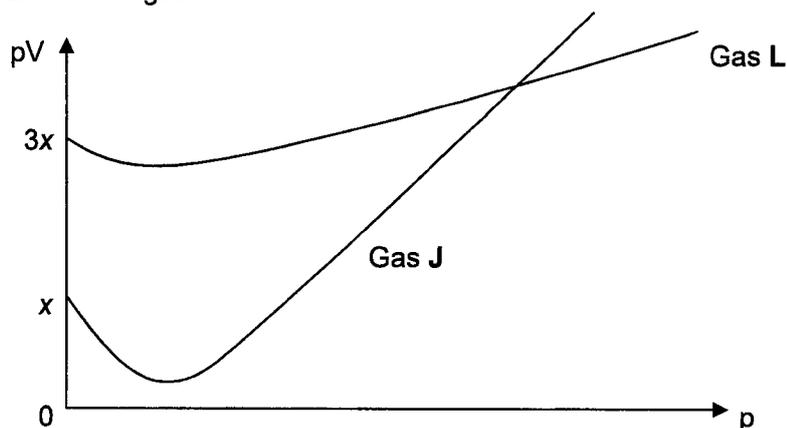


- 1 A vessel, at standard temperature and pressure, contains a mixture of $^{35}\text{Cl}_2$ and $^{37}\text{Cl}_2$. The gaseous mixture occupies a volume of 5.7 dm^3 , and has a mass of 18.0 g .
What is the percentage by mass of $^{35}\text{Cl}_2$ in the mixture?
- A 25 % B 40 % C 60 % D 75 %
- 2 A stable ion of E has the following properties:
- has a noble gas configuration
 - was obtained by removing electrons from the same orbital
- Which of the following could be E?
- A Al B Ca C Cu D S
- 3 Trifluorooxonium has the formula OF_3^{n+} and its shape is trigonal pyramidal.
What is the value of n in trifluorooxonium?
- A 1 B 2 C 3 D 4
- 4 A mixture of 10 cm^3 of methane and 20 cm^3 of ethane was sparked with an excess of oxygen.
After cooling, the residual gas was passed through aqueous potassium hydroxide.
All gas volumes were measured at the same temperature and pressure.
Which volume of gas was absorbed by the alkali?
- A 20 cm^3 B 30 cm^3 C 50 cm^3 D 100 cm^3
- 5 An ion of metal G can be oxidised by potassium manganate(VII) in acid solution to form GO_3^- .
In an experiment, $1.25 \times 10^{-3} \text{ mol}$ of the ion of G required 37.5 cm^3 of $0.0200 \text{ mol dm}^{-3}$ potassium manganate(VII) for complete reaction.
What is the initial oxidation state of the ion of G given that potassium manganate(VII) is reduced to Mn^{2+} ?
- A +1 B +2 C +3 D +4

- 6 The value of pV is plotted against p for two gases, J and L, where p is the pressure and V is the volume of the gas.



Which of the following could be the identities of the gases?

	Gas J	Gas L
1	0.5 mol of N_2H_2 at $25\text{ }^\circ\text{C}$	0.5 mol of H_2 at $75\text{ }^\circ\text{C}$
2	0.5 mol of NH_3 at $25\text{ }^\circ\text{C}$	1.5 mol of CH_4 at $25\text{ }^\circ\text{C}$
3	0.25 mol of H_2 at $25\text{ }^\circ\text{C}$	0.75 mol of SO_2 at $25\text{ }^\circ\text{C}$

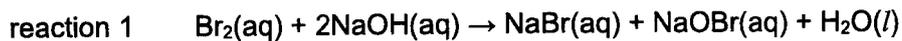
- A 1 only
 B 2 only
 C 1 and 2 only
 D 2 and 3 only
- 7 Three statements about potassium and chlorine and their ions are listed.
- 1 The atomic radius of a potassium atom is greater than the atomic radius of a chlorine atom.
 - 2 The first ionisation energy of potassium is greater than the first ionisation energy of chlorine.
 - 3 The ionic radius of a potassium ion is greater than the ionic radius of a chloride ion.

Which statements are correct?

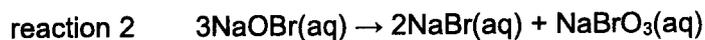
- A 1 only
 B 2 only
 C 1 and 3 only
 D 2 and 3 only

- 8 A disproportionation reaction is a reaction where a single compound is both oxidised and reduced simultaneously.

Bromine reacts with aqueous sodium hydroxide at 25 °C.

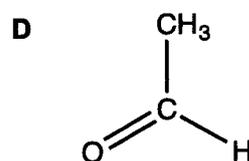
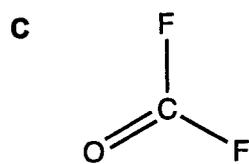
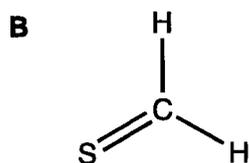
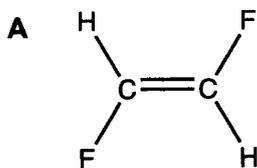


The NaOBr formed is unstable at 25 °C and reacts further.



In which reactions are disproportionation reactions?

- A reaction 1 only
 B reaction 2 only
 C neither reaction 1 nor reaction 2
 D both reaction 1 and reaction 2
- 9 Which molecule has the largest dipole?



- 10 *Use of the Data Booklet is relevant to this question.*

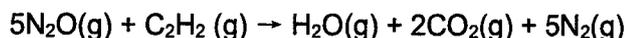
The lattice energies of the compounds, magnesium oxide, magnesium bromide, sodium oxide and sodium bromide, are given in the options below.

Which of the following values corresponds to the lattice energy of magnesium bromide?

- A -752 kJ mol^{-1}
 B $-2421 \text{ kJ mol}^{-1}$
 C $-2564 \text{ kJ mol}^{-1}$
 D $-3790 \text{ kJ mol}^{-1}$

11 *Use of Data Booklet is relevant to this question.*

Nitrous oxide, N_2O , commonly known as laughing gas, contains one $\text{N}=\text{N}$ and one $\text{N}=\text{O}$ bond per molecule. It burns in ethyne, $\text{HC}\equiv\text{CH}$, to produce water vapour, carbon dioxide and nitrogen gas as the only products.



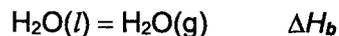
Given that the $\text{N}=\text{N}$ and $\text{N}=\text{O}$ bond energies in nitrous oxide are $+418 \text{ kJ mol}^{-1}$ and $+686 \text{ kJ mol}^{-1}$ respectively, what is the enthalpy change of the above reaction?

- A $+1930 \text{ kJ mol}^{-1}$
 B $+2260 \text{ kJ mol}^{-1}$
 C $-1680 \text{ kJ mol}^{-1}$
 D $-3980 \text{ kJ mol}^{-1}$

12 The average intermolecular forces in water are much stronger than the average intermolecular forces in steam.

The average intermolecular forces in ice are slightly stronger than the average intermolecular forces in water.

Enthalpy changes are associated with the equilibrium processes shown.



Which statements are correct?

- 1 The numerical value of ΔH_b is greater than ΔH_m .
- 2 ΔH_b and ΔH_m are both negative.
- 3 The intermolecular forces in ice and water are of the same type.

