THE COPPERBELT UNIVERSITY

DEPARTMENT OF CHEMISTRY

CH110: TUTORIAL SHEET 2

STOICHIOMETRY

Term I (2023-2024)

1. (i) Calculate the number of moles that contain 4.50×10^{24} atoms of zinc.
   (ii) What amount of H is there in 5.6 mol of N_2H_4(hydrazine)?
   (iii) Find the amount of penicillin,$C_{16}H_{18}N_2O_4S$, that contains 0.10 mol C.
   (iv) What mass of CO_2 contains 5.10×10^{24} molecules of CO_2?

2. Ethylene glycol used in automobile antifreeze, contains only carbon, hydrogen and oxygen. Combustion analysis of a 23.46 mg sample yields 20.42 mg of H_2O and 33.27 mg CO_2. What is the empirical formula and molecular formula of the ethylene glycol if it has a molecular mass of 62.0 *amu.*

3. Barium peroxide, BaO_2, reacts with hydrochloric acid, HCl, to give hydrogen peroxide, H_2O_2, and barium chloride, $BaCl_2$. In a particular experiment, it was planned to treat 1.45 g of barium peroxide with 25.5 mL of hydrochloric acid solution containing 0.0277 g of HCl per mL
   (a) Write a balanced chemical equation for the reaction.
   (b) Which is the limiting reactant
   (c) What mass in grams of hydrogen peroxide (H_2O_2) should result?
   (d) How many grams of the reactant in excess will be left over?
   (e) If 1.34 g of $BaCl_2$ were produced, calculate the percentage yield for $BaCl_2$

4. Silver (Ag) is a precious metal used mainly in jewelry. What is the mass (in grams) of one Ag atom?

5. How many hydrogen atoms are present in 43.8 g of urea [$(NH_2)_2CO$], which is used as a fertilizer, in animal feed, and in the manufacture of polymers? The molar mass of urea is 60.06 g.

6. Phosphoric acid (H_3PO_4) is a colorless, syrupy liquid used in detergents, fertilizers, toothpastes, and in carbonated beverages for a "tangy" flavor. Calculate the percent composition by mass of H, P, and O in this compound.

7. Ascorbic acid (vitamin C) contains 40.92% carbon, 4.58% hydrogen and 54.50% oxygen by mass. What is the empirical formula of ascorbic?

8. Iron (Fe), the main component of steel, is the most important metal in industrial society. How many Fe atoms are in 95.8 g of Fe?

9. Ammonium carbonate is a white solid that decomposes with warming. Among its many uses, it is a component of baking powder, fire extinguishers, and smelling salts. How many formula units are in 41.6 g of ammonium carbonate?

10. In mammals, lactose (milk sugar) is metabolized to glucose ($C_6H_{12}O_6$), the key nutrient for generating chemical potential energy.
    (a) What is the mass percent of each element in glucose?
    (b) How many grams of carbon are in 16.55 g of glucose?

11. Write a balanced equation for the reaction between aqueous strontium chloride and aqueous lithium phosphate to form solid strontium phosphate and aqueous lithium chloride.

12. Aspirin, acetylsalicylic acid ($C_9H_8O_4$), is the most commonly used pain reliever in the world. It is produced by the reaction of salicylic acid ($C_7H_6O_3$) and acetic anhydride ($C_4H_6O_3$) according to the following equation:

$$C_7H_6O_3(l) + C_4H_6O_3(l) \rightarrow C_9H_8O_4(s) + HC_2H_3O_2(l)$$

    In a certain aspirin synthesis, 104.8 g of salicylic acid and 110.9 g of acetic anhydride are combined. Calculate the percent yield of the reaction if 105.6 g of aspirin are produced.

