A-Level Chemistry

Physical Practical Questions

Question Paper

Time available: 77 minutes
Marks available: 63 marks

1. A student uses this method to prepare a standard solution of sodium carbonate.

1. Weigh a clean, dry, empty container on a balance that reads to 2 decimal places.
2. Add about 2.5 g of solid sodium carbonate to the container.
3. Tip the solid into a beaker.
4. Add approximately 100 cm^3 of distilled water to the beaker and stir until all the solid has dissolved.
5. Pour the solution into a 250 cm^3 volumetric flask.
6. Add distilled water until the top of the meniscus is level with the graduation mark.

(a) Suggest **three** improvements to this method.

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2 ____

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3 ____

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(3)

(b) A different student uses the correct method to prepare 250 cm^3 of sodium carbonate solution in a volumetric flask.
The uncertainty for the volumetric flask is ±0.20 cm^3

Calculate the percentage uncertainty in the volume of this sodium carbonate solution.

Percentage uncertainty ____________________

(1)

(Total 4 marks)

2. This question is about acid–base titrations.

Citric acid reacts with sodium hydroxide.

$$C_6H_8O_7(aq) + 3\ NaOH(aq) \rightarrow Na_3C_6H_5O_7(aq) + 3\ H_2O(l)$$

(a) A student makes a solution of citric acid by dissolving some solid citric acid in water.

Describe a method to add an accurately known mass of solid to a beaker to make a solution.

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(2)

(b) The student dissolves 0.834 g of citric acid in water and makes the solution up to 500 cm^3

Calculate the concentration, in mol dm^{-3}, of citric acid in this solution.

Concentration ________________ mol dm^{-3}

(3)

(c) The student uses this method to complete a titration.

- Rinse a burette with distilled water.
- Fill the burette with sodium hydroxide solution.
- Use a measuring cylinder to transfer 25 cm^3 of the citric acid solution into a conical flask.
- Add 5 cm^3 of indicator.
- Slowly add the sodium hydroxide solution from the burette into the conical flask.
- Add the sodium hydroxide solution dropwise near the end point until the indicator just changes colour.
- Repeat the titration to get concordant results.

The method used by the student includes three practical steps that will lead to an inaccurate final result.

For each of these three steps

- identify the mistake
- explain why it is a mistake
- suggest how the mistake can be overcome.

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(6)

(d) The table below shows the student's burette readings after the mistakes in the practical procedure have been corrected.

	Rough	Run 1	Run 2	Run 3
Final reading / cm^3	23.65	22.95	46.05	26.30
Start reading / cm^3	0.00	0.00	22.95	3.40
Titre / cm^3	23.65			

Complete the table.

Use the data in the table above to calculate the mean titre.

Mean titre ___________ cm^3

(2)

(e) The total uncertainty in the use of the burette is ±0.15 cm^3

Calculate the percentage uncertainty in the use of the burette in **Run 1**.

Percentage uncertainty _______________

(1)

(Total 14 marks)

3. This question is about rates of reaction.

Potassium manganate(VII), $KMnO_4$, reacts with sodium ethanedioate, $Na_2C_2O_4$, in the presence of dilute sulfuric acid.

$$2\ MnO_4^-(aq) + 16\ H^+(aq) + 5\ C_2O_4^{2-}(aq) \rightarrow 2\ Mn^{2+}(aq) + 8\ H_2O(l) + 10\ CO_2(g)$$

The reaction mixture is purple at the start and goes colourless when all the MnO_4^-(aq) ions have reacted.

The rate of reaction can be measured as $\frac{1000}{t}$ where t = the time taken for the mixture to go colourless.

A student investigated how long it takes for this reaction mixture to go colourless at different temperatures. The same concentrations and volumes of each reagent were used in an experiment at each temperature. The table below shows the results.

Temperature / °C	32	38	44	54	67
Time *t* / s	155	85	50	22	9
$\frac{1000}{t}$	6.45	11.8	20.0	45.5	

(a) Complete the table above.

(1)

(b) State the independent variable in this investigation.

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(1)

(c) The student noticed that the temperature of each reaction mixture decreased during each experiment.

Suggest how the student calculated the temperature values in the table above.

