Energetics – A2 2022 Chemistry P2

1. June/2022/Paper_7405/2/No.5

0 5 This question is about the preparation of hexan-2-ol.
Hexan-2-ol does not mix with water and has a boiling point of 140 °C

Hexan-2-ol can be prepared from hex-1-ene using this method.

a Measure out 11.0 cm^3 of hex-1-ene into a boiling tube in an ice bath.

b Carefully add 5 cm^3 of concentrated phosphoric acid to the hex-1-ene.

c After 5 minutes add 10 cm^3 of distilled water to the mixture and transfer the boiling tube contents to a separating funnel.

d Shake the mixture and allow it to settle.

e Discard the lower (aqueous) layer.

f Add a fresh 10 cm^3 sample of distilled water and repeat steps **d** and **e**.

g Transfer the remaining liquid to a beaker.

h Add 2 g of anhydrous magnesium sulfate and allow to stand for 5 minutes.

i Filter the mixture under reduced pressure.

j Distil the filtrate and collect the distillate that boils in the range 130–160 °C

0 5 . 1 It is important to wear eye protection and a lab coat when completing this experiment.

Suggest, with a reason, **one** other appropriate safety precaution for this experiment.

[2 marks]

Precaution _____

Reason _____

_____

0 5 . 2 Give a reason for adding the distilled water in steps **c** and **f**.

[1 mark]

_____

_____

0 5 . 3 Give a reason for adding anhydrous magnesium sulfate in step **h**.

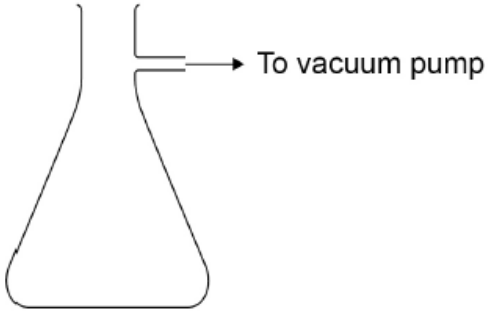
[1 mark]

_____

_____

0 5 . 4 Complete and label the diagram of the apparatus used to filter the mixture under reduced pressure in step **i**.

[2 marks]



0 5 . 5 Identify the most likely organic impurity, other than hex-1-ene, in the distillate collected in step **j**.

Suggest **one** reason why it could be difficult to remove this impurity.

[2 marks]

Impurity _____

Reason _____

_____

0 5 . 6 Calculate the mass, in g, of hexan-2-ol formed from 11.0 cm^3 of hex-1-ene if the yield is 31.0%

Give your answer to 1 decimal place.

Density of hex-1-ene = 0.678 g cm^{-3}

[4 marks]

Mass _____ g

2. June/2022/Paper_7405/3/No.1

0 1 A value for enthalpy of solution can be determined in two ways:

- from a cycle, using lattice enthalpy and enthalpies of hydration
- from the results of a calorimetry experiment.

0 1 . 1 Define the term enthalpy of lattice dissociation.

[2 marks]

0 1 . 2 The enthalpy of solution for ammonium nitrate is the enthalpy change for the reaction shown.

$$NH_4NO_3(s) + aq \rightarrow NH_4^+(aq) + NO_3^-(aq) \quad \Delta H = +26\,kJ\,mol^{-1}$$

Table 1

	$NH_4^+(g)$	$NO_3^-(g)$
Enthalpy of hydration $\Delta_{hyd}H$ / kJ mol^{-1}	–307	–314

Draw a suitably labelled cycle and use it, with data from **Table 1**, to calculate the enthalpy of lattice dissociation for ammonium nitrate.

[3 marks]

Enthalpy of lattice dissociation _____ kJ mol^{-1}

0 1 . 3 A student does an experiment to determine a value for the enthalpy of solution for ammonium nitrate.

The student uses this method.

- Measure 25.0 cm^3 of distilled water in a measuring cylinder.
- Pour the water into a beaker.
- Record the temperature of the water in the beaker.
- Add 4.00 g of solid NH_4NO_3 to the water in the beaker.
- Stir the solution and record the lowest temperature reached.

Table 2 shows the student's results.

Table 2

Initial temperature / °C	20.2
Lowest temperature / °C	12.2

Calculate the enthalpy of solution, in kJ mol^{-1}, for ammonium nitrate in this experiment.

Assume that the specific heat capacity of the solution, c = 4.18 $J K^{-1} g^{-1}$

Assume that the density of the solution = 1.00 $g\,cm^{-3}$

[3 marks]

Enthalpy of solution _____ kJ mol^{-1}

0 1 . 4 The uncertainty in each of the temperature readings from the thermometer used in this experiment is ±0.1°C

Calculate the percentage uncertainty in the temperature change in this experiment.

[1 mark]

Percentage uncertainty _____

0 1 . 5 Suggest a change to the student's method, using the same apparatus, that would reduce the percentage uncertainty in the temperature change.

Give a reason for your answer.

