16 Magnesium nitrate decomposes on heating according to the equation shown.

$$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$$

One mole of magnesium nitrate is completely decomposed.

(a) What is the maximum volume of gas formed at 600 K and 101 000 Pa?

[$pV = nRT$ $R = 8.31\ J\,mol^{-1}\,K^{-1}$]

(1)

☒ **A** $0.025\ m^3$

☒ **B** $0.099\ m^3$

☒ **C** $0.123\ m^3$

☒ **D** $0.247\ m^3$

(b) What is the percentage yield if 25.0 g of magnesium oxide is produced?

[M_r MgO = 40.3]

(1)

☒ **A** 13.6%

☒ **B** 16.9%

☒ **C** 31.0%

☒ **D** 62.0%

12 A sample of 25.0 cm^3 of 0.205 mol dm^{-3} sulfuric acid was titrated with sodium hydroxide solution. The titre obtained was 14.60 cm^3.

(a) What is the concentration of the sodium hydroxide solution?

(1)

- ☒ **A** 0.176 mol dm^{-3}
- ☒ **B** 0.239 mol dm^{-3}
- ☒ **C** 0.351 mol dm^{-3}
- ☒ **D** 0.702 mol dm^{-3}

(b) What is the percentage error in the titre?

[The burette is accurate to 0.05 cm^3 per reading]

(1)

- ☒ **A** 0.10%
- ☒ **B** 0.34%
- ☒ **C** 0.40%
- ☒ **D** 0.68%

8: 20 g of an impure sample of calcium carbonate is heated and decomposes completely.
3.6 dm^3 of carbon dioxide is produced at room temperature and pressure (r.t.p.).

What is the percentage purity of the sample?
Assume that the impurities do not produce carbon dioxide when heated.

[M_r $CaCO_3$ = 100 molar volume of a gas = 24 dm^3 mol^{-1} at r.t.p.]

- ☒ **A** 15%
- ☒ **B** 20%
- ☒ **C** 25%
- ☒ **D** 75%

7 Sulfuric acid and sodium hydroxide react as shown.

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

Which sample of sulfuric acid solution will be exactly neutralised by $20\,cm^3$ of $0.5\,mol\,dm^{-3}$ sodium hydroxide?

	Volume of sulfuric acid / cm^3	Concentration of sulfuric acid / $mol\,dm^{-3}$
☒ **A**	20	0.25
☒ **B**	20	0.5
☒ **C**	40	0.5
☒ **D**	10	1.0

8 A 20 g sample of iron(III) sulfate, $Fe_2(SO_4)_3$, was dissolved in water. How many sulfate ions are in the solution formed?

[Assume M_r $Fe_2(SO_4)_3 = 400$
Avogadro constant, $L = 6.0 \times 10^{23}\,mol^{-1}$]

☒ **A** 3×10^{22}

☒ **B** 9×10^{22}

☒ **C** 1.2×10^{23}

☒ **D** 1.5×10^{23}

1: 25 cm^3 of sodium hydroxide solution, of concentration 2.00 mol dm^{-3}, was added to 30 cm^3 of ethanoic acid solution, of concentration 1.00 mol dm^{-3}, in a polystyrene cup. The mixture was stirred, causing the temperature to increase by 6.5 °C.

(a) What is the expression for the enthalpy change of neutralisation of sodium hydroxide and ethanoic acid, in J mol^{-1}?

[Assume: the specific heat capacity of the mixture = 4.18 J g^{-1} $°C^{-1}$
the density of the mixture = 1.00 g cm^{-3}]

(1)

☒ **A** $-(25 \times 4.18 \times 6.5) \div 0.05$

☒ **B** $-(30 \times 4.18 \times 6.5) \div 0.03$

☒ **C** $-(55 \times 4.18 \times 6.5) \div 0.05$

☒ **D** $-(55 \times 4.18 \times 6.5) \div 0.03$

(b) The measurement uncertainty in the thermometer used in the experiment is ±0.5 °C for each reading.

What is the percentage uncertainty in the temperature change of 6.5 °C?

(1)

☒ **A** 3.8%

☒ **B** 7.7%

☒ **C** 15.4%

☒ **D** 30.8%

(Total for Question 1 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

15 A volume of 10.0 cm^3 of magnesium chloride solution was added to an excess of sodium hydroxide solution, forming a precipitate of magnesium hydroxide. After filtering and drying, 0.398 g of magnesium hydroxide was obtained.

What was the concentration of the magnesium chloride solution?

