

## Chemistry 1154 Fall 2022 Test 1

Thursday, September 29, 2022

Time: 1 hour 50 minutes

Name: ANSWERS

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

This test consists of **seven** 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 **27** marks (and four bonus marks) available. Good luck!

- 1) [2 marks] How many grams of  $C_2H_6$  (30.07 g/mol) would be required to react with 45.96 grams of  $O_2$ ?



$$45.96 \text{ g } O_2 \times \frac{1 \text{ mol}}{31.998 \text{ g}} \times \frac{2 C_2H_6}{7 O_2} \times \frac{30.07 \text{ g}}{1 \text{ mol}} = \boxed{12.34 \text{ g } C_2H_6}$$

- 2) [2 marks] How many mL of 0.007490 M  $Ca(OH)_2$  are required to react with 20.00 mL of 0.004127 M  $H_3PO_4$ ?



$$20.00 \text{ mL} \times \frac{0.004127 \text{ moles } H_3PO_4}{L} \times \frac{3 Ca(OH)_2}{2 H_3PO_4} \times \frac{1 L}{0.007490 \text{ moles } Ca(OH)_2} = \boxed{16.53 \text{ mL}}$$

3) [3 marks] When a 12.34-gram sample of  $M_3PO_4$  was reacted with excess  $CaCl_2$



16.53 grams of  $Ca_3(PO_4)_2$  (310.2 g/mol) was collected. What was the metal, M?

$$16.53 \text{ g } Ca_3(PO_4)_2 \times \frac{1 \text{ mol}}{310.2 \text{ g}} \times \frac{2M_3PO_4}{1Ca_3(PO_4)_2} = 0.1065 \dots \text{ mol } M_3PO_4$$

$$\therefore 0.1065 \dots \text{ mol} = 12.34 \text{ g}$$

or

$$1 \text{ mol} = 115.78 \dots \text{ g}$$

$$= 3M + 30.974 \times 4 \times 15.999 \Rightarrow M = 6.938 \dots \frac{\text{g}}{\text{mol}}$$
$$= \boxed{\text{Li}}$$

4) [3 marks] A 0.0241 percent (m/m) solution of NaCl (58.443 g/mol) has a density of 1.001 g/mL. What is the concentration of NaCl in the solution? Give your answer in moles/L.

$$1.001 \frac{\text{g}}{\text{mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}} \times \frac{0.0241 \text{ g NaCl}}{100 \text{ g}} \times \frac{1 \text{ mol}}{58.443 \text{ g}} = \boxed{0.004128 \text{ M}}$$

5) [4 marks] A 0.5218-gram sample of  $M_3P$  was dissolved in 20.00 mL of 1.000 M HCl:



The resulting solution was then made up to a total volume of 200.0 mL and a 15.00 mL aliquot taken. The excess HCl was titrated with 32.53 mL of 0.005000 M  $Mg(OH)_2$ :



What was the metal, M?

excess HCl in 15 mL:

$$32.53 \text{ mL} \times \frac{5.000 \times 10^{-3} \text{ moles } Mg(OH)_2}{L} \times \frac{2HCl}{1Mg(OH)_2} \\ = 0.3253 \text{ mmol HCl}$$

∴ excess HCl in 200 mL

$$= 0.3253 \text{ mmol} \times \frac{200.0 \text{ mL}}{15.00 \text{ mL}} = 4.337... \text{ mmol HCl}$$

total HCl added:

