Index No.:_____ AM06/I.19s

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2019 SECOND SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	I
DATE:	2nd September 2019
TIME:	9:00 a.m. to 12:05 p.m.

Required Data: Relative atomic masses: H = 1; C = 12; O = 16

Answer ALL questions

1. Consider the following lattice enthalpies for sodium chloride and silver chloride.

	Sodium Chloride	Silver Chloride
Theoretical lattice enthalpy (KJ mol^{-1})	766	770
Experimental lattice enthalpy (KJ mol^{-1})	771	905

Explain why there is a large discrepancy between the theoretical and experimental lattice enthalpies in the case of silver chloride and **not** in the case of sodium chloride.

_____

_____

_____ (3)

(Total: 3 marks)

2. a) Sketch and label the phase diagram of water. On your diagram label the boiling point and freezing point for water.

(7)

b) At RTP carbon dioxide undergoes sublimation, whilst water does not.
(i) Define the term sublimation.

_____

_____ (1)

(ii) Explain why carbon dioxide sublimes at RTP whilst water does **not**.

_____

_____ (1)

c) One key difference between the phase diagrams of water and carbon dioxide is the solid-liquid phase boundary.
(i) Identify this difference.

_____

_____ (1)

(ii) What happens to solid water if pressure is increased at constant temperature?

_____

_____ (1)

(iii) Explain your answer in part c(ii).

_____

_____ (2)

(Total: 13 marks)

3. a) A 0.42 mol dm^{-3} aqueous solution of a monobasic acid HX has a pH of 2.56.
Calculate the acid dissociation constant (K_a) of acid HX.

_____

_____

_____

_____

(6)

b) (i) Sketch a curve to show the changes in pH when aqueous NaOH is added dropwise to an aqueous solution of acid HX.

(3)

(ii) Explain the shape of the curve you have drawn in part b(i).

(3)

c) Calculate the pH of an aqueous solution having 0.37 mol dm^{-3} HX and 0.16 mol dm^{-3} NaX (the sodium salt of acid HX).

_____

_____

_____

_____

_____

_____

_____ (3)

(Total: 15 marks)

4. This question is about the chemistry of manganese, a transition metal.

a) Give the electron configuration of Mn^{2+} using the *spdf* notation.

_____ (2)

b) A sample of manganese is placed in a test-tube, and a small amount of dilute hydrochloric acid is added until the metal dissolves completely. A few cm^3 of dilute sodium hydroxide solution are then added to the resulting solution. Finally, the mixture is left to stand. On standing a colour change is observed.

(i) Write balanced chemical equations for each of the mentioned reactions. Include state symbols.

_____

_____

_____ (3)

(ii) What is the colour of final product containing manganese? _____ (1)

(iii) Write the formula of the most commonly encountered anions which contain:

Mn(VII): _____

Mn(VI): _____ (1)

(iv) Sketch the structure of the Mn(VII) ion named in part b iii), showing clearly its shape.

(1)

(v) Solutions containing Mn(VII) ions cannot be acidified using hydrochloric acid since a reaction occurs. Name the type of reaction which occurs and give a balanced full chemical equation.

_____

_____ (2)

(vi) Mn(IV) ions are strong oxidising agents. Write an example of a balanced chemical reaction in which Mn(IV) behaves as an oxidising agent.

_____

_____ (2)

(Total: 12 marks)

5. This question is about the elements lithium, sodium and potassium, and their ions.

a) Distinguish clearly between the terms: s-block metals, Group 1 elements, and Alkali metals.

_____

_____

_____

_____ (3)

b) Define the term ionisation energy.

_____

_____ (2)

c) Which of the three elements (lithium, sodium and potassium) has the highest first ionisation energy? Explain your answer by describing a number of trends which are observed in Group 1.

_____

_____

_____

_____ (4)

d) Compare the first ionisation energy of lithium, sodium and potassium to the Group 2 elements in the same periods. Give an explanation for your answer.

_____

_____

_____

_____ (4)

e) When a small amount of the salt of each of the group 1 elements mentioned above is moved into a strong flame, a distinctive colour is produced. Lithium ions form a crimson red flame. Sodium ions form a golden yellow flame. Potassium ions form a purple or lilac flame. Explain how a colour is produced when these ions are moved into a strong flame. Use this explanation to explain the term 'quantised'.

