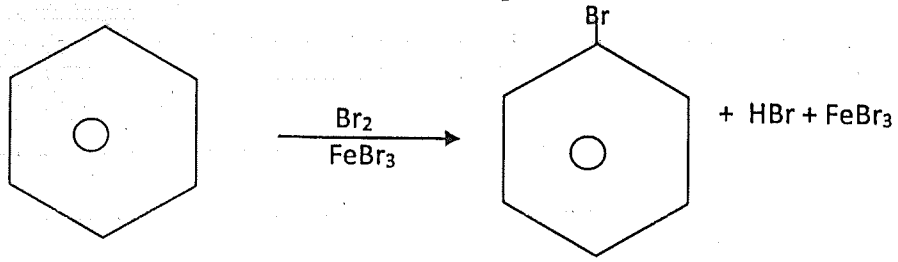
4mks)

(b) (i) Arrange the following compounds in order of their reactivity towards electrophiles such as E^+(putting the most reactive first): Benzene, Phenol, Nitrobenzene; and explain.

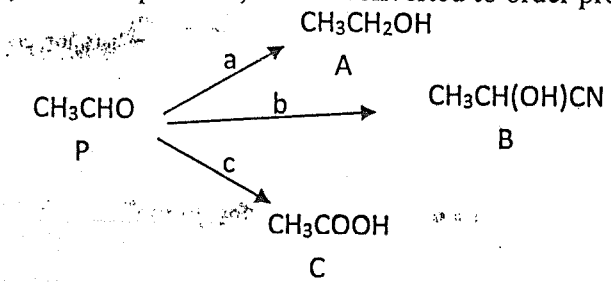
Order: ----------

Explanation: ----------

(ii) Write the mechanism for the following reaction.



(c) The compound P, can be converted to order products according to the scheme below.



(i) Give the reagents and reaction conditions for the conversions, a, b and c.

Conversion	Reagents	Reaction conditions
a		
b		
c		

(ii) Write the mechanism for the formation of B. ----------

(iii) Write the equation for the reaction of compound A with concentrated sulphuric acid at 170 °C. ----------

(iv) Name the reaction that occurs between compounds C and A. ----------
---

(7mks)

(d) Organic compounds can be classified according to their functional group.

(i) Define the term "functional group". ----------

(ii) Write an equation for the reaction between Bromoethane (CH_3CH_2Br) and each of the following compounds.

A: Potassium cyanide. ----------

B: Aqueous sodium hydroxide ----------

(3 mks)

PROPOSED ANSWERS

SET 1: SECTION A (CGCEB 2009)

Physical And General Chemistry

1. (a) (i) The number of times the average mass of one atom of the element is as heavy as than one twelfth ($^1/_{12}$) the mass of one atom of carbon-12 isotopes.

(ii) Mass of **isotope 1** = 35 and mass **isotope 2** =37

(iii)

Isotopes	Protons	Neutrons	Electrons
Isotope1	17	18	17
Isotope 2	17	20	17

(v) $\frac{35\times75.53+37\times24.47}{100} = 35.5$

(b) (i) Radium

(ii) Mass=4 and charge +2

(iii) *most of the α-particles passed through the gold foil undeflected

*Few of the α-particles bounced toward the source

*Some of the α-particles where deflected through an angle greater than 90°

(iv)

- Since α-particles are positively charge, those that bounced back toward the source has a direct impact with the concentrated positive charge nucleus
- Most of the α-particles pass through the gold foil undeflectedd implying that the atom is made up of empty space which is large compare to the small region of the positive charge
- Most of the particles were deflected through larger angle implying large positive charge (large force)

