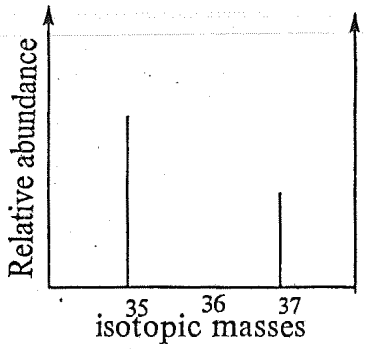
PART II

GENERAL AND PHYSICAL CHEMISTRY

SET 1 : SECTION A (CGCEB 2009)

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



(a) (i) What do you understand by "*relative atomic mass*"?----------

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(ii) From the spectrum, give the masses of the isotopes

Isotope 1----------

Isotope 2----------

(iii) Give the number of protons, electrons, and neutrons in each isotope

Isotopes	protons	electrons	neutrons
Isotope 1			
Isotope 2			

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

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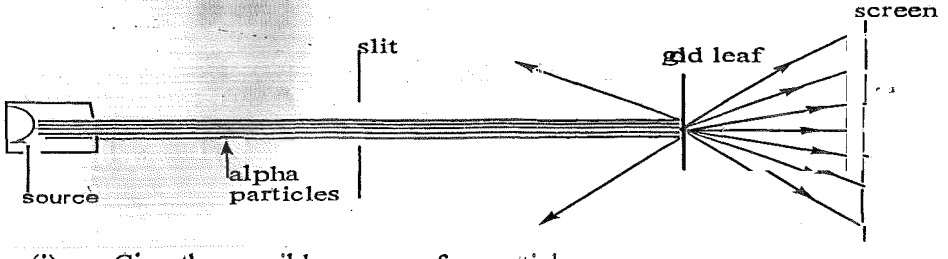
(6 marks)

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



(i). Give the possible source of α-particles ----------

(ii). State the mass and charge of the α-particles----------

(iii). Give TWO observations that were obtained from the experiment

(Observation1) ----------

Directions summarised			
	FIRST STATEMENT	SECOND STATEMENT	
A	TRUE	TRUE	Second statement is a CORRECT EXPLANATION of the first
B	TRUE	TRUE	Second statement is NOT a CORRECT EXPLANATION of the first
C	TRUE	FALSE	
D	FALSE	TRUE	

FIRST STATEMENT	SECOND STATEMENT
46. $HClO_4$ is a stronger acid than $HClO_3$	The higher the oxidation state of the chlorine atom, the more electron density it pulls from the O-H bond and the more easily the proton is lost.
47. An aqueous solution of sodium ethanoate is likely to be alkaline (pH >7)	Sodium ethanoate is an electrolyte and ionizes completely in aqueous solution.
48.Beryllium and aluminum are diagonally related	Beryllium and aluminum have similar electronegativities.
49.Pentane has a higher boiling point than n-butane	Pentane has more branched chain isomers than butane
50.Ionic compounds are usually insoluble in non-polar solvents	When an ionic compound dissolves in a polar solvent the solvation energy is higher than the lattice energy.

(Observation 2) ----------

(iv). State four conclusions that were obtained from the experiment

1st----------

2nd----------

3rd----------

4th----------

(8 marks)

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

(i). Give TWO reasons to explain the differences in the first and second ionisation energies of

Argon----------

Potassium----------

(ii). Write the electronic configuration of the ion K^{2+} (using the spd notation)----------

(iii) What information can be obtained about the arrangement of electrons from ionisation energies? ----------

6 marks (Total 20 marks)

2. You are given the following data:

Process	ΔH^{θ} KJ mol^{-1}
A. $K_{(s)} \longrightarrow K_{(g)}$	+ 90
B. $Cl_{2(g)} \longrightarrow 2Cl_{(g)}$	+ 121
C. $K_{(g)} \longrightarrow K^{+}_{(g)}$	+ 418
D. $Cl_{(g)} \longrightarrow Cl^{-}_{(g)}$	− 364
E. $K^{+}_{(g)} \longrightarrow K^{+}_{(aq)}$	− 322
F. $Cl^{-}_{(g)} \longrightarrow Cl^{-}_{(aq)}$	− 364
G. $K^{+}_{(g)} + Cl^{-}_{(g)} \longrightarrow KCl_{(s)}$	− 701

(a) (i) Use the data to construct a Born-Haber cycle for the formation of potassium chloride

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(ii). What bonds are broken in the atomisation of

Potassium?----------

Chlorine? ----------

(iii). Sketch a labelled diagram to show the type of bonding in solid potassium----------

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(iv). Calculate the heat of hydration for potassium chloride ----------

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6 marks

(b) (i) Sketch the dot and cross models to represent the species $(CuCl_4)^{2-}$ and $NH_3.BF_3$

(ii). Indicate in the models a dative covalent bond and a simple covalent bond

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(iii). Sketch the shape and predict the bond angles of the species NH_3, BH_3. ----------

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5marks

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

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

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(ii). In the table below state a named physical property and a named example where the intermolecular force has influenced the physical property.