_____

_____

_____

_____

_____ (4)

(Total: 17 marks)

6. Organic compound **A** contains C, H, and O only. On complete combustion, 11.63 g of this compound yields 25.5 g CO_2 and 14.0 g H_2O.

   a) Use this information to find the empirical formula of compound **A**.

(4)

   b) Compound **A** does not react with acidified potassium dichromate or PCl_5. Reaction of compound **A** with excess HI results in the formation of two different compounds, compound **B** and compound **C**. Compound **B** has a higher molecular mass than compound **C**. Adding silver nitrate solution to compounds **B** and **C** results in a pale yellow precipitate.

   Given that the RMM of the molecular formula of compound **A** is the same as that of its empirical formula, give the structural formula of compound **A**. Explain your reasoning, giving equations where required.

(5)

c) Outline a suitable route for the conversion of compound **B** to butan-2-one. All organic reagents used in the proposed reaction pathway must be prepared from compound **B**. More than one step may be required. Your answers should include reagents and conditions used where appropriate.

(6)

d) Write down the hybridisation (sp, sp^2 or sp^3) of all carbon atoms in butan-2-one.

(2)

(Total: 17 marks)

7. This question is about alcohols and phenol.

a) Phenylmethanol and phenol can both form the $R\text{-}O^-$ ion. However the ease of formation of this ion from phenylmethanol and phenol is different.

(i) Give chemical equations showing the production of the $R\text{-}O^-$ ion from phenylmethanol and phenol.

_____

_____

_____ (2)

(ii) Explain why phenylmethanol and phenol form the $R\text{-}O^-$ ion with different degrees of ease.

_____

_____

_____

_____

_____ (3)

(iii) Phenylmethanol react readily with PCl_5. Do you expect phenol to react in a similar manner with PCl_5? Explain.

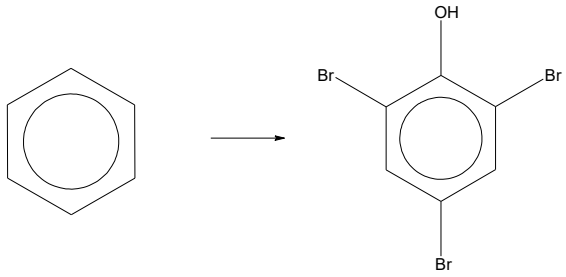
_____

_____

_____ (2)

Question continues on next Page

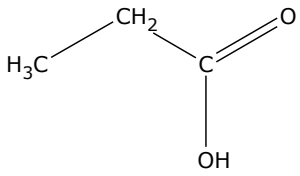
b) Outline a suitable route for the following conversion. More than one step may be required. Your answers should include reagents and conditions used where appropriate.

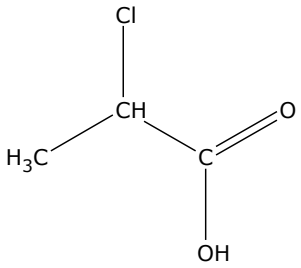


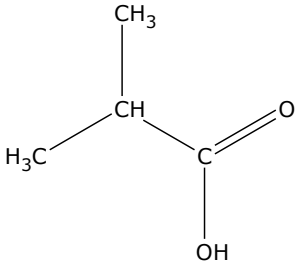
(5)

(Total: 12 marks)

8. a) Consider the following organic compounds.

D: 

E: 

F: 