$$20.00 \text{ mL} \times 1.000 \frac{\text{mol HCl}}{L} = 20.00 \text{ mmol}$$

∴ HCl reacted w/ $M_3P$ : <sup>1L</sup>

$$20.00 \text{ mmol} - 4.337... = 15.662... \text{ mmol}$$

∴ moles  $M_3P$  reacted

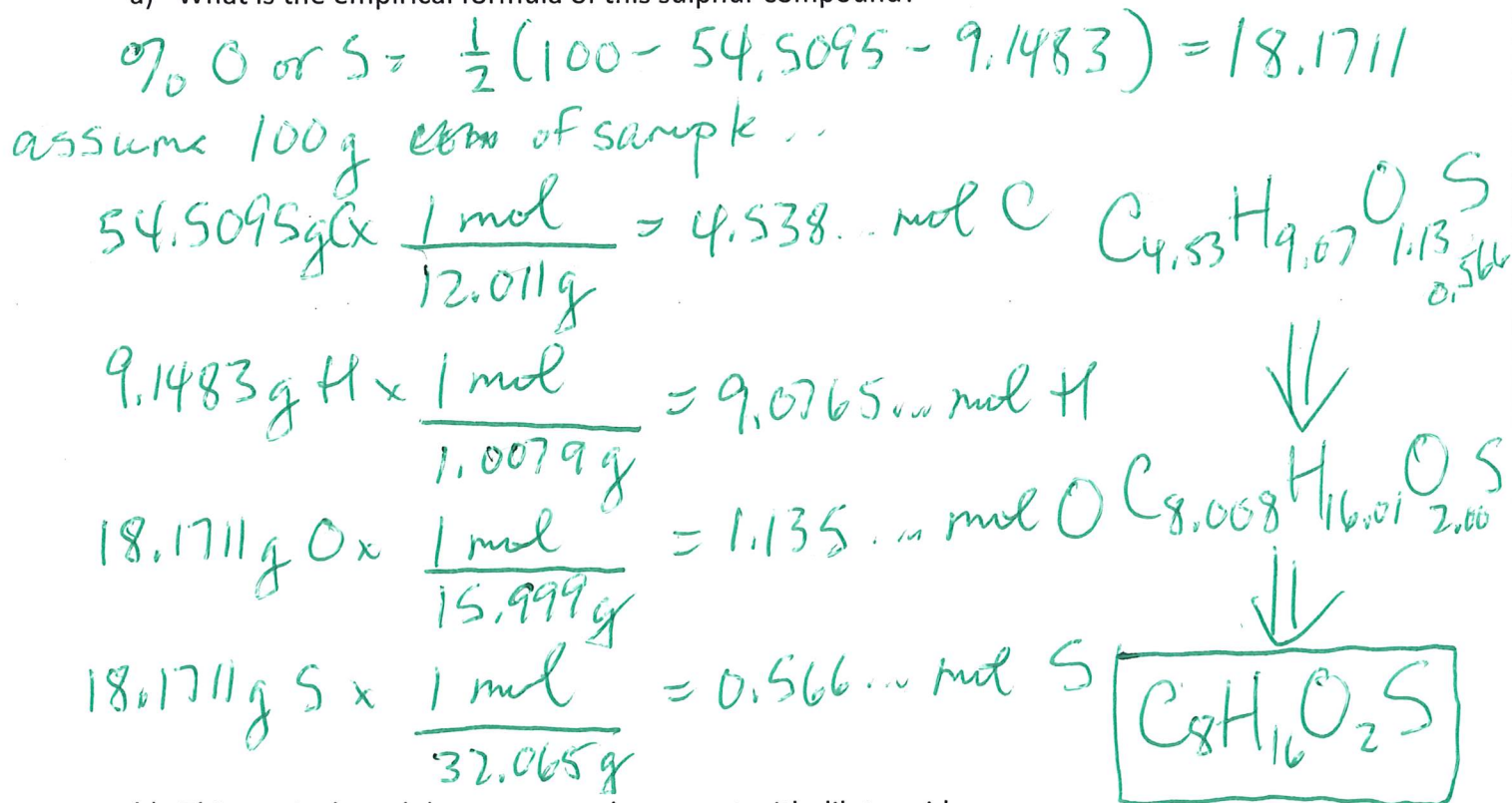
$$15.662... \text{ mmol HCl} \times \frac{1M_3P}{3HCl} = 5.22... \text{ mmol}$$

$$5.22... \text{ mmol} = 521.8 \text{ mg}$$

$$\text{or} \\ 1 \text{ mol} = 99.94... \text{ g} = 3M + 30.974 \Rightarrow M = 22.99 \\ \equiv \boxed{Na}$$

6) [6 marks total] Sulphur compounds are common in food flavours. One such (said to have the odor of tropical fruit) contains 54.5095 percent carbon, 9.1483 percent hydrogen, and equal amounts oxygen and sulphur, all by mass.

