

Chemistry 1105 R11 Fall 2023 Test 2

Friday, October 27, 2023

Time: 1 hour 50 minutes

Name: ANSWERS

Student #: \_\_\_\_\_

*This test consists of **nine** pages of questions, a page containing 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 **49** marks available. Good luck!*

1) [4 marks] Give the oxidation number of sulphur (S) in the following compounds or ions:





- 3) [3 marks] A 1456.6-mg sample of a compound of formula  $M_3PO_4$  (where M is an unknown element) was reacted with excess  $CaCl_2$  and 790.9 mg of  $Ca_3(PO_4)_2$  (310.174 g/mol) collected:



What is the metal, M?

$$790.9 \text{ mg } Ca_3(PO_4)_2 \times \frac{1 \text{ mol}}{310.174 \text{ g}} \times \frac{2M_3PO_4}{1Ca_3(PO_4)_2} = 5.09 \dots \text{ mmol } M_3PO_4$$

$$\frac{1456.6 \text{ mg}}{5.09 \dots \text{ mmol}} = 285.6 \dots \frac{\text{g}}{\text{mol}}$$

$$3M + 30.974 + 4 \times 15.999 = 285.6 \dots$$

$$\Rightarrow M = 63.55, \text{ close to } \boxed{Cu}$$

- 4) [4 marks] A certain volume of 12.4 M HCl was taken and diluted to 200.0 mL to make solution A. 25.00 mL aliquot of solution A was then taken and diluted to 500.0 mL to form solution B. The concentration of solution B was found to be 0.0310 M. How many mL of 12.4 M HCl were used to make solution A?

$$\frac{x \text{ mL} \times 12.4 \text{ moles/L}}{200 \text{ mL}} \times \frac{25.00 \text{ mL}}{500.0 \text{ mL}} = 0.031 \text{ M}$$

$$\frac{12.4x}{200} \times \frac{25}{500} = 0.031$$

$$\Rightarrow x = \boxed{10 \text{ mL}}$$

5) [3 marks] A 102.5-mg sample of KHP (204.2 g/mol) required 26.70 mL of  $\text{Ca}(\text{OH})_2$  to titrate:



What was the concentration of the  $\text{Ca}(\text{OH})_2$ ? Give your answer in moles/L.

$$\frac{102.5 \text{ mg KHP} \times \frac{1 \text{ mol}}{204.2 \text{ g}} \times \frac{1 \text{ Ca}(\text{OH})_2}{2 \text{ KHP}}}{26.70 \text{ mL}}$$

$$= \boxed{0.00940 \text{ M}}$$

6) [2 marks] Calculate the percent by mass of sulphur in  $\text{Al}_2(\text{SO}_4)_3$ .

$$\begin{array}{r} 2 \times 26.982 \\ + 3 \times 32.065 \\ + 12 \times 15.999 \\ \hline 342.147 \end{array}$$

$$\frac{3 \times 32.065}{342.147} \times 100\% = \boxed{28.115\%}$$

7) [6 marks] Zonisamide is an antibiotic – a “sulfa drug” in particular. It consists of 45.276% carbon, 3.799% hydrogen, 13.200% nitrogen, 22.616% oxygen, and (maybe obviously) the rest Sulphur, all by mass.

a) What is the empirical formula of Zonisamide?

$$\% S = 100 - 45.276 - 3.799 - 13.200 - 22.616 = 15.109$$

assume 100g sample

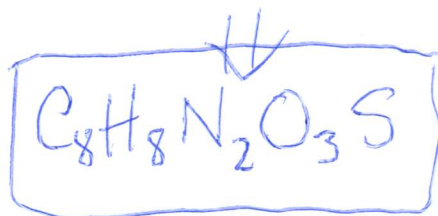
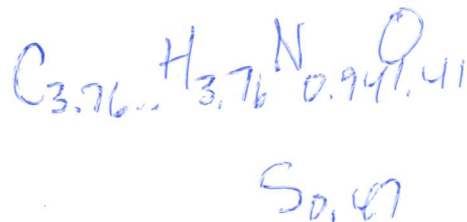
$$45.276 \text{g C} \times \frac{1 \text{ mol}}{12.011 \text{g}} = 3.76 \dots \text{ mol C}$$

$$3.799 \text{g H} \times \frac{1 \text{ mol}}{1.0079 \text{g}} = 3.76 \dots \text{ mol H}$$

$$13.200 \text{g N} \times \frac{1 \text{ mol}}{14.007 \text{g}} = 0.94 \dots \text{ mol N}$$

$$22.616 \text{g O} \times \frac{1 \text{ mol}}{15.999 \text{g}} = 1.4135 \dots \text{ mol O}$$

$$15.109 \text{g S} \times \frac{1 \text{ mol}}{32.065 \text{g}} = 0.47 \dots \text{ mol S}$$



b) If Zonisamide were a gas, it would have a density of 0.100 g/L at 8.81 torr pressure and 26.66°C. What is the molecular formula of Zonisamide?

