**Chem 10113, Exam 1** **Answer Key**
September 19, 2018

1. (7 points) **SHOW ALL WORK.** The density of a solution of $H_2SO_4$ in water is 1.26 g/mL. The solution is 30.0 % $H_2SO_4$ (by mass). Determine the molarity of the $H_2SO_4$ solution.
(molar masses: $H_2SO_4$ = 98.1, $H_2O$ = 18.0)

mass of 1 L of soln = (1000 mL soln) (1.26 g/mL) = 1,260 g

mass of $H_2SO_4$ = (1,260 g soln) (30.0 g $H_2SO_4$ / 100 g soln) = 378 g

molarity = moles $H_2SO_4$ / L = (378 g) (1 mole / 98.1 g) / 1 L = 3.85 M

2. (5 points) Balance the following chemical equations.

(a) $2\ N_2O_5 + 6\ H_2 \longrightarrow 4\ NH_3 + 5\ O_2$

(b) $Si_3N_4 + 6\ H_2O \longrightarrow 3\ SiO_2 + 4\ NH_3$

3. Most metals react with acids to produce a metal salt and $H_2$ gas. In a simple lab experiment, when 35.0 g Al was added to 1.60 L of 2.50 M $HNO_3$, the chemist was able to isolate 3.70 g of pure $H_2$.

$$2\ Al_{(s)} + 6\ HNO_{3(aq)} \longrightarrow 2\ Al(NO_3)_{3(aq)} + 3\ H_{2(g)}$$

(a) (10 points) **SHOW ALL WORK.** Determine the percentage yield of the reaction.

moles of reactants:

(35 g Al) (1 mole / 26.98 g) = 1.297 mole Al

(1.6 L) (2.50 mole $HNO_3$ / L) = 4.00 mole $HNO_3$

Limiting Reactant?

(1.297 mole Al) (3 mole $H_2$ / 2 mole Al) (2.016 g $H_2$ / mole $H_2$) = 3.923 g $H_2$

(4.00 mole $HNO_3$) (3 mole $H_2$ / 6 mole $HNO_3$) (2.016 g $H_2$ / mole $H_2$) = 4.032 g $H_2$

∴ Al is the limiting reactant and theoretical yield is 3.923 g $H_2$

percent yield of $H_2$ = (3.70 g) / (3.923 g) x 100 % = 94.3 %

(b) (7 points) **SHOW ALL WORK.** Determine the molarity of $HNO_3$ in solution after the above experiment is completed.

How much $HNO_3$ is required to consume all of the Al?

(1.297 mole Al) (6 mole $HNO_3$ / 2 mole Al) = 3.891 mole

excess $HNO_3$ = 4.00 mole total - 3.891 mole required = 0.109 mole $HNO_3$

molarity of $HNO_3$ = (0.109 mole $HNO_3$) / 1.60 L = 0.0681 M

4. (10 points) **SHOW ALL WORK.** A mixture of $CH_4$ and $C_5H_{12}$ has a mass of 24.0 g. It is burned completely in excess $O_2$ to form a mixture of $CO_2$ and $H_2O$. The product mixture contains 1.50 times as many moles of $H_2O$ as of $CO_2$. Determine the mass of $CH_4$ in the original mixture. (***Hint***: Write the ***two*** combustion reactions and ***think moles*** as well as grams! Use the approximate molar masses, $CH_4 = 16$ and $C_5H_{12} = 72$, to simplify the math.)

$CH_4 + 2\,O_2 \longrightarrow CO_2 + 2\,H_2O$

$C_5H_{12} + O_2 \longrightarrow 5\,CO_2 + 6\,H_2O$

let x = moles $CH_4$ and y = moles $C_5H_{12}$

then, moles $CO_2$ = x + 5y and moles $H_2O$ = 2x + 6y

moles $H_2O$ = 1.5 (moles $CO_2$) so, 2x + 6y = 1.5(x + 5y)

rearranging, 0.5x = 1.5y or x = 3y

24.0 g = 16x + 72y = 16(3y) + 72y so, y = 0.20 moles $C_5H_{12}$

x = 3y = 0.60 moles $CH_4$

(0.60 moles $CH_4$) (16 g/mole) = 9.6 g

5. (3 points) Write the complete symbol of the specific ***atom or ion*** that has 36 electrons, 42 neutrons, and a mass number of 75.

