

GCE June 2012: Advanced Level Paper 2

SECTION A (CGCEB 2012)

General and Physical Chemistry

1. This question concerns, bonding, intermolecular forces and energetics.
- (a) Various forces of attraction are encountered in strontium and ammonium chloride
- (i) Identify the forces present in
- A. Strontium-----
- B. Ammonium chloride. -----

5 marks

- (b) Complete the table below by giving the shapes and bond angles of the species given.

species	shape	Bond angles
Cl_2O		
AlCl_3		

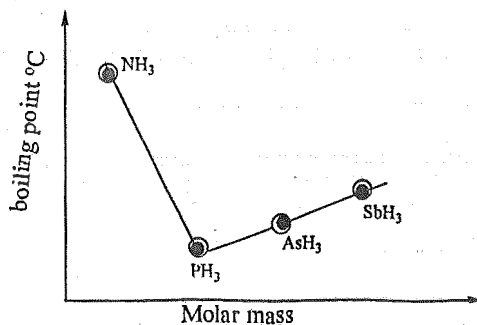
2 marks

- (c) Aluminium trichloride (AlCl_3) exists as a dimer (Al_2Cl_6) in the gas phase.

- (i) What is a dimer? -----
-
- (ii) Draw the dot-and-cross diagram of this dimer? -----
-
-
-

2 marks

- (d) The graph below shows the variation in boiling point of the hydrides of Group V elements.



(i). Account for the regular increase in boiling point from PH_3 to SbH_3 -----

(ii). Why is the boiling point of NH_3 exceptionally high?-----

2 marks

(e) With reference to specific examples, define:

(i). Lattice energy -----

(ii). Standard enthalpy of atomisation -----

4 marks

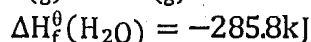
(f) The standard enthalpy change for the reaction between sodium hydroxide and hydrochloric acid can be determined experimentally.

(i). What is the name given to the enthalpy change for this type of reaction?-----

(ii). In one such experiment 25 cm^3 each of solutions of sodium hydroxide and hydrochloric acid of concentration 1 mol dm^{-3} were mixed. The temperature rose from 27 $^\circ\text{C}$ to 34.5 $^\circ\text{C}$. Calculate the standard enthalpy change for the reaction in kJ mol^{-1} (assume that the specific heat capacity of the solution is 4.2 $\text{kJ kg}^{-1}\text{K}^{-1}$ and no heat is lost to the calorimeter) -----

3 marks

(g) Given the following standard enthalpies.



Calculate the O-H bond enthalpy in water-----

2 marks

Total= 20 marks

2. (a) The table below gives the standard electrode potential values of some electrodes

	Electrode	E^θ/V
I.	$\text{MnO}_4^-_{(\text{aq})} + 8\text{H}^+_{(\text{aq})} + 5\text{e}^- \rightarrow \text{Mn}^{2+}_{(\text{aq})} + 4\text{H}_2\text{O}_{(\text{l})}$	+1.51V
II.	$\text{Cl}_{2(\text{g})} + 2\text{e}^- \rightarrow 2\text{Cl}^-_{(\text{aq})}$	+1.36V
III.	$\text{Cr}_2\text{O}_7^{2-}_{(\text{aq})} + 14\text{H}^+_{(\text{aq})} + 6\text{e}^- \rightarrow 2\text{Cr}^{3+}_{(\text{aq})} + 7\text{H}_2\text{O}_{(\text{l})}$	+1.33V
IV.	$\text{Fe}^{3+}_{(\text{aq})} + \text{e}^- \rightarrow \text{Fe}^{2+}_{(\text{aq})}$	+0.78V

- (i). A. What standard reference electrode could be used to obtain the values in the table?-----
 B Under what condition is the standard electrode used? -----
- (ii). Under what four (4) conditions will the standard e.m.f of electrode IV be obtained? ---

- (iii). A salt bridge is used when a cell is set up to obtain an e.m.f.
 A. What is the function of the salt bridge?-----

- B. What substance could be used as a salt bridge? -----
- (iv). The electrodes III and IV are linked to form an electrochemical cell.
 A. Which species is reduced? -----
 B. Write the equation for the redox process-----

8 marks

(b) A 25.0 cm³ sample of a 0.1 moldm⁻³ solution of ethanoic acid ($K_a = 1.8 \times 10^{-5}$) was titrated with 0.1 moldm⁻³ sodium hydroxide.

