Index No.:_____ AM06/I.19m

L-Università ta' Malta

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2019 FIRST SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	I
DATE:	22nd May 2019
TIME:	9:00 a.m. to 12:05 p.m.

Required Data: Relative atomic masses: H = 1; N = 14

Answer ALL questions

1. Argon exists as three stable isotopes namely Ar-36, Ar-38 and Ar-40.

   a) Define the term isotope.

   _____

   _____ (1)

   b) A sample of argon exists as a mixture of the three isotopes as follows:
   - mass number 36, relative abundance 0.337%;
   - mass number 38, relative abundance 0.063%;
   - mass number 40, relative abundance 99.600%.

   Calculate the relative atomic mass of argon to three decimal places.

   _____

   _____

   _____ (2)

   c) Ar-39 is a radioactive isotope of the element which decays to K-39 with a half-life of 269 years.

   i) Write out a balanced nuclear equation for the process.

   _____ (1)

   ii) Explain what the term half-life means.

   _____

   _____ (1)

   iii) Write out the electronic configuration of K-39 in terms of s, p and d notation.

   _____ (1)

(Total: 6 marks)

2. The equation for the main reaction in the Haber process is

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H \text{ is negative}$$

a) Use this information to state and explain the effect on the yield of ammonia of:

i) increasing the pressure at constant temperature:

ii) increasing the temperature at constant pressure:

(4)

b) Typical conditions used in the Haber process are a temperature of 500°C and a pressure of 200 atmospheres. Explain how one of these conditions is not in accordance to the responses predicted in part (a) and why such conditions are required.

(2)

c) Write the equilibrium constant expression, K_p, for the production of ammonia.

(1)

d) Ammonia dissolves in water to give a weakly basic solution. The K_b of the compound in water is 1.8×10^{-5} mol dm^{-3}. Calculate the pH of a solution composed of 0.59 g of ammonia in 100 cm^3 of water.

(6)

(Total: 13 marks)

3. a) A solution of benzene and methylbenzene is said to be an ideal solution and follows Raoult's Law. Explain what is meant by:

i) ideal solution;

(1)

ii) Raoult's law;

(1)

Question continues on next page

b) Benzene is the more volatile of the two compounds in part a). In the space below, sketch a T-X diagram and use this to explain how mixtures of the two can be fully separated through fractional distillation.

(5)

c) Ethanol and water are said to form an azeotropic mixture. State why this system forms an azeotropic mixture and cannot be fully separated.

(2)

d) Water and phenylamine are immiscible. A mixture of these compounds results in both compounds boiling at a temperature lower than that of the individual compounds. Explain this behaviour.

(2)

(Total: 11 marks)

4. This question is about the chemistry of chlorides.

a) Write a formula and physical state at room temperature for each of these compounds.

i) The chloride of carbon:

Chemical formula _____

Physical state at room temperature :_____ (1)

ii) The chloride of silicon:

Chemical formula _____

Physical state at room temperature :_____ (1)

iii) A chloride of phosphorous:

Chemical formula _____

Physical state at room temperature :_____ (1)

b) Write the systematic name for the chloride of silicon.

_____ (1)

c) Describe a method for the preparation of the chloride of silicon.

_____

_____

_____ (2)

d) Write a full, balanced chemical equation to show the reaction of the chloride of silicon with water.

_____ (2)

e) The chloride of silicon reacts with water but the chloride of carbon does not. Give a reason for this observation.

_____

_____

_____ (2)

Question continues on next page

f) Draw the structure of the chloride of silicon according to VSEPR theory in the space below.

(2)

g) The chloride of carbon does not have a dipole moment. Give a reason for this.

_____

_____

_____

_____ (3)

(Total: 15 marks)

5. This question concerns the chemistry of aluminium.

a) Aluminium oxide is considered to be amphoteric.

i) Explain the term amphoteric.

_____

_____ (1)

ii) Write two balanced chemical equations to illustrate the amphoteric behaviour of aluminium oxide.