- A 1, 2 and 3
 B 1 and 2
 C 1 and 3
 D 3 only

13 The table below gives data for the reaction between **N** and **P** at constant temperature.

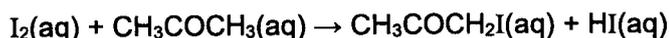
Experiment	[N] / mol dm ⁻³	[P] / mol dm ⁻³	Initial rate / mol dm ⁻³ min ⁻¹
1	0.003	0.4	1.6×10^{-3}
2	0.006	0.4	1.6×10^{-3}

3	0.006	0.8	6.4×10^{-3}
---	-------	-----	----------------------

Which statement about the reaction is not correct?

- A The reaction is a one-step reaction.
- B The rate constant k has the units of $\text{mol}^{-1} \text{dm}^3 \text{min}^{-1}$.
- C The half-life of **N** is not constant.
- D The order of reaction with respect to **[P]** is 2.

14 Iodine and propanone react according to the following equation.

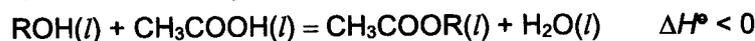


If the concentration of propanone is increased, keeping the total reaction volume constant, the initial rate of the reaction also increases.

Which of the following statements could be the reason for this?

- A A greater proportion of collisions are successful at the higher concentration.
- B The particles are further apart at the higher concentration.
- C The particles have more energy at the higher concentration.
- D There are more effective collisions per second between particles at the higher concentration.

15 An alcohol, ROH, reacts reversibly with ethanoic acid to produce an ester.



3.0 mol of ROH, 2.0 mol of CH_3COOH and 1.0 mol of water are mixed together and heated to a constant temperature. At this temperature, 1.5 mol of CH_3COOH is present in the equilibrium mixture.

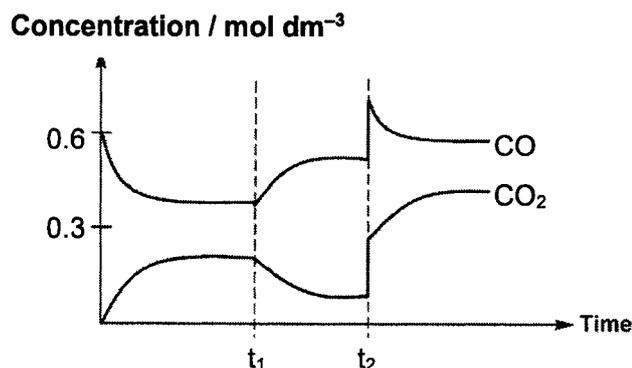
Which statement is correct?

- A The value of the equilibrium constant is 0.20.
- B At a lower temperature, the equilibrium amount of CH_3COOH is higher than 1.5 mol.
- C K_c has units of $\text{mol}^{-1} \text{dm}^3$.
- D The equilibrium amount of ester is the same as the equilibrium amount of water.

16 At a temperature $T \text{ K}$, 0.60 mol dm^{-3} of CO and 0.30 mol dm^{-3} of O_2 were introduced into a 5 dm^3 vessel and allowed to reach equilibrium.



The graph below shows the changes in the concentration of CO and CO₂ in the system with time. A change was made to the system at time, t₁ and t₂.



What were the changes made at time, t₁ and t₂?

	t ₁	t ₂
A	A catalyst was added	Volume of the system is increased
B	The temperature was increased	Volume of the system is decreased
C	Some O ₂ was removed	An inert gas was added at constant volume
D	The temperature was increased	More O ₂ was added

- 17 What is the pH of the resultant solution when 100 cm³ of 0.10 mol dm⁻³ aqueous NH₄Cl and 40 cm³ of 0.15 mol dm⁻³ aqueous NaOH are mixed at 25 °C? (pK_b of NH₃ = 4.75)

A 4.57 **B** 4.93 **C** 9.07 **D** 9.43

- 18 The solubility of Group 2 metal hydroxides increases down the group. Given that the solubility product, K_{sp}, of magnesium hydroxide at 25 °C is X and the solubility of magnesium hydroxide at 25 °C is S. Which of the following statements is correct at 25 °C?

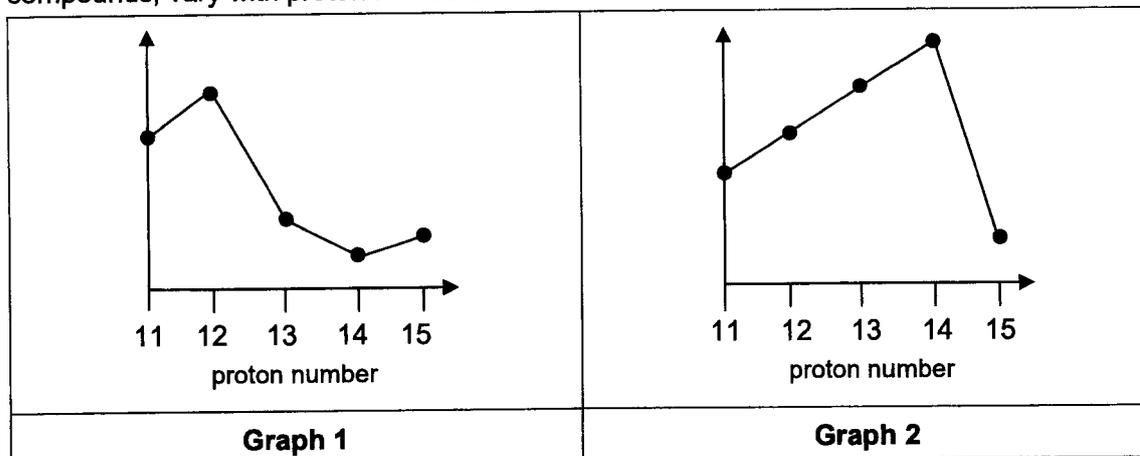
A The K_{sp} of barium hydroxides is smaller than X.
B The pH of a saturated solution of magnesium hydroxide is 14 + lg(2X)^{1/3}.
C The solubility of magnesium hydroxide in a solution of magnesium nitrate is larger than S.
D When solid sodium hydroxide is dissolved in a saturated solution of magnesium hydroxide, K_{sp} of magnesium hydroxide becomes smaller than X.

- 19 Which of the following changes does not affect the reduction potential measured for a Cl₂/Cl⁻ half-cell?

A Adding water into the half-cell.

- B** Increase the size of the platinum electrode in the half-cell.
C Placing the half-cell in an ice-water bath.
D Adding silver ions into the half-cell.

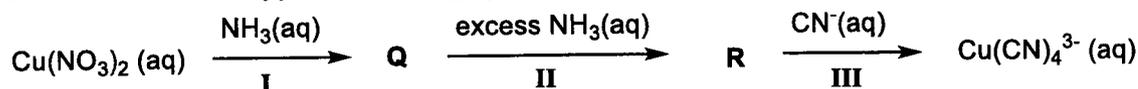
- 20** The following graphs show how three properties of the elements, Na to P, and their compounds, vary with proton number.



What properties are shown by the two graphs?