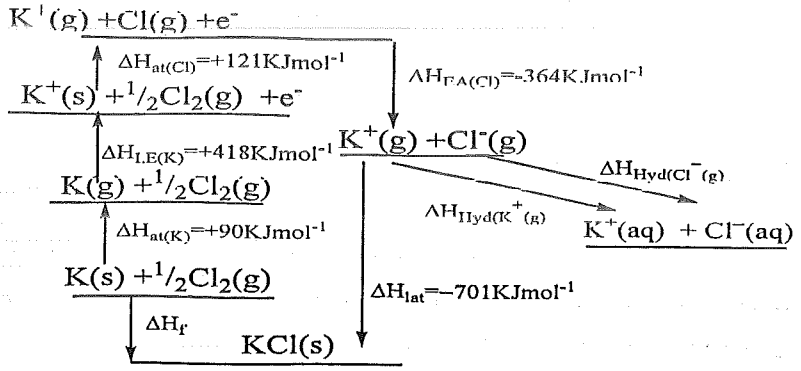
(c) (i) **Argon:** There is no significant difference between the first and the second ionisation indicating that the electrons are knocked off from the same shell, the second is higher than the first this is because the same nuclear charge is attracting fewer electrons after the first has been removed (or increase in effective nuclear charge after the first electron has been removed)

Potassium: There is greater difference between the first and the second ionisation energy in potassium because the electrons are removed from different shells. After the remover of the first electron, there is an increase in effective nuclear charge coupled with a stable octet structure assumed. This makes the second ionisation energy greater than the first.

(iii) $1s^2 2s^2 2p^6 3s^2 3p^5$

(iv) It gives information about the existence of shells and sub-shells in an atom. The group and period of an element can also be obtained from ionisation energy graph.

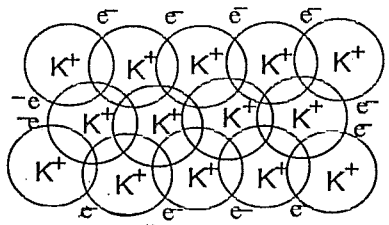
2. (a) (i)



(ii) **Potassium:** metallic bond

Chlorine: covalent bond

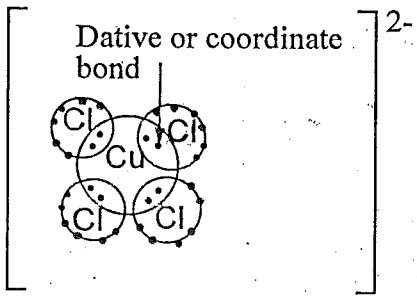
(iii)

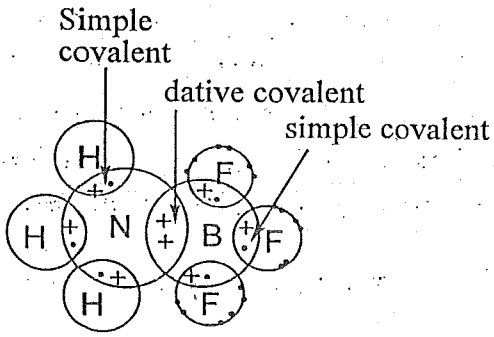


(iv) $\Delta H_{hyd\left(K^+_{(g)}\right)} + \Delta H_{hyd(Cl^-_{(g)})}$

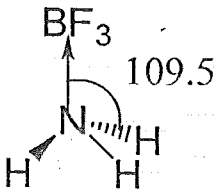
$-364 kJmol^{-1} + -322 KJmol^{-1} = -686 KJmol^{-1}$

(b) (i)





(iii)

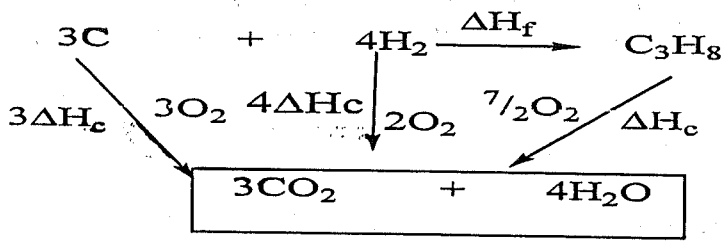


(c) (i) Because oxygen is highly electronegative than sulphur hence it will turn to pull bonded pair of electrons more to itself making hydrogen to behave as if it has an empty orbital to attract lone pair of electrons from another oxygen atom of water molecule.

