A-Level Chemistry

Ideal Gas Equation

Question Paper

Time available: 64 minutes
Marks available: 56 marks

www.accesstuition.com

1. This question is about two experiments on gases.

(a) In the first experiment, liquid **Y** is injected into a sealed flask under vacuum. The liquid vaporises in the flask.
The table below shows data for this experiment.

Mass of **Y**	717 mg
Temperature	297 K
Volume of flask	482 cm^3
Pressure inside flask	51.0 kPa

Calculate the relative molecular mass of **Y**.

Show your working.

The gas constant, R = 8.31 J K^{-1} mol^{-1}

Relative molecular mass of **Y** _____

(5)

(b) In the second experiment, another flask is used for a combustion reaction.

Method

- Remove all the air from the flask.
- Add 0.0010 mol of 2,2,4-trimethylpentane (C_8H_{18}) to the flask.
- Add 0.0200 mol of oxygen to the flask.
- Spark the mixture to ensure complete combustion.
- Cool the mixture to the original temperature.

The equation is

$$C_8H_{18}(g) + 12\frac{1}{2}\,O_2(g) \rightarrow 8\,CO_2(g) + 9\,H_2O(l)$$

Calculate the amount, in moles, of gas in the flask after the reaction.

Amount of gas _____ mol

(2)

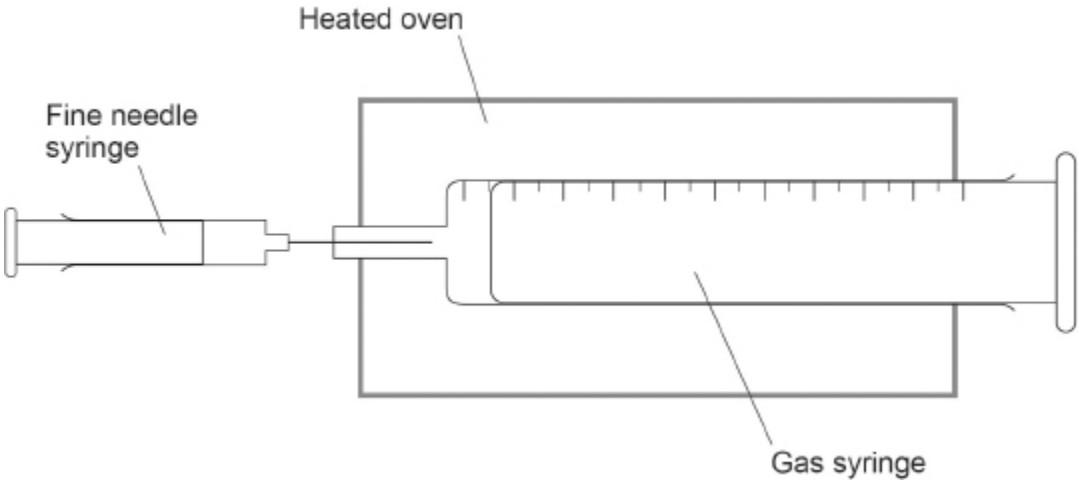
(Total 7 marks)

2. This question is about a volatile liquid, **A**.

(a) A student does an experiment to determine the relative molecular mass (M_r) of liquid **A** using the apparatus shown in the figure below.

The student injects a sample of **A** into a gas syringe in an oven.

At the temperature of the oven, liquid **A** vaporises.



The table shows the student's results.

Mass of fine needle syringe and contents before injecting	11.295 g
Mass of fine needle syringe and contents after injecting	10.835 g
Volume reading on gas syringe before injecting	0.0 cm^3
Volume reading on gas syringe after injecting	178.0 cm^3
Pressure of gas in syringe	100 kPa
Temperature of oven	120 °C

Calculate the M_r of **A**.

Give your answer to 3 significant figures.

The gas constant, $R = 8.31$ J K^{-1} mol^{-1}

M_r _____

(4)

(b) The student noticed that some of the liquid injected into the gas syringe did **not** vaporise.

Explain the effect that this has on the M_r calculated by the student.

_____

_____

_____

_____

_____

(2)

The table is repeated here.