[M_r $Mg(OH)_2$ = 58.3]

☒ **A** 0.00683 mol dm^{-3}

☒ **B** 0.0137 mol dm^{-3}

☒ **C** 0.683 mol dm^{-3}

☒ **D** 1.37 mol dm^{-3}

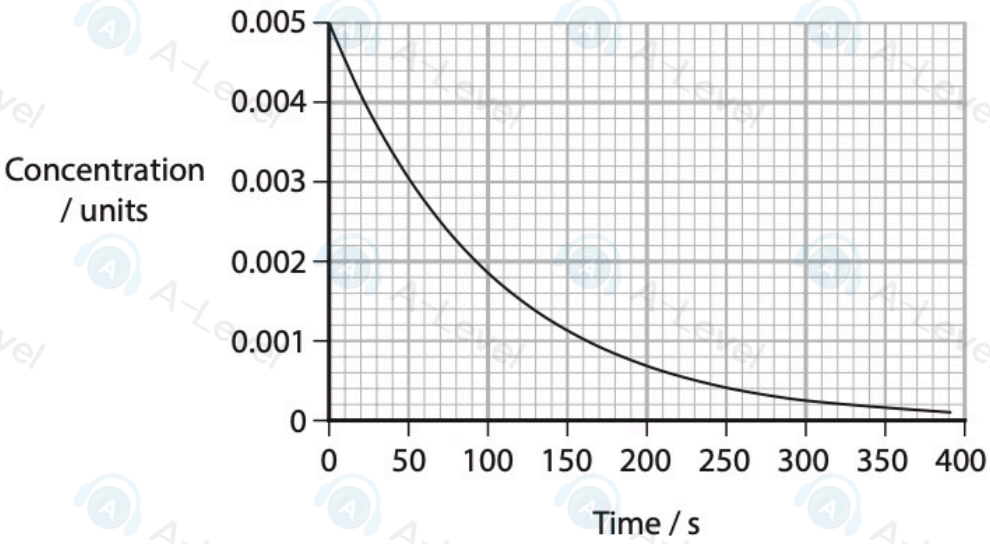
(Total for Question 15 = 1 mark)

14 What is the concentration, in mol dm^{-3}, when 64.5 g of sodium nitrate is dissolved in water to form 750 cm^3 of solution?

[M_r $NaNO_3$ = 85.0]

- ☒ **A** 0.086
- ☒ **B** 0.113
- ☒ **C** 0.759
- ☒ **D** 1.012

8 An experiment measuring the concentration of a reactant over time produced the graph shown.



(a) What is the approximate value of the initial rate of reaction?

(1)

- ☒ **A** 4.5×10^{-5}
- ☒ **B** 1.8×10^{-5}
- ☒ **C** 1.3×10^{-5}
- ☒ **D** 2.0×10^{-6}

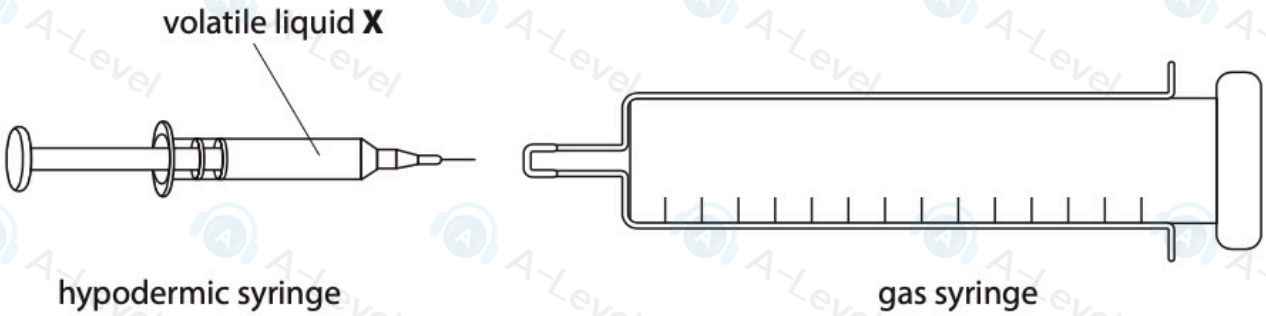
(b) What are the units for the rate of reaction?

