Anglo-Chinese School
(Independent)

Year 6 Preliminary Examination 2018
INTERNATIONAL BACCALAUREATE DIPLOMA PROGRAMME
CHEMISTRY HIGHER LEVEL

PAPER 2

Tuesday 11th September 2018 2 hours 15 minutes

Candidate Session Number

0	0	2	3	2	9				

INSTRUCTIONS TO CANDIDATES

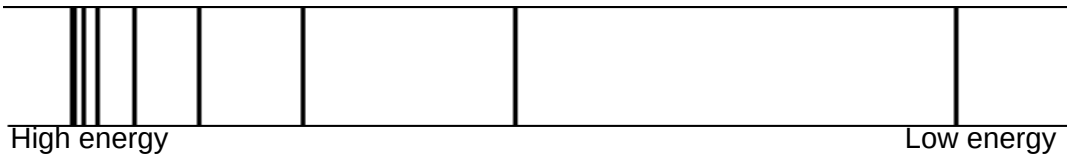
- Do not open this examination paper until instructed to do so.
- Write your **candidate session number in the box above**.
- A calculator is required for this paper.
- A copy of the Chemistry Data Booklet is required for this paper.
- Write your answers in the boxes provided.
- If you use additional sheets of paper for your answer, attach them to the booklet. Indicate the question number clearly on these sheets.

For examiner's use	
Qn 1	/6
Qn 2	/11
Qn 3	/5
Qn 4	/18
Qn 5	/9
Qn 6	/11
Qn 7	/11
Qn 8	/15
Qn 9	/9
Wrong s.f. /units	
Total	/95

This question paper consists of 22 printed pages including this cover page.

Answer **all** questions. Write your answers in the boxes provided.

1. (a) The emission spectrum of hydrogen is shown in the diagram below.



(i) Describe the emission spectrum of hydrogen. [2]

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(ii) State an electron transition that corresponds to a line in the visible emission spectrum. [1]

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(b) The first seven ionization energies of an atom, **X**, in kJ mol^{-1}, are

1012 1903 2912 4957 6274 21 269 25 298

(i) Write the electronic configuration of element **X** which belongs to Period 3. [1]

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(This question continues on the following page)

(Question 1 continued)

(ii) Explain the general increase in the ionization energy values. [2]

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2. The halogens form many interhalogen compounds and ions with other halogen atoms. Two such species are ClF_5 and ICl_4^-.

(a) Draw the Lewis (electron dot) structures of ClF_5 and ICl_4^- and state their molecular geometry. [4]

Molecular Geometry:	Molecular Geometry:
.....	.....

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(Question 2 continued)

(b) A student proposed the two possible shapes for the ClF_3 molecule were trigonal planar and T-shape. He did some research and learnt that the molecule has an overall dipole moment. Which of the two shapes is consistent with the fact that the ClF_3 molecule has an overall dipole moment? Justify your answer in terms of bond polarity and molecular geometry. [2]

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(c) (i) The following exergonic equilibrium gives rise to triiodide ion:

$$I_2 + I^- \rightleftharpoons I_3^-$$

Explore if the reaction is an acid-base reaction. [2]

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(ii) Explain with reference to its atomic structure, why the magnitude of the electron affinity of iodine is lower than fluorine. [2]

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(Question 2 continued)

(iii) Use section 15 of the data booklet, state **one** change if all the ligands in $[FeI_6]^{3-}$ complex are replaced with fluoride ligands. [1]

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3. The oxides MgO and SiO_2 are used as refractory materials due to their high melting points.

