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.

$\Delta H_f^{\ominus}(P_4O_{10}(s)) = -3012\,kJ\,mol^{-1}$

$\Delta H_f^{\ominus}(H_2O(l)) = -286\,kJ\,mol^{-1}$

$\Delta H_f^{\ominus}(H_3PO_4(s)) = -1279\,kJ\,mol^{-1}$

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

$$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(s)$$

A $-9844\,kJ\,mol^{-1}$

B $-388\,kJ\,mol^{-1}$

C $-97\,kJ\,mol^{-1}$

D $+2019\,kJ\,mol^{-1}$

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}.

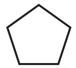
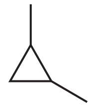
cyclopentane			**C**
			

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} + ... → C_5H_9• + ...

propagation 2 C_5H_9• + ... → ....

[2]

(iii) The final step is shown.

$$C_5H_9\bullet + Cl\bullet \rightarrow C_5H_9Cl$$

Give the name for this step in the reaction.

.... [1]

(d) Fig. 3.2 shows a reaction cycle involving cyclopentane, cyclopentene and C_5H_9Cl.

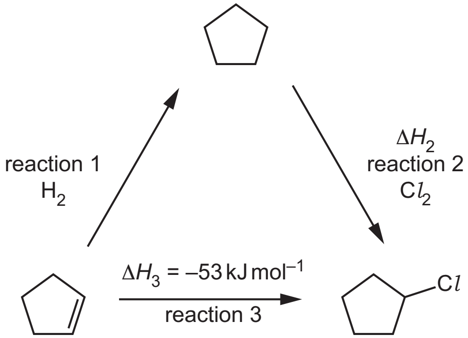


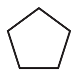
Fig. 3.2

(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, ΔH_c / $kJ\,mol^{-1}$
	–3292
	–3115
H_2	–286

ΔH_2 = ... $kJ\,mol^{-1}$ [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.

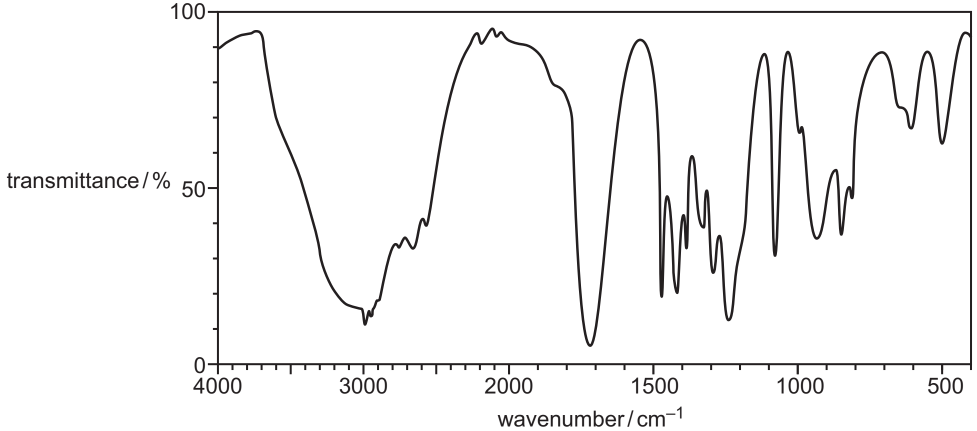


Fig. 3.3

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, $MnSO_4(aq)$.

Solution **Y** is alkaline aqueous potassium iodide, KI(aq).

(a) Calculate the mass of solid hydrated manganese(II) sulfate, $MnSO_4{\bullet}H_2O(s)$, needed to make 100.0 cm^3 of solution **X**.

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

mass of $MnSO_4{\bullet}H_2O(s)$ = ... g [1]

(b) The student is given a small beaker containing the mass of $MnSO_4{\bullet}H_2O(s)$ 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.

....

....

....

....

....

....

.... [3]

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

step 1 Place 100 cm^3 of distilled water in a 250 cm^3 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, $Mn(OH)_3(s)$, 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 $1.00 \times 10^{-3}\,mol\,dm^{-3}$ aqueous sodium thiosulfate, $Na_2S_2O_3(aq)$. 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 = ... cm^3 [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**

$$4Mn^{2+}(aq) + 8OH^-(aq) + O_2(aq) + 2H_2O(l) \rightarrow 4Mn(OH)_3(s)$$

step 5

$$2Mn(OH)_3(s) + 2I^-(aq) + 6H^+(aq) \rightarrow I_2(aq) + 6H_2O(l) + 2Mn^{2+}(aq)$$

step 7

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

(i) Calculate the amount, in mol, of iodine, $I_2(aq)$, in 25.0 cm^3 of solution **Z**.

amount of $I_2(aq)$ = ... mol [1]

(ii) Use your answer to **(f)(i)** and the equations given to calculate the amount, in mol, of dissolved oxygen, $O_2(aq)$, in 500.0 cm^3 of solution **Z**.

amount of $O_2(aq)$ 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 $O_2(aq)$ in 500.0 cm^3 of solution **Z** = 7.12×10^{-5} mol. This is **not** the correct answer.]

dissolved oxygen content = ... $mg\,dm^{-3}$ [1]

[Total: 10]