(1)

- ☒ **A** mol s^{-1}
- ☒ **B** mol dm^{-3} s^{-1}
- ☒ **C** mol dm^3 s^{-1}
- ☒ **D** dm^3 mol^{-1} s

(Total for Question 8 = 2 marks)

18 A student determined the molecular mass of an unknown volatile organic liquid, **X**, using the apparatus shown.
The student used a hypodermic syringe to inject a sample of liquid **X** into a gas syringe.
The gas syringe was placed in an oven and liquid **X** vaporised.



hypodermic syringe gas syringe

Results

Mass of hypodermic syringe and liquid **X** before injection	5.71 g
Mass of hypodermic syringe and liquid **X** after injection	5.59 g
Mass of **X** added to the gas syringe	0.12 g
Temperature of oven	95 °C
Pressure of gas in the gas syringe	99 kPa
Volume of gas syringe after **X** had been vaporised	81 cm^3

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

$pV = nRT$ Gas constant $R = 8.31\ J\ K^{-1}\ mol^{-1}$

(5)

(b) Each molecule of **X** contains carbon atoms, hydrogen atoms, and **one** atom of oxygen.
Identify **X**, by name or formula, using your answer from (a).

(1)

22 Ammonia, ammonium nitrate and urea are nitrogen-based fertilisers.
The nitrogen in the fertiliser is taken up by the roots of plants and promotes growth.

Ammonia, NH_3, is manufactured by the reaction between nitrogen and hydrogen.
The nitrogen is obtained from the air.

Hydrogen can be obtained by two methods.

Method 1

The hydrogen is usually obtained by reacting methane gas with steam.

$$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$$

Method 2

Hydrogen can also be obtained using solar power to split water into hydrogen and oxygen.

$$2H_2O \rightarrow O_2 + 2H_2$$

(a) Evaluate which of these two methods used to obtain hydrogen is more sustainable.

(3)

.....

.....

.....

.....

.....

(b) Ammonia can be used directly as a fertiliser or converted to other compounds such as ammonium nitrate and urea.

Name of fertiliser	ammonia	ammonium nitrate	urea
Formula	NH_3	NH_4NO_3	NH_2CONH_2
% nitrogen by mass	82.4		46.7

(i) Complete the table by calculating the percentage by mass of nitrogen in ammonium nitrate.

(1)

(ii) Give **one** advantage and **one** disadvantage of applying ammonia directly into the soil as a fertiliser.
Use information in the table and your knowledge of ammonia.

(2)

Advantage

.....

.....

Disadvantage

.....

.....

(c) Ammonium nitrate, NH_4NO_3, can be made by reacting ammonia with nitric acid.

(i) Give the equation for this reaction. State symbols are not required.

(1)

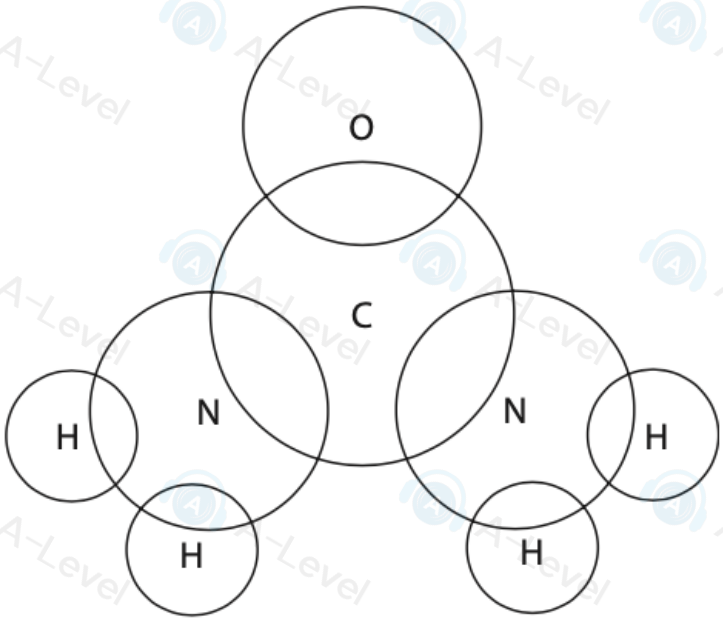
(ii) Name the type of reaction occurring.

(1)

(d) Urea, NH_2CONH_2, can also be made from ammonia.

Complete the dot-and-cross diagram for the urea molecule.

(2)



*(e) Both urea and ammonium nitrate are soluble in water.

Discuss the differences in the interactions of water molecules with both urea and ammonium nitrate.

Include **three** diagrams showing these interactions.

(6)

(f) A field needs 160 kg of N per hectare to be applied using urea fertiliser.
The field size is 500 m × 640 m.

[1 hectare (ha) = 10 000 m^2, molar mass of urea = 60 g mol^{-1}]

Urea contains 46.7 % N by mass.

Calculate the mass of urea, in tonnes, that needs to be applied to the field.

Give your answer to an appropriate number of significant figures.

(4)