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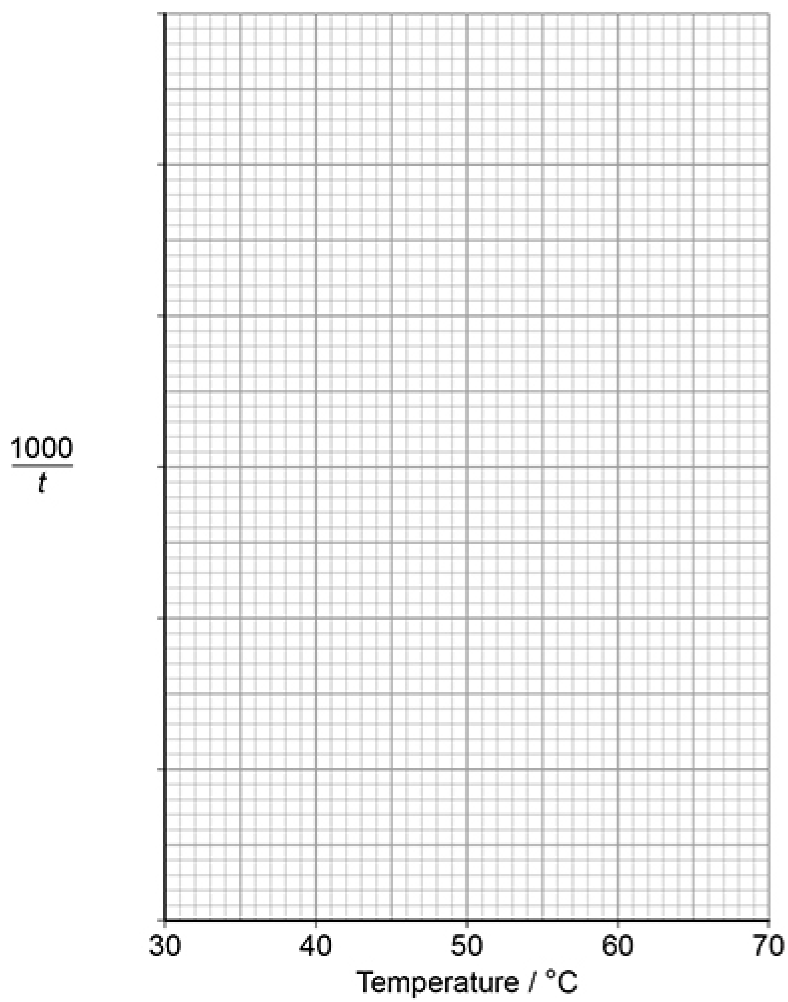
(1)

(d) Use the data in the table to plot a graph of $\frac{1000}{t}$ against temperature.



(3)

(e) Use your graph in part (d) to find the time taken for the mixture to go colourless at 60 °C
Show your working.

Time *t* __________ s

(1)

(f) The investigation shows that increasing the temperature causes the rate of reaction to increase.

Explain why a small increase in temperature causes a large increase in the rate of reaction.

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(2)

(Total 9 marks)

4. Hydrogen peroxide solution decomposes to form water and oxygen.

$$2\ H_2O_2(aq) \rightarrow 2\ H_2O(l) + O_2(g)$$

The reaction is catalysed by manganese(IV) oxide.

A student determines the order of this reaction with respect to hydrogen peroxide. The student uses a continuous monitoring method in the experiment.

The student places hydrogen peroxide solution in a conical flask with the catalyst and uses a gas syringe to collect the oxygen formed. The student records the volume of oxygen every 10 seconds for 100 seconds.

(a) Explain why the reaction is fastest at the start.

