L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2025 SECOND SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	I
DATE:	29th August 2025
TIME:	9:00 a.m. to 12:05 p.m.

Answer ALL questions.

1. a) Define isotope.

_____

_____ (1)

b) Carbon-14 is used to estimate the age of organic artefacts.

i) Explain why this is possible. In your answer, include a balanced equation for the decay of carbon-14.

_____

_____

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_____ (3)

ii) Prehistoric human remains were discovered, and scientists measured the carbon-14 specific activity at 1.8 counts min^{-1} g^{-1} for these prehistoric ashes. Knowing that the half-life of carbon-14 is 5730 years and its specific activity in living organisms is 14.2 counts min^{-1} g^{-1}, estimate the age of the prehistoric remains.

_____

_____

_____

_____ (2)

c) i) Give the electronic configuration of the sodium atom in the s and p notation.

_____ (1)

Question continues on the next page.

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ii) When sodium atoms are heated, light is emitted at specific wavelengths. Explain this statement.

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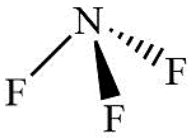
_____ (3)

(Total: 10 marks)

2. This question is about the bonding in chlorides of nitrogen, beryllium and lithium.

a) The shape of the NF_3 molecule is given below.



i) Give the name of the shape assumed by NF_3 according to the VSEPR theory and state whether the molecule is polar or non-polar.

_____

_____ (1)

ii) In the space below, draw the Lewis structure (electron dot structure) for NF_3.

(1)

iii) Using the VSEPR theory, explain why NF_3 and BF_3 have different shapes.

_____

_____

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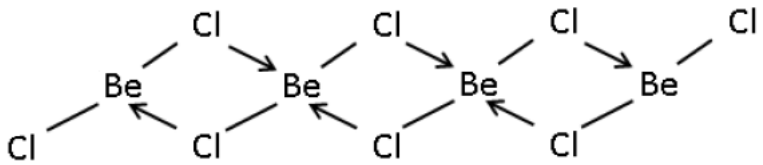
_____ (3)

b) Beryllium chloride is an inorganic compound with the formula $BeCl_2$. In the solid form, its crystalline structure can be represented by the diagram shown below.



i) State what the arrows in this diagram represent.

_____ (1)

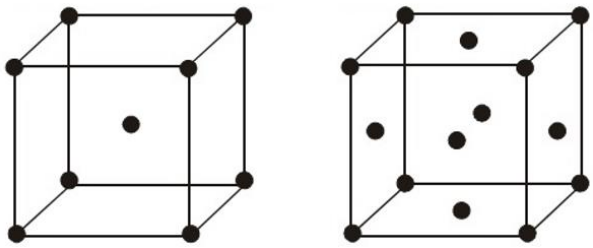
ii) Describe the difference between the bonds represented by the arrows and those represented by lines.

_____

_____ (1)

c) Lithium chloride (LiCl) is another crystalline solid.

i) The crystal lattice structure present in LiCl is identical to that present in NaCl. Circle the lattice structure of LiCl.



A B

(1)

This question continues on the next page.

ii) State the main factor that determines which lattice structure a particular ionic compound attains.

_____ (1)

iii) Explain whether LiCl has a higher or lower ionic character than NaCl.

_____

_____

_____

_____

_____

_____ (2)

(Total: 11 marks)

3. This question is about periodicity.

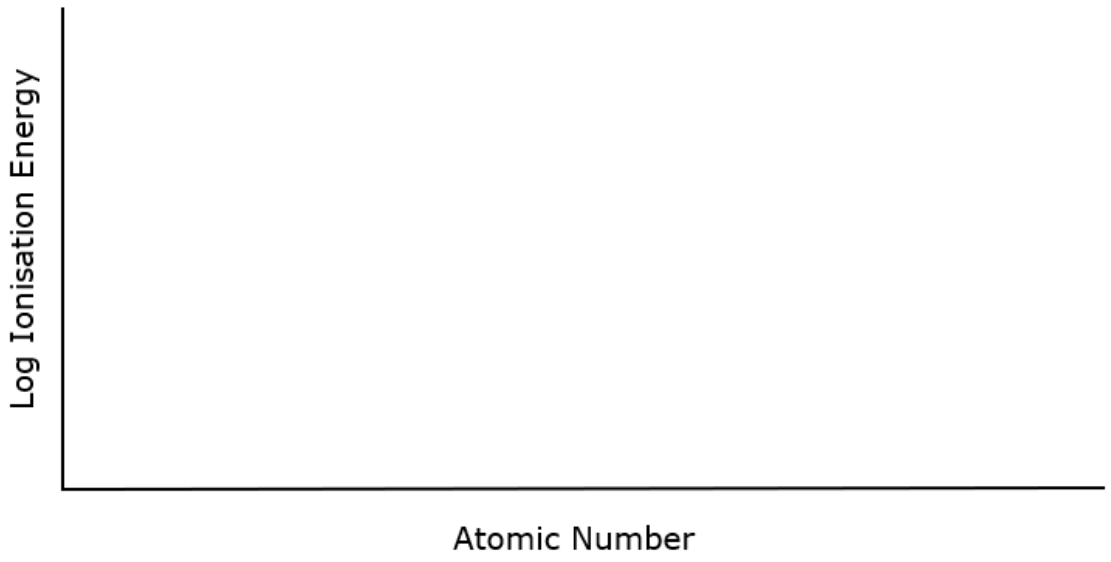
a) Explain what is meant by *first ionisation energy* of an element.