(ii)

	Named physical properties	Specific examples
Van der waal force	solid	Iodine is a solid due to increase in van der waal force
Hydrogen bonding	Melting and boiling point	Water has a high boiling point than other group VI hydride. Or ammonia has a high boiling point than other group V hydride due to hydrogen bonding *HF has a high boiling point due to hydrogen bonding

(d) (i)



$4\Delta H_{c(H_2)} + 3\Delta H_{c(C)} = \Delta H_f + \Delta H_{C(C_2H_6)}$

$4\Delta H_{c(H_2)} + 3\Delta H_{c(C)} - \Delta H_{C(C_2H_6)} = \Delta H_f$

$4(-286) + 3(-394) - (-890) = -1436 K]mol^{-1}$

(ii) By standard enthalpy of atomisation

Or bond energy term

---

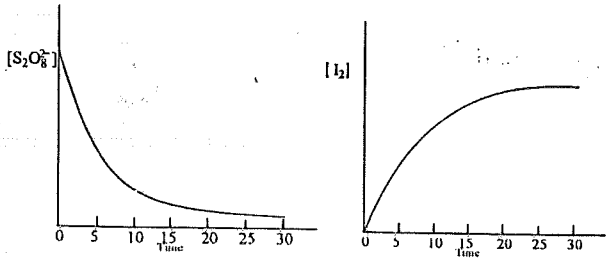
3. (a) (i) Colorimetry or conductivity method

(ii) Colorimetry: change in colour intensity with time

Conductivity method: The variation in electrical conductivity with time (or resistance with time)

(ii) To slow down or to stop the reaction so that the concentration at that time "t" can be determine

(iii) Add the sample to ice water in conical flask before titration.



(b) (i) From exp't (2) and (3) the conc. of I^- is double and the rate doubles thus the order is 1st order w.r.t I^-

From exp't (1) and (2) The conc. of $S_2O_8^{2-}$ is double and the rate is double hence 1st order w.r.t $S_2O_8^{2-}$

(ii) rate = $K[I^-]^1[S_2O_8^{2-}]^1$ the overall order is 1+1−2. i.e. 2nd order overall

(c) (i) It is the e.m.f of the cell measured between a standard hydrogen electrode and the standard half cell in a 1M solution of the ions at 298K and 1atm

(ii) $S_2O_{8(aq)}^{2-} + e^- \rightarrow 2SO_{4(aq)}^{2-}$

(iii) $Pt/2I_{(aq)}^-, I_{2(aq)} :: S_2O_{8(aq)}^{2-}, SO_{4(aq)}^{2-}/Pt$

(iv) $e.m.f = 2.0 - 0.54 = +1.47V$

(v) Valve volt meter or high resistant volt meter or potentiometer.

Characteristics: To draw little current from the cell.

(d) (i) proton donor

(ii) acid; H_2SO_4 conjugate; HSO_4^-

SET 2: SECTION A (CGCEB 2010)
Physical And General Chemistry

1. (a)(i) Small, dense, positive charge portion of an atom.

(ii) The number of protons in the nucleus of an atom OR the number of electrons in a neutral atom.

(iii) Atoms of the same element with same atomic numbers but different mass number due to differences in the number of neutrons.

(b) (A) It gives information about the fragmentation pattern and the molar mass of a compound or the relative abundance of all the isotopes present in the atom.

(B) The energy levels and the ionisation energy in atom.

(ii) (A) Produce high energy electron which help to ionise the vaporised sample.