……END……

(1, i) moles = $\frac{4.50 \times 10^{24} \text{ atoms}}{6.02 \times 10^{23} \text{ atoms/mol}}$ = 7.47 mol

(ii) # since there are 4 atoms of H

Amount = 4 × 5.6 = 22.4 mol ≈ 22 mol

iii 1 mol of $C_{16}H_{18}N_2O_4S$ ≡ 16 mol of C

x = 0.1 mol of C

∴ $x = \frac{0.1}{16}$ = 0.00625 mol of the chi compound

(iv) moles = $\frac{5.10 \times 10^{24} \text{ molecules}}{6.02 \times 10^{23}}$ = 8.47 mol

mass = mol × m

= 8.47 × 44.01

= 371.75 g

Q. # mass of H from H_2O

$\frac{2.02}{18.02} \times 20.42 \times 10^{-3}$ g = 0.002289 g of H

mass of C from CO_2

$\frac{12.01}{44.01} \times 33.27 \times 10^{-3}$ g = 0.009079 g of C

mass of O

sample = C + H + Oxy

O_{xy} = sample − (C + H)

$O_{xy} = 23.46 \times 10^{-3}\,g - (0.009079 + 0.002289)$

$O_{xy} = 0.01209\,g$ of O

moles :

$C = \frac{0.009079}{12.01} = 0.000755595$

$H = \frac{0.002289}{1.01} = 0.002266$

$O = \frac{0.01209}{16} = 0.0007556$

$\frac{0.000755595}{0.000755} \quad \frac{0.002266}{0.000755} \quad \frac{0.0007556}{0.000755}$

C = 1 : H = 3 : O = 1

CH_3O is the empirical formular

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finding molecular formular

CH_3O

12.01
3.03
16
31.04 g/mol

$n = \frac{62.0\ g/mol}{31.04} = 2$

$(CH_3O)_n$

$(CH_3O)_3$

$C_2H_6O_2$ is the molecular formula

Question 3

(a) $BaO_2 + 2HCl \longrightarrow H_2O_2 + BaCl_2$

b # Find the given moles

BaO_2

$moles = \frac{mass}{m.m}$

$= \frac{1.45g}{169.33}$

$moles = 0.00856 mol$

HCl

~~$moles = \frac{mass}{m.m}$~~

~~$= \frac{0.097g}{36.46}$~~

mass of HCl;

$0.0277 g/ml \times 25.5 ml$

$0.70635 g$

$\therefore moles = \frac{0.70635}{36.46}$

$moles = 0.01937 mol$

$\therefore$ $T_1 = 60.18\,N$

$T_2 = 79.86\,N$

$T_3 = 100\,N$

$BaO_2 : HCl$

$1 : 2$

$0.00856 : x$

$x = 0.01712$ moles of HCl

0.01712 moles of HCl needed to react with 0.00856 moles of BaO_2 but 0.01937 moles of HCl were given, making ~~HCl~~ the reactant in excess making BaO_2 the limiting reagent