	Graph 1	Graph 2
A	Melting point of chloride	Melting point of element
B	Electrical conductivity of element	Melting point of chloride
C	Melting point of chloride	Electrical conductivity of element
D	Melting point of oxide	Melting point of element

- 21** A reaction scheme starting from aqueous copper(II) nitrate solution is shown below. Both **Q** and **R** are copper-containing species.



Which of the following statements are correct about the above reaction scheme?

- 1** One of the reactions involves a redox reaction.
 - 2** CN^- is a stronger ligand than NH_3 .
 - 3** Precipitation occurs in step I.
- A** 1, 2 and 3 **B** 2 and 3 only **C** 1 and 2 only **D** 2 only

- 22** A non-cyclic organic compound has the molecular formula $\text{C}_5\text{H}_9\text{O}_2\text{N}$. Which functional groups could be present in this molecule?

- 1 one ketone group and one amide group
 2 one ester group and one amine group
 3 one carboxylic acid group and one nitrile group

A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 1 only

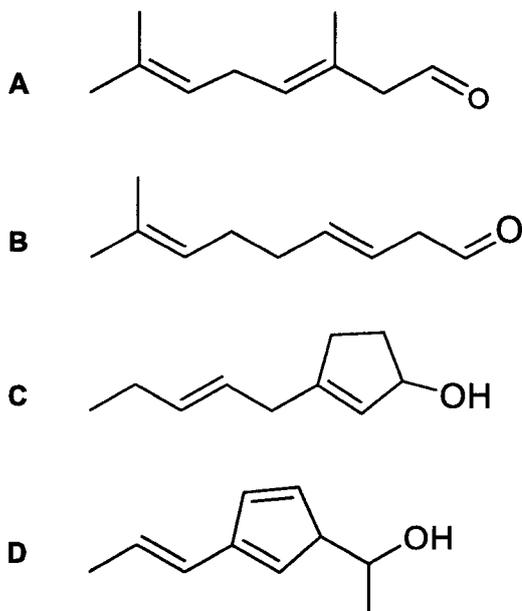
23 Which of the following cannot be formed when but-1-ene reacts with IBr, dissolved in methanol?



24 The reaction of compound **T** ($M_r = 152$) with hot acidified potassium manganate(VII) yields three products, **U**, **V** and **Y**.

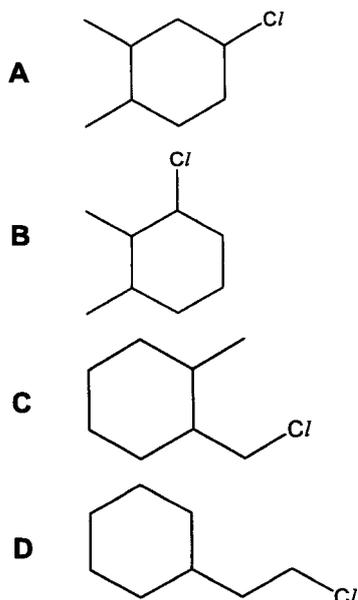
U can be converted to **V** with the use of alkaline aqueous iodine followed by acidification with aqueous sulfuric acid.

Which of the following shows the structure of compound **T**?



25 Compound **W** is able to rotate the plane of polarised light. When **W** is heated with ethanolic KOH, only **one** organic product is formed.

What is compound **W**?



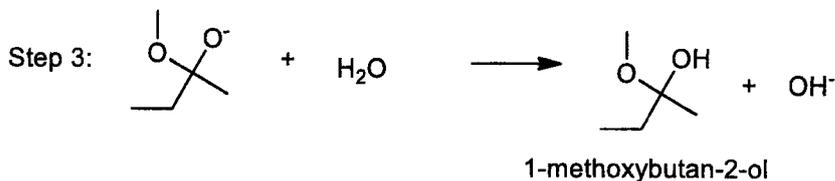
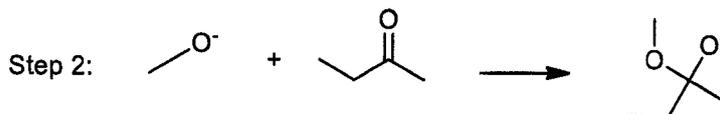
26 When ethyl ethanoate undergoes hydrolysis with dilute sulfuric acid in the presence of H_2^{18}O , a mixture of two products is formed.

Which of the following pairs correctly gives the structures of the two products?

- A** $\text{CH}_3\text{CO}^{18}\text{OH}$ and $\text{CH}_3\text{CH}_2^{18}\text{OH}$
- B** CH_3COOH and $\text{CH}_3\text{CH}_2^{18}\text{OH}$
- C** $\text{CH}_3\text{C}^{18}\text{OOH}$ and $\text{CH}_3\text{CH}_2\text{OH}$
- D** $\text{CH}_3\text{CO}^{18}\text{OH}$ and $\text{CH}_3\text{CH}_2\text{OH}$

27 1-methoxybutan-2-ol is an organic compound which has an alcohol and an ether (R-O-R) attached to the same carbon atom. It is formed when butan-2-one reacts with methanol in the presence of a catalyst.

The reaction follows the mechanism below.

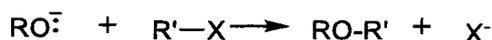


Which of the following statements about the reaction is correct?

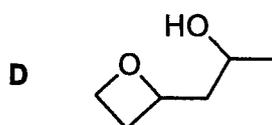
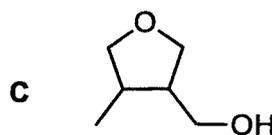
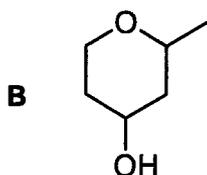
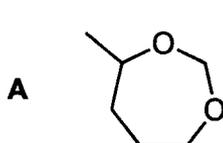
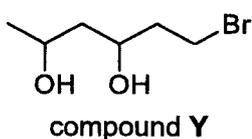
- 1 Methanol acts as a Lewis acid in step 1.
- 2 Step 2 is a nucleophilic addition reaction.
- 3 KOH can be used as a catalyst for this reaction.
- 4 Step 3 is a redox reaction.

- A 1 and 2 B 2 and 4 C 2 and 3 D 1 and 4

- 28 Williamson ether synthesis is a very useful reaction in the formation of ethers from halogenoalkanes, $R'-X$, via the S_N2 mechanism shown below.

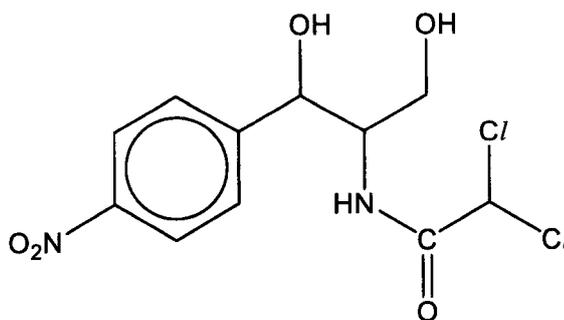


Which of the following compounds will be formed as a major product when compound **Y** undergoes Williamson ether synthesis?



- 29 *Chloramphenicol* is an antibiotic useful for the treatment of a number of bacterial infections.

12

*Chloramphenicol*

Which of the following statements regarding *Chloramphenicol* is not correct?

