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1. An organic compound **T** on complete combustion yielded 13.2g of carbon dioxide and 2.7g of water. When 4.7g of **T** was vaporized at 273^{o}C and at 760mmHg , it occupied a volume of $2.7\ x10^{-3}m^{3}$.

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(a) (i) Calculate empirical formula of **T** (02marks)

(ii) Determine the molecular formula of **T** (2½marks)

(b) **T** burns with a sooty flame. Identify **T**. (0½mark)

(c) Discuss the reactions of **T** with

(i) Bromine (4½marks)

(ii) Propene (4½marks)

(iii) Ethanoyl bromide (4½marks)

(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 (1½marks)

2. (a) What is meant by the terms.

(i) order of reaction (01mark)

(ii) half –life of a reaction (01mark)

(b) The rate equation for the reaction.

$S_2O_3^{2-}(aq) + 2H^+(aq) \longrightarrow SO_2(g) + S(s) + H_2O(l)$ is

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. (02mark)

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

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

$C_4H_9Br(l) + KOH(aq) \longrightarrow C_4H_9OH(aq) + KBr(aq)$

Experiment	$[C_4H_9Br]$ $(moldm^{-3})$	$[KOH(aq)]$ $(moldm^{-3})$	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}

(i) determine the overall order of reaction. (01mark)

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

(iii) identify the aklybromide. (0½marks)

(d) Write the mechanism for the reaction in (c) above. (3½marks)

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

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. (01marks)

(b) Describe how :

(i) carbon , silicon and lead react with water. (06marks)

(ii) oxides of the elements in b(i) react with sodium hydroxide. (08marks)

(c) Dilute nitric acid was added to trileadtetraoxide (Pb_3O_4) and the mixture warmed.

(i) State what would be observed. (01mark)

(ii) Write equation for the reaction that took place. (1½marks)

(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. (01mark)

(ii) Write equation for the reaction. (1½marks)

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

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

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

Number of carbon atoms (n)	0	1	2	3	4	5
Enthalpy of combustion of alkanes , $-\Delta H_c$ ($kJmol^{-1}$)	286	890	1560	2220	2877	3509

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

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

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

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

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

Enthalpy of formation of copper(I) oxide = -166.7kJmol^{-1}

First ionization energy of copper = +750kJmol^{-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. (01mark)

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

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

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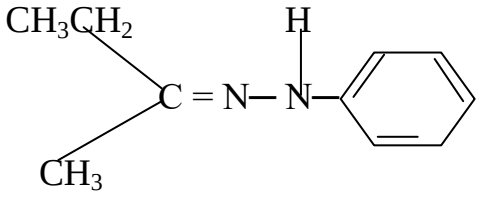
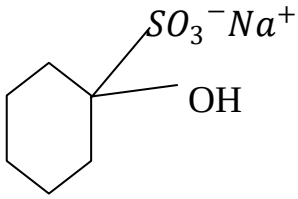
5. Write equations to show how the following conversions can be effected.

(a) bromobenzene from nitrobenzene (05marks)

(b)  from but- 1-ene (05marks)

(c) Aminoethane from propanal (05marks)

(d)  from phenol (05marks)

6. (a) What is meant by the term **standard electrode potential?** (01mark)

(b) (i) State and explain **two** factors that affect electrode potential of a metal. (03marks)

(ii) Describe how the standard electrode potential of iron can be determined in the laboratory. (07marks)

(c) The standard reduction potentials of some half- cells are given in the table below.

Half –cell reaction	Standard lectrode potential (V)
A: $Fe^{2+}(aq) + e \longrightarrow Fe(s)$	-0.44
B: $Cr_2O_7^{2-}(aq) + 6e + 14H^+(aq) \longrightarrow Cr^{3+}(aq) + 7H_2O(l)$	+1.33
C: $MnO_4^-(aq) + 5e + 8H^+(aq) \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$	+1.52
D: $Cl_2(g) + 2e \longrightarrow 2Cl^-(aq)$	+1.36

(i) State which species is the

- strongest reducing agent. (0½marks)
- strongest oxidizing agent. (0½marks)

(ii) Write the cell convention for the cell formed by combining the following half – cells:

- **A** and **B** (01marks)
- **C** and **D** (01marks)

(iii) State what would be observed at the cathode in each of the cells in (ii) above. (02marks)

(iv) Draw a labelled diagram for the cell formed by combining **B** and **C**.