- (i). Calculate the pH of ethanoic acid -----

- (ii). The table below gives the names and the pH ranges for some acid/base indicators

Name of indicator	pH range
Bromophenol blue	2.8-4.6
bromothymol blue	6.0-7.6
phenolphthalein	8.2-10.0

Which of the above indicators would you use for the titration in (b) above? Explain.

Indicator: -----

Explanation: -----

2marks

*Kinetics

(c) Rates of reactions are found to increase with temperature.

- (i). In the space below, sketch a labelled diagram that shows the distribution of molecular energies at two different temperatures-----

(ii). State two theories that explain the effect of temperature increase on the rate of reaction. -----

(iii). This part concerns a kinetic study on a reaction of your choice.

A. Reaction chosen -----

B. State the property (parameter) that could be used for the kinetic study of the reaction -

C. Give the method that will be used to measure the chosen property, and the instruments/apparatus to be used.

Method -----

Apparatus -----

8 marks

Total =20 marks

3. This question is on atomic structure, mole concept and phase equilibrium

(a) The isotopes of bromine have the following relative abundances $^{79}\text{Br} = 50.5\%$, $^{81}\text{Br} = 49.5\%$

(i). State one way in which the isotopes are similar -----

(ii). What instrument is used to detect the isotopes in the laboratory? -----

(iii). Calculate the relative atomic mass of bromine from the data. -----

4 marks

(b) Write the electronic configuration of the element of the atomic number 12, and sketch a labelled energy level diagram of the electrons -----

3 marks

(c) Some miscible liquids show negative deviation from Raoult's law and others show positive deviation.

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

(ii). Give two experimental evidence for negative deviation from Raoult's law. -----

3 marks

(d) An ethanol/ water mixture forms an azeotropic mixture.

(i). Why is it not possible to obtain a pure sample of the ethanol from the mixture by fractional distillation? -----

(ii). How would you obtain pure ethanol from the azeotropic mixture? -----

3 marks

(e) (i) Draw a well labelled diagram of the experimental set-up (apparatus) that would be used to determine the molar mass of a volatile compound such as liquid hexane.

(ii). Using the ideal gas equation, derive the expression that could be used to obtain the molar mass of the liquid.

(iii). In one such experiment carried out at a temperature of 470 °C and a pressure of 100 atmospheres, 4.3 g of the volatile liquid produced 30.6 cm³ of the gas. Calculate the molar mass of the liquid. (molar gas constant, $R = 8.314 \text{ JK}^{-1}\text{mol}^{-1}$, molar gas volume at s.t.p = 22400 cm³ 1 atmosphere = $1.0 \times 10^5 \text{ Nm}^{-2}$)

7 marks

Total 20 marks

GCE June 2012: Advanced Level Paper 2

SECTION B (CGCEB 2012) Inorganic Chemistry

4. The first part of this question concerns Group VII (halogens).
- (a) (i) Give the colour and physical state of the elements bromine and iodine.
- -----

- (ii) From your knowledge of halogens suggest the colour and physical state of astatine.
- -----
- 3 marks**
- (b) (i) The iodate/iodide reaction is used in the laboratory for iodimetry. Complete the equation for the reaction below:
- $$\text{IO}_3^- (\text{aq}) + \text{I}^- (\text{aq}) + \text{H}^+ (\text{aq}) \rightarrow$$
- (ii) What indicator is used in the titration of aqueous iodine with aqueous thiosulphate?
-
- 2 marks**
- (c) What is observed when chlorine water is added separately to solutions of sodium chloride and sodium bromide?
- A. Sodium chloride: -----
B. Sodium bromide: -----
- 3 marks**
- (d) The hydrides of the halogens dissolve in water forming acidic solutions. Arrange the following hydrides in order of decreasing strength: HF, HBr, HCl. -----
- 1 mark**
- (e) State one problem caused by organo-halogen compounds in the society. -----
- 1 mark**

This part of the question concerns the group IV elements (carbon to lead).

- (f) (i) write:
- A. The general outer shell electronic configuration of the elements. -----
B. The principal oxidation states of the elements in their chlorides -----

- (ii) What is the trend in the stability of these oxidation states? -----

- 3 marks**
- (g) (i) Using equations only, predict the reactions of silicon tetrachloride and carbon tetrachloride with water.
- SiCl₄: -----

- CCl₄: -----

(ii). Account for the similarities and difference in their reactions with water, if any.-----

3 marks

(h) State the type of bonding in:

(i). Lead(II) oxide. -----

(ii). Carbon dioxide ----- 2 marks

(i) State two ways in which carbon differs from the rest of the elements in the group. -----

2 marks

(5) This question is on periodicity and the s-block elements (groups I and II).

