SECTION A (60 Marks)

Answer only **three** questions from this section.

1. An organic compound **T** on combustion yielded **13.2g** of carbon dioxide and **2.7 g** of water. When **4.7g** of **T** was vaporized at **273°c** and at **760 mmHg**, it occupied a volume of **$2.4 \times 10^{-3} m^3$**.
   a) i) Calculate empirical formula of **T**. (02 marks)
   ii) Determine the molecular formula of **T**. (02½ marks)
   b) **T** burns with a sooty flame. Identify **T**. (0½ mark)
   c) Discuss the reactions of **T** with: (@04½ marks)
      i) Bromine.
      ii) Propene.
      iii) Ethanoyl bromide.

      (You answer should include conditions for the reactions and mechanisms for the reactions where possible)

   d) Write equations to show how **T** can be synthesized from benzaldehyde. (01½ marks)

2. a) What is meant by the terms? (@01 mark)
      i) Order of reaction
      ii) Half – life of a reaction

   b) The **rate equation** for the reaction.

$$S_2O_3^{2-}{}_{(aq)} + 2H^+{}_{(aq)} \longrightarrow S_{(s)} + SO_{2(g)} + H_2O_{(l)}$$

$$\text{Rate} = K[S_2O_3^{2-}][H^+]^2$$

   i) State how the **rate** will be affected if the concentrations of the reactants are both **doubled**. (02 marks)

   ii) Describe an experiment to determine the **order of the reaction** with respect to **$S_2O_3^{2-}$** in the laboratory. (06 marks)

   c) The table below shows the kinetic data for the reaction between hot aqueous potassium hydroxide and alkylbromide, C_4H_9Br.

Experimental numbers	$[C_4H_9Br]/moldm^{-3}$	$[KOH]/moldm^{-3}$	Initial rate $/moldm^{-3}s^{-1}$
1	1.0×10^{-3}	1.0×10^{-3}	5.0×10^{-8}
2	2.0×10^{-3}	1.0×10^{-3}	1.0×10^{-7}
3	2.0×10^{-3}	2.0×10^{-3}	2.0×10^{-7}

$C_4H_9Br_{(l)} + KOH_{(aq)} \longrightarrow C_4H_9OH_{(aq)} + KBr_{(aq)}$.

i) Determine the **overall order** of reaction. (01 mark)

ii) Determine the **rate constant** for the reaction and state its units. (02 marks)

iii) Identify the akylbromide. (0½ mark)

d) Write the mechanism for the reaction in **(c)** above. (03½ marks)

e) Draw a well **labeled energy level diagram** for the reaction mechanism illustrated in **(d)** above. (03 marks)

3. Carbon, silicon, germanium, tin and lead are elements of Group (IV) of the periodic Table.
   a) Write the **electronic configuration** of the outer most energy level of group (IV) elements. (01 mark)
   b) Describe how;
      i) **Carbon**, **silicon** and **lead** react with **water**. (06 marks)
      ii) **Oxides** of the elements in b (i) react with sodium hydroxide. (08 marks)
   c) Dilute nitric acid was added to trileadtetraoxide (Pb_3O_4) and the mixture warmed.
      i) State what would be **observed**. (01 mark)
      ii) Write **equation** for the reaction that took place. (01½ marks)
   d) The resultant mixture in (c) above was filtered and the residue was added to a solution of manganese (II) sulphate followed by few drops of concentrated nitric acid and the mixture warmed.
      i) State what would be **observed**. (01 mark)
      ii) Write **equation** for the reaction. (01½ marks)

4. a) i) What is meant by the term **standard enthalpy of combustion**? (01 mark)

ii) Describe an experiment that can be carried out to determine the **enthalpy of combustion of liquid cyclohexane. Diagram not required**. (05 marks)

b) The standard enthalpies of combustion of the first five straight chain alkanes are shown in the table below.

Number of carbon atom	0	1	2	3	4	5
Enthalpy of combustion of alkanes, $\bar{}\Delta H_C$ ($KJmol^{-1}$)	286	890	1560	2220	2877	3509
Enthalpy of combustion of alkanols, $\bar{}\Delta H_C$ ($KJmol^{-1}$)	0	715	1371	2010	2673	3305

i) Plot a graph of the **enthalpies of combustion of alkanes** against **number of carbon atoms**. (03 marks)

ii) **Use** the graph to determine the **enthalpy of combustion** of hexane. (01 mark)

iii) Explain the shape of the graph. (03 marks)

c) Some thermo chemical data for copper, copper (I) oxide and oxygen is given below.

Sublimation energy of copper = $^{+}339.3KJmol^{-1}$

Enthalphy of formation of copper (I) oxide = $^{-}166.7KJmol^{-1}$

First ionization energy of copper = $^{+}750.0KJmol^{-1}$

Bond dissociation energy of oxygen = $^{+}498.4KJmol^{-1}$

First electron affinity of oxygen = $^{-}141.4KJmol^{-1}$

Second electron affinity of oxygen = $^{+}790.8KJmol^{-1}$

i) Define the term **standard enthalpy of formation**. (01 mark)

ii) Draw an **energy level diagram** for the formation of copper (I) oxide using the enthalpy data given. (04 marks)

iii) Determine the **lattice energy** of copper (I) oxide. (02marks)

SECTION B (40 Marks)

Answer only **two** questions from this section.

