

- 7 When 1.0 mol of ethanoic acid, CH_3COOH , in aqueous solution is neutralised by an excess of aqueous sodium hydroxide, 55 kJ mol^{-1} of energy is released.

Which statement about this reaction is correct?

- A** The reaction is exothermic because only bond breaking takes place.
B The reaction is exothermic because only bond forming takes place.
C The reaction is exothermic because more energy is given out in breaking bonds than is taken in to form bonds.
D The reaction is exothermic because more energy is given out in forming bonds than is taken in to break bonds.

- 8 In an experiment, 1.60 g of a fuel is burnt. 45.0% of the energy released is absorbed by 200 g of water. The temperature of the water rises from 18.0°C to 66.0°C .

What is the total energy released per gram of fuel burnt?

- A** 25 100 J **B** 55 700 J **C** 89 200 J **D** 143 000 J

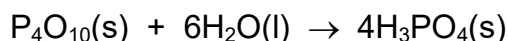
- 9 The data shown are needed for this question.

$$\Delta H_f^\ominus(\text{P}_4\text{O}_{10}(\text{s})) = -3012 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus(\text{H}_2\text{O}(\text{l})) = -286 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\ominus(\text{H}_3\text{PO}_4(\text{s})) = -1279 \text{ kJ mol}^{-1}$$

What is $\Delta H^\ominus$ for the reaction shown?



- A** $-9844 \text{ kJ mol}^{-1}$
B -388 kJ mol^{-1}
C -97 kJ mol^{-1}
D $+2019 \text{ kJ mol}^{-1}$

- 3 Cycloalkanes show similar chemical properties to alkanes but have the same empirical formula as alkenes.

(a) Define empirical formula.

.....
 [1]

(b) Cyclopentane, C_5H_{10} , has four cyclic structural isomers. One of these isomers is **C**, shown in Fig. 3.1.

Complete Fig. 3.1 to show two other cyclic structural isomers of C_5H_{10} .

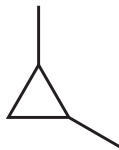
cyclopentane 			C 
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Fig. 3.1

[2]

(c) Cyclopentane reacts with Cl_2 in the presence of ultraviolet light to form C_5H_9Cl .

(i) The reaction is initiated by the bond fission of Cl_2 .

State the type of bond fission shown in the initiation step.

..... [1]

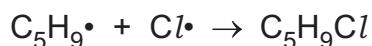
(ii) Complete the equations to show the two propagation steps that follow the initiation step.

propagation 1 $C_5H_{10} + \dots \rightarrow C_5H_9\cdot + \dots$

propagation 2 $C_5H_9\cdot + \dots \rightarrow \dots$

[2]

(iii) The final step is shown.



Give the name for this step in the reaction.

..... [1]

(d) Fig. 3.2 shows a reaction cycle involving cyclopentane, cyclopentene and $\text{C}_5\text{H}_9\text{Cl}$.

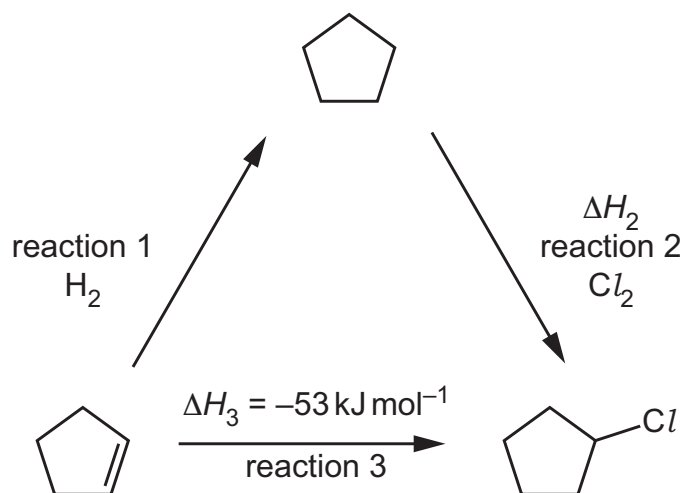


Fig. 3.2

(i) Identify a suitable reagent for reaction 3.

..... [1]

(ii) Use the data in Fig. 3.2 and in Table 3.1 to calculate the enthalpy change of reaction 2, ΔH_2 .

Table 3.1

compound	enthalpy change of combustion, $\Delta H_c / \text{kJ mol}^{-1}$
	-3292
	-3115
H_2	-286

③ $\Delta H_2 = \dots\dots\dots \text{kJ mol}^{-1}$ [2]

(e) Cyclopentene, C_5H_8 , reacts with hot concentrated acidified $KMnO_4$ to form compound **W**, $C_5H_8O_4$.

(i) Draw the structure of **W**.

