The GIANT Stoich Review

Part One: Just plain Stoichiometry

1 Calculate the amount of oxygen in grams produced by the reaction of 69.0 g of water. $2H_2O \rightarrow 2H_2 + O_2$

$$69.0 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.0152 \text{ g } H_2O} \times \frac{1 \text{ mol } O_2}{2 \text{ mol } H_2O} \times \frac{31.9988 \text{ g } O_2}{1 \text{ mol } O_2}$$

$$= 61.28 \text{ g } O_2$$

2\. Calculate the energy in KJ produced by the reaction of 10.0 Kg of hydrogen with excess oxygen. $2H_2 + O_2 \rightarrow 2H_2O + 213\text{KJ}$

$$10.0 \text{ Kg} \times \frac{1000 \text{ g } H_2}{1 \text{ Kg}} \times \frac{1 \text{ mol } H_2}{2.0158 \text{ g } H_2} \times \frac{213 \text{ ~~mol~~ "~~energy~~" KJ}}{2 \text{ mol } H_2}$$

$$= 528326.2 \text{ KJ}$$

3 Calculate the number of Fe atoms produced in the reaction if 500. J of energy are absorbed. $2Fe_2O_3 + 3C + 235\ KJ \rightarrow 4Fe + 3CO_2$

$$500\ \text{J} \times \frac{}{235}$$

$$500\ \text{J} \times \frac{1\ \text{KJ}}{1000\ \text{J}} \times \frac{4\ \text{mol Fe}}{235\ \text{KJ}} \times \frac{6.02\times10^{23}\ \text{part. Fe}}{1\ \text{mol Fe}} \times \frac{1\ \text{atom Fe}}{1\ \text{particle Fe}}$$

$$= 5.12 \times 10^{21}\ \text{atoms Fe}$$

4 Calculate the number of moles CO_2 produced by the reaction of 8.45 g of C.
$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$

$$8.45\ \text{g C} \times \frac{1\ \text{mol C}}{12.011\ \text{g C}} \times \frac{3\ \text{mol CO}_2}{3\ \text{mol C}} = 0.704\ \text{mol CO}_2$$

5 How many liters of O_2, measured at STP, will be released on the decomposition of 2.65 g of mercury (II) oxide: $2HgO \rightarrow 2Hg + O_2$

$$2.65\text{ g HgO} \times \frac{1\text{ mol HgO}}{216.5894\text{g HgO}} \times \frac{\Phi\text{ mol } O_2}{2\text{ mol HgO}} \times \frac{22.4\text{ L } O_2}{1\text{ mol } O_2}$$

$$= 0.137\text{ L } O_2$$

6 Chloroform or trichloromethane, $CHCl_3$, may be prepared in the laboratory by the reaction between Chlorine and methane. Calculate the number of grams of chlorine that are required to produce 50.0 g of trichloromethane.

$$\underset{?\text{ g}}{3Cl_{2(g)}} + CH_{4(g)} \rightarrow \underset{50.0\text{g}}{CHCl_{3(l)}} + 3HCl_{(g)}$$

$$50.0\text{g } CHCl_3 \times \frac{1\text{ mol } CHCl_3}{119.377\text{g } CHCl_3} \times \frac{3\text{ mol } Cl_2}{1\text{ mol } CHCl_3} \times \frac{70.0954\text{g } Cl_2}{1\text{ mol } Cl_2}$$

$$= 89.09\text{ g } Cl_2$$

7

The purification ability and bleaching action of bleaching activity of chlorine both come from the effective release of oxygen by the reaction below. How many grams of oxygen will be liberated by 255 g of chlorine?

$$2H_2O_{(l)} \quad + \quad 2Cl_{2(g)} \quad \rightarrow \quad 4HCl_{(aq)} \quad + \quad O_{2(g)}$$

$$255 g\ Cl_2 \times \frac{1\ mol\ Cl_2}{70.9054\ g\ Cl_2} \times \frac{1\ mol\ O_2}{2\ mol\ Cl_2} \times \frac{31.9988\ g\ O_2}{1\ mol\ O_2}$$

$$= 57.54\ g\ O_2$$

8

What mass of potassium chlorate must be decomposed to produce 1.50 liters of oxygen at STP?

$$2KClO_{3(s)} \quad \rightarrow \quad 2KCl_{(s)} + \quad 3O_{2(g)}$$

$$1.50 L\ O_2 \times \frac{1\ mol\ O_2}{22.4\ L\ O_2} \times \frac{2\ mol\ KClO_3}{3\ mol\ O_2} \times \frac{122.5492 g\ KClO_3}{1\ mol\ KClO_3}$$

$$= 5.47\ g\ KClO_3$$

9 Dinitrogen oxide N_2O- Known also as nitrous oxide and laughing gas –was one of early anesthetics, and has recently regained popularity in this role in the dental field. It is made by the decomposition of ammonium nitrate which equations shown below. How many grams of $NH_4NO_{3\ (S)}$ are required to prepare 12.8 grams of N_2O?