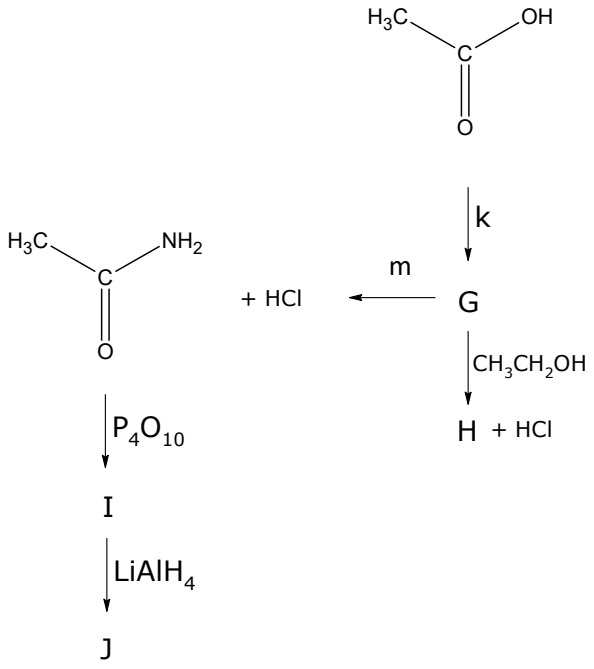
(i) Which of the above molecules has the highest acid dissociation constant (K_a)?

_____ (1)

(ii) Explain your reasoning for the answer given in part a (i) above.

(5)

b) Consider the following reaction scheme.



Question continues on next page

(i) Give the structural formulae for organic compounds **G, H**, **I**, **J**.

G: (1)

H: (1)

I: (1)

J: (1)

(ii) Name reagents k and m.

_____ _____ (1)

(Total: 11 marks)

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MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2019 SECOND SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	II
DATE:	3rd September 2019
TIME:	9:00 a.m. to 12:05 p.m.

A Periodic Table is provided. F = 9.65 x 10^4 C mol^{-1}; R = 8.314 J mol^{-1} K^{-1}; 1 atm = 101325 Pa.

Answer TWO questions from each section and ANY other question.

SECTION A

1) Iron can exist in a number of oxidation states, notably Fe(0), Fe(II) and Fe(III). The standard electrode potentials for the reduction of Fe(II) and Fe(III) are given below:

Fe^{2+} (aq) + 2 e^-	⇌	Fe (s)	E° = −0.44 V
Fe^{3+} (aq) + 3 e^-	⇌	Fe (s)	E° = −0.04 V
Fe^{3+} (aq) + e^-	⇌	Fe^{2+} (aq)	E° = +0.77 V

a) Give the equation relating the free energy change to the standard electrode potential and explain **all** the terms in the equation in detail. (4)

b) In nature, Fe(III) is more common than Fe(II). However the standard electrode potential values given above seem to indicate otherwise. Using these values, calculate the free energy value which expresses by how much Fe(II) is favoured over Fe(III), and then give a reason for why Fe(III) is more common than Fe(II) in nature. (5)

c) While the salts $FeCl_3$ and $FeBr_3$ exist, the salt FeI_3 is extremely difficult to obtain. Account for this observation. (3)

d) Iron(III) carbonate is another salt which cannot exist in solution. Explain this statement in detail. (3)

e) The Brown-Ring experiment involves the specific complex ion containing iron. Explain the Brown-ring experiment in detail. Make sure to include what the experiment is done for, what chemicals are required, any observations which can be made, and any balanced ionic equations where applicable. (5)

(Total: 20 marks)

2) This question concerns the chemistry of compounds of Sulfur and their applications.

a) H_2O is a liquid at room temperature, while H_2S is a gas. Explain how this is possible, given that H_2S has a higher molecular weight than H_2O. (2)

Question continues on next page

b) H_2S can be employed in the extraction and separation of certain metals.
   i) Name **ONE** way of producing H_2S, including a balanced chemical equation. (1)
   ii) Name **TWO** metals which can be extracted from solution using H_2S, and give a balanced chemical equation for their extraction. (2)
   iii) Name **TWO** metals which cannot be extracted from solution using H_2S. (1)

c) H_2S is a pollutant which has several negative effects.
   i) Name **ONE** reason why H_2S is considered to be a pollutant. (1)
   ii) In order to mitigate its negative effects, H_2S is burnt in air, releasing the resulting gases into the atmosphere. Explain why this practice still results in environmental pollution, and describe the mechanism through which the negative environmental effects occur. (5)
   iii) Describe in detail the main human-related source which results in the release of sulfur-containing gases into the air. Include in your description measures which can be taken to reduce this source. (4)

d) Sulfuric(VI) acid is formed industrially in the Contact Process. Sulfuric(VI) acid is one of the most useful chemical substances in modern industry. Name **THREE** uses of sulfuric acid and explain the phrase 'sulfuric(VI) acid shows strong intermolecular bonding'. Include a diagram in your explanation. (4)

