Chemistry 1110 R10 Fall 2023 Test 1

Thursday, September 28, 2023   Time: 1 hour 50 minutes

Name: _____   Student #: _____

*This test consists of **eight** pages of questions, a page of useful constants and conversions, and a periodic table. Please ensure that you have a complete test and, if you do not, obtain one from me **immediately**. There are **40** marks available. Good luck!*

1) **[3 marks]** How many mL of 0.1116 M H_3PO_4 are required to completely titrate a 635.9 mg sample of Na_2CO_3 (105.99 g/mol)?

$$2H_3PO_4(aq) + 3Na_2CO_3(aq) \longrightarrow 2Na_3PO4(aq) + 3CO_2(g) + 3H_2O(l)$$
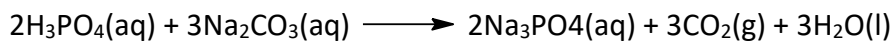
2) **[3 marks]** A 612.7-mg sample of CuX_2 was reacted with excess Na_3PO_4 and 578.1 mg of $Cu_3(PO_4)_2$ (380.58 g/mol) collected:

$$3CuX_2(aq) + 2Na_3PO_4(aq) \longrightarrow Cu_3(PO_4)_2(s) + 6NaX(aq)$$
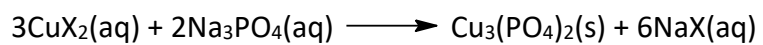
What is the element, X?

3) **[4 marks]** A 1258.0-mg sample of $Na_2X_2O_3$ was reacted with 20 mL of 0.500 M $KMnO_4$:

$5Na_2X_2O_3(aq) + 14HCl(aq) + 8KMnO_4(aq) \longrightarrow$ <products>

The resulting solution was made up to a total volume of 200.0 mL and a 25.00-mL aliquot taken. The excess $KMnO_4$ in the aliquot required 15.70 mL of 0.0400 M $Na_2C_2O_4$ for complete titration:

$2KMnO_4(aq) + 5Na_2C_2O_4(aq) + 16HCl(aq) \longrightarrow$ <products>
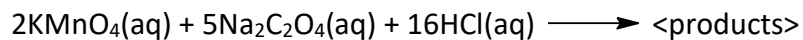
What is the element, X?

4) **[6 marks]** Caffeine is known to be 49.481 percent carbon, 28.852 percent nitrogen, and 16.477 percent oxygen (all by mass); the rest is hydrogen.

a) What is the empirical formula of caffeine?

b) Caffeine is a base; there are four potential parts of it where an acid (like HCl) could attach. If all of them attached an HCl, the balanced reaction would be:

Caffeine + 4HCl(aq) ⟶ <products>
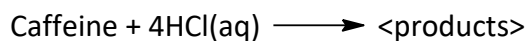
A fresh 592.5-mg sample of caffeine reacting in this way required 39.00 mL of 0.3129 M HCl for complete reaction. What is the molecular formula of caffeine?

5) **[6 marks]** Propylene glycol is known to contain C, H, and O.

a) Combustion of a 501.6-mg sample of propylene glycol resulted in the production of 870.3 mg of CO_2 (44.009 g/mol) and 475.0 mg of H_2O (18.015 g/mol). What is the empirical formula of propylene glycol?

b) As a gas, propylene glycol has a density of 0.211 g/L at a pressure of 50 torr and a temperature of 15.99°C. What is the molecular formula of propylene glycol?

6) **[4 marks]** How many grams of 62.5 percent pure $CaCl_2$ (110.98 g/mol) are required to collect 14.58 grams of AgCl (143.32 g/mol) if the reaction

$$CaCl_2(aq) + 2AgNO_3(aq) \longrightarrow Ca(NO_3)_2(aq) + 2AgCl(s)$$
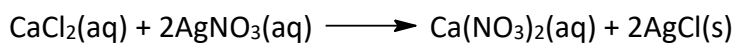
proceeds with an 80.0 percent yield?

7) **[3 marks]** A 0.500 M solution of NaBr (102.9 g/mol) is 5.059 percent NaBr by mass. What is the density of the solution? Give your answer in g/mL.

8) **[4 marks]** If you mix 49.23 grams of $Ca(NO_3)_2$ (164.1 g/mol) with 49.18 grams of Na_3PO_4 (163.9 g/mol), how many grams of $Ca_3(PO_4)_2$ (310.2 g/mol) should you collect?

$$3Ca(NO_3)_2(aq) + 2Na_3PO_4(aq) \longrightarrow Ca_3(PO_4)_2(s) + 6NaNO_3(aq)$$
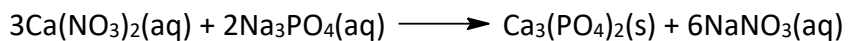
9) **[3 marks]** If you wanted to build a barometer that used maple syrup to indicate its pressures (decidedly more delicious and less lethal than mercury), how many metres tall would it need to be to indicate a pressure of 765.9 torr? The density of maple syrup is 1.37 g/cm³.

10) **[4 marks]** The Sinn UX EZM 2 B GSG9 diving watch is waterproof to 5000 metres (yes, five *thousand* metres) of seawater. If you were to dive into maple syrup (density 1.37 g/cm^3) instead of seawater (1.025 g/cm^3), to how many feet would you be able to dive with the Sinn UX EZM 2 B GSG9 diving watch? One foot is 12 inches, and one inch is 2.54 cm.