$$NH_4NO_{3(s)} \rightarrow N_2O_{(g)} + 2H_2O_{(l)}$$

$$12.8\ g\ N_2O \times \frac{1\ mol\ N_2O}{\underset{44.0128}{1}\ g\ N_2O} \times \frac{1\ mol\ NH_4NO_3}{1\ mol\ N_2O} \times \frac{80.0432g\ NH_4NO_3}{1\ mol\ NH_4NO_3}$$

$$= \ldots g\ NH_4NO_3$$

$$23.28\ g\ NH_4NO_3$$

10 Photosynthesis is the process by which carbon dioxide is converted into sugar, $C_6H_{12}O_6$, with the help of sunlight and the chlorophyll of green plants acting as a catalyst. It may be summarized by the equation below. How many grams of sugar may be produced in the reaction that consumes 6.90 grams of carbon dioxide?

$$\overset{6.90g}{6CO_2}{}_{(g)} + 6\,H_2O_{(g)} \xrightarrow[\text{Light energy}]{\text{Chlorophyll}} \overset{?\ g}{C_6H_{12}O_6} + 6\,O_{2\ (g)}$$

$$6.90\ g\ CO_2 \times \frac{1\ mol\ CO_2}{44.0098\ g\ CO_2} \times \frac{1\ mol\ C_6H_{12}O_6}{6\ mol\ CO_2} \times \frac{180.1572g\ glucose}{1\ mol\ glucose}$$

$$= 4.71\ g\ C_6H_{12}O_6$$

11

Calculate the amount of oxygen in grams produced by the reaction of 125 g of water. $2H_2O \rightarrow 2H_2 + O_2$

$$125\ g\ H_2O \times \frac{1\ mol\ H_2O}{18.0152\ g\ H_2O} \times \frac{1\ mol\ O_2}{2\ mol\ H_2O} \times \frac{31.9988\ g\ O_2}{1\ mol\ O_2}$$

$$= 111.01\ g\ O_2$$

12

Calculate the mass of carbon required to produce 5.67 g of iron.

$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$

$$5.67\ g\ Fe \times \frac{1\ mol\ Fe}{55.845\ g\ Fe} \times \frac{3\ mol\ C}{4\ mol\ Fe} \times \frac{12.011\ g\ C}{1\ mol\ C}$$

$$= 0.915\ g\ C$$

13

25.0 g of sodium reacts with water, how many grams of hydrogen are produced? How many grams of sodium hydroxide are produced?

$$2Na + 2H_2O \rightarrow 2NaOH + H_2$$

$$25.0\ g\ Na \times \frac{1\ mol\ Na}{22.9898\ g\ Na} \times \frac{1\ mol\ H_2}{2\ mol\ Na} \times \frac{2.0158\ g\ H_2}{1\ mol\ H_2} = 1.096\ g\ H_2$$

$$25.0\ g\ Na \times \frac{1\ mol\ Na}{22.9898\ g\ Na} \times \frac{2\ mol\ NaOH}{2\ mol\ Na} \times \frac{39.9971\ g\ NaOH}{1\ mol\ NaOH} = 43.49\ g\ NaOH$$

14

Calculate the volume of H_2 gas produced at STP by the reaction of 400.0 mL of 0.800 M HCl with excess Zn.

$Zn + 2HCl \rightarrow H_2 + ZnCl_2$

$mol = M \times V_L$

$= (0.800M)(0.400L)$

$= 0.32$ moles

$$0.32\ mol\ HCl \times \frac{1\ mol\ H_2}{2\ mol\ HCl} \times \frac{22.4\ L\ H_2}{1\ mol\ H_2}$$

$$= 3.584\ L\ H_2.$$

15.

Calculate the mass of KF required to produce 100. L of F_2 gas at STP.

$2KF \rightarrow 2K + F_2$

$$100.\ L\ F_2 \times \frac{1\ mol\ F_2}{22.4\ L\ F_2} \times \frac{2\ mol\ KF}{1\ mol\ F_2} \times \frac{58.0967g\ KF}{1\ mol\ KF}$$

$$= 518.72\ g\ KF$$

16 16 g of Ca react with water. Calculate the volume of H_2 gas produced at STP.

$Ca + 2H_2O \rightarrow H_2 + Ca(OH)_2$

$$16\ g\ Ca \times \frac{1\ mol\ Ca}{40.078\ g\ Ca} \times \frac{1\ mol\ H_2}{1\ mol\ Ca} \times \frac{22.4\ L\ H_2}{1\ mol\ H_2} = 8.94\ L\ H_2$$

17 Calculate the volume of F_2 gas at STP produced by the electrolysis of 8.2 g of KF.

$2KF \rightarrow 2K + F_2$

$$8.2\ g\ KF \times \frac{1\ mol\ KF}{58.0967\ g\ KF} \times \frac{1\ mol\ F_2}{2\ mol\ KF} \times \frac{22.4\ L\ \cancel{g}\ F_2}{1\ mol\ F_2} = \text{[illegible]}\ 1.58\ L\ F_2$$

18

Calculate the number of molecules of CO_2 produced by the reaction of 2.45g of iron III oxide. $2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$

$$2.45\ g\ Fe_2O_3 \times \frac{1\ mol\ Fe_2O_3}{159.6882\ g\ Fe_2O_3} \times \frac{3\ mol\ CO_2}{2\ mol\ Fe_2O_3} \times \frac{6.02 \times 10^{23}\ molec.\ CO_2}{1\ mol\ CO_2}$$

$$= 1.39 \times 10^{22}\ molec.\ CO_2$$

19 How many grams of H_2 would be needed to produce 260. KJ of energy?

$2H_2 + O_2 \rightarrow 2H_2O + 130KJ$

$$260\ KJ \times \frac{2\ mol\ H_2}{130\ KJ} \times \frac{2.0158g\ H_2}{1\ mol\ H_2} = 8.0632\ g\ H_2$$

