Question 9

(a) 1.5 g of a metal oxide, MO_2 reacts with excess hydrochloric acid, HCl to produce 386 mL chlorine gas at STP. The reaction is given by the following equation:

$$MO_2(s) + HCl(aq) \longrightarrow MCl_2(aq) + Cl_2(g) + H_2O(l)$$

i) Balance the above equation.

$MO_2(s)$ + $HCl(aq)$ → $MCl_2(aq)$ + $Cl_2(g)$ + $H_2O(l)$

ii) Determine the relative molecular mass of MO_2 and the relative atomic mass of M.

Ar of M is unknown. We cannot determine the number of mole of MO

Luckily, the volume of Cl_2 produced at STP is given

All products are formed depend on LR @ MO_2. Thus, by using backward calculation, we can determine mole of LR

Answer: At STP (0°C and 1 atm),

1 mol of gas occupies 22.4L

22.4 L = 1 mol of Cl_2

_____ L = _____mol Cl_2

From the balanced equation,

1 mol Cl_2 = 1 mol MO_2

_____ mol Cl_2 = _____mol MO_2

Mole x = $\frac{\text{mass X}}{\text{Molar mass X}}$

Molecular mass of MO_2 = $\frac{\text{mass } MO_2}{\text{Mole } MO_2}$

Ar of O = 16

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Molecular mass of MO_2 = _____

= _____ g/mol

87.04g/mol = M + _____

M = _____g/mol

Thus, Relative molecular mass of MO_2 = _____

Relative atomic mass of M =_____

(b) In a separate experiment, 0.20 g of MO_2 was added to 25 mL of 0.10 M HCl solution.

i. Determine the limiting reactant.

You have calculated the Ar of M. Use it to determine the number of mole of MO_2

There are **3 methods** to determine the LR:

1) Compare mole ratios of the reactants

2) Compare the amount of products based on different reactants

3) Compare the mole needed vs mole required

Lets say, we use 2nd method to determine the LR!!

$MO_2(s)$ + $4HCl(aq) \rightarrow$ $MCl_2(aq)$ + $Cl_2(g)$ + $2H_2O(l)$

0.2 g 25mL of 0.1M

Mole MO2 = $\frac{\text{mass } MO_2}{\text{Molar mass } MO_2}$

= _____ mole

Mole HCl = $\frac{MV}{1000}$

= _____ mole

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From the balance equation

Any products can be used for comparison. Better choose MCl_2 because question (ii) ask about the mass of MCl_2

1 mole of MO_2 = 1 mole MCl_2

_____ mole of MO_2 = _____mole MCl_2 produced

4 mole HCl = 1 mole MCl_2

_____mole HCl = _____mole MCl_2 produced

_____ produces less amount of product MCl2

Limiting reactant is _____

ii) Calculate the mass of MCl_2 produced in the reaction.

Ar of M= 55

Ar of Cl = 35.5

Mole of MCl_2 = 6.25×10^{-4} mole

Mass of MCl_2 = _____ g

From part (i), you have calculated the mole of MCl_2 produced based on LR. Just use the value

iii) Calculate the percentage yield if the actual mass of MCl_2 produced is 0.072 g.

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

= _____ %

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