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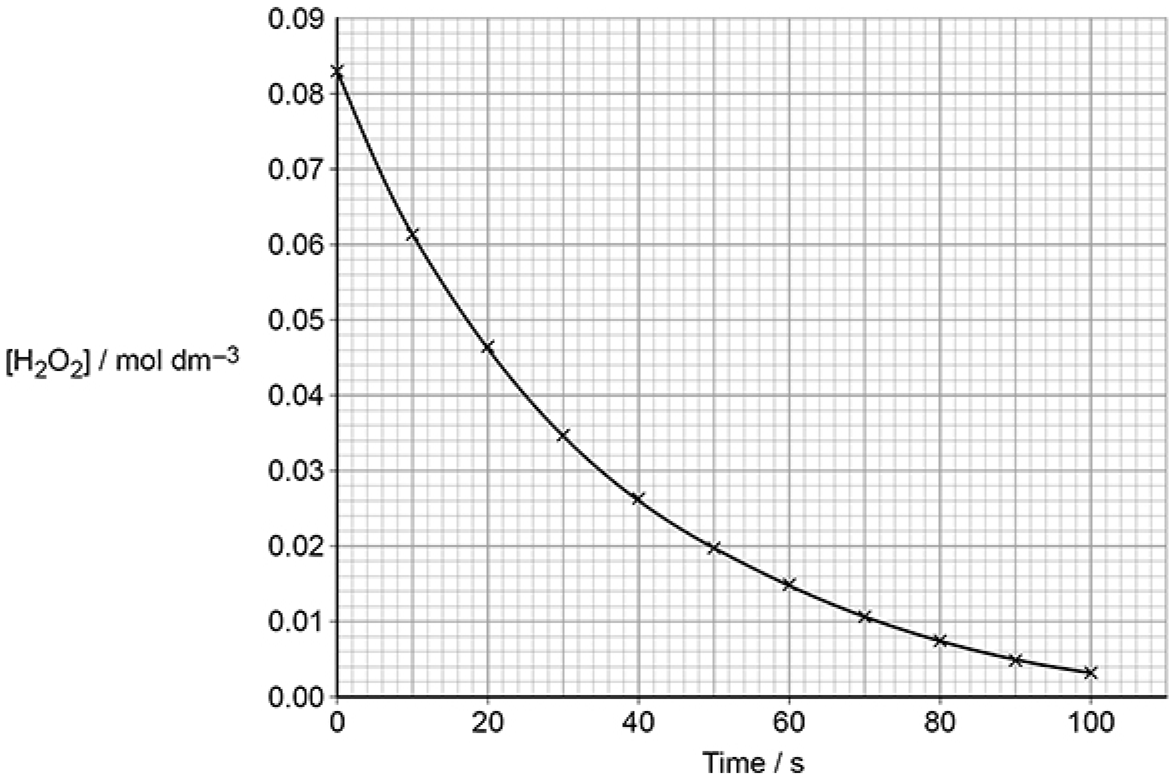
(2)

(b) The graph in **Figure 1** shows how the concentration of hydrogen peroxide changes with time in this experiment.

Figure 1



Tangents to the curve in **Figure 1** can be used to determine rates of reaction.

Draw a tangent to the curve when the concentration of hydrogen peroxide solution is 0.05 mol dm^{-3}

Use your tangent to calculate the gradient of the curve at this point.

Gradient _______________ mol dm^{-3} s^{-1}

(2)

(c) The concentration of hydrogen peroxide solution at time *t* during the experiment can be calculated using this expression.

$$[H_2O_2]_t = [H_2O_2]_{initial}\left(\frac{V_{max} - V_t}{V_{max}}\right)$$

$[H_2O_2]_t$ = concentration of hydrogen peroxide solution at time *t* / mol dm^{-3}

$[H_2O_2]_{initial}$ = concentration of hydrogen peroxide solution at the start / mol dm^{-3}

V_{max} = total volume of oxygen gas collected during the whole experiment / cm^3

V_t = volume of oxygen gas collected at time *t* / cm^3

In this experiment, V_{max} = 100 cm^3

Use **Figure 1** and the expression to calculate $[H_2O_2]_t$ when 20 cm^3 of oxygen has been collected.