(Total: 20 marks)

3) This question concerns the chemistry of Nitrogen.

a) Nitrous oxide (N_2O) was used in the past as a sedative. In fact, it was commonly known as 'laughing gas'. It is also used in motor racing to increase the power output of engines. Explain, giving balanced chemical equation/s, a method for the production of nitrous oxide on a small scale. (2)

b) Nitrogen dioxide (NO_2) is an important pollutant.
   i) Give **ONE** way, including a balanced chemical equation, of forming nitrogen dioxide in the lab. (2)
   ii) Name **ONE** human activity which produces NO_2 on a large scale. (1)
   iii) Explain why NO_2 is a pollutant, including a disproportionation reaction in your explanation. (2)

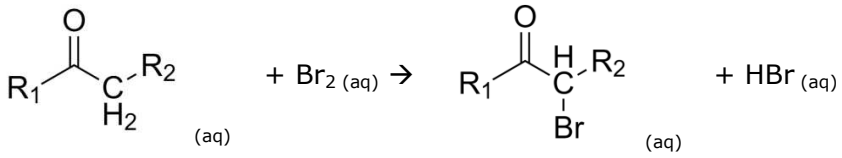
c) Dinitrogen tetroxide (N_2O_4) is used as a rocket propellant. A sample of N_2O_4 has an apparent molecular mass of 80 g/mol. Explain why this value is so low and calculate the percentage of N_2O_4 in the sample. (4)

d) Give the laboratory preparation of nitrogen monoxide (NO) and dinitrogen pentoxide (N_2O_5). Include chemical equations. (4)

e) Draw the electronic structures, showing **all** the canonical forms including the outer shell electrons, of the following chemicals: N_2O, NO_2 and NO. (5)

(Total: 20 marks)

4) The reaction between bromine and a ketone is being investigated. The reaction proceeds as follows:



This reaction is catalysed by H^+ ions. Concentrated sulphuric(VI) acid is used as a source of H^+ ions. (Assume that this dibasic acid is fully dissociated in solution).

In order to investigate the reaction, different volumes of sulphuric(VI) acid, ketone, and bromine water were mixed. The time taken for the reaction to reach the end point was measured. The results are given in the table below.

Experiment	**Volume of 2 mol/dm^3 H_2SO_4 added (cm^3)**	**Volume of 2 mol/dm^3 ketone added (cm^3)**	**Volume of 0.01 mol/dm^3 bromine added (cm^3)**	**Volume of Water added (cm^3)**	**Time taken for all bromine to react (s)**
1	10.0	10.0	1.0	10.0	301
2	20.0	10.0	1.0	0	151
3	10.0	7.5	1.0	12.5	401
4	10.0	10.0	2.0	9.0	603
5	10.0	10.0	0.5	10.5	152

a) Explain **ONE** method which can be used to follow the rate of this chemical reaction. (2)

b) Explain why no water was added to Experiment 2. (2)

c) Deduce the rate equation for this reaction, including the value and units of any constants, showing your working and explaining your reasoning. (11)

d) Using the answer to part c), discuss the possible steps in the mechanism of this reaction. (3)

e) Sketch a graph showing the relation between concentration of bromine and time of reaction. (2)

(Total: 20 marks)

Questions continue on next page

SECTION B

5) a) Polypropene (PP), is an important plastic made through addition polymerisation which is used to produce various products such as automotive parts. Identify the monomer used to produce this polymer and give the mechanism for the production of polypropene. Your answer should also include the repeat unit of polypropene. (6)

b) Reaction of but-1-ene with HCl results in the production of one major product, although the production of two different products is possible. Explain this statement giving mechanistic details where appropriate. (8)

c) But-1-yne reacts with ammonical silver nitrate, whilst but-2-yne does not. Explain. (6)

(Total: 20 marks)

