Chemistry 1110 Spring 2024 Test 1

Wednesday, January 31, 2024   Time: 1 hour 50 minutes

Name: _____   Student #: _____

*This test consists of **eight** 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 **38** marks available. Good luck!*

1) **[2 marks]** How many mL of 0.1048 M H_3PO_4 are required to titrate 0.5078 grams of $Ca(OH)_2$ (74.092 g/mol)?

$$2H_3PO_4(aq) + 3Ca(OH)_2(s) \longrightarrow Ca_3(PO_4)_2(s) + 6H_2O(l)$$
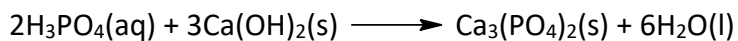
2) **[3 marks]** A 0.2999-gram sample of $Al_2(CO_3)_3 \cdot nH_2O$ required 25.90 mL of 0.2031 M HCl for complete titration:

$$Al_2(CO_3)_3 \cdot nH_2O(s) + 6HCl(aq) \longrightarrow 2AlCl_3(aq) + 3CO_2(g) + (3+n)H_2O(l)$$
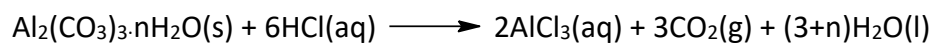
What is the value of n in the formula $Al_2(CO_3)_3 \cdot nH_2O$?

3) **[4 marks]** HCl solution **A** had an unknown concentration. A 10.00 mL aliquot of solution **A** was taken and diluted to 250.0 mL to form solution **B**. A 20.00 mL aliquot of solution **B** required 18.51 mL of 0.002000 M $Mg(OH)_2$ for complete reaction:

$Mg(OH)_2(aq) + 2HCl(aq) \longrightarrow MgCl_2(aq) + 2H_2O(l)$
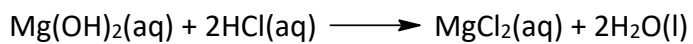
What was the concentration of solution **A**?

4) **[3 marks]** Reaction of 652.1 mg of MCl_3 with excess $AgNO_3$ resulted in the collection of 1592.4 mg of AgCl (143.321 g/mol):
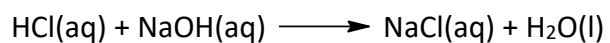
$MCl_3(aq) + 3AgNO_3(aq) \longrightarrow 3AgCl(s) + M(NO_3)_3(aq)$
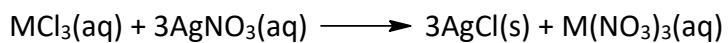
What is the element, M?

5) **[4 marks]** A 0.5000-gram sample of $Na_2X_2O_3$ was dissolved in enough water to make 200.0 mL of solution. A 25.00-mL aliquot was taken and 15.00 mL of 0.2500 M HCl added:

$$Na_2X_2O_3(aq) + 2HCl(aq) \longrightarrow 2NaCl(aq) + XO_2(g) + X(s) + H_2O(l)$$
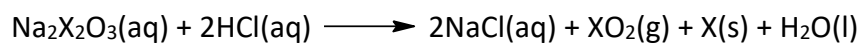
The excess HCl required 29.96 mL of 0.09878 M NaOH to titrate:

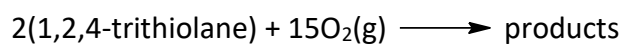$$HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

What is the element, X?

6) **[6 marks]** 1,2,4-trithiolane (found commonly in shitake mushrooms and truffles) contains 19.334 percent carbon, 3.245 percent hydrogen, and the rest sulphur, all by mass.

a) What is the empirical formula of 1,2,4-trithiolane?

b) 1,2,4-trithiolane is flammable, according to the equation:

2(1,2,4-trithiolane) + 15O_2(g) $\longrightarrow$ products

A 254-mg sample of 1,2,4-trithiolane required 490.6 mg of O_2 for complete reaction. What is the molecular formula of 1,2,4-trithiolane?

7) **[5 marks total]** Sulfamethoxazole (SMZ) is an antibiotic used to treat bacterial infections and bronchitis (among others). SMZ contains carbon, hydrogen, nitrogen, oxygen, and sulphur.

a) **[4 marks]** Combustion of a 511-mg sample of SMZ produced 887.9 mg of CO_2 (44.009 g/mol), 199.9 mg of H_2O (18.015 g/mol), 133.2 mg of N_2O (44.013 g/mol), and 161.5 mg of SO_3 (80.062 g/mol). What is the empirical formula for SMZ?

b) **[1 mark]** The molar mass of SMZ is 253.28 grams. What is the molecular formula of SMZ?

8) **[3 marks]** A 0.3217 M solution of CaX_2 (where X is an unknown element) is 3.500 percent CaX_2 by mass, and has a density of 1.02 g/mL. What is the element, X?

9) **[4 marks]** The reaction of 25.13 grams of (impure) $AgNO_3$ (169.872 g/mol) with excess Na_2S resulted in the collection of 11.00 grams of Ag_2S (247.801 g/mol):

$Na_2S(aq) + 2AgNO_3(aq) \longrightarrow Ag_2S(s) + 2NaNO_3(aq)$
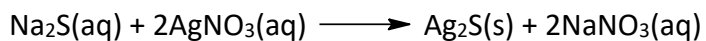
If the reaction proceeded with 75.00 percent yield, what was the percent purity of the $AgNO_3$?

10) **[4 marks]** If you react 390 mg of $Al(OH)_3$ (78.00 g/mol) with 60.0 mL of 0.100 M H_2SO_4:

$$2Al(OH)_3(s) + 3H_2SO_4(aq) \longrightarrow Al_2(SO_4)_3(aq) + 6H_2O(l)$$
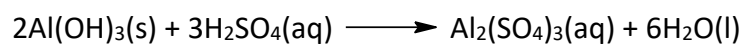
what will be the concentration of the $Al_2(SO_4)_3$ (in moles/L) after reaction?