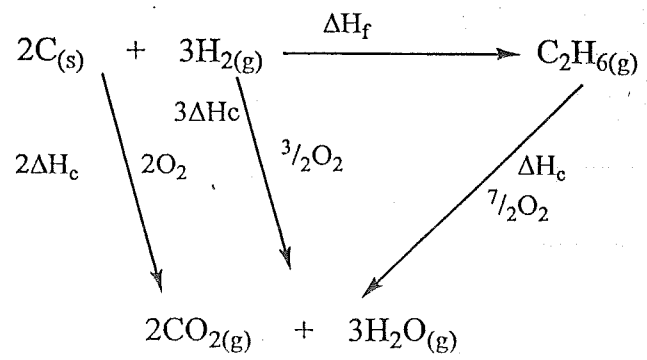
(B) To deflect the ions of sample base on their mass to charge ratio (m/e)

(iii) $\frac{(114\times20)+(21\times0.2)+(22\times11.2)}{114+0.2+11.2} = 20.2$

(iv) 10 protons and 12 neutrons

(c) (i) The enthalpy change accompanying a chemical reaction is the same and independent of the route taken by the chemical reaction provided the initial and final physical conditions of the reaction remain the same.

(ii)

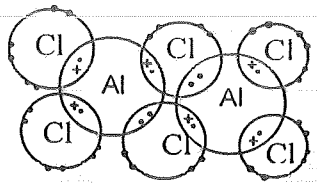


(iii) $2\Delta H_{C(C)} + 3\Delta H_{C(H_2)} = \Delta H_f + \Delta H_{C(C_2H_6)}$

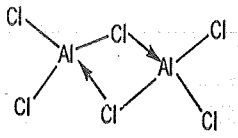
$$2(-394) + 3(-286) = \Delta H_f - 1559.7$$

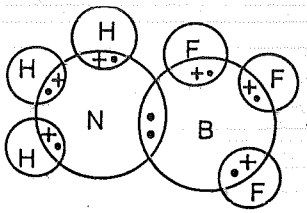
$$2(-394) + 3(-286) + 1559.7 = \Delta H_f = -86.3 KJmol^{-1}$$

(d) (i)

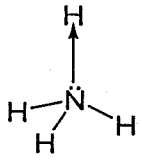


OR



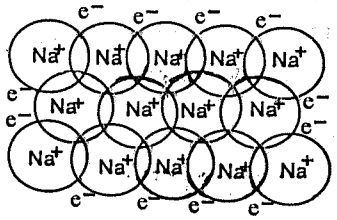


$H_3N \rightarrow BF_3$



Or

(ii)



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2. (i) In homogeneous catalysis, the catalyst, reactant and product are of the same phase while in heterogeneous catalysis, the catalyst, reactant and product are of different phases.

(ii) Initiation step, propagation step, and termination step.

(iii) Increase in concentration, increases the number of reactant particles per unit volume. This increase in the number of effective collision thus increase in the rate of reaction

(b) (i) It states that " A dissolved substance, irrespective of its amount, distributes itself between two non-miscible solvents in such a way that at equilibrium, the ratio of the concentrations of the substance in the two layers is constant at any given temperature'' OR If a solutes X distribute itself between two immiscible solvent A and B at constant temperature, and X is in the same molecular condition in both solvents, then $\frac{\text{concentration of X in A}}{\text{conentration of X in B}} = K_D$ where K_D = partition coefficient

(ii) It is a solution with similar intermolecular forces in the separate liquid components and in the solution. Or a solution in which there is no chemical interaction between the molecules. Or a solution that obey Raoult's law perfectly at all solute concentration.

(iii) A constant boiling point mixture with the same composition (mole fraction) in the vapour as in the liquid

(c) (i) (X) Thermometer

(Y) Stirrer

(ii) $NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

or $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$

(iii) (I) Neutralisation continues on each addition of NaOH, with the release of heat energy. Neutralisation is complete when $14cm^3$ is added

(II) Neutralisation is complete and heat is lost to the environment.

(iv) $8cm^3$

---

3. (a) (i) (A) Sn (the species with the most negative electrode potential value)

(B) MnO_4^- (the species with the most positive electrode potential value)

(C) Valve volt meter or potentiometer or high resistant volt meter.

(D) *To complete the electrical circuit by allowing ions carrying charges to move from one half cell to another

* It provides cations and anions to replace those consumed at the electrodes and balance the charge of any ion formed at the electrode.

(ii) (I) $E_{RHs} - E_{LHS}$

$$1.5 - -0.14 = +1.65V$$

(II) It is an inert electrode which conducts electrons to the ion-ion half cell.