(a) If a sample of one of the oxides was provided as a white powder, describe a **chemical reaction** that can be carried out to determine the identity of the unknown oxide sample. Hence, state the chemical equation for the reaction. [3]

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(b) Explain in terms of bonding, why silicon dioxide does not exist as simple molecules like carbon dioxide. [2]

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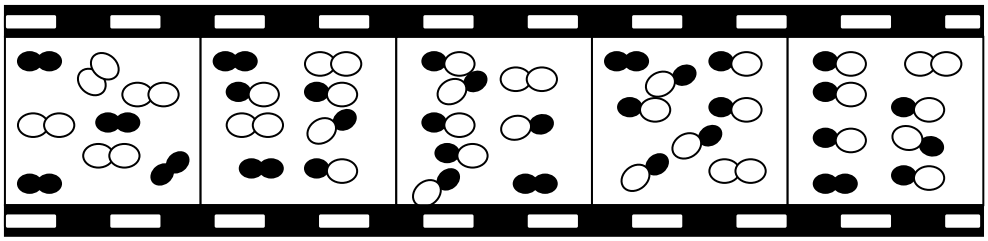
4. At 400 K, 0.400 mole of hydrogen and 0.400 mole of iodine gas were introduced into a reaction vessel in the presence of a platinum catalyst. The reaction scheme represented five molecular scenes, **A** to **E** of the reaction between hydrogen and iodine over time to liberate hydrogen iodide gas. Each "diatomic" symbol represented 0.100 mole.



A **B** **C** **D** **E**

● Hydrogen atom ○ Iodine atom

(a) (i) State an equation for the reversible reaction between hydrogen and iodine gas. [1]

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(ii) State **two** characteristics of a system in dynamic equilibrium. [2]

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(b) (i) Write the expression for the reaction quotient, Q_c, for the reaction between hydrogen and iodine. [1]

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(This question continues on the following page)

(Question 4 continued)

(ii) Calculate the value of Q_c for each scene, **A** to **E** in the reaction scheme. [3]

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(iii) Hence, state the value of K_c for the reaction of hydrogen and iodine at 400 K. [1]

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(iv) State the significance of the magnitude of K_c in (b)(iii). [1]

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(v) The reaction mixture in scene **E** is heated to 600 K causing 50% of hydrogen iodide present to decompose. Calculate the value of K_c at 600 K. [3]

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(This question continues on the following page)

(Question 4 continued)

(vi) State and explain the effect of platinum catalyst on the position of equilibrium and the magnitude of K_c. [2]

(c) (i) Use section 1 of the data booklet and your answer in (b)(v), determine the value of ΔG, in kJ mol^{-1}, for the above reaction at 600 K
(If you did not obtain an answer to (b)(v), use a value of 1.50 for the K_c value at 600 K, although this is not the correct answer.) [1]

(ii) Using your answers in (b)(iii) and (b)(v), deduce with reason, the sign of the enthalpy change of reaction between hydrogen and iodine. [3]

5. The production of a colour-treating solution involves the acid buffered oxidation of iodide to iodine by hydrogen peroxide in one of the many steps in the synthesis process.

$$2I^- + H_2O_2 + 2H^+ \rightarrow I_2 + 2H_2O$$

Two experiments were carried out to determine the rate of the oxidation reaction and the results are given below.

	Experiment with $[H_2O_2]$ = 0.1 mol dm^{-3}	Experiment with $[H_2O_2]$ = 0.2 mol dm^{-3}
Time / s	[KI] / mol dm^{-3}	[KI] / mol dm^{-3}
0	0.0200	0.0200
5	0.0190	0.0175
25	0.0149	0.0103
50	0.0112	0.0054
75	0.0085	0.0030
100	0.0063	0.0015
125	0.0047	0.0003

(a) Suggest how you could determine the concentration of KI with respect to time indirectly in the laboratory. [2]