_____

_____ (2)

b) Solutions of Al^{3+} are acidic. Explain this observation by making reference to the chemical nature of Al^{3+} ions in solution.

_____

_____

_____

_____ (3)

c) Explain how door and window frames made of aluminium corrode less than those made of iron even though aluminium is ranked as more reactive than iron in the reactivity series.

(3)

d) Anhydrous aluminium chloride is produced industrially for a wide variety of uses.

i) Give the full, balanced chemical reaction for the direct production of this chemical.

(1)

ii) Aluminium chloride can form dimers. Draw the structure of the aluminium chloride dimer in the space below.

(2)

e) Aluminium can form alums.

i) Explain the term alum.

(2)

ii) Give any **TWO** examples of alums.

(1)

(Total: 15 marks)

6. The reaction between compounds **X** and **Y** in the presence of a small amount of concentrated sulfuric acid generates compound **Z** which has $C_4H_8O_2$ as its molecular formula. Both **X** and **Y** can be synthesised from ethanal in single step reactions. Simplified IR spectra of **X** and **Y** are shown below.

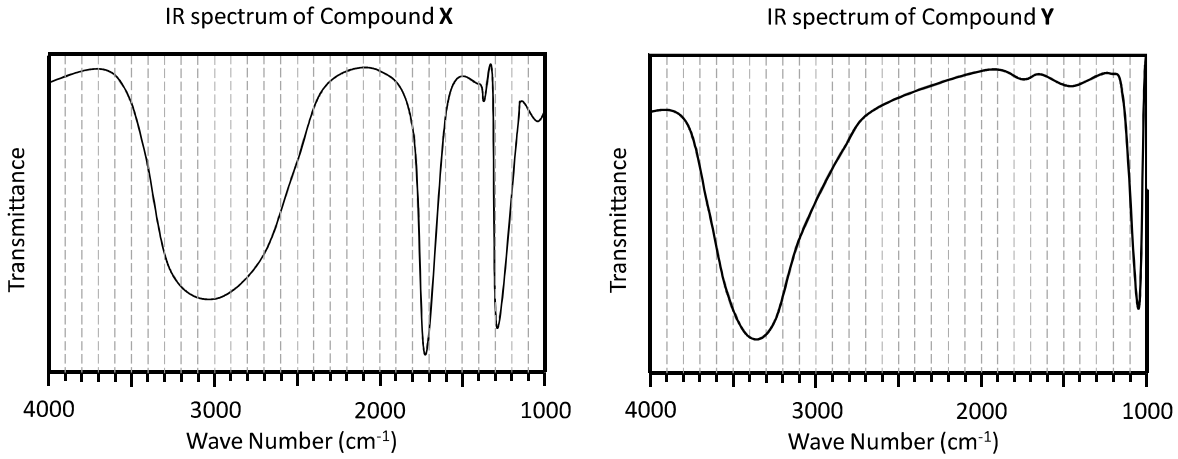


Table of Typical vibrational frequencies of functional groups

Group	Functionality	Wavenumber (cm^{-1})
C-O	Alcohols	1250 - 970
C-O	Ethers	1300 - 1000
C-O	Carboxylic acids	1320 - 1210
C=O	Aldehydes, ketones	1740 - 1710
C=O	Carboxylic acids	1720 - 1705
C=O	Amides	1680-1630
O-H	Alcohols	3650-3200
O-H	Carboxylic acids	3300 - 2500
C-N	Amines	1350-1000

a) Name and give the structural formula for compounds **X**, **Y** and **Z**. In the case of compounds **X** and **Y**, justify your answer using IR Data.

Structural Formula of **X**

Systematic name of **X**_____ (2)

Justification from IR data for compound **X**: _____

_____ (1)

Structural Formula of **Y**

Systematic name of **Y**_____(2)

Justification from IR data for compound **Y**: _____

_____(1)

Structural Formula of **Z**

Systematic name of **Z**_____ (1)

b) Explain how compounds **X** and **Y** can be made from ethanal (chemical equations are not required).