(iii) (I)

$$2MnO^-_{4(aq)} + 5Sn_{(s)} + 16H^+_{(aq)} \rightarrow 2Mn^{2+}_{(aq)} + 5Sn^{2+}_{(aq)} + 8H_2O_{(l)}$$

(II) They will move from the left electrode (Sn half cell) to the right electrode (MnO_4^- half cell)

(b) (i) A weak acid is an acid which ionises only partially in solution e.g. ethanoic acid, lactic acid, carbonic acid. A strong acid is an acid which ionises completely in solution e.g. sulphuric acid, hydrochloric acid, nitric acid

(ii)

$$CH_3CH_2COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3CH_2COO^-_{(aq)} + H_3O^+_{(aq)}$$

$$K_a = \frac{[CH_3CH_2COO^-_{(aq)}]_{eqm}[H_3O^+_{(aq)}]_{eqm}}{[CH_3CH_2COOH_{(aq)}]_{eqm}}$$

(iii) $P^H = -\log\sqrt{Ka[CH_3CH_2COOH]}$

$$P^H = -\log\sqrt{0.1 \times 1.3 \times 10^{-5}} = 2.94$$

(e) (i) A buffer is a solution which resist pH change upon addition of slight amount of acid or base.

(ii) An acid buffer

(d) (i)

$$CH_3CH_2COO^-_{(aq)} + H^+_{(aq)} \rightleftharpoons CH_3CH_2COOH_{(aq)}$$

(ii)

$$CH_3CH_2COOH_{(aq)} + OH^-_{(aq)} \rightleftharpoons CH_3CH_2COO^-_{(aq)} + H_2O_{(l)}$$

(e) $-\log Ka + \log\frac{[salt]}{[acid]} \Longrightarrow P^H = -\log(1.3 \times 10^{-5}) - \log\frac{[0.1]}{[0.1]} = 4.89$

SET 3: SECTION A (CGCEB 2011)
Physical And General Chemistry

1. (a) mass needed $= \frac{\text{vol}\times M\times RMM}{1000} = \frac{0.025\times250\times134}{1000} = 0.8375\text{ g}$

0.8375 g of $Na_2C_2O_4$ is measured using a sensitive balanced and dissolved in a $250cm^3$ volumetric flask. The volume of the solution is made up to 250 make using distilled water. The flask is corked and shaken. This gives a $0.025moldm^{-3}$.

(b) (i) molar mass of ozone $=3\times16=48g$

$48g\ of\ O_3\ contain\ 6.02\times10^{23}\ atoms$

18g will contain $\frac{18\times60\times10^{23}}{48} = 2.2575\times10^{23}$ atoms

(ii) N° of moles of $Ca(NO_3)_2 = \frac{10}{164} = 6.1\times10^{-3}mol$

eqn $Ca(NO_3)_2 \rightarrow Ca^{2+} + 2NO_3^-$

N°of mole of NO_3^- ions $= 2\times6.1\times10^{-2} = 0.122$ mol

1mol of NO_3^- contains 6.02×10^{23} ions

0.122 mol will contain $\frac{0.122\times6.02\times10^{23}}{1} = 7.34\times10^{22}$ ions

(b) (i)

	N	O
	$\frac{30.51}{14} = 2.1793$	$\frac{69.49}{16} = 4.3431$
Mol ratio	$\frac{2.1793}{2.1793} = 1$	$\frac{4.3431}{2.1793} = 1.99 \approx 2$
E.f.	N_1O_2	

(ii) density $(\rho) = \frac{\text{mass(m)}}{\text{Volume(V)}} \Longrightarrow m = \rho V$

at s. t. p, $\rho = 0.0041gcm^{-3} \Longrightarrow$

$m = 0.0041gcm^{-3}\times22400cm^3 = 91.84g$

(iii) $(14+16\times2)n = 98.84 \Longrightarrow$

$(46)n = 91.84 \Longrightarrow n = \frac{91.84}{46} = 1.998 \approx 2$

$Mf = N_2O_4$

(c) (i) To produce a beam of high energy electron which bombard the gaseous atom generating positive ions

(ii) To accelerate the positive charge ions toward the magnetic field.