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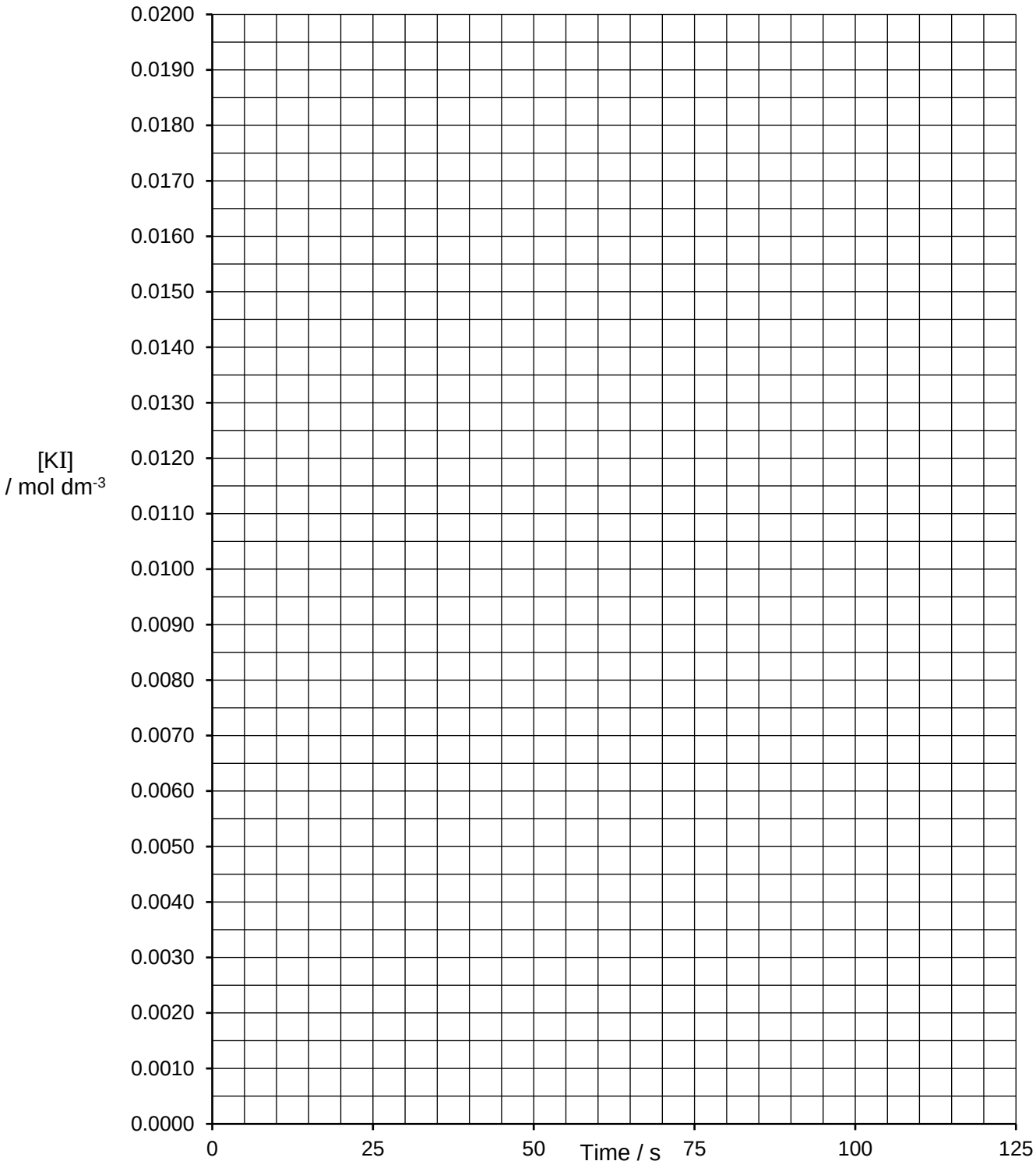
(**Question 5 continued)**

(b) Plot the [KI] vs Time graphs for **both** experiments on the axes provided in **pencil**. [2]