- A It has a total of 4 stereoisomers.
- B Addition of lithium aluminium hydride causes two atoms of hydrogen to be incorporated into the molecule.
- C On reacting with ethanoyl chloride, two mole of ethanoyl chloride are used up per mole of *Chloramphenicol*.
- D On reacting with aqueous bromine, two mole of bromine is used up per mole of *chloramphenicol*.

- 30 **Z** is synthetic nonapeptide (contain 9 amino acids) that is resynthesised from the amino acids found in honey bee venom. To investigate the sequence of amino acids in **Z**, the nonapeptide was first hydrolysed by two enzymes. The protein fragments were then separated and their sequence determined.

The following protein fragments were obtained from the first enzyme which hydrolysed the peptide chain at the carboxylic end of the amino acid isoleucine, Ile.

Arg-Ile
Ser-Lys-Trp-Ile
Lys-Leu-Arg

The second enzyme, which hydrolysed the peptide chain at the carboxylic end of the amino acid lysine, Lys, yielded the following fragments

Trp-Ile-Lys
Arg-Ile-Ser-Lys
Leu-Arg

Which of the following is the correct primary structure of the nonapeptide **Z**?

- A Lys-Leu-Arg-Ile-Ser-Lys-Trp-Ile-Lys
- B Ser-Lys-Trp-Ile-Arg-Ile-Lys-Leu-Arg
- C Arg-Ile-Ser-Lys-Trp-Ile-Lys-Leu-Arg
- D Arg-Ile-Ser-Lys-Leu-Arg-Trp-Ile-Lys

NAME _____

CLASS 24S

JURONG PIONEER JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION 2025

CHEMISTRY

Paper 2 Structured Questions

9729/02

29 August 2025

2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page.

Write in dark blue or black pen.

You may use a HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.

A Data Booklet is provided.

The number of marks is given in brackets [] at the end of each question or part question.

For Examiner's Use	
1	16
2	11
3	14
4	18
5	16
Penalty (delete accordingly)	
Lack 3sf in final answer	-1 / NA
Missing/wrong units in final ans	-1 / NA
Bond linkages	-1 / NA
Total	75

This document consists of 20 printed pages.

Answer **ALL** the questions in the spaces provided.

- 1 Nitrogen is found in inorganic compounds such as the oxides of nitrogen, NO_2 and NO .

- (a) NO_2 can be produced from the thermal decomposition of gaseous N_2O_5 .



Table 1.1 gives some data relevant to this question.

Table 1.1

process	$\Delta H / \text{kJ mol}^{-1}$
standard enthalpy change of formation of $\text{N}_2\text{O}_5(\text{g})$	+11.3
standard enthalpy change of formation of $\text{NO}(\text{g})$	+89.0
$\text{NO}(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{NO}_2(\text{g})$	-58.1

- (i) Explain what is meant by standard enthalpy change of formation.

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.....

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[1]

- (ii) Use data from Table 1.1 to calculate $\Delta H_1'$. You may find it helpful to draw an energy cycle.

[2]

- (iii) In the solid state, N_2O_5 has an ionic structure and consists of the ions, NO_2^+ and NO_3^- .

Draw and name the shapes of NO_2^+ and NO_3^- .

ion	NO_2^+	NO_3^-
diagram of shape		
name of shape		

[3]

- (b) Nitrogen dioxide, NO_2 , and dinitrogen tetraoxide, N_2O_4 , exist in dynamic equilibrium with each other.



At 50°C and a pressure of $1.68 \times 10^5 \text{ Pa}$, 4.60 g of the equilibrium gaseous mixture occupies 1.00 dm^3 .

- (i) Assuming the gaseous mixture behaves ideally, calculate the average relative molecular mass, M_r , of the gaseous mixture.

[1]

- (ii) Using the following relationships, calculate the mole fraction of N_2O_4 , m , and the mole fraction of NO_2 , n , in the mixture.

$$m + n = 1$$

$$\text{Average } M_r = 92m + 46n$$

[1]

(iii) Hence calculate the partial pressures of N_2O_4 and NO_2 in the mixture.

[1]

(iv) Write an expression for equilibrium constant, K_p , for the reaction, and calculate its value. Include units in your answer.

[3]

(v) State and explain the effect of increasing the temperature on the average M_r of the equilibrium mixture.

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[2]

(c) With the aid of suitable equations, describe and explain the role of NO_2 in the oxidation of atmospheric sulfur dioxide.

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[2]

[Total: 16]

- 2 Copper(I) salts in aqueous solution are unstable as shown by equation 1.

equation 1



- (a) (i) Using relevant data from the *Data Booklet*, calculate ΔG° , in kJ mol^{-1} , for the above reaction.

[2]

- (ii) Deduce the sign of ΔS° for the reaction and explain your answer.

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[1]

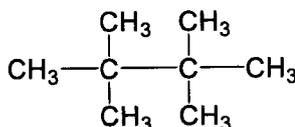
- (iii) Hence, determine if the reaction in equation 1 is exothermic or endothermic. Explain your answer.

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[1]

For
Examiner's
Use

- (b) Some copper(I) compounds are used as reagents in organic reactions where new carbon-carbon bonds are formed. Larger alkanes can also be formed through the reaction of alkanes with some halogens. However, the yield of the larger alkanes obtained through such a reaction is low.
- (i) Trace amount of alkane **A** is obtained when 2-methylpropane reacts with bromine in the presence of ultraviolet light.

**A**

Outline the mechanism of this reaction, clearly showing how **A** is formed in the above reaction.

[3]

- (ii) Chloroalkanes can be formed by the above mechanism but not iodoalkanes. Use relevant data from the *Data Booklet* to explain why iodoalkanes cannot be formed.

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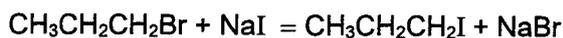
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[1]

- (iii) Iodoalkanes can be made by warming a bromoalkane with a solution of sodium iodide in dry propanone, in which sodium bromide is almost insoluble.



Suggest why the above reaction produces a high yield of $\text{CH}_3\text{CH}_2\text{CH}_2\text{I}$ despite the C–I bond being weaker than the C–Br bond.

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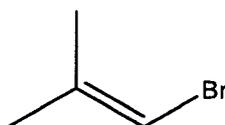
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[1]

- (iv) A student wanted to distinguish 2-bromo-2-methylpropane, $(\text{CH}_3)_3\text{CBr}$, from compound **B** shown below.

compound **B**

The student suggested the following method:

Step 1: To 2 cm³ of each compound, add an equal volume of NaOH(aq).

Step 2: Then add 1 cm³ of AgNO₃(aq).

Step 3: Then add excess of dilute HCl(aq).

Identify and explain two improvements to the student's proposed method.

Improvement 1:

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Improvement 2:

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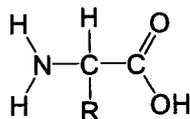
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[2]

[Total: 11]

- 3 Amino acids are the fundamental building blocks of proteins and play crucial roles in various biological processes. Amino acids are crystalline solids with high melting points, are water-soluble, and exist as zwitterions. The general structure of an α -amino acid is given below.



where R represents the side-chain on the α -carbon of amino acid.

- (a) Explain why amino acids exist as crystalline solids at room temperature.

