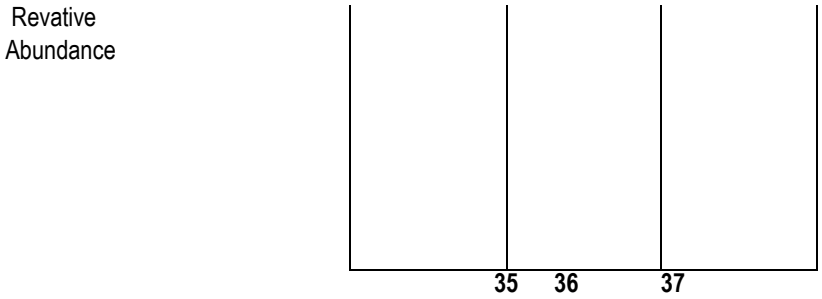
June 2009(Chemistry Paper 2)

Section A : physical and General chemistry

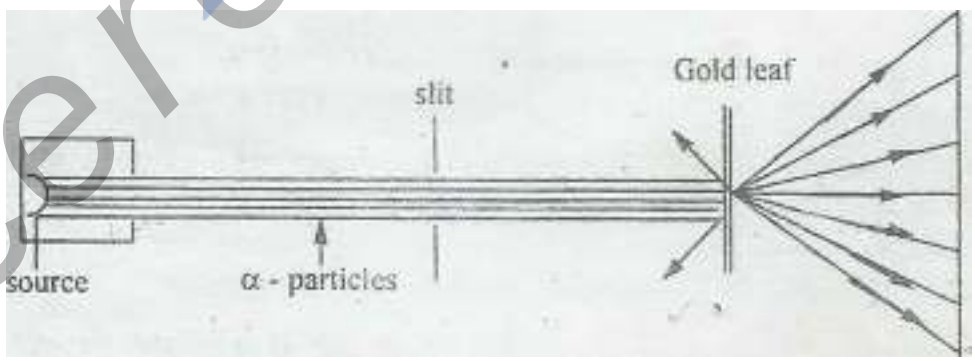
1. The diagram shows the mass spectrum of chlorine atomic number 17. The relative atomic mass of chlorine can be from the spectrum



a) i) What do you understand by "Relative atomic mass"?
ii) From the spectrum, give the masses of the two isotopes Isotope 1, Isotope 2,
(iii) Give the number of protons, neutrons and electrons in each isotope.

Isotope	Protons	Neutrons	Electrons
Isotope 1			
Isotope 2			

(iv) Given that the relative abundances are 75.53 and 24.47 percent respectively. Calculate the relative atomic chlorine.



b) Below is the diagram of the Rutherford gold-leaf experiment used in the structure of the atom

i) Give one possible source of α particles

(ii) State the mass and charge of the a-particles

iii) Give Two observations that were obtained from the experiment.

(iv) State FOUR conclusions that were obtained from Rutherford's experiment.

c) The first and second ionization energies of argon (atomic number 18) are 1521KJmol^{-1} and 2666KJ mol^{-1} respectively and for potassium (atomic number) 19 are 419 are 419KJmol^{-1} and 3051KJmol^{-1} respectively.

(i) Give Two reasons to explain the differences in the first and second ionization energies of
(ii) Argon,
(iii) Potassium
iii) Write the electronic configuration. Of the ion K^{2+} (using the spd notation)
(iv) What information can be obtained about the arrangement of electrons in atoms from ionization energies.

(2) You are given the following data:

Process	ΔH^{e}KJmoi^{-1}
A: $K_{(S)}$ —> K(g)	+ 90
B: Cl2(g) —> 2Cl(g)	+ 21
C: K(g) —>K^{+}(g)	+418
D :Cl(g) —> Cl^{-}	-364
E : K^{+}(g)→ K^{+}(aq)	-322
F: C^{l-} —> Cl^{-}(aq)	-364
G: K^{+}(aq) + Cl —> KCl(S)	- 701

a) (i) Use the d a t a to construct a Born Haber cycle tor the formation of potassium chloride.

(iv) What bonds are broken in the atomization of,
Potassium,
Chlorine

iv) Sketch a labelled diagram to show the type of bonding in solid potassium.

(v) Calculate the heat hydration for potassium chloride

b) i) Sketch the dot and cross models to represent the species $(CuCU)^{-2}$ and $NH_3.BF_3$
ii) Indicate in the model a dative covalent bond and a simple covalent bond

Sketch the shape and predict the bond angels of the species $NH_3.BF_3$

c) Hydrogen bonding is an example of an intermolecular force . Intermolecular forces influence the physical properties of . substances.

i) Why does water (H_2O) have H-bonding where as hydrogen sulphide (H_2S) has none? .

ii) In the table below state a named physical property and a named example where the intermolecular force he influenced the phvsical property

	Named physical property	**Specific example**
Van deer Waal forces		
Hydrogen bonding		

.

d) i) From the data below, draw an energy cycle diagram for the formation of propane (C_3H_8)-Calculate the heat of formation.