6) Ethene reacts with hydrogen bromide at room temperature to produce compound **A**. Compound **A** reacts with sodium hydroxide under reflux to give compound **B**. Acidified potassium dichromate(VI) in dilute sulfuric acid is added to an excess of compound **B** to form **C**, which is distilled immediately after formation. Compound **C** reacts with potassium cyanide in dilute acid to form **D**. Compound **D** reacts with phosphorous pentachloride in dry ether to form **E**. Compound **E** reacts with concentrated ammonia under reflux to generate **F**. Excess dilute acid is added to compound **F** and the mixture is refluxed to form compound **G**.

a) Give the structural formulae of compounds **A**, **B**, **C**, **D**, **E**, **F**, **G** and name compound **G**. (7)

b) The behaviour of compound **G** in an electric field is highly dependent on the pH of the solution. Discuss this statement, giving structural formulas where required. (7)

c) Compound **G** exhibits a form of stereoisomerism. Identify and define the type of stereoisomerism that compound **G** exhibits. In your answer, you should include a three dimensional representations of the stereoisomers of compound **G**. (3)

d) Compound **G** can form important biological polymers. Discuss this statement, giving chemical equations if required. (3)

(Total: 20 marks)

7) a) Wine making involves the fermentation of sugars found in grape juice to ethanol. In order to produce good wines, wine makers must ensure that the concentration of ethanol in wine does not exceed 2.39 mol dm^{-3}.

i) Calculate the amount of sugar (in g) that must be present in 100 L of grape juice in order to have a concentration of 2.39 mol dm^{-3} of ethanol after fermentation. For simplicity's sake, you may assume that glucose ($C_6H_{12}O_6$) is the only sugar present in grape juice. (6)

ii) Ethanol in wine tends to change to ethanoic acid. This is an unwanted process and wine makers try to stop this process by adding small amounts of SO_2 to the wine. Suggest, giving equations where required, why SO_2 is used. (4)

b) Besides fermentation, other industrial methods may be used to produce ethanol.
   i) Give an equation (and required conditions) for another industrial method which is used to produce ethanol. (2)
   ii) Give a reaction pathway which can be used to produce propan-2-ol from ethanol. (8)

(Total: 20 marks)

8) a) 2.06 g of organic liquid **H** occupies 620.34 cm^3 when vaporised at a temperature of 90 ^oC and a pressure of 1 atmosphere. Calculate the RMM of compound **H**. (4)

b) The mass spectrum of compound **H** has the following main characteristics:
- a parent ion having three distinct peaks with a ratio of 9:6:1; and
- two additional fragments detected at m/e of 49 and 51. These two peaks are present at a ratio of 3:1 respectively.

   i) Draw a well labelled diagram of a mass spectrometer. (4)
   ii) Determine the molecular structure of compound **H**, using the information above and the RMM calculated in part (a) of this question. (6)

c) Organic molecule **H** can react with excess aq. NaOH to form compound **I**, which in turn reacts with excess acidified potassium dichromate to give compound **J**. Compound **J** can react with aqueous NaOH to give compound **K**. Give the structural formulae of compounds **I**, **J** and **K**. (3)

d) A green precipitate is obtained when compound **K** is placed in an aqueous solution containing iron(III) ions. Explain. (3)

(Total: 20 marks)

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MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2019 SECOND SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	III – *Practical*
DATE:	29th August 2019
TIME:	3 hours 5 minutes

1. You are provided with the following:

   i) a solution of sodium thiosulfate, of concentration 0.08 M, labelled F;
   ii) a solution of copper(II) sulfate, labelled C_n;
   iii) a solution of 10% potassium iodide;
   iv) a sachet containing 5 g of zinc powder, labelled Z.

   You are required to determine:

   i) the concentration of solution C_n;
   ii) the heat of reaction for:

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

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

CANDIDATE LABORATORY NUMBER, n:.....

DO NOT WRITE ABOVE THIS LINE

Determination of the molar concentration of copper(II) sulfate in solution C_n

b) Using a suitably rinsed pipette, transfer 25 cm^3 of solution C_n to a 250 cm^3 volumetric flask and make up to the mark with distilled water. Label this solution D.

Fill the burette with solution F.

