THE CHEMISTRY DEPARTMENT

2023

CHEMISTRY

END OF TERM I, Paper 2

2 hours 30 minutes

INSTRUCTIONS:

Attempt any five questions in this paper.

Write the answers in the answer booklet(s) provided.

Begin each question on a fresh page.

Mathematical tables and graph papers are provided.

Non-programmable scientific calculators may be used.

Use equations where necessary to illustrate your answers.

Choose the questions well and manage your time properly.

1. (a) Define the terms;
      (i)   **hydrocarbon.**   *(01 mark)*
      (ii)   **alkane**   *(01 mark)*

(b) The table below shows the boiling points of straight chain alkanes.

Alkane	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}	C_6H_{14}	C_7H_{16}
Boiling point	-162	-89	-42	-0.5	36	69	98
Molecular mass(g)							

    (i)   Complete the table above.   *(3 ½ marks)*
    (ii)   Plot a graph of boiling point against molecular mass of the alkanes.   *(03 marks)*
    (iii)   Use your graph in (b)(i) to determine the molecular mass of octane.   *(01 mark)*
    (iv)   Explain the trend in boiling points of alkanes. *(2 ½ marks)*

(c) A mixture of 10 cm³ of a gaseous hydrocarbon 100 cm³ of excess oxygen were exploded. The volume after explosion was 75cm³ and this was reduced to 35cm³ on treatment with potassium hydroxide solution.

    (i) Deduce the molecular formula of the hydrocarbon. *(2 ½ marks)*
    (ii)   Write the structural formulae and IUPAC names of all the possible isomers of the hydrocarbon.   *(02 marks)*
    (iii)   Compare and explain the difference in boiling points of the isomers in (c)(ii) above.   *(3 ½ marks)*

2. (a) What is meant by each of the following terms:
    (i)   **Relative atomic mass**   *(02 marks)*
    (ii) **Relative abundance**   *(02 marks)*
    (iii) **Relative intensities**   *(02 marks)*

(b)   Briefly describe how relative atomic mass of magnesium metal which consists of three isotopes can be determined using a mass spectrometer.   *(09 marks)*

(c)   The relative atomic mass of magnesium with isotopes $^{24}_{12}Mg$, $^{25}_{12}Mg$ and $^{26}_{12}Mg$ is 24.3. If the percentage abundances of $^{25}_{12}Mg$ and $^{26}_{12}Mg$ are equal;

(i) Calculate the percentage abundance of each isotope of magnesium.   *(03 marks)*

(ii) Sketch the mass spectrum of magnesium.   *(02 marks)*

3. (a) Define the terms;
   (i)   **first ionization energy**   *(01 mark)*
   (ii)   **Atomic radius**   *(01 mark)*

   (b) State and explain any **three** factors that affect the value of first ionization energy.   *(6 ½ marks)*

   (c) The table below shows the first ionisation energy of Period 3 elements of the Periodic Table.

Element	Na	Mg	Al	Si	P	S	Cl
Atomic number	11	12	13	14	15	16	17
First ionisation energy($kJmol^{-1}$)	502	745	587	791	1020	1000	1260

   (i)   Write equation to show the first ionisation energy of magnesium atom.   *(1 ½ marks)*
   (ii)   Plot a graph of first ionisation energy against atomic number.   *(03 marks)*
   (iii) Explain the shape of the graph in c(ii) .   *(07 marks)*

4. Explain the following observations
   (a) Propene undergoes electrophilic addition reactions whereas propane doesnot.   *(05 marks)*
   (b) The first ionisation energy of phosphorus is higher than that of sulphur.   *(03 marks)*
   (c) Aluminium has a lower first ionisation energy that that of sulphur.   *(03 marks)*

(d) The ions Na^+ and Mg^{2+} have the same electronic configuration but the ionic radius of Mg^{2+} is lower than that of Na^+

(2 ½ marks)

(e) The atomic radius of the group IIA metals increases down the group. (03 marks)

(f) Hexane boils at 68°C whereas 2-methylpentane boils at 60.3°C yet the two compounds have the same molecular mass.

(3 ½ marks)

5. (a) (i) What is meant by the term **structural isomerism?**

(02 marks)

(ii) Describe the **three** types of structural isomerism, giving a suitable example in each case. (06 marks)

(b) Explain what is meant by the following terms;

(i) Nucleophilic addition reaction (03 marks)

(ii) Nucleophilic substitution reaction (03 marks)

(iii) Electrophilic substitution reaction (03 marks)

(iv) Electrophilic addition reaction (03 marks)

In each of cases, state one reaction example and write an equation to illustrate your answer.

6. (a) Define the terms

(i)   **isotopes.** (02 marks)

(ii)   **Radioactivity** (02 marks)

(iii)   **Half life** (02 marks)

(b) One of the factors that affects nuclear stability of isotopes is neutron to proton ratio. State any two other factors. (02 marks)

(c) Sketch a graph of number of neutrons versus number of protons and on it indicate;

(i)   the line at which $n/p = 1$

(ii)   the stability region

(iii)   three points in the unstability region (3 ½ marks)

(d) Describe briefly how the isotopes in the unstability region in the three points indicated in b(ii) can gain stability. *(05 marks)*

(e) Gallium has two isotopes of mass numbers 69 and 71 in the ratio $x:y$. If the relative atomic mass of Gallium is 69.8. Determine the values of x and y. *(3 $\frac{1}{2}$ marks)*

7. (a) What do you understand by the term **first electron affinity**? *(01 mark)*

(b) The table below shows first electron affinities and melting points of elements in period 2 and period 3 of the periodic table respectively.

Period 2 elements	Atomic number	First electron affinity($kJmol^{-1}$)	Period 3 elements	Melting point(°C)
Li	3	−59.8	Na	97.8
Be	4	+66	Mg	650
B	5	−29.0	Al	660.3
C	6	−120	Si	1414
N	7	−3.0	P	44.2
O	8	−142	S	115.2
F	9	−348	Cl	−101.5

(i) Write an equation for first electron affinity of nitrogen *(01 mark)*

(ii) Plot a graph of first electron affinity of period 2 elements against atomic number. *(03 marks)*

(iii) State and explain the trend in first electron affinities of the elements. *(06 marks)*

(iv) The second electron affinity values are positive for all elements. Explain. *(03 marks)*

(c) Briefly explain ;

(i)   the increase in melting point from sodium to aluminium.

(03 marks)

(ii)   why silicon has the highest melting point.   (1 ½ marks)

(iii)   why there is a general decrease in melting point from phosphorus to chlorine.   (1 ½ marks)

END