$\Delta H_c(C_3H_8)$ = -890KJmol^{-1}, $\Delta H(H_2)$ = **-286KJmol^{-1}** , ΔH_c [$C_{(s)}$] - 394KJmol^{-1}

iii) By what other mean could the ΔHf for propane be obtained?

3.

3)a) The peroxo disulphate ion ($S_2O_8^{2}$) reacts with iodide ions according to the equation

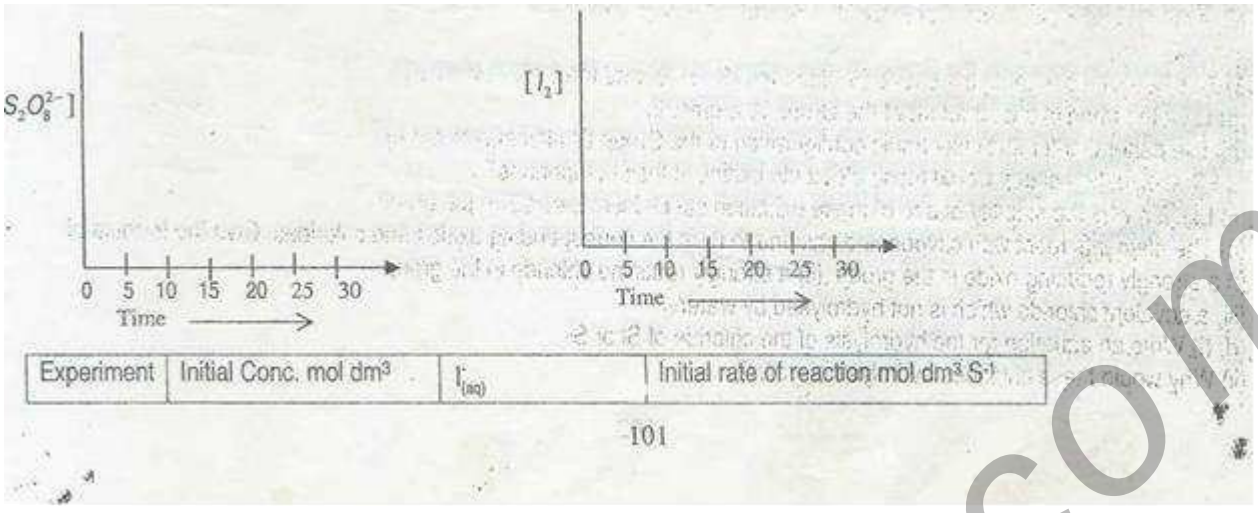
$$2I^-_{(aq)} + S_2O_8^{2-}{}_{(aq)} \rightarrow I_{2(aq)} + 2SO^{2-}{}_{4(aq)}$$

The progress of the reaction was followed by withdrawing aliquots (small samples) of the reaction mixture quenching them and titrating the sample with thiosulphate to obtain the amount of iodine produced at various times, as well as the concentration of the peroxodisulphate ion

i) What other method could be used to follow the progress of the reaction?
What variable will be measured?
(ii) Why is it necessary to "quench" the reaction?
(iii) How would you quench the reaction?

iv)In the space below, sketch how the concentration of reactant/product indicated will vary with time.

h. The experimental data obtained for the reaction id given below



Experiment	Initial concentration mol dm^{-3} [$S_2O_8^{2-}{}_{(aq)}$]	[I^- (aq)]	Initial Rate of reaction (mold dm^{-3} s^{-1})
1	3.8 x IQ^{-2}	3.0X10^{-2}	7.0 x10 ^{s}
2	7.6 x 10^2	3.0x10^{-1}	14.0 x 10^{-2}
3	7.6x10^{-2}	6.0X10^{-2}	28.0x10^{-s}

(i) What is the order of the reaction with respect to
(ii) $I^-_{(aq)}$
(iii) $S_2O_8^{2-}{}_{(aq)}$?

ii)Write the rate expression and the overall order of reaction

Rate expression .....

Overall order of Reaction .....

c) Give the following standard electrode potentials:

A. $I_{2(aq)}, 2I^-_{(aq)}$ /pt E° = +0.54 V
B. $S_2O_8^{2-}{}_{(aq)}$, $2SO^{2-}_4$ E° = +2.01 V

i) What is a standard electrode potential?
ii) Write the half equation for the reduction process in the equation of the kinetic study (in (a) above.
iii)Write diagram for the cell by linking the electrodes A and B.
iv) calculate the e.m.f of the cell
v)Name the instrument that could be used to measure the cell e.m.f. and give one main characteristic of the instrument .

instrument ……
characteristic ……..

d(i) What is an acid according to Bronsted-Lowry?