Transfer 25 cm^3 aliquots of D from the volumetric flask to each of three conical flasks. Before each titration, add 20 cm^3 of 10% potassium iodide solution to the contents of the conical flask and titrate with solution F until a faint straw colour is obtained. Add 2cm^3 of starch indicator solution and continue titrating to the endpoint. Repeat the titration in order to have **TWO** concordant results and record your data in the table below. (20)

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

Mean titre: _____ cm^3 of solution F

c) Calculate the molar concentration of the supplied copper(II) sulfate solution C_n to three significant figures.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

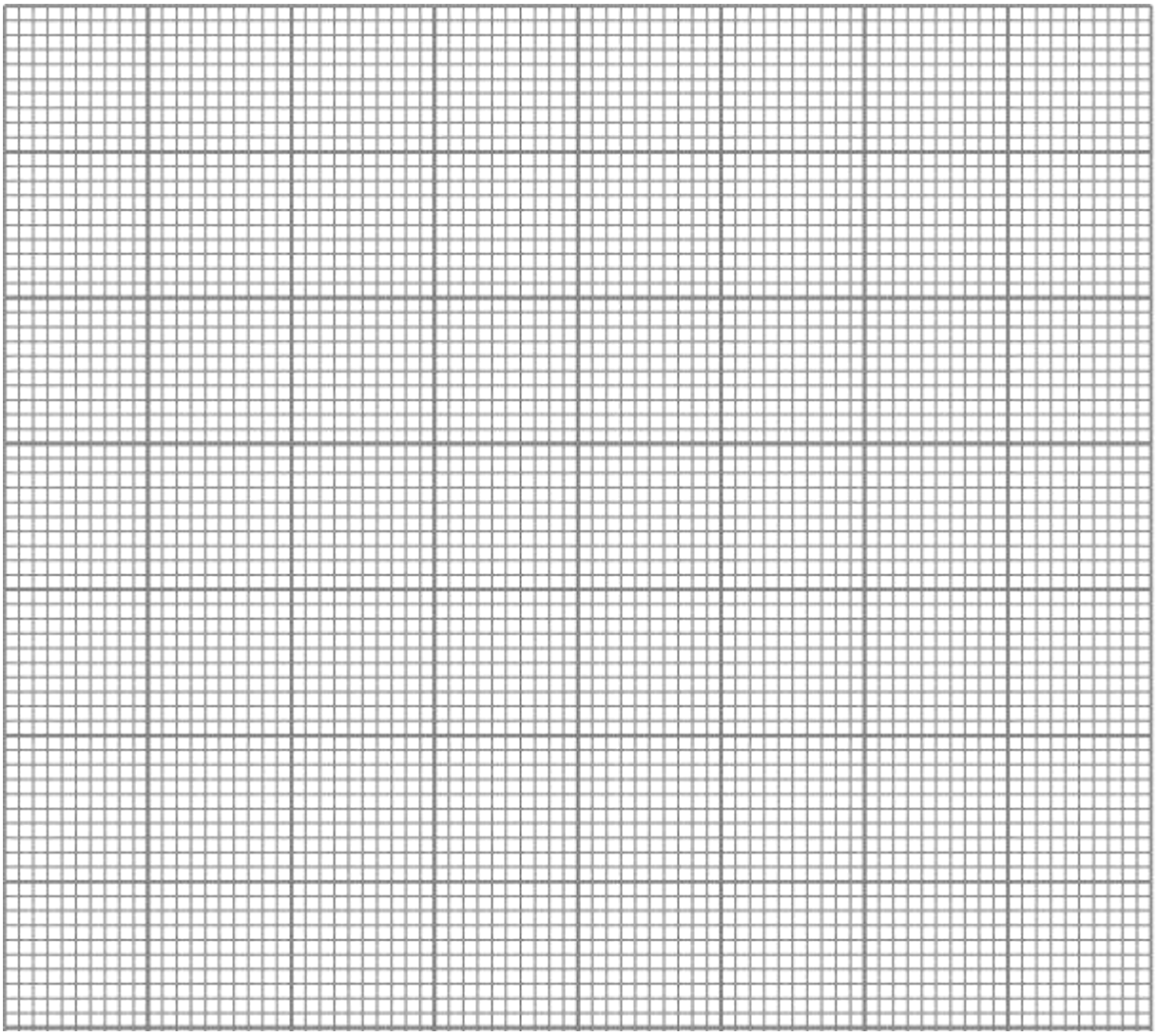
_____ (5)