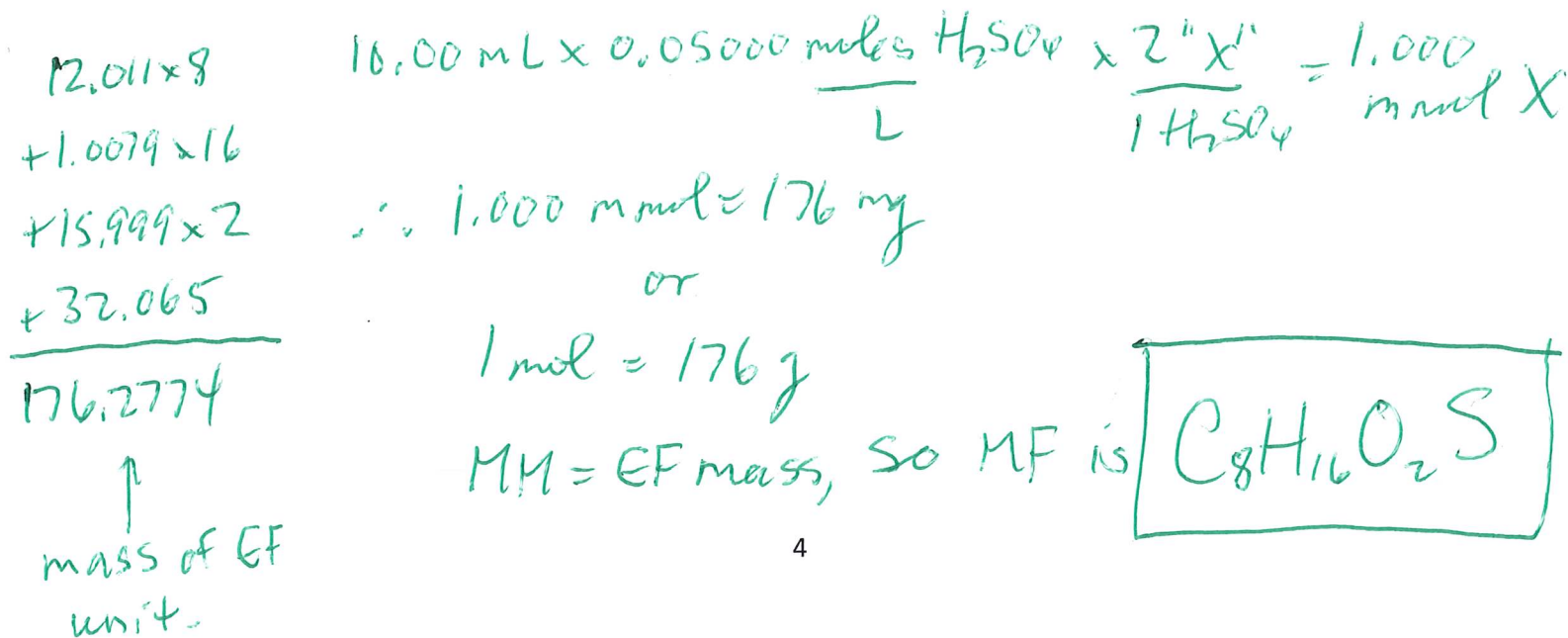
a) What is the empirical formula of this sulphur compound?



b) This particular sulphur compound can react with dilute acids:



A 176-mg sample of the sulphur compound required 10.00 mL of 0.0500 M  $\text{H}_2\text{SO}_4$  for complete reaction. What is the molecular formula of the sulphur compound?



- 7) [3 marks] "Compound X" is known to contain carbon, sulphur, oxygen, and hydrogen. When a 758.0-mg sample of "compound X" was burned, 1513.9 mg of CO<sub>2</sub> (44.009 g/mol), 619.7 mg of H<sub>2</sub>O (18.015 g/mol) and 275.5 mg of SO<sub>2</sub> (64.063 g/mol) were collected. What is the empirical formula of "Compound X"?

$$1513.9 \text{ mg CO}_2 \times \frac{1 \text{ mol}}{44.009 \text{ g}} \times \frac{1 \text{ C}}{1 \text{ CO}_2} = 34.399 \text{ mmol C} \\ = 413.17 \dots \text{ mg C}$$

$$619.7 \text{ mg H}_2\text{O} \times \frac{1 \text{ mol}}{18.015 \text{ g}} \times \frac{2 \text{ H}}{1 \text{ H}_2\text{O}} = 68.798 \text{ mmol H} \\ = 69.34 \dots \text{ mg H}$$