(ii) For of the following reaction, identify acid and its conjugate base

$HN0_3 + H_2S0_4 \rightarrow H_2N0_3^+ + HS0_4^+$

Acid…… Conjugate base……..

INORGANIC CHEMISTRY

4. This question concerns elements of the third period (Na to Ar) of the Periodic Table
(a) How does the first ionization energy vary across the period? Give an explanation for your answer

	Na	Mg	Al	Si	P	S	Cl	Ar
Formulae of oxides							Cl_2O_3 ClO_2 Cl_2O_7	
Acid-base character								

(ii) Why are the oxides of phosphorus and silicon solids at room temperature whereas the oxides of the other non-metallic elements are gases?

(iii) Write equations to show the reactions with water of the oxide of sodium, and any one oxide of chlorine

Oxide of Sodium ……..

(c) (i) Give the formulae of the covalent chlorides of the elements in the table.
(ii) Write an equation in each case to show the reaction of the chloride of silicon and a chloride of phosphorus with water.

Silicon …….

Phosphorus ……

(d) (i) With the exception of the hydride of chlorine what is the common chemical pro; y of the hydrides of these elements?
(ii) Write an equation for the reaction of the hydride of silicon with water

1 This question concerns the Group IV elements (C to Pb) and the s-block elements

(a) Give the trend in the structure of the Group IV elements

(b) The general outer shell electronic configuration of the Group IV elements is ns^2 np^2

(i) What oxidation states would these elements exhibit in their compounds?

(ii) Explain why the stability of one of these oxidation states increases down the group.

(c) The elements react with oxygen and chlorine to form the corresponding oxides and chlorides. Give the formula of

(i) a strongly reducing oxide in the group ,

(ii) a strongly reducing chloride in the group

(iii) a covalent chloride which is not hydrolysed by water.

(d) (ij Write an equation for the hydrolysis of the chloride of Si or Si.

(H) Why would these chlorides hydrolyse in water?

(e) Comment on the bonding anc tructure of the hydrides of the Group iV elements

(f) Li, Na, K, Rb, Be, Mg, Ca, Ba, and Sr are S-block elements.

(i) Why are these elements called S-block elements?

(ii) How would the elements Na, Be and Mg react with water?

Li and Mg show a diagonal relationship.

Explain the term diagonal relationship.

(i) Give two equations to illustrate this behavior.

(g) What is the trend in the solubility of the hydroxides of Group II?. Explain this trend.

(h) How would the nitrates of both groups behave when strongly heated?

6) This question concerns the Transition Elements and the Halogens (Group VII)

(a) (i) What is a transition element?

(ii) Compounds of Sc^{3+} and Zn^{2+} are not colored whereas those of V^{3+} are. Explain.

(iii) Explain the trend In atomic radius across the first Transition series of metals.

(iv) When aqueous ammonia is added drop wise to a solution of Cu(II) ions, a blue precipitate is observed which dissolves in excess aqueous ammonia. What two characteristic properties of transition elements are illustrated in td reaction?

(b) Transition meta! ions bond with ligands to form stable species (complexes).

(i) What is a ligand?,

(ii) Give an example of a bidentate ligand

(c) (1).Name the following complexes,

$[Co(en)_2Ci_2]^+$

$K_4Fe(CN)_6$

(ii) What types of isomerism will the complex, $[Co(en)_2Ci_2]^+$ exhibit?

(d) Explain the change in the physical state of the halogens as the group is descended.

(e) The halogens undergo disproportionation reactions.

(i) What is a disproportionation reaction?

(ii) Show that the reaction between iodine and aqueous sodium hydroxide is a disproportionation reaction.

(f) The hydrogen halides are gases which fume in moist air and dissolve in water to form acidic solutions.

(i) How would you prepare a sample of hydrogen iodide?

(ii) Arrange the hydrohalic acids (HX) in order of their decreasing acid strength starting with the most acidic. Explain the order.

ORGANIC CHEMISTRY

7) 1.0 g of an organic compound A containing carbon and hydrogen only, on analysis gave 0.86 g of carbon and 0.14 g of hydrogen. On treating A with acidified water, a compound B of molecular mass 74 was obtained. The reacts of B with concentrated sulphuric acid at 170°C give compound A.

(a) (i) Calculate the empirical formula of A.
(ii) Is compound A likely to be an alkane or an aikene? Give reasons.
(iii) From the reaction that produces B, deduce the molecular mass of A
(iv) Deduce the molecular formula of A.
(v) Compound A exhibits stereoisomerism. Draw and label the isomers,
(b) Ethene is obtained on a large scale from the process of cracking in the petrochemical industry.

