Exercise walk-through

3.5
Volumes of gases – chemistry only, HT (4.3.5)

AQA · GCSE · Chemistry

Conservation of mass and equations

- The law of **conservation of mass** says that atoms are not made or destroyed in a chemical reaction.
- They are only rearranged, so the total mass of the products equals the total mass of the reactants.
- A symbol equation must therefore be **balanced** : the same number of each kind of atom on both sides.
- There are two kinds of number in an equation.

$$\text{percentage by mass} = \frac{A_r \times \text{number of atoms of the element}}{M_r} \times 100$$

Concentrations in mol/dm^3 (chemistry only, higher tier)

- **Molar concentration** is the number of moles of **solute** in each dm^3 of solution:
- To change it into **mass concentration** , multiply by the Mr: 0.20 mol/dm^3 NaOH is $0.20 \times 40 = 8.0$ g/dm^3.
- In a **titration** , you measure the exact volumes of an acid and an alkali that react.
- If you know one **concentration**, you can calculate the other, using the mole ratio in the equation.

$$\text{moles} = \text{concentration (mol/dm}^3\text{)} \times \text{volume (dm}^3\text{)}$$

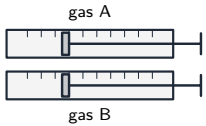
Gas volumes (chemistry only, higher tier)

- Equal volumes of different gases at the same temperature and pressure contain the same number of molecules.
- At **room temperature and pressure** (20 °C and 1 atmosphere), one mole of any gas takes up 24 dm^3.
- **Worked example 12.** What volume does 4.4 g of carbon dioxide take up at **room temperature and pressure**?
- Moles $= 4.4/44 = 0.100$ mol, so volume $= 0.100 \times 24 = 2.40$ dm^3, or 2400 cm^3.

$$\text{volume of gas } (dm^3) = \text{moles} \times 24$$

Exercises 2.1·2.2

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]

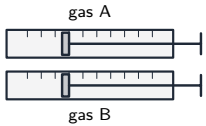
$N_2 + 3H_2 \rightarrow 2NH_3$

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



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2.1 The same number of moles.

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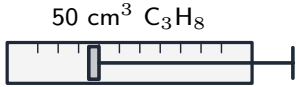


2.2 $3 \times 30 = 90$ cm^3.

2.3 50 cm^3.

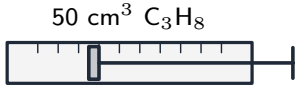
Exercise 3.1

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]



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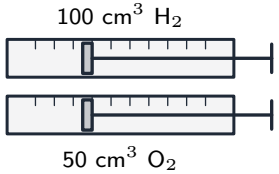
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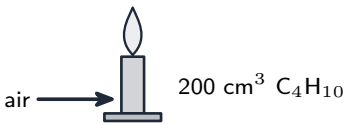
3.1 $O_2 = 5 \times 50 = 250$ cm^3; $CO_2 = 3 \times 50 = 150$ cm^3.

Setup for exercise 3.2

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]

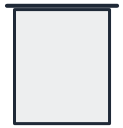


3.3 *(HT)* Air is about 20 % oxygen. What volume of air supplies the oxygen for complete combustion of 200 cm^3 of butane, $2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$? [4]



Exercise 3.2

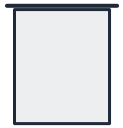
3.4 At room temperature and pressure, 24 dm^3 of gas is one mole. Calculate the volume of 4.4 g CO_2 (C = 12, O = 16), giving dm^3 and cm^3. State why 24 dm^3/mol must not be used unchanged for a gas at a different temperature and pressure. [4]



4.4 g CO_2

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3.2 Ratio H_2 : O_2 = 2 : 1; 100 cm^3 H_2 needs 50 cm^3 O_2 exactly; neither is in excess / both fully react; steam volume = 100 cm^3.

3.3 Oxygen needed = 13/2 × 200 = 1300 cm^3; air is 20 % oxygen; air volume = 1300 ÷ 0.20 = 6500 cm^3.

3.4 M(CO_2) = 12 + 2 × 16 = 44 g/mol, so n = 4.4/44 = 0.100 mol. V = 0.100 × 24 = 2.40 dm^3 = 2400 cm^3. Gas molar volume depends on temperature and pressure; the stated approximation is for room conditions.