3.5 Gas volumes

Name: _____ Class: _____ Date: _____ **Total: 19 marks**

KEY WORDS gas volume

Objective

Use equal-volume-equal-moles and equation ratios for reacting gases. Chemistry only, HT. Original questions for spec statement 4.3.5.

1 Key knowledge and worked examples

At the same temperature and pressure, **equal volumes of gases contain equal numbers of moles** – so the volumes of gases in a reaction stand in the **ratio of the balancing numbers**.

At room temperature and pressure (20 °C, one atmosphere), use 24 dm^3/mol. Gas volume = amount × 24 dm^3/mol; convert cm^3 to dm^3 before dividing by 24. This approximation does not apply unchanged under other conditions.

Examples: $2\ H_2 + O_2 \rightarrow 2\ H_2O$ – 2 volumes of hydrogen react with 1 volume of oxygen; $H_2 + Cl_2 \rightarrow 2\ HCl$ – 1 volume + 1 volume gives 2 volumes of product.

Worked example (3 marks). 60 cm^3 of methane burns completely: $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$. What volume of oxygen is needed, and of CO_2 formed (all gases measured alike)?

O_2 volume = 2 × CH_4 = 2 × 60 = 120 cm^3; CO_2 volume = 1 × CH_4 = 60 cm^3; volumes follow the equation ratio because equal gas volumes hold equal moles.

2 Practice

2.1 What does 1 cm^3 of any two gases at the same temperature and pressure contain equally? [1]

2.2 $N_2 + 3\ H_2 \rightarrow 2\ NH_3$ – 30 cm^3 of nitrogen needs what volume of hydrogen? [1]

2.3 What volume of HCl gas forms from 25 cm^3 of H_2 reacting with excess Cl_2? [1]

3 Exam-style questions

3.1 *(HT)* 50 cm^3 of propane reacts with oxygen: $C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 4\ H_2O$. Calculate the volume of oxygen needed and the volume of carbon dioxide formed. [4]

3.2 *(HT)* 100 cm^3 of hydrogen reacts with 50 cm^3 of oxygen. Determine whether either gas is in excess and the theoretical volume of steam formed, assuming complete reaction and all volumes compared at the same temperature and pressure with water remaining gaseous. [4]

3.3 *(HT)* Air is about 20 % oxygen. What volume of air supplies the oxygen for complete combustion of 200 cm^3 of butane, $2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$? [4]

3.4 At room temperature and pressure, 24 dm^3 of gas is one mole. Calculate the volume of 4.4 g CO_2 (C = 12, O = 16), giving dm^3 and cm^3. State why 24 dm^3/mol must not be used unchanged for a gas at a different temperature and pressure. [4]