20 Calculate the energy produced by the complete reaction of 150.g H_2.

$2H_2 + O_2 \rightarrow 2H_2O + 130KJ$

$$150\ g\ H_2 \times \frac{1\ mol\ H_2}{2.0158\ g\ H_2} \times \frac{130\ KJ}{2\ mol\ H_2} = 4836.79\ KJ$$

21 Calculate the mass of C_4H_{10} required to produce 2.06 x 10^6 J of energy.

$2C_4H10 + 13O_2 \rightarrow 8CO_2 + 10H_2O + 256KJ$

$$2.06 \times 10^6\ J \times \frac{1\ KJ}{1000\ J} \times \frac{2\ mol\ C_4H_{10}}{256\ KJ} \times \frac{58.123\ g\ C_4H_{10}}{1\ mol\ C_4H_{10}}$$

$$= 935.42\ g\ C_4H_{10}$$

12 What quantity of magnesium must a student react with excess hydrochloric acid to produce 85.0 ml hydrogen, measured at STP?

$Mg_{(s)} + 2HCl_{(aq)} \rightarrow H_{2(g)} + MgCl_{2(aq)}$

$$85.0\ mL\ H_2 \times \frac{1\ L\ H_2}{1000\ mL\ H_2} \times \frac{1\ mol\ H_2}{22.4\ L\ H_2} \times \frac{1\ mol\ Mg}{1\ mol\ H_2} \times \frac{24.305\ g\ Mg}{1\ mol\ Mg}$$

$$= 0.092\ g\ Mg$$

13 When sodium hydrogen carbonate is treated with sulfuric acid, carbon dioxide bubbles off:

$H_2SO_{4(aq)} + 2NaHCO_{3(s)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)} + 2CO_{2(g)}$

What volume of CO_2, measured at STP, is available from 8.58 g $NaHCO_3$?

$$8.58\ g\ NaHCO_3 \times \frac{1\ mol\ NaHCO_3}{84.0069\ g\ NaHCO_3} \times \frac{2\ mol\ CO_2}{2\ mol\ NaHCO_3} \times \frac{22.4\ L\ CO_2}{1\ mol\ CO_2}$$

$$= 2.29\ L\ CO_2$$

24

What mass of magnesium must react with excess hydrochloric acid to produce 85.0 ml hydrogen, measured at STP?

$Mg_{(s)} + 2HCl_{(aq)} \rightarrow H_2(g) + MgCl_{2(aq)}$

$$85.0 \text{ mL } H_2 \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1 \text{ mol } H_2}{22.4 \text{ L } H_2} \times \frac{1 \text{ mol Mg}}{1 \text{ mol } H_2} \times \frac{24.305 \text{ g Mg}}{1 \text{ mol Mg}}$$

$$= 0.092 \text{ g Mg}$$

25

Calculate the volume of F_2 gas at STP produced by the reaction of 15.6 g of KF.

$2KF \rightarrow 2K + F_2$

$$15.6 \text{ g KF} \times \frac{1 \text{ mol KF}}{58.0967 \text{ g KF}} \times \frac{1 \text{ mol } F_2}{2 \text{ mol KF}} \times \frac{22.4 \text{ L } F_2}{1 \text{ mol } F_2}$$

$$= 3.01 \text{ L } F_2$$

26

How many litres of O_2 gas are required to produce 100. g Al_2O_3?

$4Al + 3O_2 \rightarrow 2Al_2O_3$

$$100. \text{ g } Al_2O_3 \times \frac{1 \text{ mol } Al_2O_3}{101.9612 \text{ g } Al_2O_3} \times \frac{3 \text{ mol } O_2}{2 \text{ mol } Al_2O_3} \times \frac{22.4 \text{ L } O_2}{1 \text{ mol } O_2}$$

$$= 32.95 \text{ L } O_2$$

27

How many moles of Al_2O_3 are produced by the reaction 200. g Al?

$4Al + 3O_2 \rightarrow 2Al_2O_3$

$$200. \text{ g Al} \times \frac{1 \text{ mol Al}}{26.9815 \text{ g Al}} \times \frac{2 \text{ mol } Al_2O_3}{4 \text{ mol Al}} = 3.71 \text{ mol } Al_2O_3$$

28

How many litres of O_2 gas are required to produce 100. g Al_2O_3?

$4Al + 3O_2 \rightarrow 2Al_2O_3$

$$100.\text{ g } Al_2O_3 \times \frac{1 \text{ mol } Al_2O_3}{101.9612 \text{ g } Al_2O_3} \times \frac{3 \text{ mol } O_2}{2 \text{ mol } Al_2O_3} \times \frac{22.4 \text{ L } O_2}{1 \text{ mol } O_2}$$

$$= 32.95 \text{ L } O_2$$

29

Calculate the energy produced by the complete reaction of 150. g H_2.