[1]

(ii) The infrared spectrum of **W** is shown in Fig. 3.3.

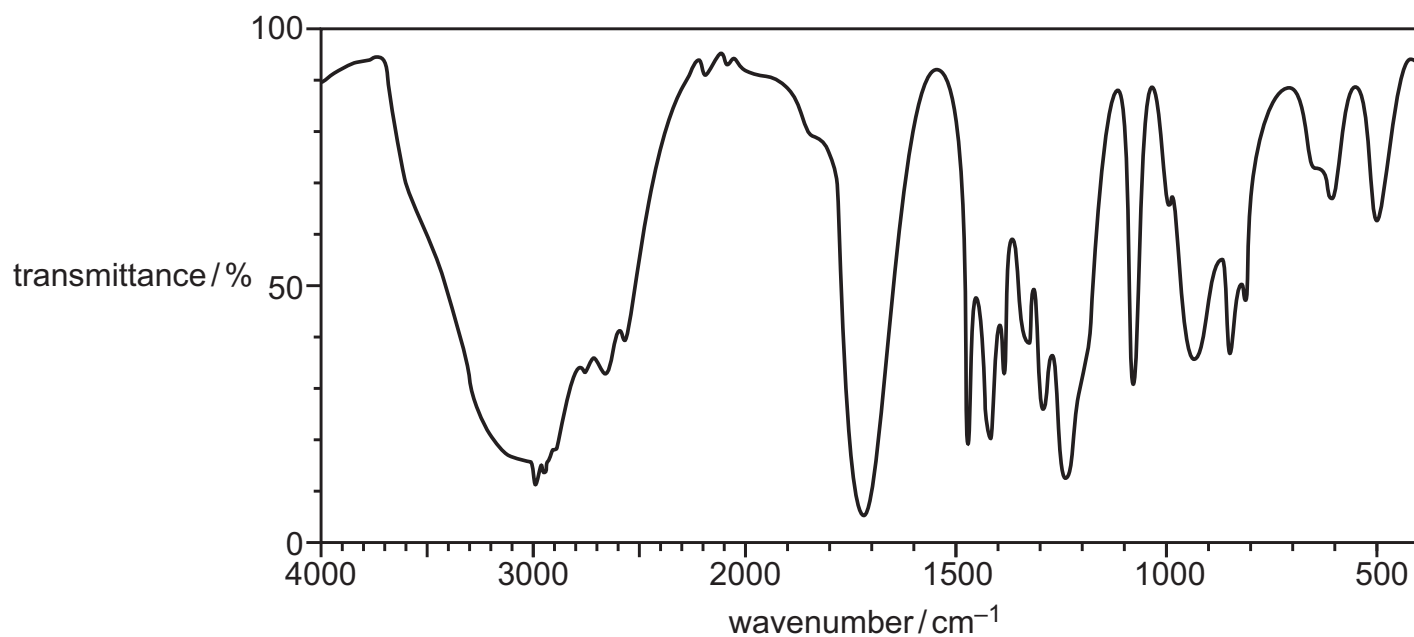


Fig. 3.3

Identify **two** absorptions in the infrared spectrum of **W** that would **not** be present in the infrared spectrum of cyclopentene.

- Write **1** or **2** on Fig. 3.3 against each of these two absorptions.
- Complete Table 3.2 to show which bond is responsible for each absorption that you have identified in Fig. 3.3.

Table 3.2

absorption	1	2
bond responsible		

[2]

Table 3.3

bond	functional groups containing the bond	characteristic infrared absorption range (in wavenumbers)/cm ⁻¹
C–O	hydroxy, ester	1040–1300
C=C	aromatic compound, alkene	1500–1680
C=O	amide carbonyl, carboxyl ester	1640–1690 1670–1740 1710–1750
C≡N	nitrile	2200–2250
C–H	alkane	2850–2950
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3650

[Total: 13]

- 1** A student uses a technique called the Winkler method to determine the mass of oxygen dissolved in a sample of water from a lake.

Two solutions, **X** and **Y**, are prepared.

Solution **X** is 2.30 mol dm^{-3} aqueous manganese(II) sulfate, $\text{MnSO}_4(\text{aq})$.

Solution **Y** is alkaline aqueous potassium iodide, $\text{KI}(\text{aq})$.

- (a)** Calculate the mass of solid hydrated manganese(II) sulfate, $\text{MnSO}_4 \cdot \text{H}_2\text{O}(\text{s})$, needed to make 100.0 cm^3 of solution **X**.

Give your answer to **two** decimal places.

mass of $\text{MnSO}_4 \cdot \text{H}_2\text{O}(\text{s}) = \dots\dots\dots \text{ g}$ [1]

- (b)** The student is given a small beaker containing the mass of $\text{MnSO}_4 \cdot \text{H}_2\text{O}(\text{s})$ calculated in **(a)**. Describe how the student should prepare exactly 100.0 cm^3 of solution **X**.