_____

_____ (1)

b) Consider period 3 of the Periodic Table.

i) On the axes provided below, sketch the trend for period 3 elements, clearly labelling each element. (1)



ii) Explain the shape of the graph sketched in part (b) (i).

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_____ (4)

iii) The ions S^{2-} and Cl^{-} have the same number of electrons. Give the electronic configuration of these ions using the s and p notation.

_____

_____ (1)

iv) State which of the ions S^{2-} or Cl^{-} has the largest ionic radius. Explain your answer.

_____

_____ (2)

Question continues on the next page.

v) Explain how and why the pH of an aqueous solution of Na^+ ions is different from that of an equimolar solution of Al^{3+}. Include an equation in your answer.

_____

_____

_____

_____

_____

_____

_____

_____ (2)

(Total: 11 marks)

4. This question is about stoichiometry.

Household bleach contains "chlorine", mainly as chlorate(I) ions (ClO^-). The strength of household bleach can be estimated by the reaction of a diluted sample of the bleach with a solution of an iodide under mildly acidic conditions. The following equation represents the reaction:

Reaction 1: $ClO^-(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow Cl^-(aq) + I_2(aq) + H_2O(l)$

The resulting solution is titrated with sodium thiosulfate solution of known concentration, using an indicator. The following equation represents the reaction.

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

a) Reactions 1 and 2 are redox reactions.

i) Which species are the oxidising agents in Reaction 1 and Reaction 2 respectively?

Reaction 1:_____

Reaction 2:_____ (1)

ii) In Reaction 1, an excess amount of potassium iodide is used. Give **TWO** reasons for this and explain your answer.

_____

_____

_____

_____

_____ (2)

iii) In Reaction 2, a specific indicator is used. Identify the indicator and describe how it functions as an indicator in this reaction.

_____

_____

_____

_____ (2)

b) The strength of a household bleach labelled X was determined by using the method described above. An aliquot of 5.0 cm^3 of solution X was added to distilled water, and the volume of the solution was made up to 100 cm^3.

Using a pipette, 25 cm^3 portions of this solution were mixed with 10 cm^3 of potassium iodide solution and 10 cm^3 of dilute sulfuric acid. The average titre value using sodium thiosulfate solution of concentration 0.0100 mol dm^{-3} was 26.20 cm^3.

i) How many moles of sodium thiosulfate were used in the titration?

_____

_____ (1)

ii) How many moles of chlorate(I) ions were present in the 25 cm^3 portion of the diluted solution?

_____

_____ (1)

iii) How many moles of chlorate(I) ions were present in the 5.0 cm^3 sample of solution X?

_____

_____

_____ (1)

iv) What is the concentration of the chlorate(I) ions in the household bleach labelled X?

_____

_____ (1)

Question continues on the next page.

c) A student planned to investigate the effect of using dilute hydrochloric acid instead of sulfuric acid in Reaction 1. Using the standard redox potentials listed below, explain how the titre value of the thiosulfate solution would change, if at all, when dilute hydrochloric acid is used.

Half-equation	**$E^{\ominus}$ (V)**
$2HClO\,(aq) + 2H^+(aq) + 2e^- \rightleftharpoons Cl_2(g) + 2H_2O(l)$	+ 1.63
$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+ 1.36

(4)

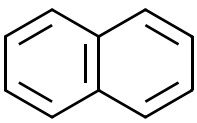
(Total: 13 marks)

5. This question concerns chemical energetics.

a) The standard enthalpy of formation of ammonia is −46.0 kJ mol^{-1}. The bond enthalpies of the H-H bond and the N≡N bond are 436 kJ mol^{-1} and 712 kJ mol^{-1}, respectively. Calculate the mean bond enthalpy of the N-H bond.