	Name physical property	Specific example
Van der Waal force		
Hydrogen bonding		

5marks

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

$\Delta H_C^\theta(C_3H_8) = -890\ kJ\ mol^{-1}, \Delta H_c^\theta(H_2) = -286\ kJ\ mol^{-1}, \Delta H_{at}^\theta(C_{(s)}) = -394 kJ mol^{-1}$ ----

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(ii) By what other means could the ΔH_f for propane be obtained?----------

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4marks

(Total 20 marks)

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

$$2I^-_{(aq)} + S_2O^{2-}_{8(aq)} \longrightarrow I_{2(aq)} + 2SO^{2-}_{4(aq)}$$

The progress of the reaction was followed by withdrawing aliquots (small samples) of the reaction mixture, quenching them and titrating the samples 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?----------

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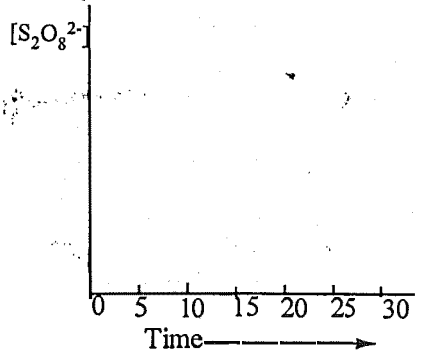
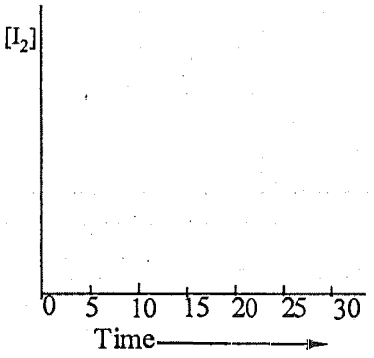
What variable will be measured? ----------

(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/ and product indicated will vary with time.





8 marks

(b) The experiment data obtained for the reaction is given below

Experiment	Initial concentrations (mol dm^{-3})		Initial rate of reaction
	$[S_2O^{2-}_{8(aq)}]$	$[I^-_{(aq)}]$	(mol $dm^{-3}s^{-1}$)
1	3.8×10^{-2}	3.0×10^{-2}	7.0×10^{-6}
2	7.6×10^{-2}	3.0×10^{-2}	14.0×10^{-6}
3	7.6×10^{-2}	6.0×10^{-2}	28.0×10^{-6}

(i). What is the order of the reaction with respect to

$I^-_{(aq)}$? ----------

$S_2O^{2-}_{8(aq)}$?----------

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

Rate expression ----------

Overall order of the reaction ----------

4 marks

(c) Given the following standard electrode potentials:

A. $I_{2(aq)}, 2I^-_{(aq)}/Pt$ $E^\circ = +0.54V$

B. $S_2O^{2-}_{8(aq)}, 2SO^{2-}_{4(aq)}/Pt$ $E^\circ = +2.01V$

(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 the cell diagram for the cell made by linking the electrodes A and B ----------

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(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 characteristics of the instrument

Instrument ----------

Characteristic----------

6 marks

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

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

$HNO_3 + H_2SO_4 \rightarrow H_2NO^+_3 + HSO^-_4$

Acid----------conjugate----------

2 marks

(Total 20 marks)

SET 2 : SECTION A (CGCEB 2010)

General and Physical Chemistry

1. (a) Explain the following terms as applied to the atom

(i). The nucleus ----------

(ii). Atomic number ----------

(iii). Isotope ----------

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3 marks

(b) (i) What information is obtained from the following about the structure of the atom?

(A). Mass spectrum ----------

(B) The line emission spectrum----------

(ii). In the mass spectrometer, what is the function of

(A). The electron gun ----------

(B). The magnet ----------

(iii) Calculate the relative atomic mass of neon given the following data

^{20}Ne: = 114, ^{21}Ne: = 0.2 and ^{22}Ne: = 11.2

(iv) How many protons and neutrons are contained in $^{22}_{10}Ne$? ----------

11 marks

(c) (i) State Hass's law ----------

(ii). Construct an enthalpy diagram that could be used to calculate the enthalpy of formation of ethane from carbon and hydrogen ----------

(iii). Given that: $C_{(S)} + O_{2(g)} \longrightarrow CO_{2(g)}$ $\Delta H_c^\theta = -394\ kJ\ mol^{-1}$