$2H_2 + O_2 \rightarrow 2H_2O + 130KJ$

$$150 \text{ g } H_2 \times \frac{1 \text{ mol } H_2}{2.0158 \text{ g } H_2} \times \frac{130 \text{ KJ}}{2 \text{ mol } H_2} = 4836.79 \text{ KJ}$$

30

25.0 g of calcium reacts with water, how many grams of hydrogen are produced?

How many grams of calcium hydroxide are produced? $Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$

$$25.0 \text{ g } Ca \times \frac{1 \text{ mol } Ca}{40.078 \text{ g } Ca} \times \frac{1 \text{ mol } H_2}{1 \text{ mol } Ca} \times \frac{2.0158 \text{ g } H_2}{1 \text{ mol } H_2} = 1.26 \text{ g } H_2$$

31

Calculate the number of grams NaCl produced by the complete reaction of 520. g Cl_2. $2Na + Cl_2 \rightarrow 2NaCl$

$$520 \text{ g } Cl_2 \times \frac{1 \text{ mol } Cl_2}{70.9054 \text{ g } Cl_2} \times \frac{2 \text{ mol NaCl}}{1 \text{ mol } Cl_2} \times \frac{58.4425 \text{ g NaCl}}{1 \text{ mol NaCl}}$$

$$= 857.20 \text{ g NaCl}$$

32 How many grams of O_2 are required to consume 100. g Al?

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

$$100.\text{ g Al} \times \frac{1 \text{ mol Al}}{26.9815 \text{ g Al}} \times \frac{3 \text{ mol } O_2}{4 \text{ mol Al}} \times \frac{31.9988 \text{ g } O_2}{1 \text{ mol } O_2}$$

$$= 88.95 \text{ g } O_2$$

33 Calculate the energy produced by the complete reaction of 150. g H_2.

$$2H_2 + O_2 \rightarrow 2H_2O + 250 \text{ KJ}$$

$$150.\text{ g } H_2 \times \frac{1 \text{ mol } H_2}{2.0158 \text{ g } H_2} \times \frac{250 \text{ KJ}}{2 \text{ mol } H_2} = 9301.52 \text{ KJ}$$

34

How many moles Al are required to produce 300. g Al_2O_3?

$$4Al + 3O_2 \rightarrow 2Al_2O_3$$

$$300.\text{ g } Al_2O_3 \times \frac{1 \text{ mol } Al_2O_3}{101.9612 \text{ g } Al_2O_3} \times \frac{4 \text{ mol Al}}{2 \text{ mol } Al_2O_3} = 5.88 \text{ mol Al}$$

35 Calculate the mass of carbon required to consume 5.67 g of iron III oxide.

$$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$$

$$5.67 \text{ g } Fe_2O_3 \times \frac{1 \text{ mol } Fe_2O_3}{159.6882 \text{ g } Fe_2O_3} \times \frac{3 \text{ mol C}}{2 \text{ mol } Fe_2O_3} \times \frac{12.011 \text{ g C}}{1 \text{ mol C}}$$

$$= 0.6397 \text{ g C}$$

36 Calculate the volume of oxygen at STP produced by the reaction of 69.0 g of water. $2H_2O \rightarrow 2H_2 + O_2$

$$69.0\text{ g }H_2O \times \frac{1\text{ mol }H_2O}{18.0152\text{ g }H_2O} \times \frac{1\text{ mol }O_2}{2\text{ mol }H_2O} \times \frac{22.4\text{ L }O_2}{1\text{ mol }O_2}$$

$$= 42.897\text{ L }O_2$$

37 How many litres of O_2, measured at STP, will be released on the decomposition of 8.56 g of mercury (II) oxide: $2HgO \rightarrow 2Hg + O_2$

$$8.56\text{ g }HgO \times \frac{1\text{ mol }HgO}{216.5894\text{g }HgO} \times \frac{1\text{ mol }O_2}{2\text{ mol }HgO} \times \frac{22.4\text{ L }O_2}{1\text{ mol }O_2}$$

$$= 0.443\text{ L }O_2$$

38 Calculate the number of Fe atoms consumed in the reaction if 100. g of Fe_2O_3 react. $2Fe_2O_3 + 3C + 235\text{ KJ} \rightarrow 4Fe + 3CO_2$

$$100.\text{ g }Fe_2O_3 \times \frac{1\text{ mol }Fe_2O_3}{159.68829\ Fe_2O_3} \times \frac{4\text{ mol }Fe}{2\text{ mol }Fe_2O_3} \times \frac{6.02\times10^{23}\text{ part. }Fe}{1\text{ mol }Fe} \times \frac{1\text{ atom }Fe}{1\text{ part. }Fe}$$

$$= 7.54 \times 10^{23}\text{ atoms Fe}$$

39

Calculate the number of moles CO_2 produced by the reaction of 8.45 g of C.
$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$

$$8.45\text{g C} \times \frac{1\text{ mol C}}{12.011\text{ g C}} \times \frac{3\text{ mol }CO_2}{3\text{ mol C}} = 0.704\text{ mol }CO_2$$