(3)

b) Naphthalene ($C_{10}H_8$) is commonly used as a pesticide in mothballs. Its molecular structure consists of two fused benzene rings forming a planar aromatic system. In theoretical calculations of enthalpy changes, naphthalene is often assumed to have the following structure.

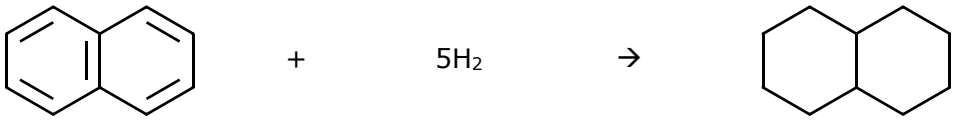


i) Considering that the heat of hydrogenation of cyclohex-1-ene (C_6H_{10}) is -120 kJ mol^{-1}, predict a theoretical value of the heat of hydrogenation of naphthalene ($C_{10}H_8$), assuming complete hydrogenation.

_____

_____ (2)

ii) The enthalpy of hydrogenation of naphthalene can be determined using enthalpies of formation. Given that the enthalpies of formation of naphthalene and its hydrogenated product ($C_{10}H_{18}$) are 147 and −210 kJ $mol^{-1,}$ respectively, calculate the enthalpy of hydrogenation of naphthalene.



_____

_____

_____

_____ (2)

iii) Explain why the value calculated in part (i) is more exothermic than the value calculated in part (ii).

_____

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_____

_____ (3)

(Total: 10 marks)

Please turn the page.

6. This question is about redox chemistry.

a) A galvanic cell is constructed from electrodes represented by the following half-equations:

Half-equation	$E^{\ominus}$ (V)
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$.	+1.33

i) Write a cell diagram which represents the above cell.

_____

_____ (2)

ii) Write the half-equation for the reaction which occurs at the negative electrode.

_____

_____ (1)

iii) Find the emf of the cell.

_____

_____

_____ (1)

iv) Write an equation for the reaction which is expected to occur if the cell is short-circuited.

_____

_____

_____ (1)

b) The Nernst equation is used to find the emf of the above cell under non-standard conditions. At 25 °C, the equation is

$$E_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{0.06}{n} \log_{10} \left(\frac{[\text{Cr}^{3+}]^2[\text{Fe}^{3+}]^6}{[\text{Cr}_2\text{O}_7^{2-}][\text{H}^+]^{14}[\text{Fe}^{2+}]^6} \right)$$

where n is the number of electrons transferred in the redox cell equation.
Calculate the cell emf at 25 °C and at a pH value of 0.30, given that the concentrations of the ions in mol dm^{-3} in the half cells are the following.

Ion	Molar concentration
Cr^{3+}	0.100
$Cr_2O_7^{2-}$	1.50
Fe^{2+}	2.00
Fe^{3+}	1.00

(3)

c) Describe how a fuel cell works, using the hydrogen-air fuel cell as an example and highlight the environmental benefit of such a cell.

(4)

(Total: 12 marks)

7. Fill in the following table by giving the structural formula as required.

Information	Structural formula of the organic compound(s)	
a) A positional isomer of hex-1-ene		(1)
b) A functional group isomer of cyclobutene		(1)
c) The products of the reductive ozonolysis of 2-methylhepta-2,5-diene		(3)
d) A halogenoalkane which can be hydrolysed to a tertiary alcohol		(1)
e) An alkyne which reacts with HCl and a mercury compound as catalyst to form the monomer used in the production of PVC		(1)
f) The compound which gives pent-1-yne after elimination of 2 moles of HBr		(1)
g) A halogenated compound which can react with a cyanide salt to form 3-methylbutanenitrile		(1)
h) The main product of the reaction of HI with 1-methylcyclopentene		(1)
i) A compound which reacts with sodium propanoate to give methyl propanoate		(1)

(Total: 11 marks)

8. This question is about the chemistry of alcohols and carbonyl compounds.

a) Fill in the table by suggesting a reagent and the observation to distinguish between the following. Use each type of reagent once.

	Reagent	**Observation**
i) Pentan-3-one and pentan-3-ol		
ii) Pentan-3-one and pentan-2-one		
iii) Pentan-3-one and pentanal		
iv) Ethanal and ethanol		

(8)

