Chemistry 1094 Spring 2017 Test 3

Wednesday, March 22, 2017 Time: 1 hour 50 minutes

Name: ANSWERS Student #: _____

*This test consists of **six** pages of questions and a periodic table. Please ensure that you have a complete test and, if you do not, obtain one from me **immediately**. There are **43** marks available. Good luck!*

Avogadro's number, should you need it, is $6.022\ 140\ 857 \times 10^{23}\ mol^{-1}$

1) **[6 marks]** Complete and balance the following reactions. Give the phases of all products.

a) _____ $Fe_2(CO_3)_3(s) \xrightarrow{\Delta} Fe_2O_3(s) + 3CO_2(g)$

b) _____ $Cu_2O(s)$ + _____ $CO_2(g) \xrightarrow[\text{pressure}]{\text{high}} Cu_2CO_3(s)$

c) 2 $C_5H_{11}OH(l)$ + 15 $O_2(g) \longrightarrow 10CO_2(g) + 12H_2O(g)$

2) **[1 mark]** Calculate the molar mass of $Al_2(CO_3)_3 \cdot 4H_2O$.

2×26.982

$3 \times (12.011 + 15.999 \times 3)$

$4 \times (2 \times 1.0079 + 15.999)$

306.0472 g/mol

3) **[14 marks total]** *Note: to receive any credit for any part of this question, you must show the complete method by which you obtained your solution.*
Na_2SO_4 has a molar mass of 142.0 grams.

a) **[1 mark]** How many grams of Na_2SO_4 are necessary to supply 0.0500 moles of Na_2SO_4?

$$0.05 \text{ moles} \times \frac{142 \text{ g}}{1 \text{ mol}} = \boxed{7.1 \text{ g}}$$

b) **[1 mark]** How many moles of Na_2SO_4 are in 5.68 grams of Na_2SO_4?

$$5.68 \text{ g} \times \frac{1 \text{ mol}}{142 \text{ g}} = \boxed{0.04 \text{ moles}}$$

c) **[1 mark]** How many moles of oxygen atoms are in 0.0200 moles of Na_2SO_4?

$$0.02 \text{ moles } Na_2SO_4 \times \frac{4\,O \text{ atoms}}{1\,Na_2SO_4} = \boxed{0.08 \text{ moles}}$$

d) **[1 mark]** How many moles of Na_2SO_4 are necessary to supply 0.100 moles of oxygen atoms?

$$0.100 \text{ moles O atoms} \times \frac{1\,Na_2SO_4}{4\,O \text{ atoms}} = \boxed{0.025 \text{ moles}}$$

e) **[2 marks]** How many grams of sodium atoms are in 0.160 moles of Na_2SO_4?

$$0.160 \text{ moles } Na_2SO_4 \times \frac{2\,Na}{1\,Na_2SO_4} \times \frac{22.99 \text{ g}}{\text{mol}} = \boxed{7.3568 \text{ g}}$$

f) **[2 marks]** How many moles of Na_2SO_4 are necessary to supply 1.1495 grams of sodium atoms?

$$1.1495 \text{ g Na} \times \frac{1 \text{ mol}}{22.99 \text{ g}} \times \frac{1\,Na_2SO_4}{2\,Na} = \boxed{0.025 \text{ moles}}$$

g) **[3 marks]** How many grams of Na_2SO_4 are necessary to supply 3.011×10^{20} atoms of sodium?

$$3.011 \times 10^{20} \text{ atoms Na} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ atoms}} \times \frac{1\,Na_2SO_4}{2\,Na} \times \frac{142 \text{ g}}{1 \text{ mol}} = \boxed{0.0355 \text{ g}}$$

h) **[3 marks]** How many sodium atoms are contained in 1.42 grams of Na_2SO_4? (Give the actual number and not just a multiple of moles.)

$$1.42\text{g } Na_2SO_4 \times \frac{1\text{ mol}}{142\text{g}} \times \frac{2Na}{1Na_2SO_4} \times \frac{6.022\times10^{23}}{1\text{ mol}} = \boxed{1.2044\times10^{22}\text{ atoms}}$$

4) **[1 mark]** Calculate the mass of a single atom of sodium in grams.

$$22.99\frac{\text{g}}{\text{mol}} \times \frac{1\text{ mol}}{6.022\times10^{23}} = \boxed{3.818\times10^{-23}\text{ g}}$$

5) **[4 marks]** Calculate the percent by mass of each element in $Ag(NH_3)_2Cl$.