40

Calculate the mass of carbon required to consume 5.67 g of iron III oxide
$2Fe_2O_3 \quad + \quad 3C \quad \rightarrow \quad 4Fe \quad +3CO_2$

$$5.67\text{ g } Fe_2O_3 \times \frac{1\text{ mol } Fe_2O_3}{159.6882\text{g } Fe_2O_3} \times \frac{3\text{ mol } C}{2\text{ mol } Fe_2O_3} \times \frac{12.011\text{ g } C}{1\text{ mol } C}$$

$$= 0.640\text{ g } C$$

41

Calculate the number of grams H_2 required to produce 500. J of energy.
$2H_2 + O_2 \quad \rightarrow \quad 2H_2O \quad + \quad 250\text{ KJ}$

$$500\text{ J} \times \frac{1\text{ KJ}}{1000\text{ J}} \times \frac{2\text{ mol } H_2}{250\text{ KJ}} \times \frac{2.0158\text{ g } H_2}{1\text{ mol } H_2}$$

$$= 8.06 \times 10^{-3}\text{ g } H_2$$

42

Calculate the energy in KJ produced by the reaction of 10.0 g of hydrogen with excess oxygen. $2H_2 \; + \; O_2 \quad \rightarrow \quad 2H_2O \quad + \quad 213\text{KJ}$

$$10.0\text{ g } H_2 \times \frac{1\text{ mol } H_2}{2.0158\text{ g } H_2} \times \frac{213 \cancel{\text{mol}}\text{ KJ}}{2\text{ mol } H_2} = 528.33\text{ KJ}$$

Part Two: Theoretical & Percent Yield

1 Calculate the theoretical yield in grams of Fe produced by the reaction of 5.67 g of iron III oxide. $2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$

$$5.67\ g\ Fe_2O_3 \times \frac{1\ mol\ Fe_2O_3}{159.6882g\ Fe_2O_3} \times \frac{4\ mol\ Fe}{2\ mol\ Fe_2O_3} \times \frac{55.845\ g\ Fe}{1\ mol\ Fe}$$

$$= 3.97\ g\ Fe$$

2 Calculate the mass of carbon dioxide produced when 5.67 g of iron III oxide reacts with excess C. If the percentage yield is 85.0 % calculate the actual yield.
$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$

$$5.67\ g\ Fe_2O_3 \times \frac{1\ mol\ Fe_2O_3}{159.6882\ g\ Fe_2O_3} \times \frac{3\ mol\ CO_2}{2\ mol\ Fe_2O_3} \times \frac{44.0098\ g\ CO_2}{1\ mol}$$

theoretical yield = $\boxed{2.34\ g\ CO_2}$

$$\%\ yield = \frac{actual}{theoretical} \times 100$$

$$actual = \frac{\%\ yield\ (theoretical)}{100}$$

$$= \frac{85\%\ (2.34\ g)}{100}$$

$$\boxed{= 1.989\ g\ CO_2}$$

3 If 5.45 g of $KClO_3$ are decomposed to form KCl and 1.95 g of O_2 are collected. Calculate the theoretical and percentage yields. $2KClO_3 \rightarrow 2KCl + 3O_2$

theoretical yield.

$$5.45\text{ g } KClO_3 \times \frac{1 \text{ mol } KClO_3}{122.5492\text{g } KClO_3} \times \frac{3 \text{ mol } O_2}{2 \text{ mol } KClO_3} \times \frac{31.9988\text{g } O_2}{1 \text{ mol } O_2}$$

$$= 2.13\text{ g } O_2$$

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

$$= \frac{1.95\text{ g } O_2}{2.13\text{ g } O_2} \times 100$$

$$= 91.5\%$$

4 Calculate the theoretical yield in grams of Fe produced by the reaction of 5.67 g of iron III oxide. If the actual yield is 2.00 g calculate the percentage yield.

$2Fe_2O_3 \quad + \quad 3C \quad \rightarrow \quad 4Fe \quad +3CO_2$

$$5.67\text{ g } Fe_2O_3 \times \frac{1 \text{ mol } Fe_2O_3}{159.6882\text{ g } Fe_2O_3} \times \frac{4 \text{ mol } Fe}{2 \text{ mol } Fe_2O_3} \times \frac{55.845\text{ g } Fe}{1 \text{ mol } Fe}$$

theoretical yield $= 3.97\text{ g } Fe$

$$\% \text{ yield} = \frac{2.00\text{ g } Fe}{3.97\text{ g } Fe} \times 100$$

$$= 50.4\%$$

If 32.7 g of $KClO_3$ are decomposed to form KCl and 11.7 g of O_2 are collected. Calculate the theoretical and percentage yield. $2KClO_3 \rightarrow 2KCl + 3O_2$

$$32.7 g\ KClO_3 \times \frac{1\ mol\ KClO_3}{122.5492\ g\ KClO_3} \times \frac{3\ mol\ O_2}{2\ mol\ KClO_3} \times \frac{31.9988\ g\ O_2}{1\ mol\ O_2}$$

theoretical yield = 12.81 g O_2

$$\%\ yield = \frac{11.7\ g\ O_2}{12.81\ g\ O_2} \times 100$$

$$= 91.3\%$$

6

100. g Al reacts with excess O_2 to produce 150. g Al_2O_3 according to Calculate the theoretical and percentage yield. $4Al + 3O_2 \text{-------}> 2\ Al_2O_3$.