(i) What is cracking?

(ii) Write the equation of a reaction in which ethene is obtained by cracking

(iii) Write the equations of TWO important reactions of ethene which make it important industrially and in every day life.

(iv) What TWO environmental problems do these industrial uses of ethene cause?

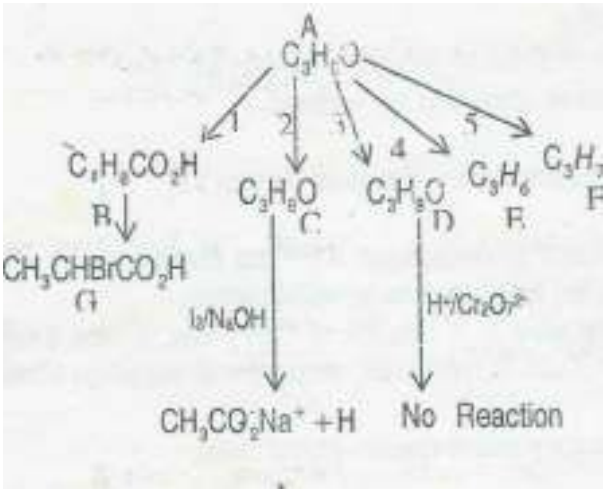
(c) Consider the alkene $CH_3CH=CHC_2H_5$.

(I) Give the reagents or series of reagents that will convert it into a ketone, and give the systematic name of the keton

(ii) Give one general method of preparing the alkene above

(iii) How can the presence of an alkene bond be tested? Give reagents, conditions and results.

8.The compound A, C_4H_8O, is an alcohol. Answer the questions based on the properties and reactions of this



i) Give the general formula of aliphatic alcohols.

(ii) Give the formulae of the first two members of the homologous series of compound A.

(iii) What type of hybridization exists in the carbon atoms of A?

(iv) What is the geometry associated with the carbon in the compound?

(b) With reference to the series of reactions of compound A, above

(i) Give the systematic name of compound B.

(ii) Draw the structures of C and D.

(iii) Identify a reaction that is a dehydration and give the reagents and reaction conditions for the reaction, Dehydration Reagents and reaction conditions

(iv) Identify a reaction that is an oxidation process and give the reagents and reaction conditions of oxidation.

(v) identify the compound H giving its formula

c) In step (5), hydrogen halide is bubbled through the alcohol under reflux.

(i) Give TWO reasons why it is necessary to carry out the reaction under reflux .

This halogenation takes place in THREE steps, write the three steps

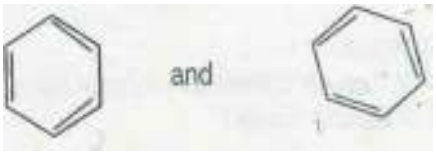
ii) What type of mechanism is involved in these halogenations?

(d) B can be converted to G which is optically active

(i) Give the reagents required for the conversion of B to G

(ii) Draw the isomers of compound G, putting an asterix on the asymmetric carbon atom (s).

9.) The benzene molecule can be represented by the structures



a) Suggest one evidence that shows that the chemistry of benzene cannot be explained on the basis of the structures above.

b) Benzene undergoes electrophilic substitution to produce nitrobenzene.

ii) Identify the electrophile.

(iii) Give the reagents and reaction conditions for the nitration of benzene.

(iii) Outline the mechanism for the nitration reaction

(vi) Further nitration to the dinitro-product is difficult. Give the structure of the possible product on further nitration and explain why this is difficult.

(c) Nitrobenzene is used to produce aniline $C_6H_5NH_2$ which is basic
(d) Give the reagents and reaction conditions for this conversion.
(i) Why are amines basic?
(iv) What separation technique would you use to obtain a pure sample of aniline in the reaction in (ci) above?

(vii) Arrange of the following nitrogen-containing compounds, in order of increasing base strength. Explain your reasoning.
$C_6H_5NH_2$ $C_6H_5NH_2$ CH_3NH_2 ?

Trend:

Explanation:

(e) Aniline reacts with aqueous sodium nitrite ($NaN0_2$) and dilute hydrochloric acid (HCl). The resulting solution reacts with a solution of 2-naphthol in aqueous sodium hydroxide.

(i) Give the equation for the reaction of aniline with aqueous sodium nitrite and dilute - hydrochloric acid, giving the reaction conditions, and name of the organic product.

(ii) Draw the structure of the product which is formed on reaction with 2-naphthol.

(iii) What name is given to the reaction occurring in (d) (ii)?

(iv) What is the significance of the compounds of the type produced by the reaction in (d) (ii)?