$$\begin{array}{l} \times 12.011 \\ \times 1.0079 \\ \times 14.007 \\ \times 15.999 \\ \times 32.065 \\ \hline 212.2272 \end{array}$$

$$MM = \frac{(0.1)(62.36 \dots)(299.81)}{8.81} = 212.2273 \dots$$

$$\frac{212.2273 \dots}{212.2272} \approx 1, \text{ so EF} = \text{MF} =$$



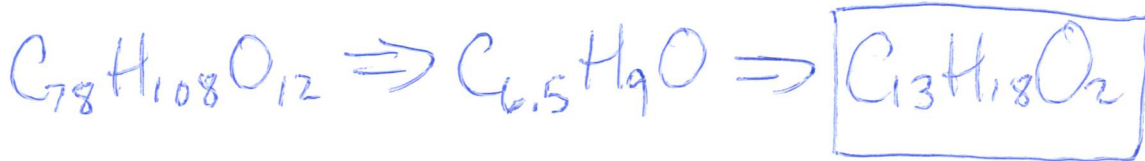
8) [6 marks] Ibuprofen is an anti-inflammatory drug. It consists of carbon, hydrogen, and oxygen.

a) If you burn a 1237.7-mg sample of ibuprofen, you'll collect 3432.7 mg of CO<sub>2</sub> (44.009 g/mol) and 972.8 mg of H<sub>2</sub>O (18.015 g/mol). What is the empirical formula of ibuprofen?

$$3432.7 \text{ mg} \times \frac{1 \text{ mol}}{44.009 \text{ g}} \times \frac{1 \text{ C}}{1 \text{ CO}_2} = \sim 78 \text{ mmol C} = 936.8 \dots \text{ mg C}$$

$$972.8 \text{ mg H}_2\text{O} \times \frac{1 \text{ mol}}{18.015 \text{ g}} \times \frac{2 \text{ H}}{1 \text{ H}_2\text{O}} = \sim 108 \text{ mmol H} = 108.8 \dots \text{ mg H}$$

$$1237.7 - 936.8 - 108.8 = 191.99 \dots \text{ mg O} = \sim 12 \text{ mmol O}$$



b) Ibuprofen is mildly acidic and, as an acid, reacts with bases like Mg(OH)<sub>2</sub> according to the balanced equation:



A fresh 226.9-mg sample of ibuprofen required 27.50 mL of 0.0200 M Mg(OH)<sub>2</sub> for complete reaction. What is the molecular formula of ibuprofen?

$$\begin{array}{r} 13 \times 12.011 \\ 18 \times 1.0079 \\ 2 \times 15.999 \\ \hline 206.2832 \end{array}$$

$$\begin{array}{l} \text{27.50 mL} \times 0.02 \text{ moles Mg}(\text{OH})_2 \times \frac{2 \text{ Ib}}{1 \text{ Mg}(\text{OH})_2} = 1.1 \text{ mmol Ib} \\ \hline \frac{226.9 \text{ mg}}{1.1 \text{ mmol}} = 206.2727 \dots \end{array}$$

$$\frac{206.2727 \dots}{206.2832} \approx 1, \text{ so MF is } \boxed{\text{C}_{13}\text{H}_{18}\text{O}_2}$$

- 9) [3 marks] A solution of  $\text{H}_2\text{SO}_4$  (98.077 g/mol) has a density of 1.0234 g/mL. A 20.00-mL aliquot of this solution required 32.38 mL of 0.5156 M NaOH for complete reaction:



What is the percent by mass of  $\text{H}_2\text{SO}_4$  in the original  $\text{H}_2\text{SO}_4$  solution?