(03marks)

(v) Calculate the standard free energy for the cell in (iv) above. (02marks

7. Explain each of the following observations

(a) When solid iodine crystals were added to s dilute sodium hydroxide solution , the grey solid dissolves to form a pale yellow solution which turns colourless on standing. (04marks)

(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. (04mark)

(c) When a mixture of anhydrous zinc chloride and concentrated hydrochloric acid was added to 2- methylpropan- 2- ol , immediate cloudiness was formed but there no observable change at room temperature if the same reagent was treated with propan- 1- ol. (4½marks)

(d) When aluminium was added to concentrated sodium hydroxide solution , the metal dissolved with effervescence of a colourless gas that burnt with a pop sound.. (3½marks)

(e) When methanoic acid was warmed with Fehling's solution a red precipitate was formed whereas with ethanoic acid , there was no observable change. (04marks)

8. (a) (i) What is meant by the term **ore**? (01mark)

(ii) Write the formula and name of **one** ore from which zinc is extracted. (01marks)

(b) Describe how pure zinc can be extracted from the ore in (a)(ii) above. (8marks)

(c) Describe the reaction of zinc with

\ (i) air (02marks)

(ii) sulphuric acid (4marks)

(iii) sodium hydroxide solution (2marks)

(v) copper(II) sulphate solution (2marks)

END

SECTIONA (46marks)

1. (a) Given the nuclear proc esses below:

$$^{212}_{82}Pb \xrightarrow{(1)} {}^{212}_{82}\boldsymbol{X} \xrightarrow{(2)} {}^{208}_{81}\boldsymbol{Y} \xrightarrow{\beta \text{ particle}} Z$$

Identify

(i) the emitted particles (1) and (2). (1½marks)

(1) …….

(2) …….

(ii) Z …… (01mark)

(b) Given that the decay constant of radium is $1.356 \times 10^{-11} s^{-1}$, calculate the time required for 80% of the sample of radium to disintegrate. (02½marks)

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2. (a) Define the term **first ionization energy** (1mark)

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(b) The table below shows the first four ionization energies in $KJmol^{-1}$ of the element A,B,C,D and E

Element	1st ionization energy	2nd ionization energy	3rd ionization enegry	4 th ionization energy
A	494	4600	9600	9500
B	740	1500	7740	10500
C	634	1600	3100	4800
D	900	1820	14800	21100
E	581	1820	2740	11600

(i) Which one of the elements belongs to groupI of the Periodic Table? Give a reason for your answer.
Element …… (½mark)

Reason (½mark)
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(ii) Which one of the elements forms a cation with three positive charges? (½mark)

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(iii) Identify the elements which belong to group II of the Periodic Table. (½mark)

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(iv) Which one of the elements in (iii) above has the smallest atomic radius. Explain your answer. (2marks)

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1. $10cm^3$ of a hydrocarbon **X** were mixed with $90cm^3$ of oxygen(excess) and the mixture ignited. The gaseous product was cooled to room temperature and the residual gases occupied a volume of $75cm^3$. On treatment with concentrated potassium hydroxide solution a contraction in volume of $40cm^3$ occurred.
(a) Calculate the molecular formula of **X**. (2½marks)

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(b) Write the structural formulae and IUPAC names of **X**. (3marks)

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4. (a) Define the term lattice energy (1 mark)

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(b) Calculate the lattice energy of sodium chloride from the following data. (4 marks)

	$\triangle H^{\theta}$/kJmol^{-1}
$Na(s) \longrightarrow Na(g)$	+109
$Na(g) \longrightarrow Na^{+}(g)$	+494
$Cl_2(g) \longrightarrow 2Cl(g)$	+242
$Cl(g) + e \longrightarrow Cl^{-}(g)$	-360
$Na(s) + ½Cl(g) \longrightarrow NaCl(s)$	-411

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5. State what was observed and write equation for the reaction when

(a) Copper turnings are added to moderately concentrated nitric acid. (3marks)

Observation

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Equation

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(b) Concentrated hydrochloric acid was added to lead(II) chloride drop-wise until in excess . (3marks)

Observation

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Equation

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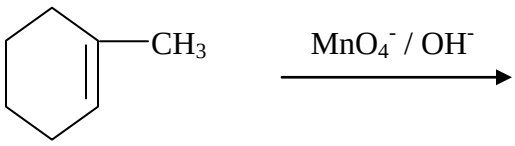
6. Complete the following reactions and in each case write the I.U.P.A.C names of the main organic product. (1marks each)

(a) 

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(b) $Br\ CH_2\ \underset{\displaystyle CH_3}{\underset{|}{CH}}\ CH_2\ CH_2\ Br \xrightarrow[\text{heat}]{EtO^- / EtOH}$

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(c) $CH_3\ \underset{\displaystyle CH_3}{\underset{|}{CH}}\ C \equiv CH \xrightarrow{H_2 / \text{Lindlar's catalyst}}$

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7. A 0.01M ammonia solution is 4% ionized .

(a) Write

(i) an equation for ionization of ammonia in water. (1marks)

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(ii) an expression for the base ionization constant , Kb for ammonia.(1mark)

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(b) Calculate the

(i) pH of the ammonia solution. ($Kw = 1.0 \times 10^{-14}\ mol^2dm^{-6}$) (1½marks)

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(ii) base ionization constant , Kb for ammonia. (2½marks)

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8. (a) Define osmotic pressure. (1mark)

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(b) A polysaccharide has the formula$(C_{12}H_{12}O_{11})_n$. A solution containing 5.00gdm^{-3} of the sugar has an osmotic pressure of 7.12x10^2 Nm^{-2} at 20^{o}C.
Find the value of n. (3½marks)

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9. The results of an investigation of a powdered element T are given in the table below.