.....

[1]

- (b) The Strecker synthesis is one method to prepare α -amino acids in the laboratory by reacting readily available aldehydes or ketones in the presence of NH_4Cl and KCN .

However, the Strecker synthesis lacks chirality control, producing racemic mixtures. This poses serious issues in pharmaceuticals, where specific enantiomers are crucial for safety and biological compatibility.

Alanine (2-aminopropanoic acid) can be prepared from the Strecker synthesis as shown in Fig. 3.1.

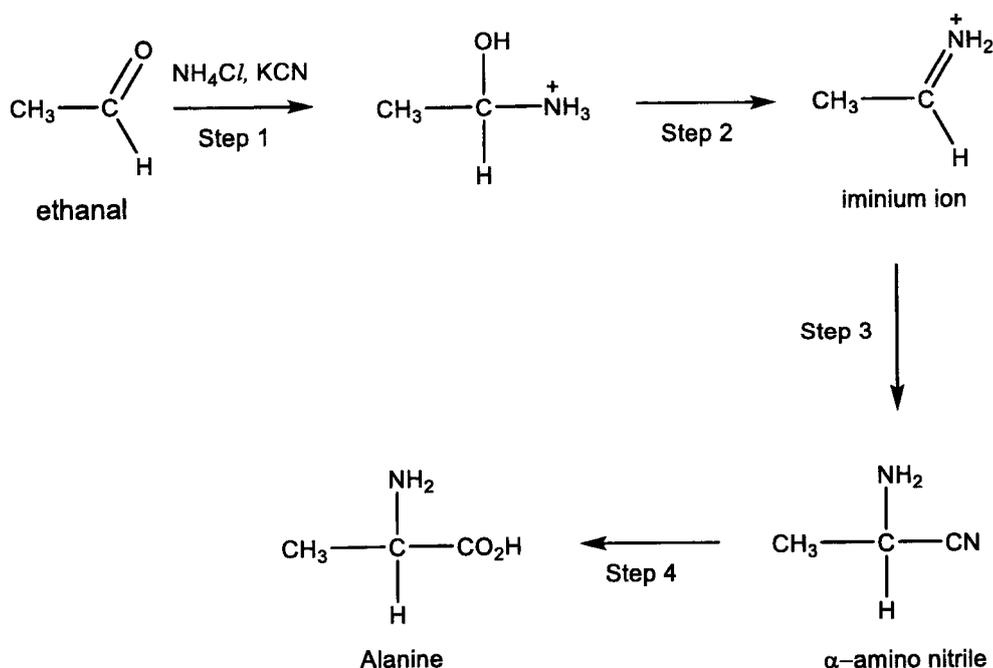


Fig. 3.1

- (i) State the type of reaction that occurred in steps 2 and 4.

step 2:

step 4:

[2]

- (ii) Step 3 in the Strecker synthesis involves the reaction of the iminium ion and CN^- to form the α -amino nitrile. This reaction is similar to the reaction between CN^- and carbonyl compounds.

State and describe the mechanism for step 3. In your answer, show relevant lone pairs of electrons and show the movement of electrons by curly arrows.

Type of mechanism:

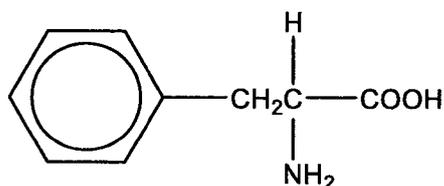
[2]

- (iii) Using your answer in (b)(ii), explain why alanine formed by the Strecker Synthesis method exists as a racemic mixture.

.....

[1]

- (iv) Phenylalanine can also be formed via the Strecker synthesis. Suggest the structure of the starting compound necessary for step 1 of the Strecker synthesis to obtain phenylalanine.



phenylalanine

[1]

- (ii) The pH of the solution changes only gradually around point **P** as aqueous KOH is added to the glutamic acid solution.
Identify the 2 major species present at point **P** and write an equation to illustrate how glutamic acid can maintain the pH of a solution at 2.1 when a small amount of OH⁻ is added.

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[2]

- (iii) State what is meant by the term *zwitterion*.

.....

.....

[1]

- (iv) Indicate on Fig. 3.2 with a cross (x) to show the point at which the predominant species of glutamic acid in the solution is the zwitterion. Explain your answer.

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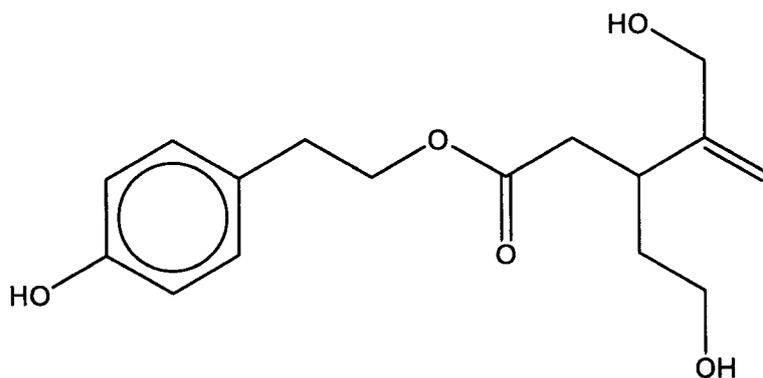
[2]

[Total: 14]

- 4 Oleocanthal, $C_{17}H_{20}O_5$, is a naturally occurring compound found in olive oil, known for its anti-inflammatory and antioxidant properties. When oleocanthal is reacted with $NaBH_4$, compound **C** is formed.

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Fig. 4.1 shows the structural formula of a molecule of compound **C**.



Compound **C**

Fig. 4.1

- (a) (i) The molecule of compound **C** contains sp^2 hybridised carbon atoms. Describe how sp^2 hybridised orbitals are formed.

.....

[1]

- (ii) State the number of sp^2 hybridised carbon atoms in a molecule of compound **C**.

.....

[1]

- (iii) Deduce the number of stereoisomers of compound **C**.

.....

[1]

- (iv) Write the equation for the reduction of oleocanthal by $NaBH_4$ to give compound **C**.

Use [H] to represent the reducing agent and use the molecular formula of oleocanthal and compound **C** in the equation.

.....

[1]

- (v) State the number of moles of $H_2(g)$ that will be evolved when 1 mol of compound **C** reacts with an excess of sodium metal.

.....

[1]

(b) Draw structures of the organic compounds formed when compound C is

(i) heated with excess dilute NaOH(aq)

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(ii) reacted with excess Br₂(aq).

[2]

[2]

- (c) Hexan-1-ol, $C_6H_{13}OH$, is one of the compounds that contribute to the aroma of olive oil.

A student used the apparatus shown in Fig. 4.2 to carry out an experiment to determine the enthalpy change of combustion of hexan-1-ol.

