Practice Calculations: Grade 11

SCH4U_06 - 07

1. Boron and hydrogen form a series of compounds called boranes, which have been used as rocket fuels. The percentage composition and molar mass of one of these boranes is given below :

% by mass boron	81.2
% by mass hydrogen	18.8
molar mass (g/mol)	53.3

Calculate the empirical and molecular formula of the borane.

2. The molar mass of a compound with the empirical (simplest) formula CH_2O was found to be 240 g/mol. What is the molecular formula of the compound ?

3. Sodium carbonate, Na_2CO_3, is used in the manufacture of glass and is made from calcium carbonate,$CaCO_3$, and sodium chloride, NaCl, according to the equation:

$$CaCO_3 + 2\ NaCl \longrightarrow Na_2CO_3 + CaCl_2$$

a) What mass in kg of NaCl is required to completely react with 1.00 kg of $CaCO_3$?

b) What mass of Na_2CO_3 could be produced from the reaction of 1.00 kg of $CaCO_3$?

4. Iron (II) sulphide, FeS, reacts in air, O_2, to produce Fe_2O_3, and SO_2

a) Write a balanced equation for the reaction of FeS in air.

b) How many grams of Fe_2O_3 are produced when 20.9 g of FeS react with 14.1 g of O_2 ?

5. One of the reactions involved in the smelting of copper sulphide ores involves copper (I) oxide and copper (I) sulphide, according to the following equation:

$$2\ Cu_2O_{(s)} + Cu_2S_{(s)} \longrightarrow 6\ Cu_{(s)} + SO_{2\,(g)}$$

If 50.0 g of Cu_2O is heated with 25.8 g of Cu_2S , then:

a) determine which reagent, if any, is in excess.

b) calculate the theoretical yield of copper.

c) determine the percent yield if 58.0 g of copper is actually obtained.

6. Some commercial drain cleaners contain sodium hydroxide and powdered aluminum. When the mixture is poured into a drain full of water and dirt, the exothermic reactions is as follows:

$$H_2O_{(l)} + Al_{(s)} + NaOH_{(s)} \longrightarrow NaAl(OH)_{4\,(s)} + H_{2\,(g)} + \text{Heat Energy}$$

a) Show the balanced chemical reaction please.

b) The heat generated by the reaction helps to melt any grease, and the gas being generated stirs up the particles and helps to unclog the drain. If you use 5.6 g of Al and excess NaOH, how many litres of gaseous hydrogen measured at 99.8 kPa and 22 °C are produced?

Solutions

1\.

no. moles:	B	:	H
	81.2 /10.8		18.8 /1.01
=	7.52	:	18.8
	1	:	2.5
	2	:	5

Empirical formula = B_2H_5

Molar mass of empirical formula, B_2H_5 = 26.6 g mol^{-1}

Hence correct molecular formula = 2 (B_2H_5) = B_4H_{10}

2\. Molar mass of empirical formula, CH_2O = 30 g mol^{-1}

multiple whole number = 240 / 30 = 8

correct molecular formula = 8 (CH_2O) = $C_8H_{16}O_8$

3\. $CaCO_3 + 2\ NaCl \longrightarrow Na_2CO_3 + CaCl_2$

(a) no. moles 1.00 kg $CaCO_3$ = 1000 g / 100 g mol^{-1} = 10

mol	:	mol
$CaCO_3$	:	NaCl
1	:	2
10	:	x

.: x = no. moles NaCl = 20

mass of NaCl = no. moles x M_R = 20 x 58.5 = 1.17 kg

(b) Mass of Na_2CO_3 produced from 10.0 g $CaCO_3$ = 1.06 kg

4\. (a) $4\ FeS + 7\ O_2 \longrightarrow 2\ Fe_2O_3 + 4\ SO_2$

(b)

no. moles:	FeS	:	O_2
	20.9g / 87.85g mol^{-1}	:	14.1 g / 32 g mol^{-1}
=	0.238	:	0.441

.: Limiting reactant = FeS

mol	:	mol
FeS	:	Fe_2O_3
4	:	2
0.238	:	x

.: x = no. moles Fe_2O_3 = 0.119

Hence, mass of Fe_2O_3 = no. moles x M_R = 0.119 mol x 159.8 g mol^{-1} = 19.0 g

5\. (a) $2\ Cu_2O_{(s)} + Cu_2S_{(s)} \longrightarrow 6\ Cu_{(s)} + SO_{2\,(g)}$

(b)

no. moles:	Cu_2O	:	Cu_2S
	50.0g / 143 g mol^{-1}	:	25.8 g / 159 g mol^{-1}
=	0.349	:	0.162

.: Limiting reactant = Cu_2S Excess reagent is Cu_2O

mol	:	mol
Cu_2S	:	Cu
1	:	6
0.162	:	x

.: x = no. moles Cu = 0.972

Hence, mass of Cu = no. moles x M_R = 0.972 mol x 63.55 g mol^{-1} = 61.77 g

(c) % yield Cu = $\frac{\text{actual}}{\text{theoretical}}$ x 100 = $\frac{58.0}{61.77}$ x 100 % = 93.9 %