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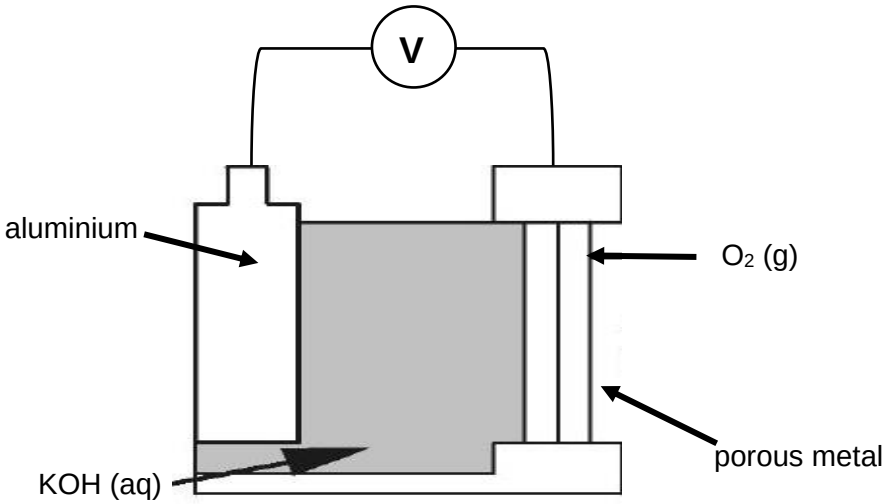
(**Question 5 continued)**

(c) Assuming the acid buffer does not affect the rate of oxidation, **use your graphs** in (b) to determine the rate expression for the oxidation of iodide ion by hydrogen peroxide. [4]

(d) Based on your answer in (c), deduce what conclusion can be made regarding the reaction mechanism of the oxidation of iodide by hydrogen peroxide. Equations for the mechanism are not required. [1]

6. Aluminium is used in electrochemical cells which can be used to power golf trolleys. The schematic diagram of the aluminium-oxygen electrochemical cell is shown in the diagram below.



One electrode is made of aluminium while the other is made by introducing pure oxygen gas through an inert porous metal. The electrolyte is aqueous potassium hydroxide.

$$Al(OH)_3\,(s) + 3e^- \rightleftharpoons Al\,(s) + 3OH^-\,(aq) \qquad E^{\ominus} = -2.30\ V$$

(a) (i) Define the term *standard electrode potential*. [1]

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(ii) Reduction is now defined in terms of change in oxidation number. Explore how earlier definitions of oxidation and reduction may have led to conflicting answers for the conversion of $Al(OH)_3$ to Al. [1]

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(**Question 6 continued)**

(b) (i) Use section 24 of the data booklet, construct a balanced equation for the reaction that occurs during discharge and calculate the standard cell potential. [3]

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(ii) Use section 24 of the data booklet, suggest, with reason, a transition metal that could replace aluminium in the cell. [2]

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(c) State with reasons, what happens to the standard cell potential when the following changes are applied separately to the aluminium-oxygen electrochemical cell.

(i) Air is used instead of oxygen gas. [2]

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(This question continues on the following page)

(**Question 6 continued)**

(ii) Size of aluminium electrode is decreased. [2]

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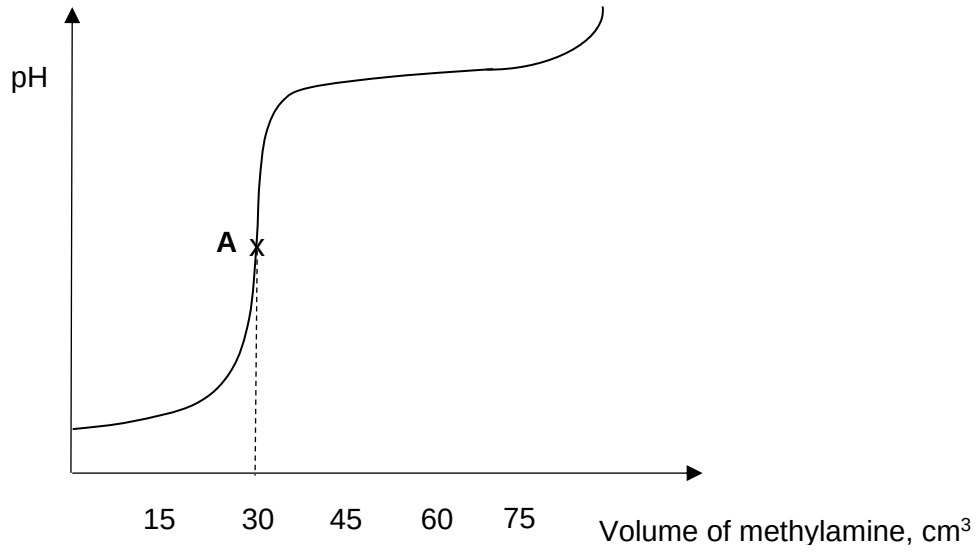
7. 0.10 mol dm^{-3} of methylamine was slowly added to 30.0 cm^3 of 0.10 mol dm^{-3} of hydrochloric acid and the change in pH was monitored and shown below.