[2 marks]

Change _____

_____

Reason _____

_____

0 1 . 6 Another student obtained a value of +15 kJ mol^{-1} using the same method.

Suggest the main reason for the difference between this experimental value for the enthalpy of solution and the correct value of +26 kJ mol^{-1}

[1 mark]

_____

_____

0 1 . 7 **Table 3** shows some entropy data at 298 K

Table 3

	Entropy S / J K^{-1} mol^{-1}
$NH_4NO_3(s)$	151
$NH_4^+(aq)$	113
$NO_3^-(aq)$	146

Calculate a value for the Gibbs free-energy change (ΔG), at 298 K, for the reaction when ammonium nitrate dissolves in water.

$$NH_4NO_3(s) + aq \rightarrow NH_4^+(aq) + NO_3^-(aq) \quad \Delta H = +26 \text{ kJ mol}^{-1}$$

Use data from **Table 3** and the value of ΔH from the equation.
Assume for the solvent, water, that the entropy change, $\Delta S = 0$

Explain what the calculated value of ΔG indicates about the feasibility of this reaction at 298 K

[4 marks]

ΔG _____ kJ mol^{-1}

Explanation _____

_____

_____

0 1 . 8 Ammonium nitrate decomposes as shown.

$$NH_4NO_3(s) \rightarrow N_2(g) + \frac{1}{2}O_2(g) + 2H_2O(g) \quad \Delta H = +123 \text{ kJ mol}^{-1}$$

The entropy change (ΔS) for this reaction is +144 J K^{-1} mol^{-1}

Calculate the temperature at which this reaction becomes feasible.

[2 marks]

Temperature _____ K

3. June/2022/Paper_7405/3/No.4

0 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.

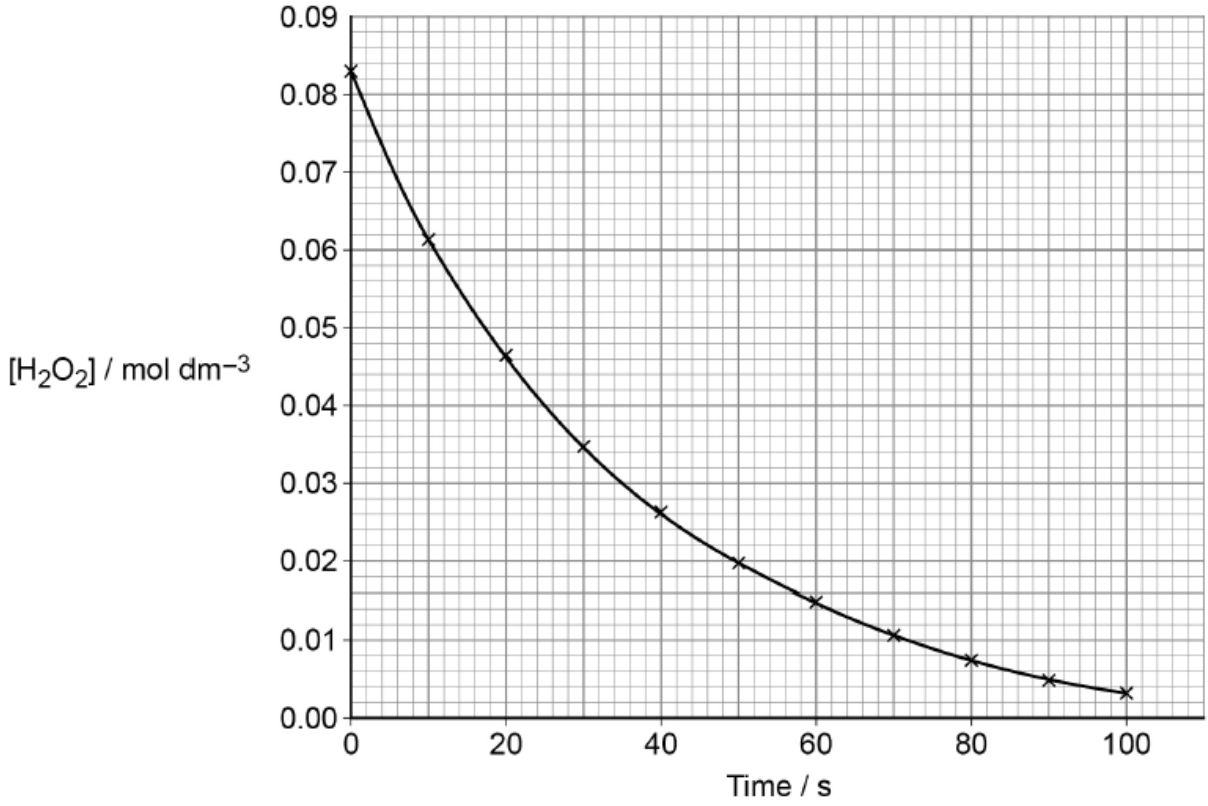
The student places hydrogen peroxide solution in a conical flask with the catalyst and uses a gas syringe to collect the oxygen formed. The student records the volume of oxygen every 10 seconds for 100 seconds.