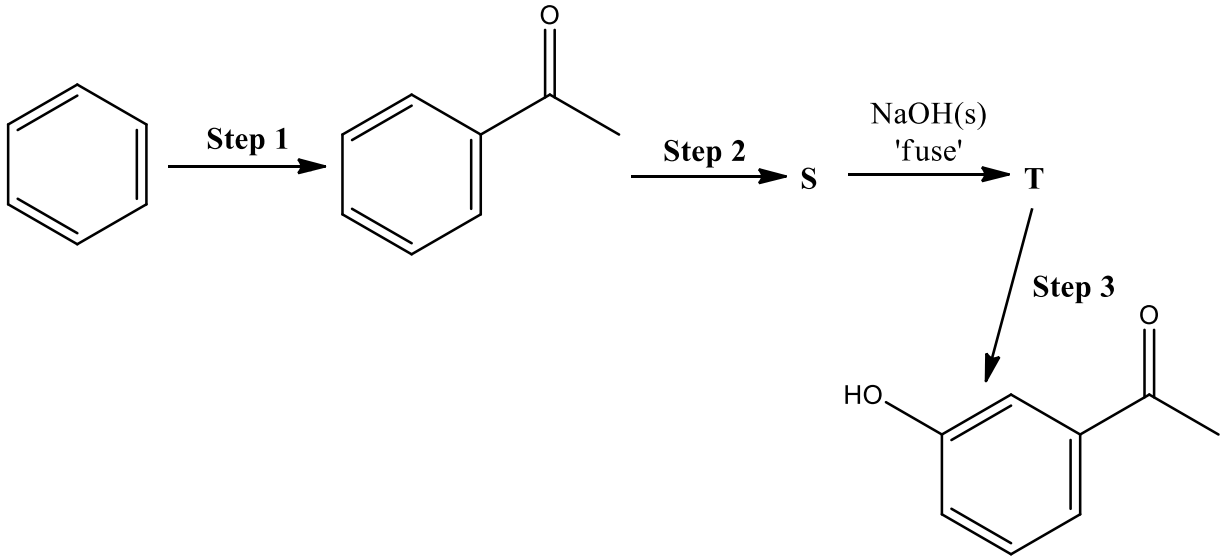
b) Give the structure and name of the organic product formed when propane-1,2,3-triol is heated under reflux with acidified potassium dichromate(VI).

_____ (2)

(Total: 10 marks)

9. This question is about aromatic chemistry.

a) Look at the following scheme and answer the questions that follow. Note that the CH_3CO- group has the same directing influence on further substitution as the -CHO group.



i) Suggest reagents and conditions for steps 1, 2, and 3.

_____

_____

_____ (4)

ii) Give the structures of compounds **S** and **T**.

(2)

iii) In what way would the product be different, if the OH group is introduced first?

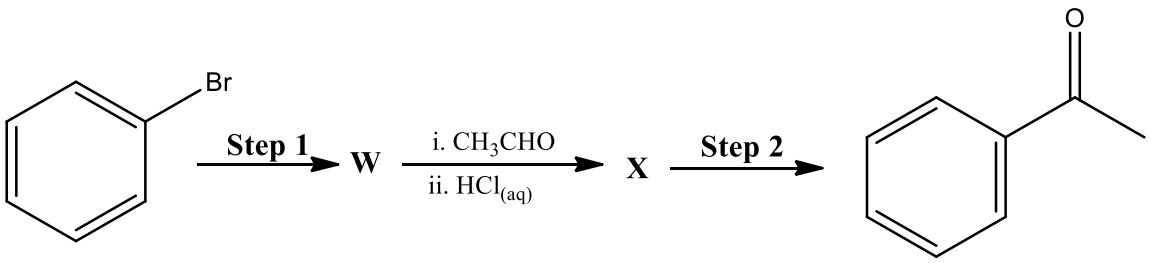
_____

_____ (1)

iv) State what would be observed if the final product had to be treated with benzenediazonium chloride.

_____ (1)

b) The phenylethanone shown in the previous scheme can also be prepared from bromobenzene using another organic reagent in one of the steps as shown below.



i) Identify the structures of **W** and **X**.

(2)

ii) Suggest reagents and conditions for steps 1 and 2.

_____

_____ (2)

(Total: 12 marks)

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ADVANCED MATRICULATION LEVEL
2025 SECOND SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	II
DATE:	1st September 2025
TIME:	9:00 a.m. to 12:05 p.m.

A Periodic Table is provided.

Answer TWO questions from each section and ANY other question.

SECTION A

1. This question is about ionic equilibria.

   a) Explain, including an example, what is meant by a Brønsted-Lowry acid and its conjugate base. (2)

   b) In a strong acid – weak base titration, methyl orange is used as an indicator instead of phenolphthalein. Explain why. (2)

   c) i) Define the ionic product of water, K_w. (1)
   ii) Given that the dissociation of H_2O into H^+ and OH^- is endothermic explain how K_w and pK_w change with increasing temperature. (2)

   d) Write expressions for K_b for reaction I and K_a for reaction II and then prove that $K_w = K_aK_b$. (3)