$$100\ g\ Al \times \frac{1\ mol\ Al}{26.9815\ g\ Al} \times \frac{2\ mol\ Al_2O_3}{4\ mol\ Al} \times \frac{101.9612\ g\ Al_2O_3}{1\ mol\ Al_2O_3}$$

theoretical yield = 188.95 g

$$\%\ yield = \frac{150\ g}{188.95\ g} \times 100$$

$$= 79.4\ \%$$

7 500. g of Fe_2O_3 are refined to produce 200. g of Fe. Calculate the percentage yield of Fe.

$$2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$$

$$500.\ g\ Fe_2O_3 \times \frac{1\ mol\ Fe_2O_3}{159.6882\ g\ Fe_2O_3} \times \frac{4\ mol\ Fe}{2\ mol\ Fe_2O_3} \times \frac{\overset{55.845}{\cancel{26.9815}}\ g\ Fe}{1\ mol\ Fe}$$

$$= \underset{349.713}{\cancel{168.96}}\ g\ Fe$$

$$\%\ yield = \frac{actual}{theoretical} \times 100$$

$$= \frac{200}{\underset{349.713}{\cancel{168.96}}} \times 100 = \underset{57.2\%}{\cancel{118.4\%}}$$

8 Calculate the number of grams water produced by the complete reaction of 14.5 g of oxygen (theoretical yield). $2H_2 + O_2 \rightarrow 2H_2O$

$$14.5\ g\ O_2 \times \frac{1\ mol\ O_2}{31.9988\ g\ O_2} \times \frac{2\ mol\ H_2O}{1\ mol\ O_2} \times \frac{18.0152\ g\ H_2O}{1\ mol\ H_2O}$$

$$= 16.33\ g\ H_2O$$

9 Calculate the theoretical yield in grams of CO_2 produced by the reaction of 15.6 g of iron III oxide. $2Fe_2O_3 + 3C \rightarrow 4Fe + 3CO_2$

$$15.6\ g\ Fe_2O_3 \times \frac{1\ mol\ Fe_2O_3}{159.6882\ g\ Fe_2O_3} \times \frac{3\ mol\ CO_2}{2\ mol\ Fe_2O_3} \times \frac{44.0098\ g\ CO_2}{1\ mol\ CO_2}$$

$$= 6.45\ g\ CO_2$$

10 25.5 mL of 0.100 M HCl reacts with excess Zn to produce 25.3 mL of H_2 gas at STP. Calculate the theoretical yield in mL and the percentage yield of H_2 gas.

$Zn + 2HCl \rightarrow H_2 + ZnCl_2$.

$$\text{mol} = M \times V_L$$
$$= (0.100M)(0.025L)$$
$$= 0.0025 \text{ mol } HCl \times \frac{1 \text{ mol } H_2}{2 \text{ mol } HCl} \times \frac{22.4 \text{ L } H_2}{1 \text{ mol } H_2} \times \frac{1000 \text{ mL}}{1 \text{ L}}$$

$$\text{theoretical yield} = 28 \text{ mL } H_2$$

$$\% \text{ yield} = \frac{25.3 \text{ mL}}{28 \text{ mL}} \times 100$$
$$= 90.4\%$$

11 The fermentation of sugar in the presence of zymase, an enzyme in yeast, can be described by the equation below. If 500. g of sugar is fermented and 200. g of alcohol are produced, calculate the theoretical and percentage yield of alcohol.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

$$500 \text{ g } C_6H_{12}O_6 \times \frac{1 \text{ mol } C_6H_{12}O_6}{180.1572 \text{ g } C_6H_{12}O_6} \times \frac{2 \text{ mol } C_2H_5OH}{1 \text{ mol } C_6H_{12}O_6} \times \frac{29.0615 \text{ g } C_2H_5OH}{1 \text{ mol } C_2H_5OH}$$

$$\text{theoretical yield} = 161.31 \text{ g } C_2H_5OH$$

$$\% \text{ yield} = \frac{200 \text{ g}}{161.31 \text{ g}} \times 100 = 124.0\%$$

12 Calculate the theoretical yield of oxygen in grams produced by the reaction of 69.0 g of water. If the actual yield of O_2 is 50.0 g, calculate the percentage yield.

$2H_2O \rightarrow 2H_2 + O_2$

$$69.0\,g\ H_2O \times \frac{1\ mol\ H_2O}{18.0152\ g\ H_2O} \times \frac{1\ mol\ O_2}{2\ mol\ H_2O} \times \frac{31.9988\ g\ O_2}{1\ mol\ O_2}$$

theoretical yield. = 61.28 g O_2

$$\%\ yield = \frac{50.0g}{61.28g} \times 100$$

= 81.6%

13 Calculate the energy produced by the reaction of 100. L of hydrogen at STP with excess oxygen. $2H_2 + O_2 \rightarrow 2H_2O + 213KJ$

$$100L \times \frac{1\ mol\ H_2}{22.4\ L} \times \frac{213\ KJ}{2\ mol\ H_2}$$ 475.45 KJ

$$100L\ H_2 \times \frac{1\ mol\ H_2}{22.4\ L} \times \frac{1\ mol\ O_2}{2\ mol\ H_2} \times \frac{22.4\ L}{1\ mol\ O_2}$$

theoretical yield = 50.0L

14 If the actual volume of oxygen is 40.0 L, what is the % yield.

$$\%\ yield = \frac{40.0L}{50.0L} \times 100$$

= 80%

Part Three: Limiting Reactant

1 If 25.0 g of Na are reacted with 40.0 g of O_2, and one ionic compound is formed.

Equation:

$$4Na + O_2 \longrightarrow 2Na_2O$$

(a) Which reactant is in excess?
(b) How many grams are in excess?
(c) Calculate the amount of ~~$AlCl_3$~~ Na_2O produced.