c ~~$HCl : H_2O_2$~~ $BaO_2 : H_2O_2$

$1 : 1$

$0.00856 : x$

$x = 0.00856$ mol of H_2O_2

mass = mol x m.m

$= 0.00856 \times 34.02$

mass = 0.2912 g

d excess = given - needed
= 0.01937 mol - 0.01712 mol
= 0.00225 mol

mass = mol x m.m
= 0.00225 x 36.46
= 0.082g of HCl were in excess

e $BaO_2 : BaCl_2$
1 : 1
0.00856 : x

x = 0.00856 mol of $BaCl_2$

mass = mol x m.m
= 0.00856 x 208.23
= 1.78g of $BaCl_2$

$$\% \text{ yield} = \frac{\text{Actual}}{\text{theoretical}} \times 100\%$$

$$= \frac{1.34g}{1.78g} \times 100\%$$

% yied = 75.3%

Q. 4

$1 \text{ mole} = 6.02 \times 10^{23} \text{ atoms}$

$x = 1 \text{ atom}$

$$x = \frac{1 \text{ atom. mole}}{6.02 \times 10^{23} \text{ atoms}}$$

$x = 1.66 \times 10^{-24} \text{ moles}$

$\text{mass} = \text{moles} \times \text{m.m}$

$= 1.66 \times 10^{-24} \times 107.87$

$\text{mass} = 1.69 \times 10^{-22} \text{ g}$

Q. 5

$$\text{moles} = \frac{\text{mass}}{\text{m.m}}$$

$$= \frac{43.8 \text{ g}}{60.06 \text{ g/mol}}$$

$\text{moles} = 0.72927 \text{ mol}$

$(NH_2)_2CO : H$

$1 : H$

$0.72927 : x$

$x = 2.91708 \text{ mols of } H$

$1 \text{ mol} = 6.02 \times 10^{23} \text{ atoms}$

$2.91708 \text{ mol} = x$

$x = 1.76 \times 10^{24} \text{ atoms of } H$

Q. 6 H_3PO_4

$3 \times 1.01 = 3.03$

$1 \times 30.97 = 30.97$

$4 \times 16 = 64$

98 g/mol

% of H $= \frac{3.03}{98} \times 100$ $= 3.09\%$

% of P $= \frac{30.97}{98} \times 100$ $= 31.6\%$

% of O $= \frac{64}{98} \times 100$ $= 65.3\%$

Q. 7

C $= \frac{40.92}{12.01}$ H $= \frac{4.58}{1.01}$ O $= \frac{54.50}{16}$

C $= \frac{3.407}{3.406}$ H $= \frac{4.534}{3.406}$ O $= \frac{3.406}{3.406}$

C $= 1$ H $= 1.33$ O $= 1$

$(C H_{1.33} O)_3$

$C_3H_4O_3$

Q.8

Try this one out, the answer is
1.032×10^{24} atoms

Q.9

keep in mind that
formular units = # of mols $\times$ 6.02×10^{23}

$$\text{moles} = \frac{\text{mass}}{\text{m.m}}$$

$$= \frac{41.6\,g}{96.09}$$

$$\text{moles} = 0.433\ \text{mol}$$

$$\text{formular unit} = (0.433\ \text{mo}) \times (6.02 \times 10^{23})\ \text{mol}^{-1}$$

$$= 2.606 \times 10^{23}\ \text{formula units}$$

Q.10

(a) $C_6H_{12}O_6$

$6 \times 12.01 = 72.06$
$12 \times 1.01 = 12.12$
$6 \times 16 = 96$
180.18

% of C
$\frac{72.06}{180.18} \times 100\%$
$= 40\%$

% of H
$\frac{12.13}{180.18} \times 100\%$
6.7%

% of O
$\frac{96}{180.18} \times 100\%$
53.3%

$C_6H_{12}O_6$: C

1 : 6

(b) moles = $\frac{\text{mass}}{\text{m.m}}$

$= \frac{16.55\text{g}}{180.18}$

$= 0.09185$ mol

$C_6H_{12}O_6$: C

1 : 6

0.09185 : x

$x = 0.5511$ moles of C

mass = moles $\times$ m.m

$= 0.5511 \times 12.01$

mass = 6.62g of C

Q.11

$3SrCl_{2(aq)} + 2Li_3PO_{4(aq)} \longrightarrow Sr_3(PO_4)_{2(s)} + 6LiCl_{(aq)}$

Q. 12

start by finding the limiting reactant

moles of $C_7H_6O_3$ = $\frac{\text{mass}}{\text{M.M}}$

= $\frac{104.8\text{g}}{138.118\text{g/mol}}$

= 0.7587 mol

moles of $C_4H_6O_3$ = $\frac{110.9}{102.089}$

= 1.086 mol

$C_7H_6O_3$: $C_4H_6O_3$

1 : 1

x : 1.086 mol

x = 1.086 mol of $C_7H_6O_3$

∴ 1.086 mol of $C_4H_6O_3$ needed 1.086 mol of $C_7H_6O_3$ but only 0.7587 mol of $C_7H_6O_3$ was provided hence $C_7H_6O_3$ is the limiting reactant

$C_7H_6O_3$: $C_9H_8O_4$

1 : 1

0.7587 : x

x = 0.7587 mol of $C_9H_8O_4$

mass = moles x m.m

= 0.7587 x 180.157

mass = 136.7 g

$$\% \text{ yield} = \frac{\text{Actual}}{\text{theoretical}} \times 100\%$$

$$= \frac{105.6\text{g}}{136.7\text{g}} \times 100\%$$

% yield = 77.2 %