   $NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-_{(aq)}$ reaction I

   $NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$ reaction II

   e) When 50 cm^3 of 0.20 mol dm^{-3} propanoic acid and 70 cm^3 of 0.10 mol dm^{-3} aqueous sodium hydroxide are mixed, a buffer solution is produced.
   i) Calculate the pH of the resulting buffer solution, given that the pK_a of propanoic acid is 4.87. (7)
   ii) Explain how the resulting buffer solution keeps the pH approximately constant when a small amount of base is added to it. (3)

(Total: 20 marks)

2. This question is about amines and amino acids.

   a) Explain the trends in the basicity of the following compounds: ammonia, secondary aliphatic amines and benzenamine in aqueous solution. (4)

   b) Consider the reaction of ethanal with aqueous hydrogen cyanide.
   i) Suggest why hydrogen cyanide gas is **not** used directly in this reaction but is produced *in situ*. Give the reagents and conditions that are typically used for this reaction. (3)
   ii) Name and illustrate the mechanism for this reaction. (4)
   iii) The product of the reaction exists as two optical isomers, yet the organic liquid from this reaction is not optically active. Explain what is meant by the term optical isomers, how they arise for this compound and why the liquid is **not** optically active. (5)

   c) Amino acids are organic compounds that can form zwitterions. Explain how such ions form and the effect on their solubility in water and their melting points. (4)

(Total: 20 marks)

Please turn the page.

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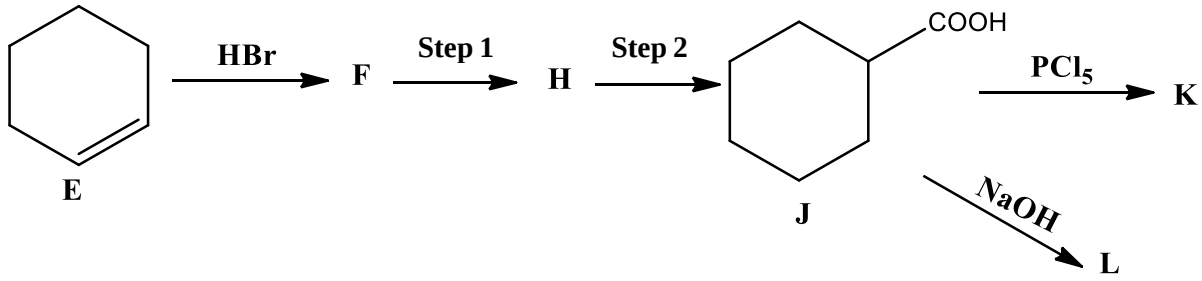
3. This question deals with organic chemistry. Consider the following reaction scheme to produce compounds **K** and **L**.



a) Give the systematic name of compound **E.** (1)

b) Complete the reaction scheme by giving the structures of compounds **F**, **H**, **K**, and **L**. (4)

c) Give the reagents and conditions for **steps 1** and **2**. (3)

d) Explain why compound **L** is a solid at room temperature and soluble in water. (3)

e) **K** and **L** can react together. Give the structure of the product. (2)

f) **K** can react with both ammonia and ethanol in two separate reactions. Give the structural formula of the product in **each** case. (2)

g) **J** can be reduced.
   i) Suggest a suitable reagent for this reduction. (1)
   ii) Give the structural formula of the product of the reduction of **J**. (1)
   iii) Compare the acidity of **J** with that of its reduction product and explain why their acidity is different. (3)

(Total: 20 marks)

4. This question is about rates of reactions and organic mechanisms.

When an alkene, such as propene, reacts with hydrogen bromide, the rate of reaction can vary depending on factors like concentration and temperature.

a) Give the mechanism of the reaction of propene with hydrogen bromide gas, showing **all** possible intermediate structures. (6)

b) i) Describe what is meant by the rate-determining step of a mechanism. (1)
   ii) Explain why the first step of the mechanism in part (a) is the rate-determining step. (1)

c) How does the rate of reaction change with the concentration of hydrogen bromide? Explain the reason for your answer. (4)

d) Discuss any possible effects of temperature on the reaction rate. (4)

e) Describe the role of carbocation stability in determining the reaction pathway. (4)

(Total: 20 marks)

SECTION B

5. This question is about chemical equilibria.

a) i) Given that the Haber process for the manufacture of ammonia is exothermic, explain what the ideal conditions of temperature and pressure should be for the maximum yield of ammonia. (2)

ii) The ideal conditions of pressure and temperature are not used in the Haber process; instead, compromise conditions of 200 atm and 450 °C are used. Explain. (4)

b) K_c for the esterification reaction of propanoic acid with ethanol is 7.5. Two moles each of propanoic acid and ethanol and one mole each of ethyl propanoate and water are mixed and allowed to reach equilibrium. Calculate the mass of the ester, which remains at equilibrium. (6)

c) i) Explain what is meant by the term degree of dissociation, α. State its numerical limits. (2)

ii) Given that the degree of dissociation of gaseous PCl_5 into gaseous PCl_3 and Cl_2 at a total pressure P is α, derive an expression for K_p of the dissociation of PCl_5 in terms of P and α. (4)

iii) Given that $\alpha = 0.2$ and P is 101 kPa, calculate K_p. (2)