(iii) To deflect the positive charge ions according to their mass to charge ratio (m/e)

(d) (i) The enthalpy change accompanying a chemical reaction is the same independent of the route taken (from reactants to products) provided the initial and final physical conditions remain the same.

(ii) (A) $Na^{+}_{(g)} + Cl^{-}_{(g)}$

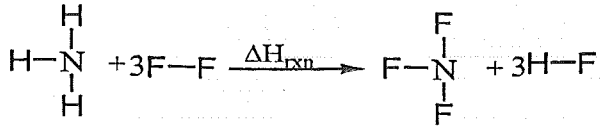
(B) $NaCl_{(s)}$

(C) $Na^{+}_{(aq)} + Cl^{-}_{(aq)}$

(iii) $\Delta H_{Sol} = \Delta H_{lat} + \Delta H_{hyd} \Rightarrow 788 - 784 = +4 kJmol^{-1}$

(iv) It will be less than that of the sodium chloride since the enthalpy of hydration of bromide ion is less than that of chloride ion due to larger ionic size in the bromide

(v) Method 1

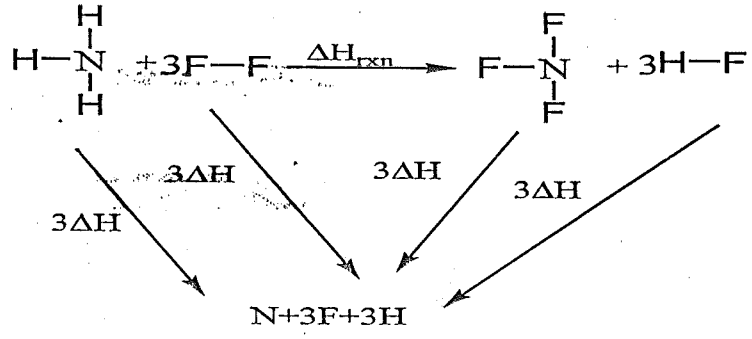


$$\sum \Delta H_{reactant} = 3(388) + 3(158) = 1638 KJmol^{-1}$$

$$\sum \Delta H_{product} = 3(562) + 3(272) = 2502 KJmol^{-1}$$

$$\Delta H_{reaction} = \sum \Delta H_{reactant} - \sum \Delta H_{product} = 1638 - 2502 KJmol^{-1} = -864 KJmol^{-1}$$

Method 2



By applying Hess's law

$3\Delta H_{disNH_3} + 3\Delta H_{disF_3}$

$= 3\Delta H_{disNF_3} + 3\Delta H_{dis\ HF} + \Delta H_{reactant}$

$3(388) + 3(158) = 3(562) + 3(272) + \Delta H_{reaction}$

$1638 KJmol^{-1} = 2502 KJmol^{-1} + \Delta H_{reaction}$

$\Delta H_{reactant} = 1638 KJmol^{-1} - 2502 KJmol^{-1} = -864 KJmol^{-1}$

---

2. (a) (i) It is an equilibrium process in a chemical reaction in which the concentration of reactant and product are constant and the rate of forward and backward reaction taking place are equal.

(ii) (A) The system must be closed

(B) The temperature must be constant

(iii) (A) The equilibrium will shift to the left to counteract the change to give more reactants since there are two moles of gaseous product and one mole of gaseous reactant

(B) The reaction is endothermic thus equilibrium constant will increase since PCl_5 will dissociate to increase the yield of PCl_3 and Cl_2

(iv) $Kc = \frac{[PCl_3]_{eqm}[Cl_2]_{eqm}}{[PCl_5]_{eqm}}$

$$\frac{mol.dm^{-3}.mol.dm^{-3}}{mol.dm^{-3}} = mol.dm^{-3}$$

(b) (i) MM of $PCl_5 = 35.5 \times 5 + 31 = 208.5g$