$[H_2O_2]_t$ _______________ mol dm^{-3}

(2)

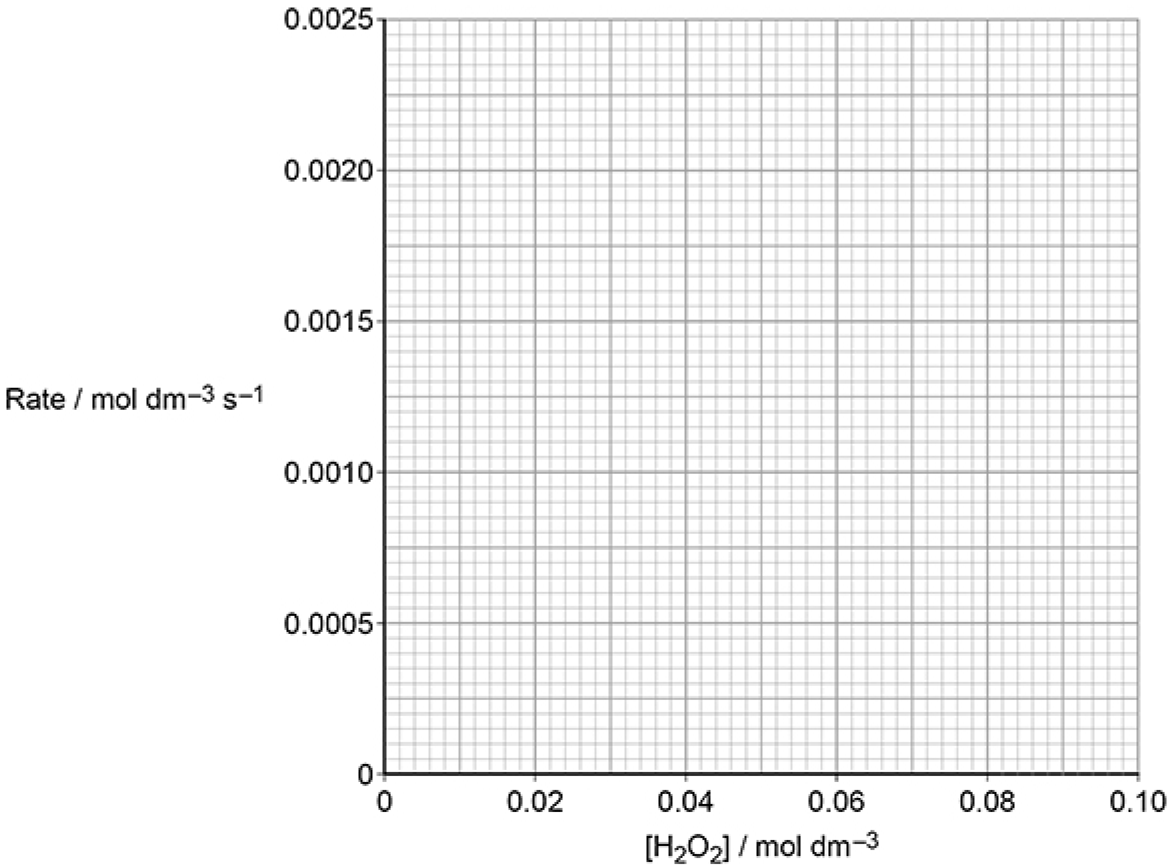
The table below shows data from a similar experiment.

$[H_2O_2]$ / mol dm^{-3}	0.02	0.03	0.05	0.07	0.09
Rate / mol dm^{-3} s^{-1}	0.00049	0.00073	0.00124	0.00168	0.00219

(d) Plot the data from the table above on the grid in **Figure 2**.

Draw a line of best fit.

Figure 2



(2)

(e) Use **Figure 2** to determine the order of reaction with respect to H_2O_2

State how the graph shows this order.

Order ____

How the graph shows this order ____

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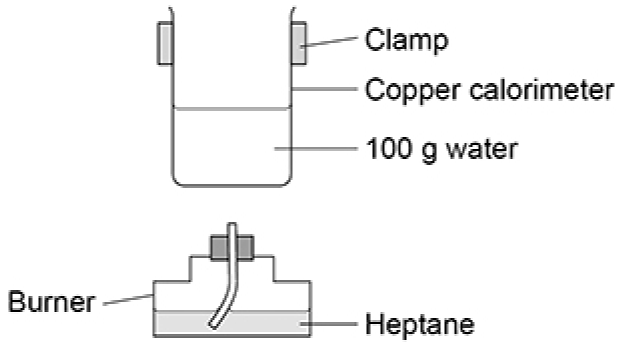
(2)

(Total 10 marks)

5. A student does an experiment to determine a value for the enthalpy of combustion of heptane.

The figure below shows some of the apparatus used.