(Total: 20 marks)

6. This question is about inorganic chemistry.

a) Magnesium sulfate is more soluble than barium sulfate, but barium hydroxide is more soluble than magnesium hydroxide. Explain this statement. (5)

b) Potassium superoxide can be used to sustain life in a sealed environment.

i) Draw a dot and cross diagram for the superoxide ion. (1)

ii) With the aid of equations, describe how potassium superoxide can be used to sustain life in a sealed environment. (6)

c) Explain the following statements.

i) Carbon dioxide sublimes at −78 °C at 1 atmosphere whilst silicon dioxide melts at 1650 °C. (3)

ii) Silicon tetrachloride hydrolyses readily with water, while carbon tetrachloride is inert towards water. (2)

iii) The two sulfur atoms in thiosulfate are present in different structural environments. (3)

(Total: 20 marks)

Please turn the page.

7. This question is about phase equilibria and amines.

   a) State Raoult's law, indicating clearly what type of solutions it applies to. (2)

   b) The saturated vapour pressures of pure hexane and pure heptane are 54 kPa and 22 kPa, respectively. A solution of the two liquids has a saturated vapour pressure of 33.2 kPa.
      i) Calculate the mole fraction of hexane in the solution and state the assumption made in your calculation. (5)
      ii) Calculate the mole fraction of hexane in the vapour above the solution. (2)

   c) Give an equation including reagents and conditions for the preparation of benzenamine from benzamide. (2)

   d) Starting with benzenamine as the only organic compound and giving reaction conditions and balanced equations, show how it can be converted to:
      i) C_6H_5I (3)
      ii) $C_6H_5N{=}NC_6H_4OH$. (6)

(Total: 20 marks)

8. This question is about transition metals.

   a) Explain each of the following statements.
      i) Chromium, atomic number 24, is both a d-block element and a transition element. (2)
      ii) The coordination number of Fe^{2+} in $[Fe(H_2NCH_2CH_2NH_2)_3]^{2+}$ is 6, but there are only three ligands around the Fe^{2+} ion. (2)
      iii) Although formation of coloured complexes is one of the characteristic properties of transition elements, complexes of Cu(I) are colourless. (2)
      iv) While $FeCl_3$ exists, FeI_3 does **not** exist. (3)
      v) $Fe_2(SO_4)_3$ solution has a pH less than 7. (3)

   b) Manganate(VII) ions are oxidizing agents in both acidic and basic solutions.
      i) In acidic solution, MnO_4^- oxidises $C_2O_4^{2-}$ to CO_2. Write the half-equations and the balanced ionic equation of the reaction of MnO_4^- with $C_2O_4^{2-}$ and state what is observed. (3)
      ii) The reaction in part (b) (i) is initially very slow but then proceeds rapidly. Explain. (2)
      iii) In basic solution MnO_4^- oxidises $CH_2{=}CH_2$ to CH_2OHCH_2OH. Write the half-equations and the balanced ionic equation of the reaction of MnO_4^- with $CH_2{=}CH_2$ and state what is observed. (3)

(Total: 20 marks)

Index No.:_____ AM06/III.25s

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MATRICULATION AND SECONDARY EDUCATION CERTIFICATE
EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2025 SECOND SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	III – *Practical*
DATE:	28th August 2025
TIME:	3 hours 5 minutes

1. You are provided with the following chemicals:

   i) A copper(II) sulfate solution labelled **A**;
   ii) A solution 0.0800 mol dm^{-3} sodium thiosulfate, labelled $\mathbf{B_n}$;
   iii) A 10 % solution of potassium iodide, labelled **C**.
   iv) A sachet containing around 2 g of zinc powder, labelled **Z**.

   In this experiment, you are required to determine the concentration of solution **A** by titration and, subsequently, determine the enthalpy change for the reaction between copper(II) sulfate and zinc.

a) Record the value of your laboratory number, n (found on solution **B**), on your answer book in the following box.

CANDIDATE LABORATORY NUMBER, n:.....

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Standardisation of solution A

b) Transfer 25.0 cm^3 of solution **A** into a 250 cm^3 volumetric flask using a suitably rinsed pipette. Make up the volume to the mark with distilled water and shake the volumetric flask to homogenise the solution. Label the diluted solution, **dA**.