X from ethanal: _____

_____

Y from ethanal: _____

_____ (2)

c) Compound **X** reacts with sodium carbonate to give a number of products.
i) Write a balanced equation illustrating the reaction described above.

_____ (1)

ii) Give an observation for this reaction.

_____

_____

_____ (1)

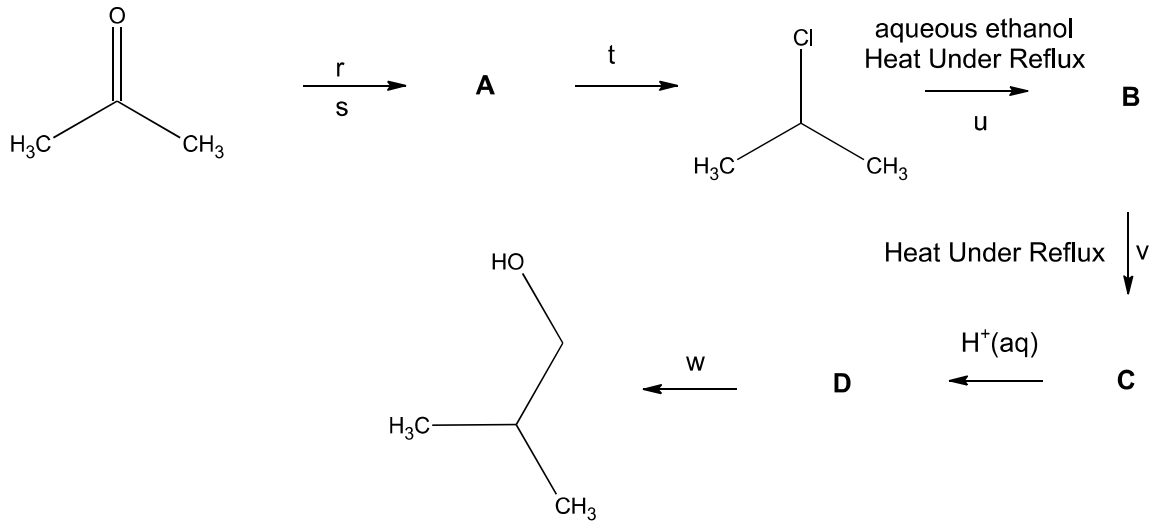
Question continues on next page

d) Addition of iodine and dilute NaOH to compound **Y** will give a pale yellow precipitate. Explain this observation, giving chemical equations.

(3)

(Total: 14 marks)

7. Consider the following reaction scheme with propanone as a starting organic compound.



a) Give the structural formulae for organic compound **A, B**, **C**, **D**.

A: (1)

B: (1)

C: (1)

D: (1)

b) Name reagents r,s,t,u,v and w.

r: _____ u: _____

s: _____ v: _____

t: _____ w: _____ (3)

c) Propanone can undergo tautomerism. Describe the term 'tautomerism' and identify the tautomeric forms of propanone by giving their structural formulae.

_____

_____

_____ (2)

d) Describe a chemical test that may be used to distinguish between propanone and propanal.