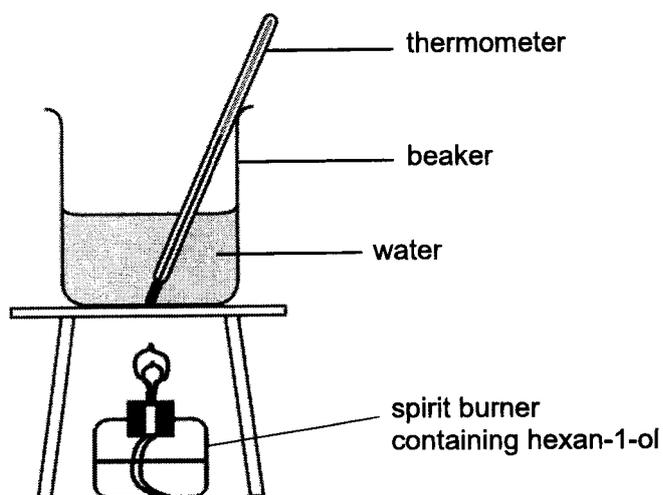


Fig. 4.2

The experimental results obtained are shown in Table 4.1.

Table 4.1

mass of water in beaker / g	250
initial temperature of water / °C	31.0
final temperature of water / °C	44.5
initial mass of spirit burner and hexan-1-ol / g	50.91
final mass of spirit burner and hexan-1-ol / g	50.34

- (i) Using data from Table 4.1, calculate the heat, in kJ, gained by the water in this experiment. The specific heat capacity of water is $4.18 \text{ J g}^{-1} \text{ K}^{-1}$.

[1]

- (ii) The enthalpy change of combustion of hexan-1-ol is $-3980 \text{ kJ mol}^{-1}$. Calculate the percentage efficiency of heat transfer in this experiment.

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[2]

- (d) Olive oil primarily contains triesters, which do not vapourise easily. Hence, raw olive oil is unsuitable as a direct fuel for diesel engine as the triesters present will accumulate and clog the engine components. Olive oil can be converted into biodiesel through a chemical process called transesterification. The resulting esters from this process are more suitable for use as fuel in diesel engines.

One transesterification reaction is shown in Fig. 4.3.

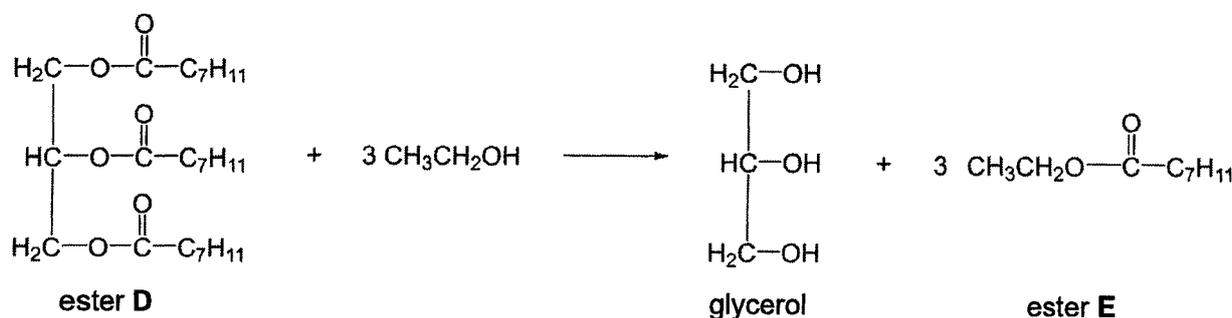


Fig. 4.3

- (i) Explain why ester E is more suitable than ester D to be used as a fuel in diesel engines.

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.....

.....

[2]

A large amount of glycerol is generated as a by-product in the production of biodiesel from natural oils. Efforts are being made to convert glycerol into more useful organic products.

- (ii) Give the systematic name of glycerol.

.....

[1]

- (iii) The properties of glycerol are affected by the intermolecular forces present between glycerol molecules.

Draw a labelled diagram to name and show the strongest intermolecular force present between two molecules of glycerol.

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Use*

[1]

- (iv) Glycerol can react with hydrogen chloride to form dichlorinated products. Draw the structures of all possible dichlorinated products from this reaction. **Ignore any stereoisomers.**

[2]

[Total: 18]

- 5 Silver is known for forming a range of sparingly soluble salts, such as silver carbonate and the silver halides. Their low solubility in water makes them useful in qualitative analysis and photographic processes.

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- (a) The values of the solubility products of some silver salts at 298 K are given in Table 5.1.

Table 5.1

salt	K_{sp} value
AgBr	5.0×10^{-13}
Ag ₂ CO ₃	6.3×10^{-12}

- (i) Write an expression for the solubility product, K_{sp} , of Ag₂CO₃.

..... [1]

- (ii) Ag₂CO₃ solid was stirred in 100 cm³ of water until no more Ag₂CO₃ solid can dissolve.

Calculate the mass of Ag₂CO₃ that was dissolved in this sample of water.

[3]

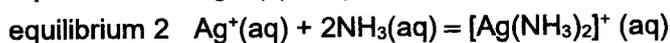
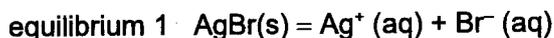
- (iii) A solution contains 0.10 mol dm^{-3} each of Br^- and CO_3^{2-} . AgBr and Ag_2CO_3 can be precipitated by adding $\text{AgNO}_3(\text{aq})$ dropwise to the solution. Which salt will precipitate out first, AgBr or Ag_2CO_3 ? Explain your answer with appropriate calculations.

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[2]

- (b) AgBr is soluble in concentrated $\text{NH}_3(\text{aq})$ but sparingly soluble in dilute $\text{NH}_3(\text{aq})$.

Consider the following two equilibria at 298K.



Use the concepts of Le Chatelier's principle **and** solubility product, as applied to equilibria 1 and 2, explain why AgBr is soluble in concentrated $\text{NH}_3(\text{aq})$ but sparingly soluble in dilute $\text{NH}_3(\text{aq})$.

Calculations are **not** required.

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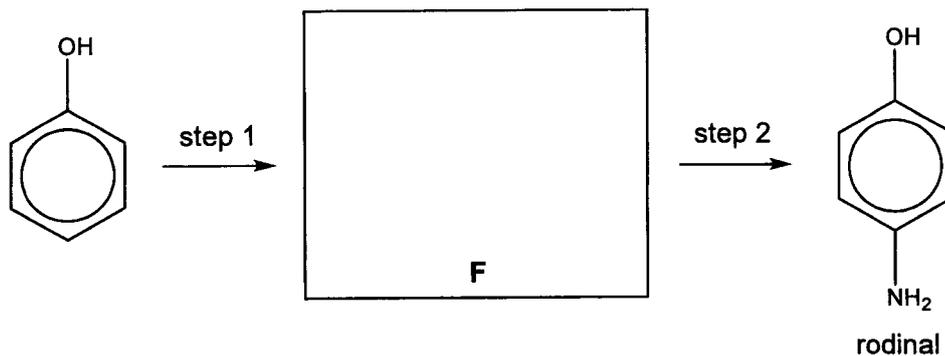
.....

[3]

(iv) Rodinal can be synthesised from phenol.

State the reagents and conditions for steps 1 and 2 and draw the structure of compound **F** in the box provided.

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step 1:

step 2:

[3]

[Total: 16]

NAME _____

CLASS 24S

JURONG PIONEER JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION 2025

CHEMISTRY

9729/03

Higher 2

17 September 2025

Paper 3 Free Response

2 hour

Candidates answer on the Question paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces at the top of this page.

Write in dark blue or black pen.