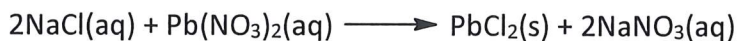
$$20 \text{ mL} \times \frac{1.0234 \text{ g}}{\text{mL}} = 20.468 \text{ g}$$

$$32.38 \times 10^{-3} \text{ L} \times 0.5156 \text{ moles NaOH} \times \frac{1 \text{ H}_2\text{SO}_4}{2 \text{ NaOH}} \times 98.077 \frac{\text{g}}{\text{mol}}$$

$$= 0.8187 \dots \text{ g}$$

$$\frac{0.8187 \text{ g}}{20.468 \text{ g}} \times 100\% = \boxed{4.0\%}$$

- 10) [3 marks] How many grams of 80.00-percent pure NaCl (58.443 g/mol) are required to collect exactly 10.00 grams of  $\text{PbCl}_2$  (278.1 g/mol) if the reaction



proceeds with a 62.50 percent yield?

$$10 \text{ g} \times \frac{100 \text{ g}}{62.50 \text{ g}} \times \frac{1 \text{ mol}}{278.1 \text{ g}} \times \frac{2 \text{ NaCl}}{1 \text{ PbCl}_2} \times \frac{58.443 \text{ g}}{1 \text{ mol}} \times \frac{100}{80} = \boxed{8.406 \text{ g}}$$

11) [4 marks] If you mix 20.00 mL of 0.00300 M  $\text{Mg}(\text{OH})_2$  with 20.00 mL of 0.00150 M  $\text{H}_3\text{PO}_4$ :



How many mL of  $\text{H}_2\text{O}$  (18.015 g/mol) should be produced? The density of  $\text{H}_2\text{O}$  is 0.9984 g/mL.

$$20 \text{ mL} \times \frac{3 \times 10^{-3} \text{ moles Mg}(\text{OH})_2}{\text{L}} \times \frac{1 \text{ rxn}}{3 \text{ Mg}(\text{OH})_2} = 0.02 \text{ moles rxn}$$

$$20 \text{ mL} \times 1.5 \times 10^{-3} \text{ moles H}_3\text{PO}_4 \times \frac{1 \text{ rxn}}{2 \text{ H}_3\text{PO}_4} = 0.015 \text{ moles rxn}$$

$$0.015 \text{ moles rxn} \times \frac{6 \text{ H}_2\text{O}}{1 \text{ rxn}} \times \frac{18.015 \text{ g}}{\text{mol}} \times \frac{1 \text{ mL}}{0.9984 \text{ g}}$$

$$= \boxed{1.6239 \times 10^{-3} \text{ mL}}$$



12) [6 marks total] The air we breathe has  $X_{O_2} = 0.21$  and  $X_{N_2} = 0.79$  (approximately). Imagine you had a room (filled with air) at  $22.8^\circ\text{C}$  at a total pressure of  $758.9$  torr. The room has a height of  $3$  metres, a length of  $6$  metres, and a depth of  $8$  metres.

a) [4 marks] How many kg of oxygen and of nitrogen would be in the room? The volume of the room is given by length  $\times$  width  $\times$  depth, and  $1 \text{ L} = 1 \text{ dm}^3$

$$3 \text{ m} \times \frac{1 \text{ dm}}{0.1 \text{ m}} = 30 \text{ dm}$$

$$6 \text{ m} \times \frac{1 \text{ dm}}{0.1 \text{ m}} = 60 \text{ dm}$$

$$8 \text{ m} \times \frac{1 \text{ dm}}{0.1 \text{ m}} = 80 \text{ dm}$$

$$V = 30 \text{ dm} \times 60 \text{ dm} \times 80 \text{ dm} \\ = 144,000 \text{ dm}^3 = 144,000 \text{ L}$$

$$n_{\text{TOT}} = \frac{(758.9)(144,000)}{(62.36359422)(295.95)} \\ \approx 5921.03 \dots$$

$$\text{So } n_{O_2} = 0.21 n_{\text{TOT}} \\ = 1243.4$$

$$\text{and } n_{N_2} = 4677.6 \dots$$

$$\begin{aligned} & 1243.4 \text{ moles } O_2 \times 31.998 \frac{\text{g}}{\text{mol}} \times \frac{1 \text{ kg}}{1000 \text{ g}} \\ & = 39.8 \text{ kg } O_2 \\ & 4677.6 \text{ moles } N_2 \times 28.014 \frac{\text{g}}{\text{mol}} \times \frac{1 \text{ kg}}{1000 \text{ g}} \\ & = 131.0 \text{ kg } N_2 \end{aligned}$$

b) [2 marks] Calculate the partial pressures of  $O_2$  and  $N_2$  in the room. Give your answer in torr.

$$P_{O_2} = 758.9 \times 0.21 = 159.369 \text{ torr}$$

$$P_{N_2} = 758.9 \times 0.79 = 599.531 \text{ torr}$$