}{4 \times 1} = 3, \quad \frac{176}{88} = 2, \text{ so MF is } \boxed{\text{C}_6\text{H}_8\text{O}_6}$$

- 4) [3 marks] A 530.0-mg sample of a compound of formula M_2CO_3 (where M is an unknown element) was reacted with excess aluminum chloride:



A total of 390.0 mg of $Al_2(CO_3)_3$ (234.0 g/mol) were collected. What is the metal, M?

$$390.0 \text{ mg } Al_2(CO_3)_3 \times \frac{1 \text{ mol}}{234.0 \text{ g}} \times \frac{3 M_2CO_3}{1 Al_2(CO_3)_3} = 5 \text{ mmol } M_2CO_3$$

$$\frac{530.0 \text{ mg}}{5.000 \text{ mmol}} = 106.0 \frac{\text{g}}{\text{mol}} \quad \begin{array}{l} 2M \\ + 12.011 \\ + 3 \times 15.999 \\ \hline 106.0 \end{array} \Rightarrow M = 23.0 \frac{\text{g}}{\text{mol}}$$

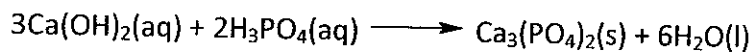
Na

- 5) [3 marks] A 20.00 mL aliquot of solution A was taken and diluted to 500.0 mL to form solution B. A 15.00 mL aliquot of solution B was taken and diluted to 100.0 mL to form solution C. The concentration of KI in solution B was 0.02000 M. What were the concentrations of KI in solutions A and C?

$$[KI] \text{ in A} = 0.02000 \text{ M} \times \frac{500.0 \text{ mL}}{20.00 \text{ mL}} = 0.5000 \text{ M}$$

$$[KI] \text{ in B} = 0.02000 \text{ M} \times \frac{15.00 \text{ mL}}{100.0 \text{ mL}} = 3.000 \times 10^{-3} \text{ M}$$

- 6) [3 marks] It took 15.00 mL of $\text{Ca}(\text{OH})_2$ to titrate a 20.00 mL aliquot of H_3PO_4 :



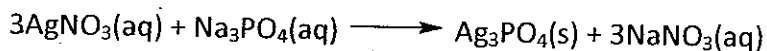
The mass of $\text{Ca}_3(\text{PO}_4)_2$ (310.2 g/mol) isolated was 77.55 mg. What was the concentration of the $\text{Ca}(\text{OH})_2$ before titration?

$$77.55 \text{ mg } \text{Ca}_3(\text{PO}_4)_2 \times \frac{1 \text{ mol}}{310.2 \text{ g}} \times \frac{3 \text{ Ca}(\text{OH})_2}{1 \text{ Ca}_3(\text{PO}_4)_2}$$

$$15.00 \text{ mL}$$

$$= \boxed{0.05000 \text{ M}}$$

- 7) [3 marks] How many grams of 80.00-percent pure AgNO_3 (169.9 g/mol) are required to produce exactly 0.4186 grams of Ag_3PO_4 (418.6 g/mol) if the reaction:



Proceeds with a 60.00-percent yield?

$$0.4186 \text{ g } \text{Ag}_3\text{PO}_4 \times \frac{100}{60} \times \frac{1 \text{ mol}}{418.6 \text{ g}} \times \frac{3 \text{ AgNO}_3}{1 \text{ Ag}_3\text{PO}_4} \times \frac{169.9 \text{ g}}{1 \text{ mol}} \times \frac{100}{80}$$

$$= \boxed{1.0619 \text{ g}}$$

8) [5 marks total] If 20.00 mL of 1.000 M H_2SO_4 are mixed with 30.00 mL of 1.000 M NaOH:



a) [3 marks] What will be the concentration of Na_2SO_4 after the reaction has taken place?

$$20.00 \text{ mL} \times \frac{1.000 \text{ mole } \text{H}_2\text{SO}_4}{\text{L}} \times \frac{1 \text{ Na}_2\text{SO}_4}{1 \text{ H}_2\text{SO}_4} = 20.00 \text{ mmol Na}_2\text{SO}_4$$

$$\text{LR} \rightarrow 30.00 \text{ mL} \times \frac{1.000 \text{ mole NaOH}}{\text{L}} \times \frac{1 \text{ Na}_2\text{SO}_4}{2 \text{ NaOH}} = 15.00 \text{ mmol Na}_2\text{SO}_4$$

$$\frac{15.00 \text{ mmol}}{50.00 \text{ mL}} = \boxed{0.3000 \text{ M}}$$

b) [2 marks] What will be the concentration of the excess reagent after the reaction has taken place?

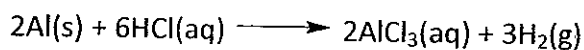
$$20 \text{ mmol H}_2\text{SO}_4 - 30 \text{ mmol NaOH} \times \frac{1 \text{ H}_2\text{SO}_4}{2 \text{ NaOH}} = 5.00 \text{ mmol H}_2\text{SO}_4$$

$$\frac{5.00 \text{ mmol}}{50.00 \text{ mL}} = \boxed{0.100 \text{ M}}$$

- 9) [4 marks] The molar mass of aluminum was determined in exactly the same way as the molar mass of magnesium. The following data were collected:

Data (units)	Value
Mass Al (mg)	40.0
V_{gas} (mL)	56.6
$T_{\text{sol'n}}$ ($^{\circ}\text{C}$)	20.8
VP H_2O (mmHg)	18.8
P_{atm} (mmHg)	754.1
h (mm H_2O)	204
$D_{\text{H}_2\text{O}}$ (kg/m^3)	1000

Given that the reaction between Al and HCl is:



and assuming that the experiment worked perfectly, how many milligrams of aluminum were used in the experiment?

$$P_{\text{H}_2} = 754.1 \text{ mmHg} - 18.8 \text{ mmHg} - \frac{1000 \times 9.80665 \times 0.204}{101325} \text{ Pa}$$

$$= 720.29 \text{ mmHg}$$

$$n_{\text{H}_2} = \frac{(720.29 \text{ mmHg})(56.6 \text{ mL})}{\left(\frac{62.3637 \text{ L}\cdot\text{torr}}{\text{mol}\cdot\text{K}}\right)(293.95\text{K})} = 2.224 \text{ mmol H}_2$$

$$2.224 \text{ mmol H}_2 \times \frac{2\text{Al}}{3\text{H}_2} \times \frac{26.982 \text{ g}}{\text{mol}} = \boxed{40.0 \text{ mg Al}}$$