You may use a HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the Question Paper. If additional space is required, you should use the pages at the end of this booklet. The question number must be clearly shown.

Section A

Answer **all** questions.

Section B

Answer **one** question.

Write the Question number of the Question you have attempted, in the box provided below.

A Data Booklet is provided.

The use of an approved scientific calculator is expected, where appropriate.

The number of marks is given in brackets [] at the end of each question or part question.

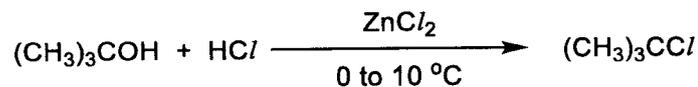
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1	17
2	19
3	24
4 or 5	20
Penalty (delete accordingly)	
Lack 3sf in final answer	-1 / NA
Missing/wrong units in final ans	-1 / NA
Bond linkages	-1 / NA
Total	80

This document consists of 28 printed pages.

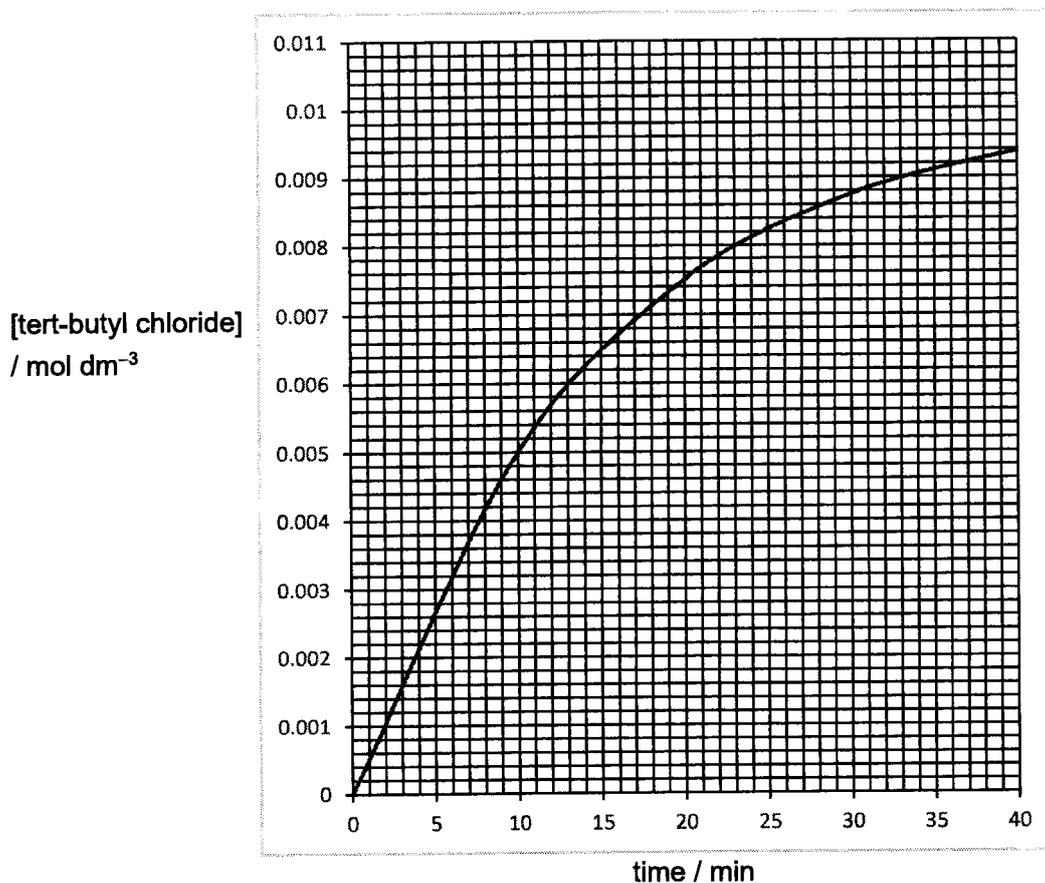
- 2 Lucas Test, named after an American chemist, Howard Luca, is a simple qualitative test, using concentrated HCl in the presence of ZnCl_2 , to classify alcohols by observing the rate of turbidity, indicating the formation of insoluble alkyl halides.

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- (a) The rate of the Lucas Test is investigated, using tert-butanol, $(\text{CH}_3)_3\text{COH}$.



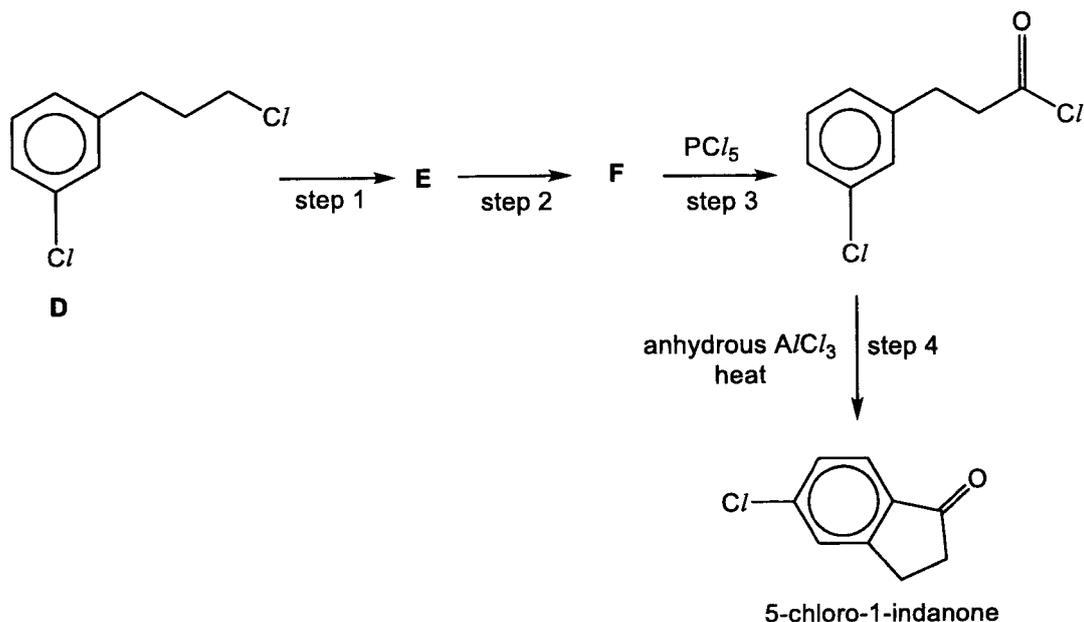
When 1 dm^3 of $0.0100 \text{ mol dm}^{-3}$ of tert-butanol is reacted with 5.00 mol of HCl in the presence of ZnCl_2 , the concentration of tert-butyl chloride, $(\text{CH}_3)_3\text{CCl}$, formed over time is shown in the graph below.



