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?

$2C_2H_6(g) + 7O_2(g) \longrightarrow 4CO_2(g) + 6H_2O(l)$

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

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?

$3Ca(OH)_2(aq) + 2H_3PO_4(aq) \longrightarrow 6H_2O(l) + Ca_3(PO_4)_2(s)$

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

$$= \boxed{16.53\text{ mL}}$$

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

$2M_3PO_4(aq) + 3CaCl_2(aq) \longrightarrow 6MCl(aq) + Ca_3(PO_4)_2(s)$

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

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

$\therefore 0.1065\ldots mol = 12.34\,g$

or

$1\,mol = 115.78\ldots\,g$

$= 3M + 30.974 + 4\times15.999 \Rightarrow M = 6.938\ldots\ \frac{g}{mol}$

$= \boxed{Li}$

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.

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

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

$M_3P(s) + 3HCl(aq) \longrightarrow 3MCl(aq) + PH_3(g)$

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 $Mg(OH)_2$:

$Mg(OH)_2(aq) + 2HCl(aq) \longrightarrow MgCl_2(aq) + 2H_2O(l)$

What was the metal, M?

excess HCl in 15 mL:

$$32.53\ mL \times 5.000\times10^{-3}\ \frac{moles}{L}\ Mg(OH)_2 \times \frac{2\ HCl}{1\ Mg(OH)_2}$$

$= 0.3253$ mmol HCl

∴ excess HCl in 200 mL

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

total HCl added:

$$20.00\ mL \times 1.000\ \frac{mol\ HCl}{1\ L} = 20.00\ mmol$$

∴ HCl reacted w/ M_3P:

$20.00\ mmol - 4.337... = 15.662...$ mmol

∴ moles M_3P reacted

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

∴ $5.22...\ mmol = 521.8\ mg$

or

$1\ mol = 99.94...\ g = 3M + 30.974 \Rightarrow M = 22.99$

$\equiv$ **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?

$\%\ O \text{ or } S = \frac{1}{2}(100 - 54.5095 - 9.1483) = 18.1711$

assume 100 g sample...

$54.5095\ g\ C \times \frac{1\ mol}{12.011\ g} = 4.538...\ mol\ C$

$9.1483\ g\ H \times \frac{1\ mol}{1.0079\ g} = 9.0765...\ mol\ H$

$18.1711\ g\ O \times \frac{1\ mol}{15.999\ g} = 1.135...\ mol\ O$

$18.1711\ g\ S \times \frac{1\ mol}{32.065\ g} = 0.566...\ mol\ S$

$C_{4.53}H_{9.07}O_{1.13}S_{0.566}$

$C_{8.008}H_{16.01}O_{2.00}S$

$\boxed{C_8H_{16}O_2S}$

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

2"Compound" + H_2SO_4 ⟶ products

A 176-mg sample of the sulphur compound required 10.00 mL of 0.0500 M H_2SO_4 for complete reaction. What is the molecular formula of the sulphur compound?

$10.00\ mL \times 0.05000\ \frac{moles\ H_2SO_4}{L} \times \frac{2\ "X"}{1\ H_2SO_4} = 1.000\ mmol\ X$

$\therefore 1.000\ mmol = 176\ mg$

or

$1\ mol = 176\ g$

MM = EF mass, so MF is $\boxed{C_8H_{16}O_2S}$

12.011×8
$+1.0079 \times 16$
$+15.999 \times 2$
$+32.065$
176.2774

↑ mass of EF unit.

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_2 (44.009 g/mol), 619.7 mg of H_2O (18.015 g/mol) and 275.5 mg of SO_2 (64.063 g/mol) were collected. What is the empirical formula of "Compound X"?

$$1513.9\ mg\ CO_2 \times \frac{1\ mol}{44.009\ g} \times \frac{1\ C}{1\ CO_2} = 34.399\ mmol\ C = 413.17\ldots\ mg\ C$$

$$619.7\ mg\ H_2O \times \frac{1\ mol}{18.015\ g} \times \frac{2\ H}{1\ H_2O} = 68.798\ mmol\ H = 69.34\ldots\ mg\ H$$

$$275.5\ mg\ SO_2 \times \frac{1\ mol}{64.063\ g} \times \frac{1\ S}{1\ SO_2} = 4.300\ldots\ mmol\ S = 137.89\ldots\ mg\ S$$

$$mass\ O = 758.0 - 413.17 - 69.38 - 137.89 = 137.588\ldots\ mg\ O$$

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

$$C_{34.399\ldots}H_{68.798}O_{8.599\ldots}S_{4.30\ldots}$$

$$\downarrow$$

$$C_{7.999}H_{15.998}O_{1.999}S$$

$$\downarrow$$

$$\boxed{C_8H_{16}O_2S}$$

8) **[4 marks]** A 1362.5 mg sample of FeX_2, when treated with excess $AgNO_3$, gives 2066.0 mg of AgX:

$FeX_2(aq) + 2AgNO_3(aq) \longrightarrow 2AgX(s) + Fe(NO_3)_2(aq)$

What is the element, X?

$$\text{mmol } FeX_2 = 1362.5 \text{ mg} \times \frac{1 \text{ mol}}{(55.845 + 2x)\text{ g}}$$

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

mmol $FeX_2 \times 2$ = mmol AgX, so:

$$\frac{1362.5}{55.845 + 2x} \times \frac{2\,AgX}{1\,FeX_2} = \frac{2066.0}{107.868 + X}$$

$$\frac{\overset{a}{\downarrow}}{\underset{\uparrow b}{2725}} = \frac{\overset{c}{\downarrow}}{\underset{\uparrow d}{2066}}$$

condensing...

$$\frac{2725}{55.845 + 2x} = \frac{2066}{107.868 + x}$$

$$ad + ax = bc + 2cx$$

$$ad - bc = 2cx - ax$$

$$x = \frac{ad - bc}{2c - a}$$

$$= 126.91\ldots$$

$$\equiv \boxed{I}$$

for neatness...

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

[BONUS – 4 marks] A 1324.0 mg mixture of $FeCl_2$ (126.751 g/mol) and $FeBr_2$ (215.653 g/mol) was reacted with excess Na_3P and 573.7 mg of Fe_3P_2 (229.483 g/mol) collected:

$3FeCl_2(aq) + 2Na_3P(aq) \longrightarrow Fe_3P_2(s) + 6NaCl(aq)$
$3FeBr_2(aq) + 2Na_3P(aq) \longrightarrow Fe_3P_2(s) + 6NaBr(aq)$

What is the mass percent of $FeCl_2$ in the original mixture?

x = mmol $FeCl_2$

y = mmol $FeBr_2$

then...

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

and...

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

$\Downarrow \times 3$ (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:

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

$$x = 3.2999...$$

So mass $FeCl_2$ = $3.2999\ mmol \times 126.751\ \frac{g}{mol} = 418.27...\ mg$

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