(a) Using information from section 21 of the data booklet, calculate the initial pH of 0.10 mol dm^{-3} of methylamine. [2]

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(Question 7 continued)

(b) At equivalence point, **A**, on the graph,

(i) Write an equation to show that pH at point **A** is less than 7. [1]

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(ii) Calculate the concentration of the salt, $CH_3NH_3^+Cl^-$, formed. [2]

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(iii) Use section 21 of the data booklet, calculate the pH at equivalence point **A**. [3]

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(This question continues on the following page)

(Question 7 continued)

(c) At a certain point during the titration, a solution of maximum buffer capacity can be obtained.

(i) State the volume of the methylamine used to reach this point. [1]

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(ii) Explain, with the help of an equation, how this solution can maintain a fairly constant pH when a small amount of OH^- ion is added. [2]

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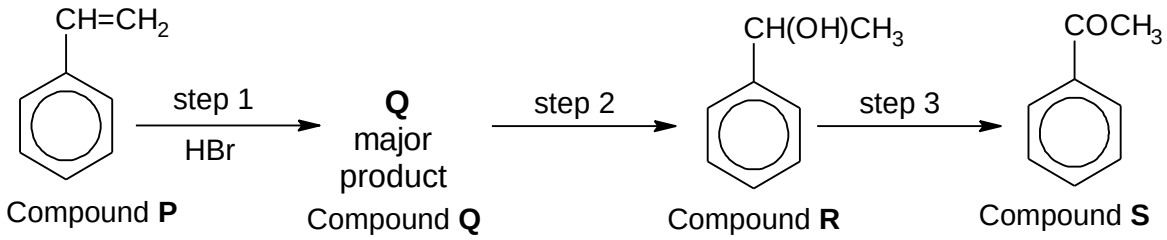
8. Consider the following reaction scheme:



(a) (i) Draw the structure of compound **Q**. [1]

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(Question 8 continued)

(ii) Explain why compound **Q** is the major product for the reaction that takes place in step 1. [2]

(iii) Deduce with reason, whether the major product in step 1 exhibits any optical activity. [2]

(b) State the reagents and conditions used in step 2 and step 3.

(i) Step 2 [1]

Reagent:

Conditions:

(ii) Step 3 [1]

Reagent:

Conditions:

(This question continues on the following page)

(Question 8 continued)

(c) State the type of reaction that takes place in step 1 and step 2. [2]

Step 1: .....

Step 2: .....

(d) (i) Given that the reaction that takes place in step 2 is a unimolecular reaction. Using curly arrows, draw the mechanism of the reaction. [4]

(ii) Between methanol and acetonitrile, explain which solvent is more suitable for the reaction in step 2? [2]