(a) Design a table to record all the readings necessary to determine an experimental value for the enthalpy of combustion for heptane in this experiment.

(2)

(b) The student considered using a glass beaker on a tripod and gauze instead of the clamped copper calorimeter.

Suggest **two** disadvantages of using a glass beaker on a tripod and gauze.

Disadvantage 1 ____

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Disadvantage 2 ____

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(2)

(c) Suggest **two** reasons why the value of enthalpy of combustion from this experiment is less exothermic than a data book value.

Reason 1 ____

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Reason 2 ____

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(2)

(d) Suggest **one** addition to this apparatus that would improve the accuracy of the enthalpy value obtained.

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(1)

(Total 7 marks)

6. One cell that has been used to provide electrical energy is the Daniell cell. This cell uses copper and zinc.

(a) The conventional representation for the Daniell cell is

$$Zn(s) \mid Zn^{2+}(aq) \mid \mid Cu^{2+}(aq) \mid Cu(s)$$

The e.m.f. of this cell under standard conditions is +1.10 V.

Deduce the half-equations for the reactions occurring at the electrodes.

At Zn electrode ____

At Cu electrode ____

(2)

(b) A Daniell cell was set up using 100 cm^3 of a 1.0 mol dm^{-3} copper(II) sulfate solution. The cell was allowed to produce electricity until the concentration of the copper(II) ions had decreased to 0.50 mol dm^{-3}.

Calculate the decrease in mass of the zinc electrode. Show your working.

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(3)

(c) You are provided with the Daniell cell referred to in part (b), including a zinc electrode of known mass.

Briefly outline how you would carry out an experiment to confirm your answer to part (b).

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(3)

(Total 8 marks)

7. The alcohol 2-methylpropan-2-ol, $(CH_3)_3COH$, reacts to form esters that are used as flavourings by the food industry. The alcohol can be oxidised to produce carbon dioxide and water.

A student carried out an experiment on a pure sample of 2-methylpropan-2-ol to determine its enthalpy of combustion. A sample of the alcohol was placed into a spirit burner and positioned under a beaker containing 50 cm^3 of water. The spirit burner was ignited and allowed to burn for several minutes before it was extinguished.

The results for the experiment are shown in **Table 1**.

Table 1

Initial temperature of the water / °C	18.1
Final temperature of the water / °C	45.4
Initial mass of spirit burner and alcohol / g	208.80
Final mass of spirit burner and alcohol / g	208.58

(a) Use the results from **Table 1** to calculate a value for the heat energy released from the combustion of this sample of 2-methylpropan-2-ol.
The specific heat capacity of water is 4.18 J K^{-1} g^{-1}.
Show your working.

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(2)

(b) Calculate the amount, in moles, of 2-methylpropan-2-ol burned in the experiment.
Hence calculate a value, in kJ mol^{-1}, for the enthalpy of combustion of 2-methylpropan-2-ol.
Show your working.

(If you were unable to calculate an answer to part (a), you should assume that the heat energy released was 5580 J. This is **not** the correct value.)

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(3)

(c) An equation for the combustion of 2-methylpropan-2-ol is

$$(CH_3)_3COH(l) + 6O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$$

Table 2 contains some standard enthalpy of formation data.

Table 2

	$(CH_3)_3COH(l)$	$O_2(g)$	$CO_2(g)$	$H_2O(l)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	–360	0	–393	–286

Use the data from **Table 2** to calculate a value for the standard enthalpy of combustion of 2-methylpropan-2-ol. Show your working.

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(3)

(d) An accurate value for the enthalpy of combustion of 2-methylpropan-2-ol in which water is formed as a gas is -2422 kJ mol^{-1}.

Use this value and your answer from part (b) to calculate the overall percentage error in the student's experimental value for the enthalpy of combustion of 2-methylpropan-2-ol.

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(1)

(e) Suggest **one** improvement that would reduce errors due to heat loss in the student's experiment.

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(1)

(f) Suggest **one** other source of error in the student's experiment. Do **not** include heat loss, apparatus error or student error.

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(1)

(Total 11 marks)