$$25.0 g\ Na \times \frac{1\ mol\ Na}{22.9898 g\ Na} = 1.0874\ mol\ Na$$ * limiting

HAVE

$$40.0 g\ O_2 \times \frac{1\ mol\ O_2}{31.9988 g\ O_2} = 1.2500\ mol\ O_2$$ * excess a)

Na

$$1.2500\ mol\ O_2 \times \frac{4\ mol\ Na}{1\ mol\ O_2}$$

$$= 5.00\ mol\ Na$$

O_2

$$1.0874\ mol\ Na \times \frac{1\ mol\ O_2}{4\ mol\ Na}$$

NEED

$$= 0.272\ mol\ O_2$$

$$1.0874\ mol\ Na \times \frac{2\ mol\ Na_2O}{4\ mol\ Na} \times \frac{61.979 g\ Na_2O}{1\ mol\ Na_2O}$$

~~the~~

c) $\boxed{= 33.70 g\ Na_2O}$

b) 1.2500 mol − 0.272 mol

$$= 0.978\ mol\ O_2 \times \frac{31.9988 g\ O_2}{1\ mol\ O_2} \boxed{= 31.29 g\ O_2}$$

2 20. mol H_2 reacts with 8.0 mol O_2 to produce H_2O. Determine the number of grams reactant in excess and number of grams H_2O produced. Identify the limiting reactant.

$$2H_2 + O_2 \rightarrow 2H_2O$$

HAVE 20 mol H_2 * excess

8.0 mol O_2 * limiting

NEED

H_2

$$8.0 \text{ mol } O_2 \times \frac{2 \text{ mol } H_2}{1 \text{ mol } O_2} = 16.0 \text{ mol } H_2.$$

O_2

$$20 \text{ mol } H_2 \times \frac{1 \text{ mol } O_2}{2 \text{ mol } H_2} = 10 \text{ mol } O_2$$

$$8.0 \text{ mol } O_2 \times \frac{2 \text{ mol } H_2O}{1 \text{ mol } O_2} \times \frac{18.0152 \text{ g } H_2O}{1 \text{ mol } H_2O} = \boxed{288.2432 \text{ g } H_2O}$$

Excess ? (H_2)

$$20 \text{ mol } H_2 - 16.0 \text{ mol } H_2$$

$$= 4.0 \text{ mol } H_2 \times \frac{2.0158 \text{ g } H_2}{1 \text{ mol } H_2} = 8.06 \text{ g } H_2$$

3

60.0 g of Al react with 60.0 g of O_2. Calculate the amount of excess reactant.

$4Al + 3O_2 \rightarrow 2Al_2O_3$

$60.0\ g\ Al \times \frac{1\ mol\ Al}{26.9815\ g\ Al} = 2.224\ mol\ Al$ * limiting

HAVE

$60.0\ g\ O_2 \times \frac{1\ mol\ O_2}{31.9988\ g\ O_2} = 1.875\ mol\ O_2$ * excess.

Al

$1.875\ mol\ O_2 \times \frac{4\ mol\ Al}{3\ mol\ O_2}$

$= 2.5\ mol\ Al$

O_2

$2.224\ mol\ Al \times \frac{3\ mol\ O_2}{4\ mol\ Al}$

$= 1.668\ mol\ O_2$

Excess (O_2)

$1.875\ mol - 1.668\ mol$

$= 0.207\ mol\ O_2 \times \frac{31.9988\ g\ O_2}{1\ mol\ O_2}$

$= 6.62\ g\ O_2$

4 If 75.4 g of Cu is reacted with 189.7 g of I_2, then CuI_2 is formed.
a) Which reactant is in excess?

$Cu + I_2 \rightarrow CuI_2$

How many grams are in excess?

Calculate the mass of CuI_2 produced.

$$75.4 \text{ g } Cu \times \frac{1 \text{ mol } Cu}{63.546 \text{ g } Cu} = \boxed{1.187 \text{ mol } Cu \ \ast \text{ excess}} \ \boxed{\text{HAVE}}$$

$$189.7 \text{ g } I_2 \times \frac{1 \text{ mol } I_2}{253.808 \text{ g } I_2} = 0.7474 \text{ mol } I_2$$

* limiting

Cu

$$0.7474 \text{ mol } I_2 \times \frac{1 \text{ mol } Cu}{1 \text{ mol } I_2}$$

$$= 0.7474 \text{ mol } Cu$$

I_2

$$1.187 \text{ mol } Cu \times \frac{1 \text{ mol } I_2}{1 \text{ mol } Cu}$$

$$= 1.187 \text{ mol } I_2$$

Excess? 1.187 mol Cu − 0.7474 mol Cu

$$= 0.4396 \text{ mol } Cu \times \frac{63.546 \text{ g } Cu}{1 \text{ mol } Cu}$$

$$\boxed{= 27.93 \text{ g } Cu}$$

$$0.7474 \text{ mol } I_2 \times \frac{1 \text{ mol } CuI_2}{1 \text{ mol } I_2} \times \frac{317.354 \text{ g } CuI_2}{1 \text{ mol } CuI_2}$$

$$\boxed{= 237.19 \text{ g } CuI_2}$$

5 If 100.0 g of Ca are reacted with 100.0 g of N_2, then Ca_3N_2 is formed.

Equation: $3Ca + N_2 \longrightarrow Ca_3N_2$

(a) Which reactant is in excess? N_2

(b) How many grams are in excess?

