Marks 4

- Acetylene, C_2H_2, can be produced by reacting calcium carbide, CaC_2, with water:

$$CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2(s) + C_2H_2(g)$$

A 1.000 g sample of CaC_2 is placed in a sealed vessel that contains 250.0 mL of $H_2O(l)$ and 250.0 mL of $N_2(g)$ at 1.000 atm, and allowed to react completely with the water. The final pressure in the sealed vessel at 22.0 ºC is 2.537 atm. Determine the vapour pressure of water in the sealed vessel at 22.0 ºC. Give your answer in mmHg. Ignore any change in the volume of the water.

The formula mass of CaC_2 is (40.08 (Ca) + 2 × 12.01 (C)) g mol^{-1} = 64.1 g mol^{-1}.

The amount of CaC_2 in 1.000 g is therefore, $n = \frac{m}{M} = \frac{1.000}{64.1}$ = 0.01560 mol.

From the chemical equation, each mole of CaC_2 that reacts leads to one mole of $C_2H_2(g)$. Therefore, 0.0156 mol of $C_2H_2(g)$ is formed. The volume available to gas is 250.0 mL. Using the ideal gas equation, $pV = nRT$, the pressure due to this amount is therefore:

$$p_{C_2H_2} = \frac{nRT}{V} = \frac{(0.01560\,\text{mol}) \times (0.08206\,\text{L atm K}^{-1}\,\text{mol}^{-1}) \times (22 + 273)\text{K}}{0.250\,\text{L}}$$

$$= 1.511 \text{ atm}$$

As there is no change in the amount of $N_2(g)$, p_{N_2} = 1.000 atm. Hence,

$$p_{total} = p_{H_2O} + p_{C_2H_2} + p_{N_2} = 2.537 \text{ atm}$$

$$p_{H_2O} + (1.511 \text{ atm}) + (1.000 \text{ atm}) = 2.537 \text{ atm}$$

Hence, p_{H_2O} = 0.026 atm. As 1 atm = 760 mmHg, this corresponds to.

$$p_{H_2O} = 0.026 \times 760 = 20 \text{ mmHg}$$

Answer: **20 mmHg**

The solubility of acetylene in water at 22.0 ºC is small. If the temperature were raised, would you expect this solubility to increase or decrease?

The solubility of gases in water decreases with temperature. The dissolution of a gas is entropically disfavoured and only occurs because it is exothermic. Like all exothermic process, the process becomes less favourable at higher temperatures (Le Chatelier's principle).