_____

_____

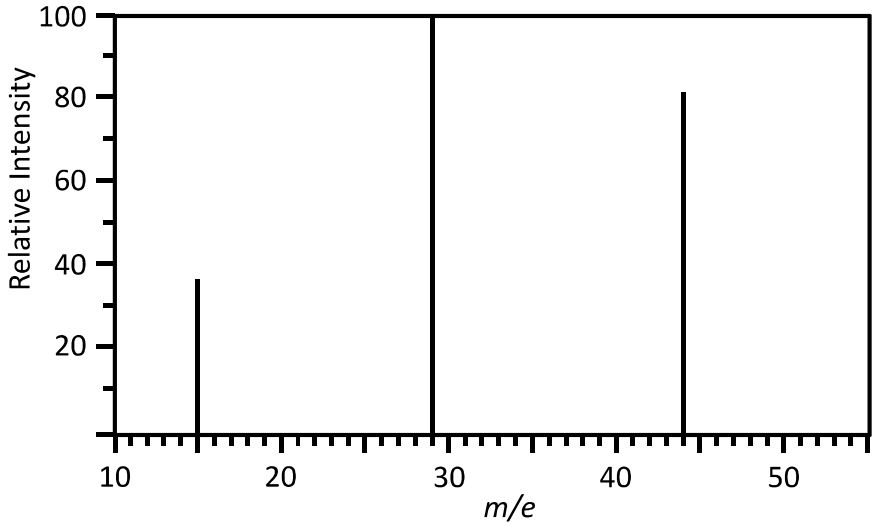
_____

_____ (3)

(Total: 12 marks)

Questions continue on next page

8. On ozonolysis, an alkene **E** gives only aldehyde **F.** A simplified mass spectrum of aldehyde **F** is shown below:



a) Suggest the molecular weight of compound **F.**

_____ (1)

b) Identify the fragments responsible for the three peaks shown in the mass spectrum.

_____

_____

_____ (3)

c) Deduce the structural formula of compound **E.** Explain your reasoning. Your answer should include the structural formulae and systematic names of the different configurations (if any) of compound **E.**

_____

_____

_____

_____

_____ (4)

d) Write chemical equations showing the ozonolysis reaction of compound **E**. Your answer should include any intermediate formed and reagents used.

_____

_____ (2)

e) Compound **E** can react with hydrogen bromide. Illustrate the mechanism for this reaction.

(4)

(Total: 14 marks)

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MATRICULATION AND SECONDARY EDUCATION CERTIFICATE
EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2019 FIRST SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	II
DATE:	23rd May 2019
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) a) Explain the difference between:
   i) the standard bond enthalpy and the standard enthalpy of atomisation of chlorine gas; and
   ii) the standard enthalpy of formation and the standard lattice enthalpy of sodium chloride. (7)

   b) Construct a Born-Haber cycle for sodium chloride. (5)

   c) The enthalpy of solution of sodium chloride is +3.87 kJ mol^{-1}. The enthalpy change of hydration of sodium ions is –424 kJ mol^{-1} whilst that of chloride ions is –364 kJ mol^{-1}. From this information, calculate the lattice enthalpy of sodium chloride. (5)

   d) Although the enthalpy of solution of sodium chloride is endothermic, the compound is highly soluble. Explain this observation. (3)

(Total: 20 marks)

2) This question is about the chemistry of the halides and their solubility.

   a) The K_{sp} value for AgCl in water is 1.8 x10^{-10} mol^2 dm^{-6}.
   i) Write an expression for the K_{sp} of AgCl. (1)
   ii) Using the value given above, calculate the solubility of AgCl in water in mol dm^{-3}. Show your working. (2)
   iii) Will the solubility of AgCl increase or decrease if ammonia is present in solution? Give a reason for your answer. (2)

   b) The halides can form acids of varying strengths. Explain the trend in acid strength for the halides. (3)

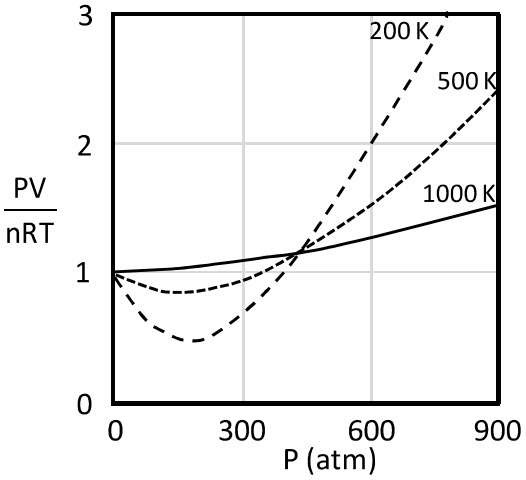
   c) Concentrated sulfuric(VI) acid reacts with some, but not all of the following chemicals: hydrogen chloride, hydrogen bromide and hydrogen iodide. Give a reason for this observation, including balanced chemical equations for the reactions which do occur. (6)

   d) Iodine can be used in redox titrimetry to find the concentration of an oxidising agent, such as potassium dichromate ($K_2Cr_2O_7$). Explain this process, giving balanced chemical equations when relevant. (6)