(c) Calculate the amount of Ca_3N_2 produced.

$$100.0 \text{ g Ca} \times \frac{1 \text{ mol Ca}}{40.078 \text{ g Ca}} = 2.495 \text{ mol Ca}$$ * limiting

HAVE

$$100.0 \text{ g } N_2 \times \frac{1 \text{ mol } N_2}{28.0134 \text{ g } N_2} = 3.5697 \text{ mol } N_2$$ * excess

Ca

$$3.5697 \text{ mol } N_2 \times \frac{3 \text{ mol Ca}}{1 \text{ mol } N_2}$$

$= 10.7091$

N_2

$$2.495 \text{ mol Ca} \times \frac{1 \text{ mol } N_2}{3 \text{ mol Ca}}$$

$= 0.8317 \text{ mol } N_2$

Excess ? $3.5697 \text{ mol} - 0.8317 \text{ mol}$

$$= 2.738 \text{ mol } N_2 \times \frac{28.0134 \text{ g } N_2}{1 \text{ mol } N_2} = \boxed{76.70 \text{ g } N_2 \text{ Excess}}$$

$$2.495 \text{ mol Ca} \times \frac{1 \text{ mol } Ca_3N_2}{3 \text{ mol Ca}} \times \frac{148.2474 \text{ g } Ca_3N_2}{1 \text{ mol } Ca_3N_2} = \boxed{123.29 \text{ g } Ca_3N_2}$$

6

If 100.0 g of Ca are reacted with 100.0 g of Cl_2, then $CaCl_2$ is formed.

Equation: $Ca + Cl_2 \longrightarrow CaCl_2$

(a) Which reactant is in excess? Ca

(b) How many grams are in excess?

(c) Calculate the amount of $CaCl_2$ produced.

$$100.0\ g\ Ca \times \frac{1\ mol\ Ca}{40.078\ g\ Ca} = 2.495\ mol\ Ca$$ * excess

$\boxed{HAVE}$

$$100.0\ g\ Cl_2 \times \frac{1\ mol\ Cl_2}{70.9054\ g\ Cl_2} = 1.410\ mol\ Cl_2$$ * limiting

Ca

$$1.410\ mol\ Cl_2 \times \frac{1\ mol\ Ca}{1\ mol\ Cl_2}$$

$= 1.410\ mol$ ~~Cl_2~~ Ca $\boxed{NEED}$

Cl_2

$$2.495\ mol\ Ca \times \frac{1\ mol\ Cl_2}{1\ mol\ Ca}$$

$= 2.495\ mol\ Cl_2$

Excess ? (Ca)

$$2.495\ mol - 1.410\ mol = 1.085\ mol\ Ca \times \frac{40.078\ g\ Ca}{1\ mol\ Ca}$$

$= 43.48\ g\ Ca.$

$$1.410\ mol\ Cl_2 \times \frac{1\ mol\ CaCl_2}{1\ mol\ Cl} \times \frac{110.9854\ g\ CaCl_2}{1\ mol\ CaCl_2} = 156.49\ g\ CaCl_2$$

7 If 25.0 g of Al are reacted with 40.0 g of Cl_2, then $AlCl_3$ is formed.

Equation: $2Al + 3Cl_2 \rightarrow 2AlCl_3$

(a) Which reactant is in excess? Al
(b) How many grams are in excess?
(c) Calculate the amount of $AlCl_3$ produced.

$$25.0\ g\ Al \times \frac{1\ mol}{26.9815\ g} = 0.9266\ mol\ Al$$

* excess

$\boxed{\text{HAVE}}$

$$40.0\ g\ Cl_2 \times \frac{1\ mol\ Cl_2}{70.9054\ \cancel{mol}\ g\ Cl_2} = 0.5641\ mol\ Cl_2$$

* limiting

Al

$$0.5641\ mol\ Cl_2 \times \frac{2\ mol\ Al}{3\ mol\ Cl_2}$$

$$= 0.3761\ mol\ Al$$

Cl_2

$$0.9266\ mol\ Al \times \frac{3\ mol\ Cl_2}{2\ mol\ Al}$$

$\boxed{\text{NEED}}$ $= 1.3899\ mol\ Cl_2$

Excess? $0.9266\ mol - 0.3761\ mol$

$$= 0.5505\ mol\ Al \times \frac{26.9815\ g\ Al}{1\ mol\ Al} = \boxed{14.85g\ Al \text{ excess}}$$

$$0.5641\ mol\ Cl_2 \times \frac{2\ mol\ AlCl_3}{3\ mol\ Cl_2} \times \frac{133.3396g\ AlCl_3}{1\ mol\ AlCl_3}$$

$$\boxed{= 50.14\ g\ AlCl_3}$$