

Chemistry 1094 Spring 2017 Test 3

Wednesday, March 22, 2017

Time: 1 hour 50 minutes

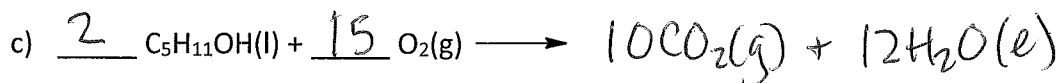
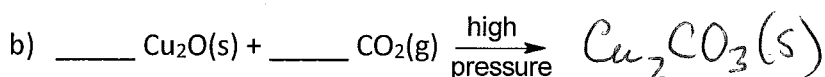
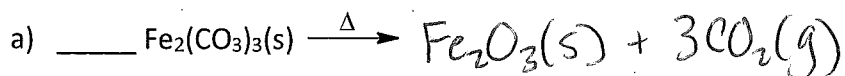
Name: ANSWERS

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 $6.022\ 140\ 857 \times 10^{23} \text{ mol}^{-1}$

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



2) [1 mark] Calculate the molar mass of $\text{Al}_2(\text{CO}_3)_3 \cdot 4\text{H}_2\text{O}$.

$$2 \times 26.982$$

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

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

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 ?

$$0.02 \text{ moles } \text{Na}_2\text{SO}_4 \times \frac{4 \text{ O atoms}}{1 \text{ Na}_2\text{SO}_4} = \boxed{0.08 \text{ moles}}$$

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

$$0.100 \text{ moles O atoms} \times \frac{1 \text{ Na}_2\text{SO}_4}{4 \text{ O atoms}} = \boxed{0.025 \text{ moles}}$$

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

$$0.160 \text{ moles } \text{Na}_2\text{SO}_4 \times \frac{2 \text{ Na}}{1 \text{ Na}_2\text{SO}_4} \times \frac{22.99 \text{ g}}{1 \text{ mol}} = \boxed{7.3568 \text{ g}}$$

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

$$1.1495 \text{ g Na} \times \frac{1 \text{ mol}}{22.99 \text{ g}} \times \frac{1 \text{ Na}_2\text{SO}_4}{2 \text{ Na}} = \boxed{0.025 \text{ moles}}$$

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

$$3.011 \times 10^{20} \text{ atoms Na} \times \frac{1 \text{ mol}}{6.022 \times 10^{23} \text{ atoms}} \times \frac{1 \text{ Na}_2\text{SO}_4}{2 \text{ Na}} \times \frac{142 \text{ g}}{1 \text{ mol}} = \boxed{0.0355 \text{ g}}$$

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.)

$$1.42 \text{ g } \text{Na}_2\text{SO}_4 \times \frac{1 \text{ mol}}{142 \text{ g}} \times \frac{2 \text{ Na}}{1 \text{ Na}_2\text{SO}_4} \times \frac{6.022 \times 10^{23}}{1 \text{ mol}} = 1.2044 \times 10^{22} \text{ atoms}$$

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

$$\frac{22.99 \text{ g}}{\text{mol}} \times \frac{1 \text{ mol}}{6.022 \times 10^{23}} = 3.818 \times 10^{-23} \text{ g}$$

5) [4 marks] Calculate the percent by mass of each element in $\text{Ag}(\text{NH}_3)_2\text{Cl}$.

$$1 \times 107.868 = 107.868$$

$$2 \times 14.007 = 28.014$$

$$6 \times 1.0079 = 6.0474$$

$$1 \times 35.453 = 35.453$$

$$177.3824$$

← mass of 1 mole of sample.

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

$$\text{N: } 15.793\%$$

$$\text{H: } 3.409\%$$

$$\text{Cl: } 19.987\%$$

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?

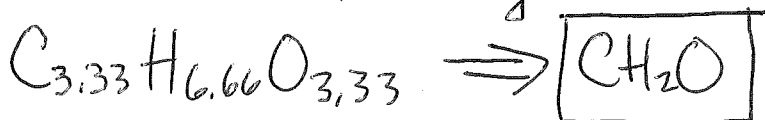
$$\% \text{H} : 100 - 40.002 - 53.285 = 6.713\%$$

Assume 100 g sample, then ...

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

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

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



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

$$\text{Mass of EF unit is } 12.011 + 2 \times 1.0079 + 15.999 \\ = 30.0258$$

$$n = \frac{180.157}{30.0258} \approx 6, \text{ so MF is } \boxed{\text{C}_6\text{H}_{12}\text{O}_6}$$

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.

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

$$\frac{0.1 \text{ mol}}{250 \times 10^{-3} \text{ L}} = \boxed{0.4 \text{ M}}$$

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

$$\frac{0.4 \text{ moles}}{\text{L}} \times 15 \times 10^{-3} \text{ L} = 6 \times 10^{-3} \text{ moles}$$

$$\frac{6 \times 10^{-3} \text{ moles}}{200 \times 10^{-3} \text{ L}} = \boxed{0.03 \text{ M}}$$

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

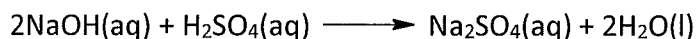
total moles NaCl in soln C:

$$\frac{1.2 \times 10^{-3} \text{ moles}}{\text{L}} \times 250 \times 10^{-3} \text{ L} = 3 \times 10^{-4} \text{ moles}$$

$$3 \times 10^{-4} \text{ moles} \times \frac{1 \text{ L}}{0.03 \text{ mol}} = 0.01 \text{ L}$$

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

8) [6 marks] It took 22.62 mL of 0.1084 M NaOH to titrate a 15.00 mL aliquot of H₂SO₄:



a) What was the [H₂SO₄] in the original aliquot? Give your answer in moles/L.

$$22.62 \times 10^{-3} \text{ L} \times \frac{0.1084 \text{ moles NaOH}}{\text{L}} \times \frac{1 \text{ H}_2\text{SO}_4}{2 \text{ NaOH}} = 1.266 \times 10^{-3} \text{ moles H}_2\text{SO}_4$$
$$\frac{1.266 \times 10^{-3} \text{ moles}}{15 \times 10^{-3} \text{ L}} = \boxed{0.08173 \text{ M}}$$

b) What was the [Na₂SO₄] after the titration was complete? Give your answer in moles/L.

$$22.62 \times 10^{-3} \text{ L} \times \frac{0.1084 \text{ moles NaOH}}{\text{L}} \times \frac{1 \text{ Na}_2\text{SO}_4}{2 \text{ NaOH}} = 1.266 \times 10^{-3} \text{ moles Na}_2\text{SO}_4$$
$$\frac{1.266 \times 10^{-3} \text{ moles}}{15.00 \times 10^{-3} \text{ L} + 22.62 \times 10^{-3} \text{ L}} = \boxed{0.03259 \text{ M}}$$