5. a) Define the following terms. (@01 mark)
   i) Colligative property
   ii)Osmotic pressure

   b) i) Describe an experiment to determine the **molecular mass** of mannitol by osmotic pressure method. (07 marks)

   ii) State three **limitations** of this method. (01½ marks)

   c) The table below shows the osmotic pressure of a solution of mannitol of various concentrations at **25^{0}C**.

Concentration of the solution (gdm^{-3})	1.5	3.0	4.5	6.0	7.5	9.0	10.5
Osmotic pressure of the solution (atm)	0.20	0.40	0.60	0.81	1.05	1.20	1.40

   i) Plot a graph of **osmotic pressure** against **concentration** of the solution. (03½ marks)
   ii) Explain the **shape** of the graph. (03 marks)
   iii) Use **your graph** to determine the **relative molecular mass** of mannitol. (03 marks)

6. Write equations to show how the following conversions can be affected.
   a) CH_3CHO to $CH_3C{\equiv}CH$ (04 marks)
   b) $CH_3CH_2C{\equiv}CCH_3$ from Calcium carbide (04 marks)
   c) $CH_3CH_2OCH_2CH_3$ from Ethane (02½ marks)
   d) CH_3COCH_3 from $CH_3CH_2CH_2OH$ (05 marks)
   e) Propanone from propene (02½ marks)
   f) Dibromoethane from ethanol (02 marks)

7. a) State **Raoult's law**. (02 marks)
   b) The vapour pressures of **n-heptane** and **n-hexane** at **50^{o}c** are **20KNm^{-2}** and **50KNm^{-2}** respectively. If the mixture contains **20g** of **n-heptane** and **30g** of **n-hexane** at **50^{o}c**, calculate the;
   i) **Vapour pressure** above the liquid mixture at **50^{o}c.** (04 marks)
   ii) **Mole fraction** of each component in the vapour. (03 marks)
   c) Liquid **A** and **B** form an ideal solution. At **25^{o}c**, the vapour pressure of pure **A** and pure **B** are **30 KNm^{-2}** and **12 KNm^{-2}** respectively.
   i) Define an **ideal solution.** (02 marks)

ii) Plot graph of vapour pressure against mole fraction of liquid A. (03 marks)

iii) Use **your graph** to determine the composition of the liquid mixture when the partial vapoour pressure of **A** is equal to that of **B**. (01 mark)

iv) Determine the composition of the vapour when the mole fraction of A in the liquid mixture is **0.62**. (02½ marks)

v) Sketch a well **labeled boiling point – composition diagram** of the system of liquid **A** and **B**. (02½ marks)

8. Explain each of the following observations.
   a) When solid iodine crystals were added to dilute sodium hydroxide solution, the grey solid dissolves to form a pale yellow solution which turns colourless on standing.
   b) When ammonium sulphate solution was mixed with sodium sulphite solution and the mixture warmed, there was effervescence of a colourless gas that turns moist red litmus paper blue.
   c) When a mixture of anhydrous zinc chloride and concentrated hydrochloric acid was added to 2 – methypropan – 2 – 01, immediate cloudiness was formed but there no observable change at room temperature if the same regent was treated with propan – 1 –ol.
   d) When aluminuim was added to concentrated sodium hydroxide solution, the metal dissolved with effervescence of a colourless gas that burnt with a pop sounds.
   e) When methanoic acid was warmed with Fehling's solution a red precipitate was formed whereas with ethanoic acid, there was no observal change occurs.

THE PERIODIC TABLE

1	2											3	4	5	6	7	8
1.0 H 1																1.0 H 1	4.0 He 2
6.9 Li 3	9.0 Be 4											10.8 B 5	12.0 C 6	14.0 N 7	16.0 O 8	19.0 F 9	20.2 Ne 10
23.0 Na 11	24.3 Mg 12											27.0 Al 13	28.1 Si 14	31.0 P 15	32.1 S 16	35.4 Cl 17	40.0 Ar 18
39.1 K 19	40.1 Ca 20	45.0 Sc 21	47.9 Ti 22	50.9 V 23	52.0 Cr 24	54.9 Mn 25	55.8 Fe 26	58.9 Co 27	58.7 Ni 28	63.5 Cu 29	65.7 Zn 30	69.7 Ga 31	72.6 Ge 32	74.9 As 33	79.0 Se 34	79.9 Br 35	83.8 Kr 36
85.5 Rb 37	87.6 Sr 38	88.9 Y 39	91.2 Zr 40	92.9 Nb 41	95.9 Mo 42	98.9 Tc 43	101 Ru 44	103 Rh 45	106 Pd 46	108 Ag 47	112 Cd 48	115 In 49	119 Sn 50	122 Sb 51	128 Te 52	127 I 53	131 Xe 54
133 Cs 55	137 Ba 56	139 La 57	178 Hf 72	181 Ta 73	184 W 74	186 Re 75	190 Os 76	192 Ir 77	195 Pt 78	197 Au 79	201 Hg 80	204 TI 81	207 Pb 82	209 Bi 83	209 Po 84	210 At 85	222 Rn 86
223 Fr 87	226 Ra 88	227 Ac 89															

139 La 57	140 Ce 58	141 Pr 59	144 Nd 60	147 Pm 61	150 Sm 62	152 Eu 63	157 Gd 64	159 Tb 65	162 Dy 66	165 Ho 67	167 Er 68	169 Tm 69	173 Yb 70	175 Lu 71
227 Ac 89	232 Th 90	231 Pa 91	238 U 92	237 Np 93	244 Pu 94	243 Am 95	247 Cm 96	247 Bk 97	251 Cf 98	254 Es 99	257 Fm 100	256 Md 101	254 No 102	260 Lw 103

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