Include the names and capacities of each piece of key apparatus used.

Write your answer using a series of numbered steps.

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.....

.....

.....

.....

..... [3]

(c) Solution **Y** is prepared as follows.

- step 1** Place 100 cm³ of distilled water in a 250 cm³ beaker.
- step 2** Add about 8 g of solid sodium hydroxide, NaOH(s), and stir to dissolve.
- step 3** Cool the solution to room temperature using an ice-bath.
- step 4** Repeat steps 2 and 3 until a total of 32 g of NaOH(s) has been dissolved.
- step 5** Dissolve about 14 g of potassium iodide, KI(s), into the solution formed in step 4.

(i) Solution **Y** is corrosive.

Other than wearing safety goggles, state **one** safety precaution that the student should take when preparing solution **Y**.

..... [1]

(ii) Suggest why the solution is cooled in step 3.

.....

.....

..... [1]

- (d) The student uses the following procedure to determine the mass of oxygen dissolved in a sample of water from the lake.

- step 1** Collect a 250 cm^3 sample of lake water in a bottle.
- step 2** Add 1 cm^3 of solution **X** and 1 cm^3 of solution **Y** to the bottle.
- step 3** Immediately stopper the bottle, ensuring as little air as possible is trapped.
- step 4** Shake the bottle to mix its contents.
A brown precipitate, manganese(III) hydroxide, $\text{Mn}(\text{OH})_3(\text{s})$, is formed.
- step 5** Add 1.5 cm^3 of concentrated sulfuric acid to the contents of the bottle.
The precipitate dissolves, and iodine is formed.
- step 6** Dilute this solution to exactly 500.0 cm^3 using distilled water to form solution **Z**.
- step 7** Transfer 25.0 cm^3 of solution **Z** into a conical flask, and titrate with $1.00 \times 10^{-3}\text{ mol dm}^{-3}$ aqueous sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$. Add 1 cm^3 of starch solution near to the end-point.
- step 8** Repeat step 7 as many times as necessary.

- (i) Suggest why it is important to avoid trapping air inside the bottle in step 3.

.....
..... [1]

- (ii) Identify the piece of apparatus that the student should use to transfer the 25.0 cm^3 of solution **Z** in step 7.

..... [1]

- (iii) Suggest why starch solution is added in step 7.

..... [1]

- (e) The student records the results shown in Table 1.1.

Table 1.1

	rough titration	titration 1	titration 2	titration 3
final burette reading / cm ³	13.60	12.75	26.20	14.50
initial burette reading / cm ³	0.00	0.05	13.15	1.35
titre / cm ³	13.60			

- (i) Complete Table 1.1 and calculate the mean titre.

mean titre = cm³ [2]

- (ii) Explain why the student does **not** need to carry out any further titrations.

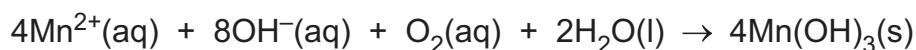
.....
..... [1]

- (iii) Calculate the percentage error in the measurement of the titre for titration 3.
Show your working.

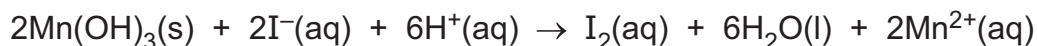
percentage error = % [1]

- (f) The following equations show the reactions that take place during the procedure in (d).

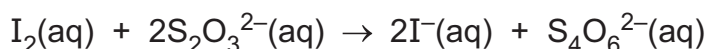
steps 2, 3 and 4



step 5



step 7



- (i) Calculate the amount, in mol, of iodine, $\text{I}_2(\text{aq})$, in 25.0 cm^3 of solution **Z**.

amount of $\text{I}_2(\text{aq})$ = mol [1]

- (ii) Use your answer to (f)(i) and the equations given to calculate the amount, in mol, of dissolved oxygen, $\text{O}_2(\text{aq})$, in 500.0 cm^3 of solution **Z**.

amount of $\text{O}_2(\text{aq})$ in 500.0 cm^3 of solution **Z** = mol [1]

- (iii) Dissolved oxygen content, mg dm^{-3} , is the mass of oxygen dissolved in water.

Use your answer to (f)(ii) to calculate the dissolved oxygen content in the lake water collected in step 1.

[If you were unable to obtain an answer to (f)(ii), then use amount of $\text{O}_2(\text{aq})$ in 500.0 cm^3 of solution **Z** = $7.12 \times 10^{-5}\text{ mol}$. This is **not** the correct answer.]

dissolved oxygen content = mg dm^{-3} [1]