(Total: 20 marks)

3) a) Gas A and gas B are present in a container having a volume of 1 m^3 at a temperature of 273 K. If gas A makes up 75% of the gas mixture and the total pressure is 150 kPa, calculate the partial pressure of gas B. (2)

b) Plots of $\frac{PV}{nRT}$ versus P for a fixed mass of nitrogen gas at different temperatures are as shown in the diagram below. Note that all symbols have their usual meaning.



i) Sketch a plot showing the expected $\frac{PV}{nRT}$ versus P plot for an ideal gas. (1)

ii) Explain the behaviour shown in the plot above and compare it to that of an ideal gas. (6)

c) i) Sketch the distribution of kinetic energies for a gas sample at temperatures T_1 and T_2, where T_2 is the higher temperature. (3)

ii) Explain why the rate of a particular gaseous reaction changes on changing temperature. In your answer, you should refer to the graphs in part c(i). Redraw these plots if you need to add additional elements to this figure to aid your explanation. (5)

iii) Explain how solid catalysts can increase the rate of a gaseous reaction. In your answer you should refer to the graphs in part c(i). Redraw these plots if you need to add additional elements to this figure to aid your explanation. (3)

(Total: 20 marks)

4) This question is about the transition elements and their complexes.

a) i) Write the full electron configuration for manganese. (1)

ii) List **FOUR** of the common oxidation states of manganese. (2)

iii) Explain why the compounds of manganese are often used as catalysts. (2)

b) Explain the term 'complex ion' and explain why complex ions of transition metal elements often have different colours. (4)

c) Give **ONE** example of tetrahedral complex involving a transition metal atom or ion, draw its structure and give the name of the complex. (4)

d) Explain the term 'bidentate ligand', and give an example of a bidentate ligand. In your answer, you should draw the structure of the bidentate ligand and give its name. (3)

e) 'Octahedral complexes can exhibit stereoisomerism', explain this term and draw a suitable example (give all stereoisomers for the chosen example). (4)

(Total: 20 marks)

SECTION B

5) a) A half cell made up of $Ce^{4+}(aq)/Ce^{3+}(aq)$ is connected to a half cell made up of $Br_2(aq)/Br^-(aq)$. The standard electrode potentials of the half cells at 25 °C are:

$$Ce^{4+}(aq) + e^- \rightleftharpoons Ce^{3+}(aq) \quad E^\circ = +1.61\ V$$
$$Br_2(aq) + 2e^- \rightleftharpoons 2Br^-(aq) \quad E^\circ = +1.07\ V$$

i) Give a cell diagram for the reaction. (2)
ii) Write a balanced ionic equation for the overall reaction. (1)
iii) Calculate the E.M.F of the cell. (3)
iv) State, giving a reason in each case, which of the following: Br^-, Br_2, Ce^{3+}, Ce^{4+} is the strongest oxidizing agent and the strongest reducing agent. (4)

b) When a Zn^{2+}/Zn half cell is connected to an Fe^{2+}/Fe half cell, the Fe electrode is positive. When the Fe^{2+}/Fe half cell is connected to a Cu^{2+}/Cu half cell, the Fe electrode is negative. Explain this observation and identify the strongest reducing agent amongst these systems giving reasons for your answer. (7)

c) Explain why underwater steel and iron structures can be protected using blocks of magnesium alloys. (3)

(Total: 20 marks)

6) This question is about specific reactions.