Experiment	Results
(a) A mixture of T and lead(IV) oxide was heated.	A colourless gas with a choking smell and turned acidified potassium dichromate from orange to green was evolved.
(b) Concentrated nitric acid is added to heated T ; the products were diluted and barium nitrate solution added.	T dissolve in nitric acid with effervescence of a brown gas . on addition of barium nitrate solution a white precipitate was formed.

(i) Identify T. (1mark)

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(ii) Write equations for the reactions in experiments (a) and (b). (4½marks)

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SECTION B (54marks)

Attempt **all** questions in this section.

10. An organic compound **Z** , contains carbon , hydrogen and oxygen only. When vaporized at 101kPa and 373K , 0.10g of **Z** occupied a volume of 66.7cm^3. On combustion in excess oxygen , 1 mole of Z produced 2 moles of carbon dioxide and 3 moles of water.

(a) Calculate the relative molecular mass of **Z**. (2marks)

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. (b) Determine the molecular formula of **Z**. (3marks)

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(c) **Z** is a liquid at room temperature and reacts with metallic sodium to produce hydrogen gas. Identify **Z.** (1mark)

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(d) Write equation and suggest a mechanism for the reaction between **Z** and concentrated sulphuric acid at $140^{o}C$. (3markas)

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11. Carbon is in group(IV) of the Periodic Table but differs from the reaction of the elements of group(IV) elements.

(a) (i) State three properties in which carbon differs from the rest of the members of group(IV) elements. (3marks)

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(ii) Give a reason for answer. (1mark)

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(b) State what would observed and write equation for the reaction that would take place if any , when the following compounds are treated with water.

(i) tetrachloromethane (1mark)

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(ii) silicon (IV) chloride (2½marks)

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(c) Give a reason for your observation in b(i) and b(ii) above. (1½marks)

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12. (a) Sulphur dioxide and oxygen react to form sulphur trioxide according to the following equation.

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ $\triangle H = -96kJ$

State what would happen to the position of equilibrium and in each case give a reason if:

(i) the pressure of the system is increased. (1½marks)

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(ii) the temperature of the system was increased. (1½marks)

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(iii) air is added to the system. (1½marks)

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(b) At 800^oC and total pressure of one atmosphere ,the partial pressure of sulphur dioxide and oxygen at equilibrium are 0.22 and 0.48atmospheres respectively.

(i) Write an expression for the equilibrium constant ,Kp. (½mark)

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(ii) Calculate the equilibrium constant, Kp (2½marks)

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(c) Write equation for the reaction to show how sulphur dioxide is obtained from iron pyrites. (1½marks)

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13. Using equations only show how the following compounds can be synthesized

(a) Propan- 2- ol from propyne (3marks)

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(b) Phenylethene from benzene (3marks)

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(c) 1,2-dibromoethane from calcium carbide and dilute hydrochloric acid.

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14. The solubility product of calcium fluoride is $4.0 \times 10^{-11} mol^3 dm^{-9}$ and Ka of hydrogen fluoride is 5.6×10^{-4} $moldm^{-3}$

(a) What is meant by the terms:

(i) solubility product of a salt. (1mark)

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(ii) the acid ionization constant , ka for a weak acid. (1marks)

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(b) Calculate the solubility in $moldm^{-3}$ of calcium fluoride:

(i) in pure water (2marks)

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(ii) in 0.2M calcium nitrate solution. (2marks)

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(iii) in 0.2M hydrogen fluoride . (3marks)

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15. The electron affinities and atomic numbers of elements of group(VII) in thr Period Table are given in the table below.

Element	F	Cl	Br	I
Electron affinity ($Kjmol^{-1}$)	-328	-349	-325	-295
Atomic number	9	17	35	53

(a) Define the term **electron affinity**. (2marks)

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(b) (i) Draw a graph of electron affinity against atomic number of the halogens. (3marks)

(ii) Explain the shape of the graph you have drawn in b(i). (4marks)

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16. (a) State :

(i) **Distribution law.** (2marks)

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(ii) **two** applications of the law. (1mark)

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(b) Iodine is dissolved in water containing 0.16M potassium iodide , and the solution was shaken with tetrachloromethane . The concentration of iodine in the aqueous layer was found to be 0.08M ; that in the organic layer 0.1M .The partition coefficient for iodine between tetrachloromethane and water is 85. Calculate the equilibrium constant for the reaction:

$$I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$$

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17. (a) Explain what is meant by the terms:

(i) Buffer solution (1½marks)

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(ii) Hydrolysis of a salt. (1½marks)

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(b) Potassium propanoate hydrolyses in water

(i) Write equation for the hydrolysis of potassium propanoate

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(ii) Calculate the mass of potassium propanoate that must dissolved in water at 25^oC to form $200cm^3$ of solution with pH = 9.64

(Kw for water = 1.0×10^{-14} mol^2dm^{-6} . Ka for propanoic acid = 1.82×10^{-6})

(03marks)

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(c) Calculate the pH of a mixture of $20cm^3$ of 0.1M potassium propanoate and $30cm^3$ of 0.1M propanoic acid.

(Ka for propanonoic acid = 1.82×10^{-6} $moldm^{-3}$) (03marks)

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