The elements in period 3 (sodium to argon) of the Periodic Table show 'periodic trends' in their properties.

(a) What is meant by the term "periodic trends"?-----

1 mark

(b) In the space below, sketch a graph of the variation of the first ionisation energy for the elements sodium to argon. -----

2 marks

(c) Two oxides of elements X and Y in the period 3 have the formulae X_2O and YO_2 . X_2O and YO_2 are very soluble in water producing solutions whose pH are more than 7 and less than 7 respectively.

(i). Identify the groups to which the elements X and Y belong.

X : -----

Y : -----

(ii). Write the dot-and-cross diagram of both oxides

X_2O : -----

YO_2 : -----

(iii). Give the formula of one other oxide of either X or Y and gives its acid/base properties. -----

5marks

(d) (i) In the table below, give the formulae of the chlorides of the elements.

Na	Mg	Al	Si	P	S	Cl

(ii). How does the nature of the bonding in the chlorides vary from left to right?-----

4 marks

(e) (i) Write the electronic configurations of Na^+ and Mg^{2+}

Na⁺: _____

Mg²⁺: _____

(ii). How are these ions similar? _____

(iii). Which of the two ions is bigger? Give reasons. _____

3 marks

(f) The atomic radii of Li, Na and K are respectively 0.157 nm, 0.191 nm and 0.235 nm. Give a reason for this trend. _____

1 mark

(g) The melting points of group II metals are generally higher than those of the group I metals. Give a reason. _____

1 mark

(h) The hydroxides of Group I elements are more soluble than those of Group II elements. Why? _____

1 mark

(i) Lithium shows a diagonal relationship with magnesium.

(a) Why are the two elements diagonally related? _____

2 marks

(b) Give one reaction in which Li and Mg show this relationship. _____

2 marks

(6). This question is on the elements of the d-block, nitrogen and sulphur, Cobalt, Nickel, Manganese, and Copper are both d-block and transition elements.

(a) Why are they considered as;

(i). D-block elements? _____

(ii). Transition elements? _____

2 marks

(b) (i) In the space below insert the electronic configuration of Fe²⁺ and Mn²⁺.

	3d							4s	
Fe ²⁺ :(Ar)									
Mn ²⁺ :(Ar)									

(ii). Explain in terms of their electronic configurations why Fe²⁺ ions are more readily oxidised to Fe³⁺ ions while Mn²⁺ are not readily oxidised to Mn³⁺ ions. _____

4 marks

(c) Transition metal ions form complexes whose shape may be linear, tetrahedral square planar or octahedral.

- (i). What is the oxidation state of cobalt in the complex $[\text{Co}(\text{H}_2\text{O})_4\text{Cl}_2]^+\text{Cl}^-$? -----

- (ii). Give an example and the name of a complex ion of one of the elements listed above which is -----
A. Tetrahedral in shape. -----

B. Square planar in shape. -----

3 marks

(d) Sulphuric acid and nitric acid are important in the chemical industry. Using equations only, show how

- (i). Ammonia is converted to nitrogen dioxide. -----

- (ii). Sulphur is converted to sulphur(VI) oxide. -----

4 marks

(e) In the conversion of sulphur(IV) oxide to sulphur(VI) oxide, the gases must be purified. How is the purification carried out? -----

2 marks

(f) The industrial manufacture of both sulphuric acid and nitric acid is one cause of atmospheric pollution such as "acid rain".

- (i). What substances released in these industrial processes is responsible for atmospheric pollution? -----

- (ii). How do these substances cause atmospheric pollution?-----

- (iii). Give two effects of "acid rain" on the environment. -----

4 marks

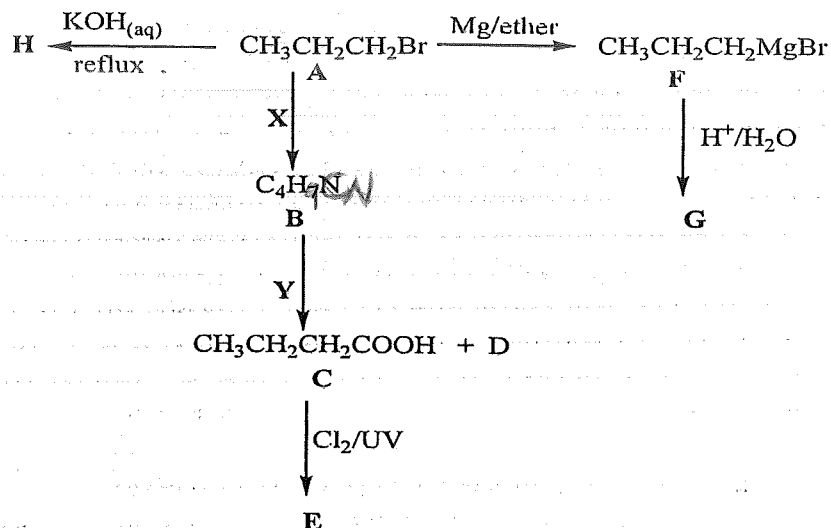
(g) Give one industrial use of nitric acid. -----1 mark