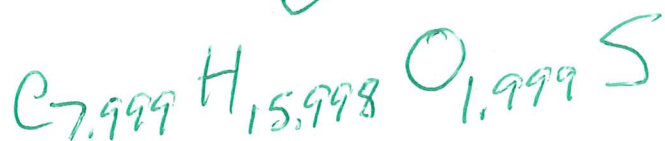
$$275.5 \text{ mg SO}_2 \times \frac{1 \text{ mol}}{64.063 \text{ g}} \times \frac{1 \text{ S}}{1 \text{ SO}_2} = 4.300 \dots \text{ mmol S} \\ = 137.89 \dots \text{ mg S}$$

$$\text{mass O} = 758.0 - 413.17 - 69.34 - 137.89 = 137.588 \dots$$

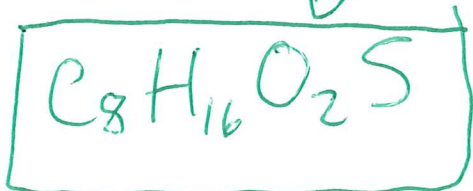
$$137.588 \dots \text{ mg O} \times \frac{1 \text{ mol}}{15.999 \text{ g}} = 8.5998 \dots \text{ mmol O}$$



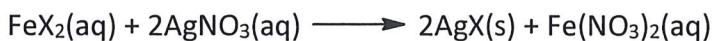
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8) [4 marks] A 1362.5 mg sample of  $\text{FeX}_2$ , when treated with excess  $\text{AgNO}_3$ , gives 2066.0 mg of  $\text{AgX}$ :



What is the element, X?

$$\text{mmol FeX}_2 = 1362.5 \text{ mg} \times \frac{1 \text{ mol}}{(55.845 + 2x) \text{ g}}$$

$$\text{mmol AgX} = 2066.0 \text{ mg} \times \frac{1 \text{ mol}}{(107.868 + x) \text{ g}}$$

mmol  $\text{FeX}_2 \times 2 = \text{mmol AgX}$ , so:

$$\frac{1362.5}{55.845 + 2x} \times \frac{2 \text{ AgX}}{1 \text{ FeX}_2} = \frac{2066.0}{107.868 + x}$$

$$\begin{array}{ccc} a & \text{condensing} & \\ \downarrow & \downarrow & \\ \frac{2725}{55.845 + 2x} & = & \frac{2066}{107.868 + x} \\ \uparrow & & \uparrow \\ b & & d \end{array}$$

$$\begin{aligned} ad + ax &= bc + 2cx \\ ad - bc &= 2cx - ax \end{aligned}$$

$$\begin{aligned} x &= \frac{ad - bc}{2c - a} \\ &= 126.91 \dots \\ &= \boxed{\text{I}} \end{aligned}$$

For neatness ...

$$\frac{a}{b + 2x} = \frac{c}{d + x}$$

[BONUS - 4 marks] A 1324.0 mg mixture of  $\text{FeCl}_2$  (126.751 g/mol) and  $\text{FeBr}_2$  (215.653 g/mol) was reacted with excess  $\text{Na}_3\text{P}$  and 573.7 mg of  $\text{Fe}_3\text{P}_2$  (229.483 g/mol) collected:



What is the mass percent of  $\text{FeCl}_2$  in the original mixture?

$$x = \text{mmol FeCl}_2$$

$$y = \text{mmol FeBr}_2$$

then ...

$$126.751x + 215.653y = 1324.0 \quad (1)$$

and ...

$$\frac{x}{3} + \frac{y}{3} = 573.7 \times \frac{1 \text{ mol}}{229.483}$$

$\Downarrow \times 3$  (for neatness)

$$x + y = 7.4999... \quad (2)$$

$$\Downarrow \times -215.653 ...$$

$$-215.653x - 215.653y = -1617.3... \quad (3)$$

add (1) + (3) to get:

$$-88.902x = -293.37...$$

$$x = 3.2999...$$

$$\text{So mass FeCl}_2 = 3.2999 \text{ mmol} \times 126.751 \frac{\text{g}}{\text{mol}} = 418.27... \text{ mg}$$

$$\% = \frac{418.27...}{1324.0} \times 100 = \boxed{31.59... \%}$$