$H_{2(g)} + \frac{1}{2}O_{2(g)} \longrightarrow H_2O_{(l)}$ $\Delta H_c^\theta = -286\ kJ\ mol^{-1}$

$C_2H_{6(g)} + \frac{7}{2}O_{2(g)} \longrightarrow 2CO_{2(g)} + 3H_2O_{(l)}$ $\Delta H_c^\theta = -1559.7\ kJ\ mol^{-1}$

Calculate the enthalpy of formation of ethane ----------

4 marks

(a) Draw and label the diagram of a species with

(i). A dative covalent bond ----------

(ii). A metallic bond ----------

2 marks

(Total: 20 marks)

2. (a) (i) Distinguish between homogenous and heterogeneous catalysis ----------

(ii). What three steps are involved in a chain reaction? ----------

(iii). How does the collision theory explain the increase of rate of reaction with concentration? ----------

6 marks

(b) (i) State the distribution law (or partition law) of a solute between two immiscible solvents? ----------

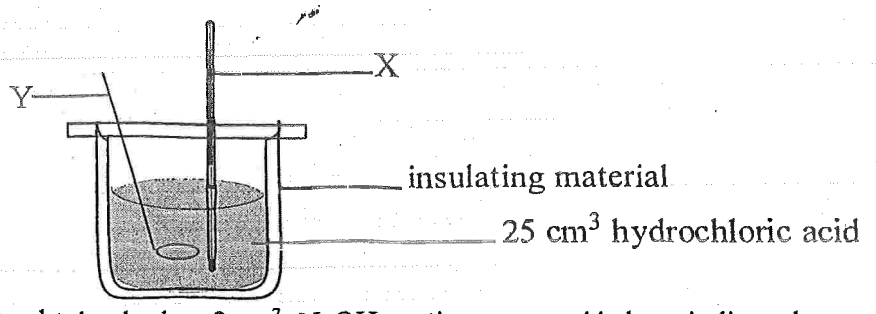
(ii). What is mean by

(I). ideal solution ----------

(II). Azeotropic mixture? ----------

6 marks

(c) In order to determine the heat of neutralization of sodium hydroxide and hydrochloric acid of concentration 1 mol dm^{-3}, the set up below was used.



The results obtained when 2 cm^3, NaOH portions were added are indicated.

Volume of NaOH(aq)/cm^3	2	4	6	8	10	12	14	16	18
Temperature rise °C	1.6	3.7	6.0	8.4	10.2	11.9	12.2	11.0	9.0

(i). Label:

X. ----------

Y. ----------

(ii). Write a balanced equation for the reaction taking place ----------

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(iii). Why is there:

(I). A temperature rise with each addition till 14 cm^3 NaOH are added? ----------

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(II). A temperature drop with each experiment from 16cm^3 NaOH added? ----------

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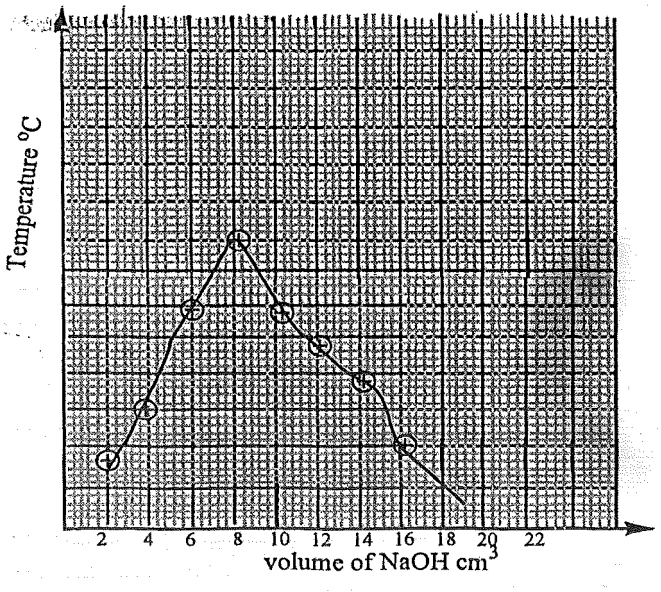
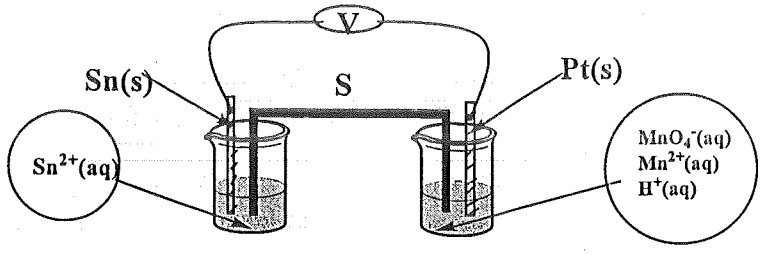
(iv). The graph below is obtained from the data above. From the graph determine the volume of NaOH needed to neutralize the acid