$1 \times 107.868 = 107.868$
$2 \times 14.007 = 28.014$
$6 \times 1.0079 = 6.0474$
$1 \times 35.453 = 35.453$

$\boxed{177.3824}$ ← mass of 1 mole of sample.

Ag: $\frac{107.868}{177.3824} \times 100 = 60.811\%$

N: 15.793%

H: 3.409%

Cl: 19.987%

6) **[5 marks total]** Glucose (an important source of energy) is 40.002 % carbon, 53.285 % oxygen, and the rest hydrogen (all by mass).

a) **[3 marks]** What is the empirical formula of glucose?

$\%\,H: 100 - 40.002 - 53.285 = 6.713\%$

Assume 100 g sample, then ...

$$40.002\text{ g C} \times \frac{1\text{ mol}}{12.011\text{ g}} = 3.330\ldots\text{ mol C}$$

$$53.285\text{ g O} \times \frac{1\text{ mol}}{15.999\text{ g}} = 3.330\ldots\text{ mol O}$$

$$6.713\text{ g H} \times \frac{1\text{ mol}}{1.0079\text{ g}} = 6.660\ldots\text{ mol H}$$

$C_{3.33}H_{6.66}O_{3.33} \Rightarrow \boxed{CH_2O}$

b) **[2 marks]** The molar mass of glucose is 180.157 grams. What is the molecular formula of glucose?

Mass of EF unit is $12.011 + 2\times1.0079 + 15.999$
$= 30.0258$

$n = \frac{180.157}{30.0258} = \sim 6$, so MF is $\boxed{C_6H_{12}O_6}$

7) **[6 marks]** A 5.844-gram sample of NaCl (58.44 g/mol) was dissolved in enough water to make 250.0 mL of solution **A**. A 15.00-mL aliquot of solution **A** was taken and diluted to 200.0 mL to form solution **B**. Some solution **B** was then taken and diluted to 250.0 mL to form solution **C**. The concentration of solution **C** was found to be 1.200×10^{-3} M.

a) What was the concentration of solution **A**? Give your answer in moles/L.

$5.844\text{ g NaCl} \times \frac{1\text{ mol}}{58.44\text{ g}} = 0.1\text{ mol NaCl}$

$\frac{0.1\text{ mol}}{250\times10^{-3}\text{ L}} = \boxed{0.4\text{ M}}$

b) What was the concentration of solution **B**? Give your answer in moles/L.

$0.4\frac{\text{moles}}{\text{L}} \times 15\times10^{-3}\text{ L} = 6\times10^{-3}\text{ moles}$

$\frac{6\times10^{-3}\text{ moles}}{200\times10^{-3}\text{ L}} = \boxed{0.03\text{ M}}$

c) How many mL of solution **B** were used to make solution **C**?

total moles NaCl in soln C:

$1.2\times10^{-3}\frac{\text{moles}}{\text{L}} \times 250\times10^{-3}\text{ L} = 3\times10^{-4}\text{ moles}$

$3\times10^{-4}\text{ moles} \times \frac{1\text{ L}}{0.03\text{ mol}} = 0.01\text{ L}$

$0.01\text{ L} \times \frac{1000\text{ mL}}{1\text{ L}} = \boxed{10\text{ mL}}$

8) **[6 marks]** It took 22.62 mL of 0.1084 M NaOH to titrate a 15.00 mL aliquot of H_2SO_4:

$2NaOH(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l)$

a) What was the $[H_2SO_4]$ in the original aliquot? Give your answer in moles/L.

$22.62\times10^{-3}\,L \times 0.1084\,\frac{moles\ NaOH}{L} \times \frac{1\,H_2SO_4}{2\,NaOH} = 1.266\times10^{-3}\ moles\ H_2SO_4$

$$\frac{1.266\times10^{-3}\ moles}{15\times10^{-3}\,L} = \boxed{0.08173\ M}$$

b) What was the $[Na_2SO_4]$ after the titration was complete? Give your answer in moles/L.

$22.62\times10^{-3}\,L \times 0.1084\,\frac{moles\ NaOH}{L} \times \frac{1\,Na_2SO_4}{2\,NaOH} = 1.266\times10^{-3}\ moles\ Na_2SO_4$

$$\frac{1.266\times10^{-3}\ moles}{15.00\times10^{-3}\,L + 22.62\times10^{-3}\,L} = \boxed{0.03259\ M}$$