GCE June 2012: Advanced Level Paper 2

SECTION C (CGCEB 2012)

Organic Chemistry

7. Study the synthetic routes below and answer the questions that follow.



(a) (i) Give the reagents and the reaction conditions for the processes x and y -----

(ii) Write the formulae or names of the products B, D, E, G, and H

Product	Formula or name
B	
D	
E	
G	
H	

(iii) What type of reaction is involved in the formation of H? -----

(iv) Write out the reaction mechanism for the formation of H. -----

10 marks

(b) But-1-ene, ($\text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2$), react with hydrogen bromide to give two possible products.

(i) Give the formulae of the products. -----

(ii) Which is the major product and why? -----

(iii). State the rule which allows you to make your decision. -----

5 marks

(c) The analysis of a halogeno-compound gave 45.9% carbon, 8.9% hydrogen, 45.2% chlorine.

(i). Calculate the empirical formula of the compound (RAM: C = 12.0, H = 1.0, Cl = 35.5). -----

(ii). What is the molecular formula of the compound, given that its relative molecular mass is 78.5? -----

(iii). How would you identify the presence of chlorine in the compound? -----

5 marks

8. Carbonyls are a class of organic compounds consisting of aldehydes and ketones.

(a) (i) What is the common feature in this class of organic compounds? -----

(ii). What general method may be used to prepare both aldehydes and ketones? -----

(iii). How would you distinguish between aldehydes and ketones? -----

(iv). Why do the carbonyl compounds have higher boiling points than corresponding alkanes? -----

6 marks

(b) Carbonyl compounds undergo nucleophilic addition reactions such as the reaction between ethanal (CH_3CHO) and hydrogen cyanide (HCN)

(i). What is meant by nucleophilic addition reaction? -----

(ii). Identify the nucleophile mentioned in the reaction above. -----

(iii). Write out the mechanism of the reaction. -----

(iv). Give the reagents and the reaction conditions for the conversion of the product (hydroxypropanonitrile) to a hydroxycarboxylic acid. -----

6 marks

(c) The oxidation of two isomers with molecular formula $\text{C}_3\text{H}_8\text{O}$ gave compounds P and Q. Both P and Q give orange precipitates with 2, 4-dinitrophenylhydrazine while only P gives a precipitate of copper(I) oxide with Fehling's solution.

(i). Suggest the structural formulae of compounds P and Q. -----

- (ii). Give the name of the compound formed by the reaction of compound Q with 2,4-dinitrophenylhydrazine -----
- (iii). Write out all the isomers of the compound of the molecular formula C_3H_8O . -----
- (iv). Draw the structures of the hemi-acetal (alkoxyalcohol) and the acetal (dialkoxyalkane) formed by the reaction of the compound P with methanol (CH_3OH) -----
- 8 marks

9. This question is on organic compounds possessing the hydroxyl (-OH) functional group.

- (a). Four compounds of molecular formula $C_4H_{10}O$ have the hydroxyl (-OH) group. Write down the structural formulae of the four isomers and give their corresponding names. -----

6 marks

- (b). Describe a simple chemical test to confirm the presence of the -OH group in the compounds in (a) above. -----

2 marks

- (h) Given the compounds R, S, and T below,



R

S

T

- (i). Compare the acidities of R and S. Explain your reasoning -----
- (ii). Describe a simple chemical test to distinguish between S and T -----
- (iii). Write an equation in each case for the esterification reaction of R and S with ethanoic acid, giving the reaction conditions.
R: -----
S: -----

6 marks

- (i) One way of obtaining compound S starts with the heating of the mixture of benzene and concentrated sulphuric acid to produce benzenesulphonic acid. Further reactions of this product with sodium hydroxide finally yield sodium phenoxide.
(i). Write down the mechanism for the sulphonation of benzene. -----