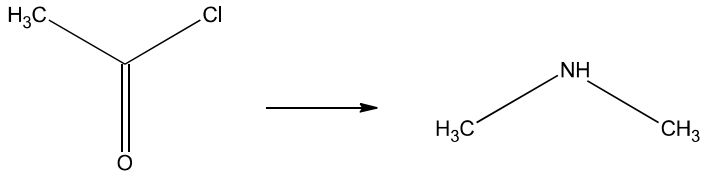
a) Explain how to carry out the following preparations (include a balanced chemical equation in each of your answers):
i) the production of hydrogen peroxide in the laboratory from barium peroxide; (4)
ii) the production of hydrogen sulfide in the laboratory from sodium sulphide; (4)
iii) the production of C_2D_2. (4)

b) Write balanced chemical equations for each of the following reactions:
i) the reaction of chromium with excess aqueous sodium hydroxide; (2)
ii) the hydrolysis of 1-bromopropane; (2)
iii) reduction of ethylethanoate; (2)
iv) alkylation of phenol. (2)

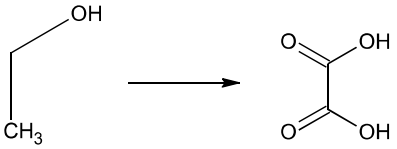
(Total: 20 marks)

7) This question is about synthetic pathways of organic compounds.

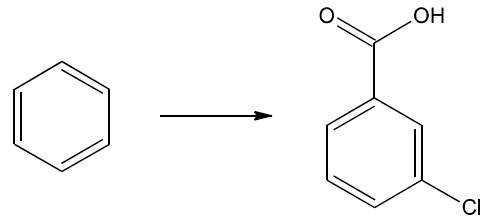
a) Outline suitable routes for the following conversions. More than one step may be required for each conversion. Your answers should include reagents and conditions used where appropriate.

i) 

(4)

ii) 

(4)

iii) 

(4)

b) An organic compound $CH_3CH_2CH_2Br$ reacts with potassium cyanide in alcohol to give **A**. When dilute hydrochloric acid is added to **A** whilst heating, compound **B** is formed. Compound **B** reacts with propan-1-ol and concentrated sulfuric acid to give compound **C**.
Warming $CH_3CH_2CH_2Br$ under reflux with magnesium turnings in a dry ether solvent and a trace of iodine results in compound **D**.
$CH_3CH_2CH_2Br$ also reacts in the presence of aqueous sodium hydroxide to give compound **E**. Compound **E** reacts with reagents **x** and **y** to form CH_3CH_2CHO. CH_3CH_2CHO reacts with compound **D** to give compound **G**.
Deduce structural formulae for substances **A**, **B**, **C**, **D**, **E** and **G** and name reagents **x** and **y**. (8)

(Total: 20 marks)

8) a) One method of preparing nitrobenzene requires benzene as a starting organic compound. Discuss this statement by giving an account of the laboratory preparation of nitrobenzene, the conditions needed for this reaction to occur, details of the extraction techniques, a mechanism for this reaction and an account for the relative stability/instability of any reaction intermediate formed. (11)

b) Discuss how nitrobenzene can be converted into phenylamine. In your answer, include an account of the laboratory preparation of phenylamine and details of the extraction techniques. (7)

c) Show by giving chemical equations, how phenylamine can be converted into phenyldiazonium chloride. (2)

(Total: 20 marks)

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MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

ADVANCED MATRICULATION LEVEL
2019 FIRST SESSION

SUBJECT:	**Chemistry**
PAPER NUMBER:	III – *Practical*
DATE:	13th June 2019
TIME:	3 hours 5 minutes

1. You are provided with the following solutions:

   i) hydrochloric acid of concentration 0.10 M, labelled C;
   ii) sodium hydroxide of unknown concentration, labelled D_n, where n is the candidate laboratory number;
   iii) an acid salt of phthalic acid, made by dissolving 23.50 g of the solid in 1000 cm^3 of water, labelled H. The structure of the acid salt is given in Figure 1, where M is a group 1 metal ion.

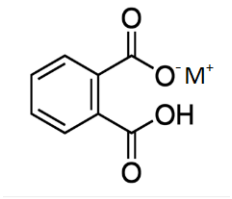

Figure 1: Structure of the acid salt of phthalic acid.