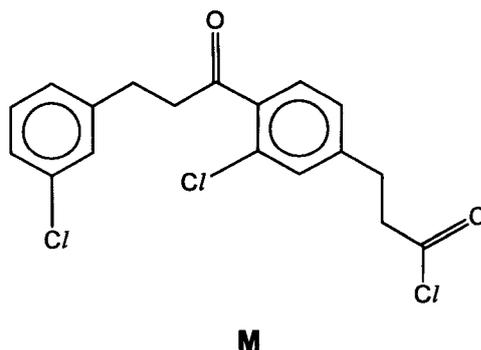
- (i) Define the term *order of reaction*. [1]
- (ii) The same graph was obtained when the test was repeated with 7.5 mol of HCl in 1 dm^3 of $0.0100 \text{ mol dm}^{-3}$ of tert-butanol
Using the information provided and the graph, deduce the orders with respect to $[(\text{CH}_3)_3\text{COH}]$ and $[\text{HCl}]$. Show clearly your working and any construction lines on the graph. [3]
- (iii) Hence, write the rate equation for the Lucas Test, and calculate a value for the rate constant. Include units in your answer. [3]

- (b) 5-chloro-1-indanone is mainly used as a chemical intermediate in pharmaceuticals, agrochemicals, and material sciences. It serves as a building block for drugs, pesticides like indoxacarb, and advanced materials such as fluorescent dyes.

5-chloro-1-indanone can be synthesised from compound **D** as shown below.



- (i) Deduce the structures of organic product **E** and **F**. [2]
- (ii) Suggest reagents for step 1 and step 2. [2]
- (iii) Name and describe the reaction mechanism for Step 4. [3]
- (iv) In step 4, another by-product **M** can be formed.

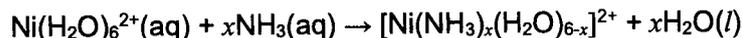


By considering the structure of the starting reactant and the overall entropy change of the reaction, explain **two** reasons why the formation of 5-chloro-1-indanone is preferred over **M**. [2]

- (v) In step 4, anhydrous AlCl_3 must be used, and no water can be introduced. With the aid of appropriate equations, explain why this is so. [1]
- (vi) When 5-chloro-1-indanone is oxidised with acidified KMnO_4 , CO_2 is evolved as a side product. Suggest the structure of the organic product formed. [1]

15
BLANK

- 4 (c) A ligand exchange reaction occurs when aqueous ammonia is added to a solution of green $\text{Ni}^{2+}(\text{aq})$.



The formula of a nickel-ammonia complex that is blue in colour can be found using a colorimeter.

Eleven tubes containing 20 cm^3 of 0.05 mol dm^{-3} of $\text{Ni}^{2+}(\text{aq})$ had 0.4 mol dm^{-3} aqueous ammonia added. The first tube has 2 cm^3 of aqueous ammonia added, the second tube 4 cm^3 and so on. Distilled water was added to bring the total volume to 50 cm^3 .

Each tube was then placed in a calorimeter and the absorbance recorded. The absorbance intensity is proportional to the concentration of the complex.

The results are shown in Fig 4.2 below.

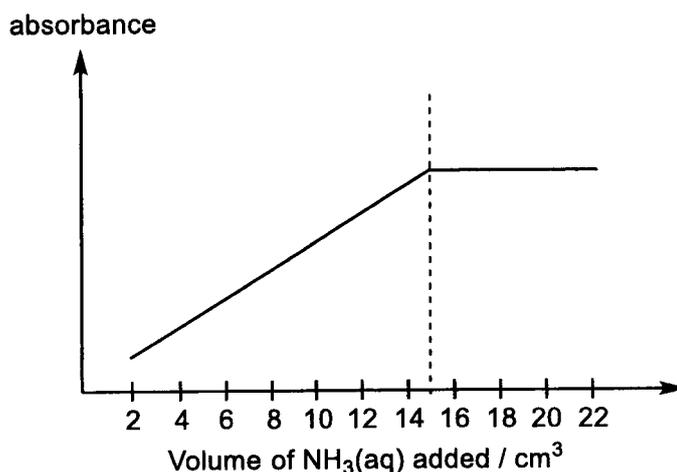
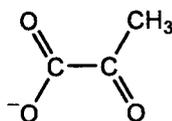


Fig 4.2

- (i) Explain why the absorbance value in Fig 4.2 remains constant after 15 cm^3 of $\text{NH}_3(\text{aq})$ is added. [1]
- (ii) Deduce the formula of the complex based on the stoichiometry information that could be inferred from the graph. [2]
- (iii) Z is a bidentate ligand, and experiments show that two mole of Z react with each mole of $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ to form an octahedral complex.



ligand Z

Given that the octahedral complex has no dipole moment, draw the structure of the complex formed, showing the 3-dimensional arrangement around the nickel ion. Indicate the overall charge, if any, on this complex. [2]

.....

.....

.....

- (c) When an aqueous solution of the ligand **Q** is mixed with an aqueous solution of cobalt salt, the following equilibrium is set up:



A similar equilibrium occurs with the ligand **R**, forming $\text{CoR}_6^{3+}(\text{aq})$.

Solutions **X**, **Y** and **Z** were made by mixing 0.1 mol dm^{-3} solutions of Co^{3+} , **Q** and **R**. The table below gives the volumes of each used.

Solution	Volumes of 0.1 mol dm^{-3} solution / cm^3		
	$\text{Co}^{3+}(\text{aq})$	Q (aq)	R (aq)
X	4	96	0
Y	4	0	96
Z	4	48	48

The visible absorption spectra of the three solutions **X**, **Y** and **Z** are shown in Fig 5.1.

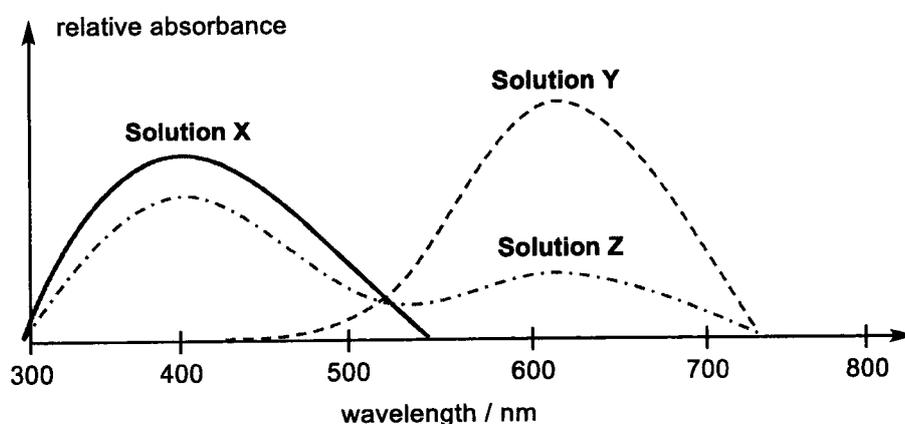


Fig 5.1

The wavelength at which the maximum absorbance is observed is inversely proportional to the energy gap between the two sets of d orbitals in an octahedral complex.

- (i) The spectra show that the peak in the curve for solution **Y** is at a longer wavelength than is the peak in the curve for solution **X**.

What deduction can be made from this fact about the size of the d-orbital splitting in the two complexes? [1]

- (ii) The absorbance of a solution at a particular wavelength is proportional to the concentration of the ion responsible for the absorption.

Use this information and the given absorption spectra in Fig 5.1 to suggest and explain which ligand, **Q** or **R**, forms the stronger bond with Co^{3+} . [2]