Mass of fine needle syringe and contents before injecting	11.295 g
Mass of fine needle syringe and contents after injecting	10.835 g
Volume reading on gas syringe before injecting	0.0 cm^3
Volume reading on gas syringe after injecting	178.0 cm^3
Pressure of gas in syringe	100 kPa
Temperature of oven	120 °C

(c) Each reading on the balance used to record the mass of the fine needle syringe and contents had an uncertainty of ±0.001 g

Calculate the percentage uncertainty in the mass of liquid **A** injected in this experiment.

Percentage uncertainty _____

(1)

(Total 7 marks)

3. A student does an experiment to determine the percentage of copper in an alloy.

The student

- reacts 985 mg of the alloy with concentrated nitric acid to form a solution (all of the copper in the alloy reacts to form aqueous copper(II) ions)
- pours the solution into a volumetric flask and makes the volume up to 250 cm^3 with distilled water
- shakes the flask thoroughly
- transfers 25.0 cm^3 of the solution into a conical flask and adds an excess of potassium iodide
- uses exactly 9.00 cm^3 of 0.0800 mol dm^{-3} sodium thiosulfate ($Na_2S_2O_3$) solution to react with all the iodine produced.

The equations for the reactions are

$$2\ Cu^{2+} + 4\ I^- \rightarrow 2\ CuI + I_2$$

$$2\ S_2O_3^{2-} + I_2 \rightarrow 2\ I^- + S_4O_6^{2-}$$

(a) Calculate the percentage of copper by mass in the alloy.

Give your answer to the appropriate number of significant figures.

% copper _____

(6)

(b) Suggest **two** ways that the student could reduce the percentage uncertainty in the measurement of the volume of sodium thiosulfate solution, using the same apparatus as this experiment.

1 _____

_____

2 _____

_____

3 _____

_____

(2)

(c) State the role of iodine in the reaction with sodium thiosulfate.

_____

(1)

(d) Give the full electron configuration of a copper(II) ion.

_____

(1)

(e) Copper(I) iodide is a white solid.

Explain why copper(I) iodide is white.

_____

_____

_____

_____

_____

_____

(2)

(f) Iodine vaporises easily.

Calculate the volume, in cm^3, that 5.00 g of iodine vapour occupies at 185 °C and 100 kPa

The gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$

Give your answer to 3 significant figures.

Volume _____ cm^3

(4)

(Total 16 marks)

4. This question is about sodium and some of its compounds.

(a) Use your knowledge of structure and bonding to explain why sodium bromide has a melting point that is higher than that of sodium, and higher than that of sodium iodide.

(6)

(b) When 250 mg of sodium were added to 500 cm^3 of water at 25 °C a gas was produced.

Give an equation for the reaction that occurs.
Calculate the volume, in cm^3, of the gas formed at 101 kPa

The gas constant, R = 8.31 J K^{-1} mol^{-1}

Equation _____

Volume _____ cm^3

(6)

(c) Calculate the concentration, in mol dm^{-3}, of sodium ions in the solution produced in the reaction in **part (b)**.

Concentration _____ mol dm^{-3}

(1)

(d) Sodium reacts with ammonia to form the compound $NaNH_2$ that contains the NH_2^- ion.

Draw the shape of the NH_2^- ion.
Include any lone pairs of electrons that influence the shape.

Predict the bond angle.
Justify your prediction.

Shape

Bond angle _____

Justification _____

_____

(4)

(Total 17 marks)

5. An experiment was carried out to determine the relative molecular mass (M_r) of a volatile hydrocarbon **X** that is a liquid at room temperature.

A known mass of **X** was vaporised at a known temperature and pressure and the volume of the gas produced was measured in a gas syringe.

Data from this experiment are shown in the table.

Mass of **X**	194 mg
Temperature	373 K
Pressure	102 kPa
Volume	72 cm^3

(a) Calculate the relative molecular mass of **X**.

Show your working.

Give your answer to the appropriate number of significant figures.

The gas constant, R = 8.31 J K^{-1} mol^{-1}

Relative molecular mass _____

(5)

(b) Analysis of a different hydrocarbon **Y** shows that it contains 83.7% by mass of carbon.

Calculate the empirical formula of **Y**.

Use this empirical formula and the relative molecular mass of **Y** (M_r = 86.0) to calculate the molecular formula of **Y**.

Empirical formula _____

Molecular formula _____

(4)

(Total 9 marks)