You are required to determine:

i) the concentration of solution D_n;
ii) the relative molecular mass of the acid salt of phthalic acid, and hence the atomic mass of M.

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

CANDIDATE LABORATORY NUMBER, n:.....

DO NOT WRITE ABOVE THIS LINE

Determination of the molar concentration of sodium hydroxide in solution D_n

b) Pipette 25.0 cm^3 of solution C into each of three conical flasks. Fill your burette with solution D_n and titrate using phenolphthalein as an indicator. 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 D_n

c) Calculate the molar concentration of the sodium hydroxide solution D_n to three significant figures.

_____ (4)

Determination of the relative mass of the acid salt of phthalic acid.

d) Pipette 25.0 cm^3 of solution H into each of three conical flasks. Fill your burette with solution D_n and titrate using phenolphthalein as an indicator. 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			

Mean titre: _____ cm^3 of solution D_n.

e) Calculate the concentration of solution H and hence the relative molecular mass of the acid salt of phthalic acid. Determine the atomic mass of M.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ (6)

(Total: 50 marks)

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2. Sample T is a mixture of two inorganic salts. Carry out tests as described below and suggest possible identities for the components.

a) Place the contents of the sachet in a small beaker and add 20 cm^3 of distilled water. Stir and filter the mixture. **Retain both residue and filtrate for subsequent tests**. (3)

Observation	*Inference*

b) Carry out the following tests to the residue obtained in part a.

i) Transfer the residue to a boiling tube and carefully add 20 cm^3 of dilute nitric acid. Test for any gases evolved. **Retain this solution for subsequent tests**. (4)

Observation	*Inference*

ii) To about 1 cm^3 of the solution obtained in test b(i), add aqueous sodium hydroxide dropwise, until in excess. (3)

Observation	*Inference*

iii) To about 1 cm^3 of the solution obtained in test b(i), add aqeous ammonia dropwise, until in excess. (3)

Observation	*Inference*

iv) To about 1 cm^3 of the solution obtained in test b(i), add 1 cm^3 of dilute hydrochloric acid. Heat gently and then cool under running water. (5)

Observation	*Inference*

c) Carry out the following tests to the filtrate obtained in part a.

i) Transfer 1 cm^3 of the filtrate obtained in part a to a test tube. Add 1 cm^3 of iron(II) sulfate solution. Hold the test-tube at an angle and carefully add two drops of concentrated sulfuric acid. (3)

Observation	*Inference*

ii) Carry out a flame test on the filtrate obtained in part a. (2)

Observation	*Inference*

Hence suggest possible cations and anions that may be present in the salts of mixture T. (2)

Cations: _____ and _____

Anions: _____ and _____

(Total: 25 marks)

3. You are provided with an organic liquid labelled P. Carry out the following reactions and suggest a possible identity for the substance.

a) Burn a few drops of P on a crucible lid. (3)

Observation	*Inference*

b) To a few drops of P add a few drops of 2,4-dinitrophenylhydrazine (2,4-DNPH). (4)

Observation	*Inference*

c) To 1 cm^3 of iodine in potassium iodide, add aqueous sodium hydroxide dropwise until a pale straw colour is obtained. Then add about 10 drops of P and observe for 30 seconds. (5)

Observation	*Inference*

d) To five drops of P, add five drops of aqueous potassium dichromate solution. Acidify the mixture with three drops of concentrated sulfuric acid. Add three drops of 2,4-dinitrophenylhydrazine (2,4-DNPH). (5)

Observation	*Inference*

e) In a boiling tube, add four drops of P to four drops of glacial ethanoic acid, followed by two drops of concentrated sulfuric acid. Heat for 1 minute in a boiling water bath. Add 5 cm^3 of 10% sodium hydrogencarbonate solution and carefully note the odour. (5)

Observation	*Inference*

Hence, suggest a possible structure for substance P. Give the systematic name for the suggested compound. (3)

Possible structure for substance P: _____

Systematic name for P: _____

(Total: 25 marks)

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