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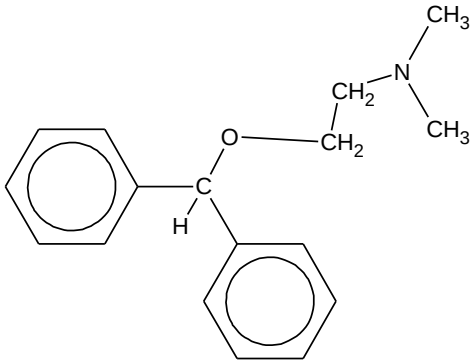
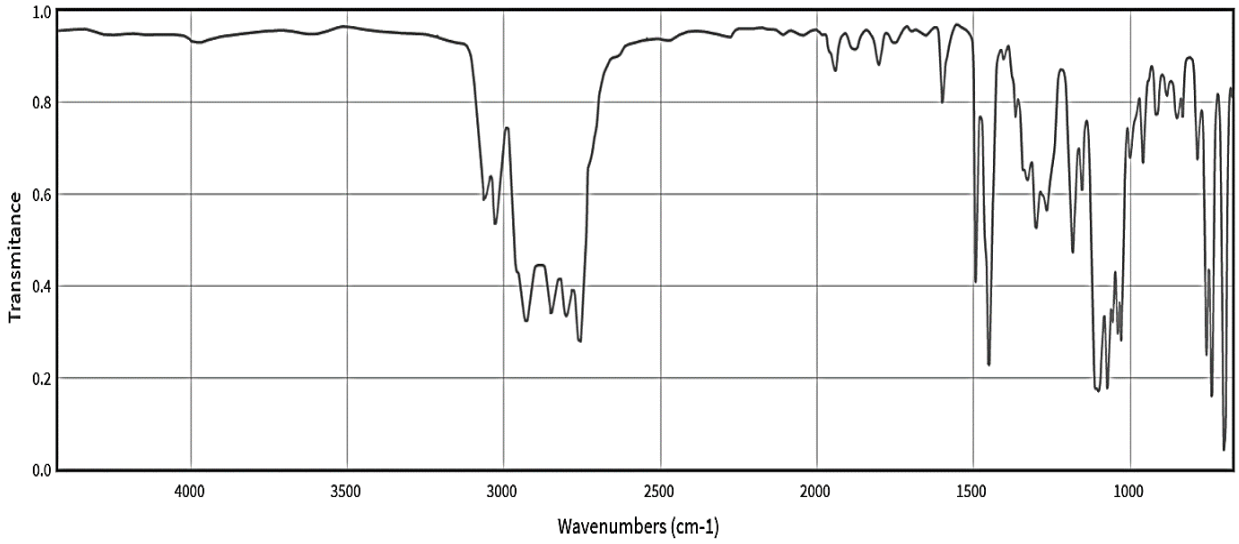
9. (a) Diphenhydramine (2-diphenylmethoxy-N,N-dimethylethanamine) is an antihistamine that reduces the effects of histamine in the body. Diphenhydramine is used to treat sneezing, runny nose and other cold or allergy symptoms. The structure of diphenhydramine is shown below:



Diphenhydramine

(i) Use section 26 of the data booklet, identify the bonds responsible for the absorptions at the following wavenumbers in the infrared (IR) spectrum of diphenhydramine. [2]



bond	wavenumber cm^{-1}
	2900
	1100

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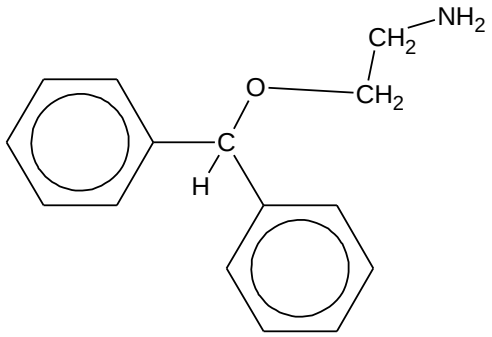
(Question 9 continued)

(ii) The structure of **another** organic amine, 2-(diphenylmethoxy)ethan-1-amine is shown below.