$^{75}_{33}As^{3-}$

6. (4 points) Circle any of the following that are ***ionic compounds***.

$BrCl_3$ $Sn(S_2O_3)_2$ HI $SeF_4$ $XeO_3$ $NH_4IO_3$ $Li_2O_2$ $PbS_2$

7. (8 points) Complete the following statements for the substance $C_2B_8H_8$. (Work need not be shown!) This substance has a molar mass of 118.6 g/mole and is 72.9 % boron by mass. The ***empirical formula*** of this substance is $CB_4H_4$. The number of ***boron atoms*** in 0.50 mole of $C_2B_8H_8$ is $2.41 \times 10^{24}$.

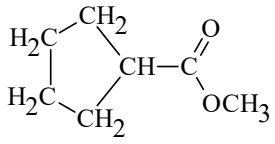
8. (7 points) For the following organic molecules, write the appropriate family name (i.e., alkane, alcohol, etc.) below each one.

$CH_3CH{=}CHCH_3$

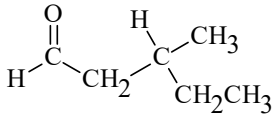
alkene

$CH_3CH_2N(CH_3)_2$

amine



ester



aldehyde

$CH_3CH_2CH_2OCH_3$

ether

9. Write a ***complete, balanced chemical equation*** for each of the following processes.

(a) (2 points) The addition of hydrogen iodide gas to water.

$HI_{(g)} + H_2O \longrightarrow H_3O^+_{(aq)} + I^-_{(aq)}$

(b) (3 points) The preparation of barium nitrate by a ***neutralization*** reaction.

$2\ HNO_{3(aq)} + Ba(OH)_{2(aq)} \longrightarrow Ba(NO_3)_{2(aq)} + 2\ H_2O_{(aq)}$

10. (19 points) Write the chemical formula for each of the following compounds.

| Name | Formula |
|---|---|
| butane | $C_4H_{10}$ |
| rubidium oxalate | $Rb_2C_2O_4$ |
| triantimony heptasulfide | $Sb_3S_7$ |
| potassium hydrogen tellurate | $KHTeO_4$ |
| aluminum acetate | $Al(C_2H_3O_2)_3$ |
| hypoiodous acid | $HIO$ |
| cobalt(II) phosphate octahydrate | $Co_3(PO_4)_2 \bullet 8\ H_2O$ |
| calcium peroxide | $CaO_2$ |
| sodium thiocyanate | $NaSCN$ |
| magnesium nitride | $Mg_3N_2$ |

11. (7 points) **SHOW ALL WORK.** An aluminum-containing compound has the formula $Al_xS_yO_9$ and is 36.9 % oxygen by mass. Determine x and y.

in 1 mole of compound: mass of O = 9 moles O (16 g/mole) = 144 g

molar mass = mass O / 0.369 = 144 g/mole / 0.369 = 390 g/mole

$Al_xS_yO_9$: $27x + 32y + 144 = 390$

$27x + 32y = 246$ (where x and y are integers)

$\therefore\ x = 2$ and $y = 6$ $\qquad Al_2S_6O_9$

12. (8 points) **SHOW ALL WORK.** Determine the number of sulfate ions in 10.0 aL of a dilute solution that is $1.50 \times 10^{-5}$ M $Fe_2(SO_4)_3$. (Remembering the metric prefixes, you'll note that an *atto*liter (aL) is an extremely small volume.) $1\ aL = 10^{-18}\ L$

$(10.0 \times 10^{-18}\ L)\ (1.50 \times 10^{-5}\ mole\ Fe_2(SO_4)_3 / L)\ (3\ moles\ SO_4^{2-} / mole\ Fe_2(SO_4)_3)$

$= 4.5 \times 10^{-22}\ mole\ SO_4^{2-}$

$(4.5 \times 10^{-22}\ mole\ SO_4^{2-})\ (6.022 \times 10^{23}\ ions/mole) = 271\ SO_4^{2-}\ ions$