8 marks

(Total: 20 marks)

3. (a) Refers to the galvanic cell below



Half-cell reactions:

$MnO^-_{4(aq)} + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$ $\quad E^\circ = +1.51V$

$Sn^{2+}(aq) + 2e^- \longrightarrow Sn(s)$ $\quad E^\circ = -0.14V$

(i). When a current is allowed to flow,

A. Which species is oxidized? ----------

B. Which species is reduced? ----------

C. Name a suitable instrument that can be used to measure the e.m.f of the cell----------

D. What is the function of the part label S? ----------

4 marks

(ii).(I) Calculate the value of the e.m.f of the cell ----------

(II). Why is platinium used in the cell above?----------

2 marks

(iii). (I) The half-equations above are balanced. Write a balanced equation for the overall redox reaction ----------

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(iv). In what direction do electrons flow in the external circuit on the diagram?----------

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2 marks

(b) Propanoic acid, $CH_3CH_2CO_2H$ is a **WEAK** acid with a Ka $=1.3 \times 10^{-5}$mol dm^{-3}. A mixture of propanoic acid and sodium propanoate, $CH_3CH_2CO_2Na$ in appropriate ratio gives a buffer solution.

(i). What is the difference between a weak acid and a strong acid? Give one example of each ----------

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(ii). Write an equation to show the ionization of propanoic acid in aqueous medium, and give an expression for the dissociation constant of the acid. ----------

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(iii). Calculate the pH of a 0.1 mol dm^{-3} of the propanoic acid ----------

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6 marks

(c) (i) What is a buffer solution? ----------

(ii). What kind of buffer is obtained by mixing propanoic acid and sodium propanoate? ---

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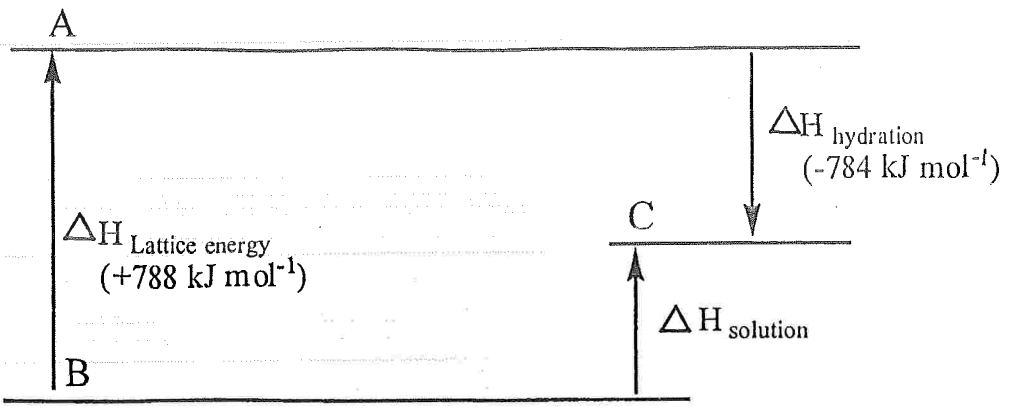
2 marks

(d) By means of equations show how the buffer solution mentioned above reacts on addition of a small quantity of:



(i). State Hass's law ----------

(ii). Use symbols to indicate the species present at A, B, C on the diagram above. Species at:

A. ----------

B. ----------

(iii). Calculate the molar enthalpy of solution of sodium chloride ----------

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(iv). Predict, giving reasons, whether the value for the enthalpy of hydration for sodium bromide will be the same, less than or greater than the value for sodium chloride ------

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(v). Use the data in the table below to calculate the molar enthalpy change for the reaction,

$NH_{3(g)} + 3F_{2(g)} \longrightarrow 3HF_{(g)} + NF_{3(g)}$

BOND	N-H	F-F	H-F	N-F
Average bond enthalpy/kJ mol^{-1}	388	158	562	272

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10 marks

(Total =20 marks)

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2. (a) The following reaction is in a state of ***dynamic chemical equilibrium***

$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$; ΔH = +ve

(i). Explain the team ***dynamic chemical equilibrium***----------

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(ii). Give two conditions needed for a system to attain a state of chemical equilibrium

A. ----------

B. ----------

(iii). What will be the effect on

A. The position of the above equilibrium if the total pressure on the system was increased at constant temperature? ----------

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