0 4 . 1 Explain why the reaction is fastest at the start.

[2 marks]

0 4 . 2 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.

[2 marks]

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

0 4 . 3 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.

[2 marks]

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

Table 5 shows data from a similar experiment.

Table 5

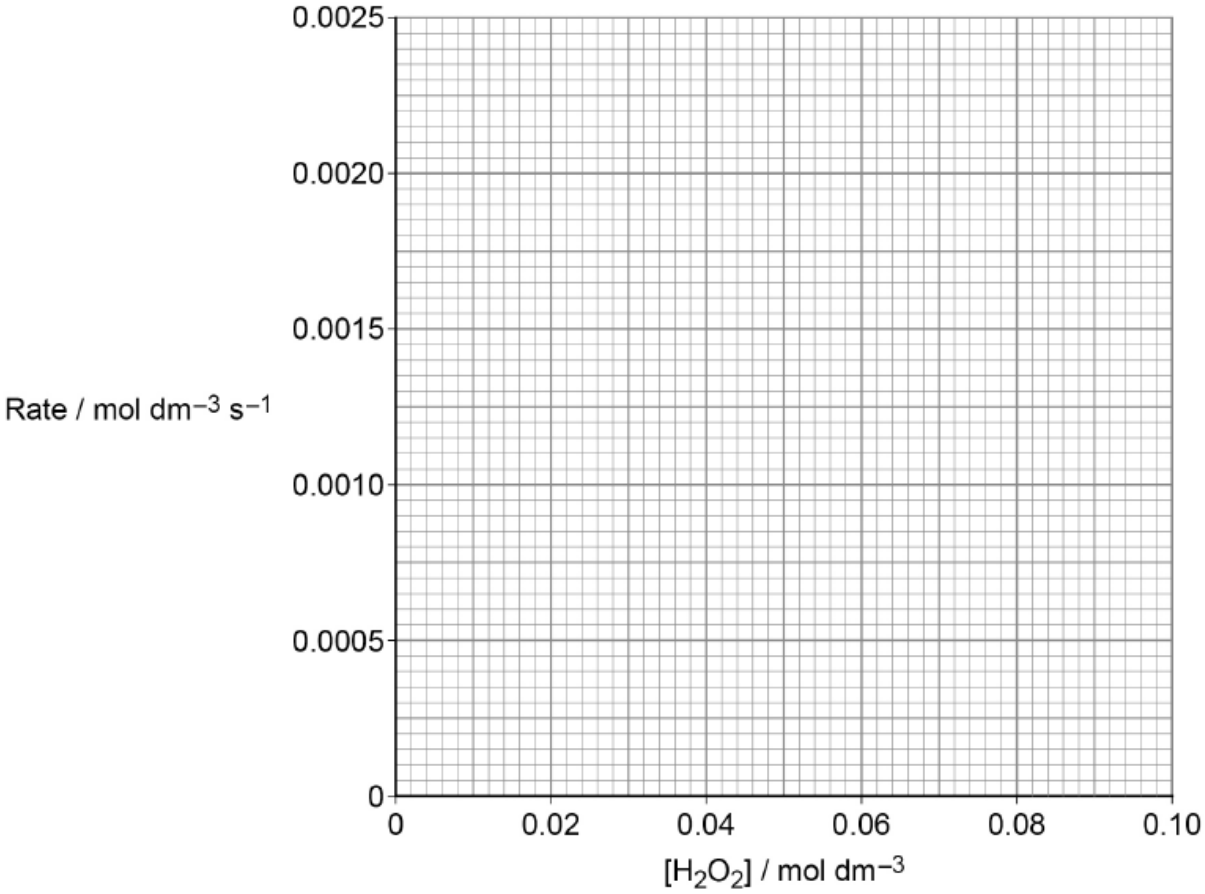
$[H_2O_2]$ / mol dm^{-3}	0.02	0.03	0.05	0.07	0.09
Rate / mol dm^{-3} s^{-1}	0.00049	0.00073	0.00124	0.00168	0.00219

0 4 . 4 Plot the data from **Table 5** on the grid in **Figure 2**.

Draw a line of best fit.

[2 marks]

Figure 2



0 4 . 5 Use **Figure 2** to determine the order of reaction with respect to H_2O_2

State how the graph shows this order.

[2 marks]

Order _____

How the graph shows this order _____

_____

_____

4. June/2022/Paper_7405/3/No.17

Which statement is correct about the Group 1 elements?

[1 mark]

A The Cs^+ ion has a more negative enthalpy of hydration than the Rb^+ ion. ⬭

B The enthalpy of atomisation for potassium is greater than the enthalpy of atomisation for sodium. ⬭

C The melting point of potassium is higher than the melting point of sodium. ⬭

D The second ionisation energy of rubidium is lower than the second ionisation energy of lithium. ⬭