2-(diphenylmethoxy)ethan-1-amine

Use section 26 of the data booklet, identify and explain **one** difference in the infrared (IR) spectrum of diphenhydramine and 2-(diphenylmethoxy)ethan-1-amine. [2]

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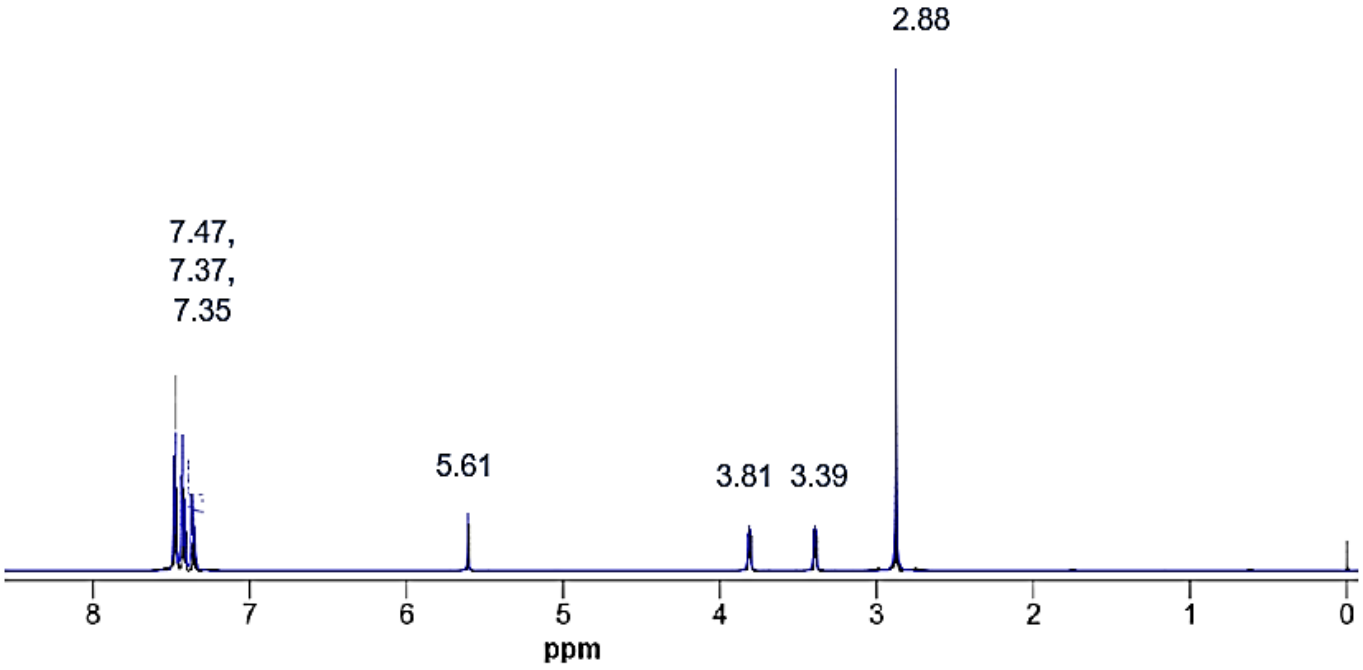
(Question 9 continued)

(iii) The following shows the **low** resolution nuclear magnetic resonance (^{1}H NMR) spectra of diphenhydramine.



Use section 27 of the data booklet, interpret the ^{1}H NMR spectrum and fill in the table below. [3]

Chemical Shift (ppm)	Integration ratio	Splitting pattern seen using a **High**-resolution ^{1}H NMR
2.88	3	
3.39		Triplet
3.81	1	

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(Question 9 continued)

(b) An iron cube was electroplated uniformly with a layer of copper metal for an hour. After electroplating, Keane measured three sides of the cube immediately using a ruler and recorded the data.

Side	Measurement (cm)
1	0.62 ± 0.02
2	0.60 ± 0.02
3	0.60 ± 0.02

Using the above data, calculate the volume of the cube and its absolute uncertainty after electroplating. Present your answers to the correct significant figures. [2]

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End of Paper