Determining the enthalpy change of the reaction between Zn(s) and Cu^{2+}(aq).

d) Place the polystyrene cup provided in a 500 cm^3 beaker and using your burette, transfer 50.0 cm^3 of solution $C_{n.}$ Take the temperature of the solution at 1 minute intervals. At time=5 minutes add the entire contents of sachet Z, and continue reading the temperature at 1 minute intervals up to 15 minutes, using your thermometer for constant stirring. Enter your data in the table below:

Time / min	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temp / °C					×										

e) Plot your data on the grid provided below and determine the rise in temperature. (20)



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f) Assuming that the solution has a specific heat capacity of 4200 J kg^{-1} K^{-1}, calculate the standard enthalpy change of the reaction $Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$.

(5)

(Total: 50 marks)

2. You are provided with two inorganic salts in sachets labelled L and M. Carry out the tests described, record your observations and suggest possible identities for the compounds.

a) Dissolve about 1 g of substance L in 10 cm^3 of water. **Retain this solution for subsequent tests.** (3)

Observation	*Inference*

b) To 1 cm^3 of the solution obtained in test a) add drops of aqueous sodium hydroxide, until in excess. Allow the contents of the test tube to stand for a few minutes. (5)

Observation	*Inference*

c) To 1 cm^3 of the solution obtained in test a) add aqueous ammonia dropwise, until in excess. (3)

Observation	*Inference*

d) Acidify 1 cm^3 of the solution obtained in test a) with dilute nitric acid and add a few drops of aqueous potassium permanganate solution. **Retain this solution for the next test.** (4)

Observation	*Inference*

e) To the solution obtained in test d), add a few drops of aqueous potassium thiocyanate. (4)

Observation	*Inference*

f) Carry out a flame test on substance M. (2)

Observation	*Inference*

g) Dissolve about 1 g of substance M in 10 cm^3 of water. **Retain this solution for subsequent tests.** (3)

Observation	*Inference*

h) Acidify 1 cm^3 of the solution from test g) with 1 cm^3 of dilute nitric acid and add a few drops of aqueous silver nitrate. Add aqueous ammonia dropwise with shaking, until in excess. (5)

Observation	*Inference*

i) Acidify 1 cm^3 of the solution from test a) with 1 cm^3 of nitric acid. To this, add 1 cm^3 of the solution from test g). (3)

Observation	*Inference*

Hence suggest possible cations and anions that may be present in the salts L and M. (2)

	Cation	Anion
Salt L	_____	_____
Salt M	_____	_____

(Total: 34 marks)

3. You are provided with an organic substance labelled U. Carry out the following tests and suggest a possible identity for this substance.

a) Burn a few crystals of U on a crucible lid. (2)

Observation	*Inference*
_____	_____
_____	_____
_____	_____
_____	_____

b) Warm 2 cm^3 of water in a boiling tube and add about 0.2 g of U. Test with litmus paper.(3)

Observation	*Inference*
_____	_____
_____	_____
_____	_____
_____	_____

c) Place about 0.2 g of U in 5 cm^3 water; add aqueous sodium hydroxide dropwise. (3)

Observation	*Inference*
_____	_____
_____	_____
_____	_____
_____	_____

d) Place about 0.1 g of solid U in a test tube and add 2 cm^3 of water. Warm gently and add 1 cm^3 of neutral iron(III) chloride solution. (3)

Observation	*Inference*
_____	_____
_____	_____
_____	_____
_____	_____

e) In a boiling tube, add 5 drops of methanol to about 0.1 g of U. Acidify with 1 drop of concentrated sulfuric acid and heat in a water bath for one minute. Neutralise with 5 cm^3 of 10% sodium hydrogencarbonate and note any odour produced. (3)

Observation	*Inference*
_____	_____
_____	_____
_____	_____
_____	_____

Hence, suggest a possible structure for substance U. (2)

Possible structure for substance U: _____

(Total: 16 marks)