Stoichiometry of Gases

e.g. 0.672g of CaC_2 reacts with water according to the following equation:

$$CaC_{2(s)} + 2H_2O \rightarrow C_2H_2 + Ca(OH)_{2(aq)}$$

What volume of gas will be formed at STP?

We can use the molar mass of CaC_2 to calculate the moles of CaC_2 present and then refer to the balanced chemical equation which indicates the ratio of moles of C_2H_2 gas produce per moles of CaC_2 reacting and finally derive a conversion factor from the standard molar volume to estimate the volume of gas formed at STP…

$$M_{CaC_2} = 40.08g + 2(12.00g/mol)$$
$$= 64.1g/mol$$

1 mol CaC_2 = 64.1 (c.f. derived from molar mass of CaC_2)

$$0.672g\ CaC_2 \times \frac{1\ mol\ CaC_2}{64.1g\ CaC_2} = 0.0105\ mol\ CaC_2$$

1 mole CaC_2 = 1 mole C_2H_2 (c.f. derived from the balanced chemical equation)

$$0.0105\ mol\ CaC_2 \times \frac{1\ mol\ C_2H_2}{1\ mol\ CaC_2} = 0.0105\ mol\ C_2H_2$$

1 mol = 22.4 L at STP (c.f. is Standard Molar Volume)

$$0.0105\ mol\ C_2H_2 \times \frac{22.4\ L}{1\ mol} = 0.235\ L\ C_2H_2$$

e.g. excess magnesium reacts in 15ml of 0.10 mol/L HCl according to the following equation:

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

What is the temperature if 20ml of H_2 gas is produced at a pressure of 101.3 kPa?

Since Mg is in excess, HCl is the limiting reactant and we know the concentration and volume of the HCl solution so we can derive the number of moles of HCl. After that we can get a conversion factor for moles of $H_{2(g)}$ per moles of HCl from the balanced chemical equation. Once we have the moles of $H_{2(g)}$ we can use the Ideal Gas Equation to calculate the temperature of the 20ml of $H_{2(g)}$.

$$C = \frac{n}{V} \qquad \frac{n}{0.015\ L} = 0.10\ \text{mol/ L HCl} \qquad n = 0.0015\ \text{mol HCl}$$

1 mole HCl = 2 mole H_2 (c.f. derived from balanced chemical equation)

$$0.0015\ \text{mol HCl} \times \frac{1\ \text{mol}\ H_2}{2\ \text{mol HCl}} = 0.00075\ \text{mol}\ H_2$$

$$PV = nRT \qquad T = \frac{PV}{nR} \qquad T = \frac{(101.3\text{kPa})(0.020\ \text{L})}{(0.00075\ \text{mol})\ (8.31\ \frac{\text{kPa} \cdot \text{L}}{\text{mol} \cdot \text{K}})} = 325.07\ \text{K}$$

$$= 52°C$$

∴ the temperature of the $H_{2(g)}$ produced is 52°C