Fill the burette with solution $\mathbf{B}_n$. Using a suitably rinsed pipette, transfer 25.0 cm^3 of solution **dA** into a conical flask and add approximately 20 cm^3 of solution **C** . Titrate with solution $\mathbf{B}_n$ and add 1 cm^3 starch indicator close to the endpoint. Continue the titration until the blue-black colour disappears. Record the results in the table below.

	1st Titration	2nd Titration	3rd Titration
Final burette reading			
Initial burette reading			
Titre (cm^3)			

Mean titre: _____ cm^3 of solution $\mathbf{B_n}$.

(20)

c) Copper(II) ions react with iodide ions as follows:

$$2Cu^{2+}\ (aq) + 4I^-\ (aq) \rightarrow 2CuI\ (s) + I_2\ (aq)$$

The iodine thus generated is reduced back to iodide by thiosulfate as follows:

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

Using the stoichiometry of these reactions and your experimental data from part (b), calculate the molar concentration of solution **A**.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ (5)

Determination of the enthalpy of reaction between copper(II) ions and zinc

d) Using a suitably rinsed pipette, transfer 25.0 cm^3 of the undiluted solution **A** to the polystyrene cup provided, supported in a 250 cm^3 beaker for stability.

Use the thermometer provided to stir the contents of the cup. Start the timer and measure the temperature to the nearest 0.1 °C, recording these temperatures at half-minute intervals. Skip the temperature reading at the three-minute mark and add all of the zinc powder (an excess) to the cup at exactly three minutes. Keep stirring while taking temperature readings until the ten-minute mark.

Enter your data in the table below.

Time (min)	**0**	**0.5**	**1**	**1.5**	**2**	**2.5**	**3**
Temperature (°C)							**X**
Time (min)	**3.5**	**4**	**4.5**	**5**	**5.5**	**6**	**6.5**
Temperature (°C)							
Time (min)	**7**	**7.5**	**8**	**8.5**	**9**	**9.5**	**10**
Temperature (°C)							

(5)

e) Plot a graph of temperature against time on the graph paper provided and determine the temperature change (ΔT), corrected for heat losses, for the reaction:

ΔT = _____ °C

(20)

Question continues on the next page.

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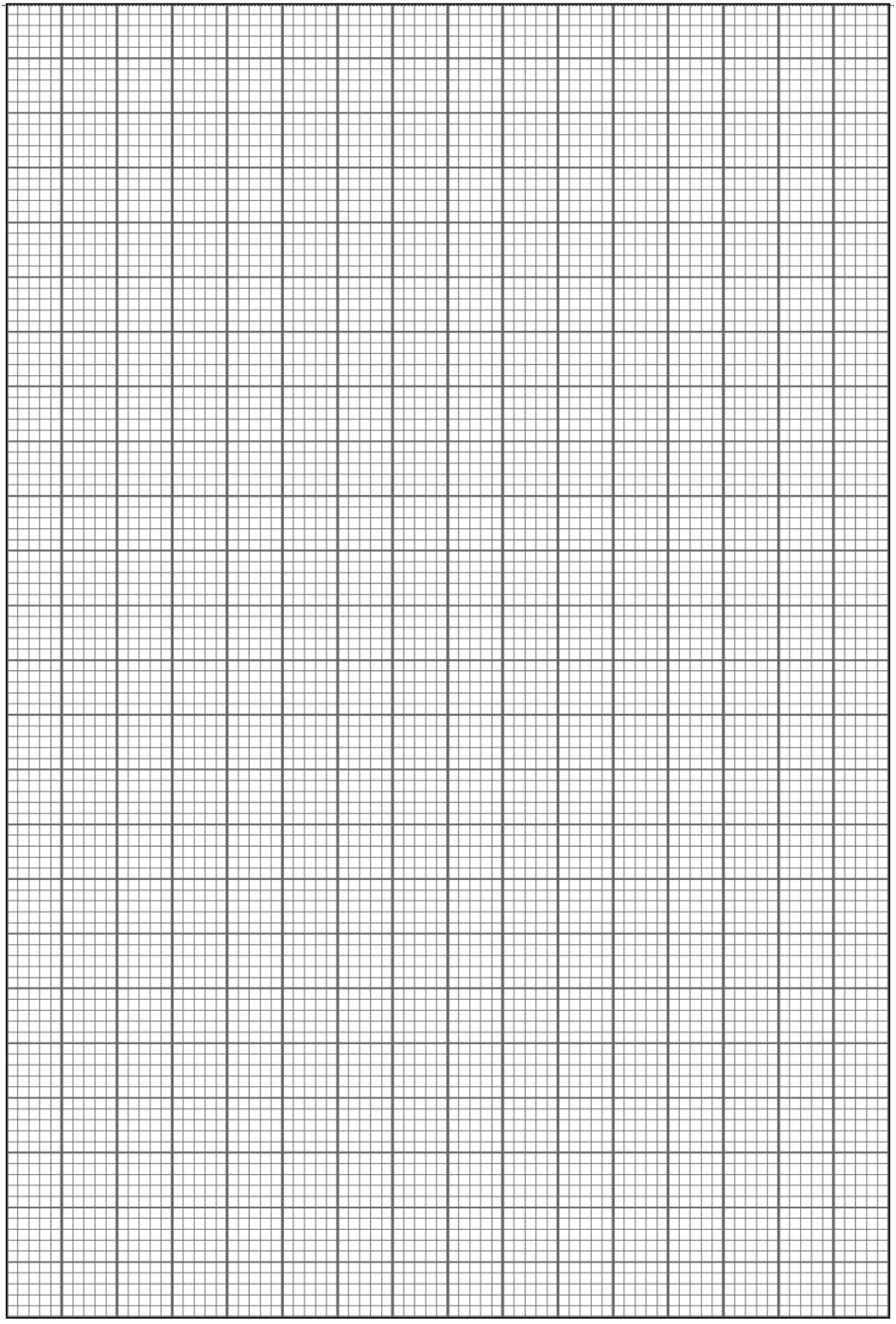

f) Determine the molar enthalpy change of the reaction (ΔH) given that the specific heat capacity of the solution is 4.2 J g^{-1} K^{-1}. Assume that the density of the solution is 1.0 g cm^{-3}.

_____

_____

_____

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_____

_____

_____ (5)

(Total: 55 marks)

2. You are provided with aqueous solutions of two inorganic salts, **Q** and **R**. Carry out the tests described below and identify the salts **Q** and **R**.

a) To about 1 cm^3 of solution **Q**, add an equal volume of sodium hydroxide solution. Allow the mixture to stand for 5 minutes.

Observation	*Inference*
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____ (3)

Question continues on the next page.

b) To about 1 cm^3 of solution **Q**, add an equal volume of ammonia solution. Allow the mixture to stand for 5 minutes.

Observation *Inference*

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____ (3)

c) To about 1 cm^3 of solution **Q**, add an equal volume of sodium chlorate(I) solution.

Observation *Inference*

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____ (3)

d) To about 1 cm^3 of solution **R**, add sodium hydroxide solution, followed by excess.

Observation *Inference*

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____ (3)

e) To about 1 cm^3 of solution **R**, add an equal amount of dilute sulfuric acid.

Observation *Inference*

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____ (3)

f) To about 1 cm^3 of solution **R**, add 1 cm^3 of aqueous potassium chromate and shake the resulting mixture. Add 2 cm^3 of glacial ethanoic acid.

Observation *Inference*

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____ (4)

g) To about 1 cm^3 of solution **R**, add 3 drops of silver nitrate(V) solution, followed by 5 cm^3 of aqueous ammonia solution.

Observation *Inference*

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____ (4)

h) To about 1 cm^3 of solution **R**, add an equal volume of **Q** followed by 2 cm^3 of dilute hydrochloric acid.

Observation *Inference*

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____ (4)

Conclusion

Suggest a possible identity for substance **Q**: _____ (1)

Suggest a possible identity for substance **R**: _____ (1)

(Total: 29 marks)

Please turn the page.

3. Substance **S** is a solid organic compound. A molecule of **S** has four carbon atoms and three functional groups, two of which are the same. Carry out the following tests and suggest a chemical structure for this compound.

a) Place about a tip of a spatula of solid **S** on a crucible lid and carefully burn it.

Observation *Inference*

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____ (3)

b) Dissolve half of your sample of solid **S** in approximately 10 cm^3 of water. If necessary, warm gently to aid dissolution. Carry out the following tests with this solution.

i) To 1 cm^3 of a solution of **S,** add 1 cm^3 of dilute sulfuric acid, followed by a few drops of manganate(VII) solution.

Observation *Inference*

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____ (3)

ii) To 2 cm^3 of a solution of **S**, add one drop of bromine water solution.

Observation *Inference*

_____ _____

_____ _____

_____ _____

_____ _____ (3)

iii) To about 1 cm^3 of 2,4-DNPH solution in a test tube, add 5 drops of compound **S**.

Observation *Inference*

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____ (2)

c) Place about a tip of a spatula of solid **S** in a test tube and add 2 cm^3 of sodium carbonate solution. Test any gas which is evolved.

Observation *Inference*

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____ (3)

Conclusion

Suggest a possible structure for compound **S**.

_____ (2)

(Total: 16 marks)

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