

# AL CHEM 2015 PAPER 2

## Section A: physical, and general chemistry

1.
  - a. What do you understand by the term First Ionization Energy? (1 mark)
  - b. The hydrogen emission spectrum shows different series of line known as Lyman, Balmer, Paschen, etc
    - (i) What do the lines represent?
    - (ii) What is the difference between the Lyman and the Balmer series of lines?
    - (iii) State one important information about the structure of the atom that can be obtained from the emission spectrum of an element (3 marks)
  - c. The first 8 successive ionization energies in kJ/mol of an element M (where M is not the usual symbol of the element) are  
789, 1577, 3232, 4356, 16091, 19755, 23789, 29253
    - (i) Write the electronic configuration of the outermost shell of M
    - (ii) Predict the Group of the periodic table to which M belongs  
Explain your reasoning
  - d.
    - (i) Briefly explain the shape of the ammonia (NH<sub>3</sub>) molecule (2 marks)
    - (ii) What is the difference between a covalent bond and intermolecular force?
    - (iii) Using a suitable example, explain how an intermolecular force can affect the molar mass of a substance (4 marks)
  - e. A mixture of ethanoic acid (CH<sub>3</sub>COOH) and sodium ethanoate (CH<sub>3</sub>COONa) is an acid buffer
    - (i) What is an acid buffer?
    - (ii) Using equations only, show how the acid buffer will react in the presence of  
A: Excess acid  
B: Excess base (alkali)
    - (iii) A solution contains 0.02M CH<sub>3</sub>COOH and 0.2M CH<sub>3</sub>COONa. Calculate the pH of the solution which results from the addition of 50 cm<sup>3</sup> of 0.04M NaOH to the solution  
(K<sub>a</sub>CH<sub>3</sub>COOH = 1.7 x 10<sup>-5</sup> mol dm<sup>-3</sup>)
2.
  - a.
    - (i) Define 'Mole of a substance'
    - (ii) Calculate the mass of iron (in grams) contained in 250 cm<sup>3</sup> of 0.1M iron (III) chloride solution
  - b. When NaOH is dissolved in water, the temperature of the solution rises, but when NH<sub>4</sub>NO<sub>3</sub> is dissolved in water, the temperature of the solution falls. Explain the difference in behavior
  - c. The standard lattice enthalpy of NaBr is -735 kJ/mol and its heat of solution is -0.06 kJ/mol
    - (i) Sketch an energy diagram that can be used to determine its heat of solvation (hydration energy)
    - (ii) Calculate the solvation energy
  - d.
    - (i) What do you understand by "Order of a reaction"?
    - (ii) Given the following data for the reaction  $A + 2B \rightarrow C$

Experiment	Initial [A] mol dm <sup>-3</sup>	Initial [B] mol dm <sup>-3</sup>	Rate of formation of C mol dm <sup>-3</sup> s <sup>-1</sup>

1	0.10	0.10	0.001
2	0.10	0.20	0.004
3	0.20	0.10	0.001
4	0.20	0.30	0.009

A: Determine the overall order of the reaction

B: Write the rate expression and calculate the value of the rate constant and give its units

C: Based on the rate expression, suggest a mechanism for the reaction

- e. Trichloromethane ( $\text{CHCl}_3$ ) and ethyl ethanoate ( $\text{CH}_3\text{CO}_2\text{C}_2\text{H}_5$ ) form a completely miscible solution which does not obey Raoult's Law
- State Raoult's law
  - Explain why the liquid mixture would deviate from Raoult's law
  - Predict and explain the change in temperature when the two liquids are mixed
  - Draw a labelled diagram of variation of total pressure against composition for the mixture

### Section B: inorganic (mineral) chemistry

3.

- a. All halogens (except fluorine) form compounds I which they have oxidation numbers ranging from -1 to +7

(i) Explain why

A: Fluorine has only one oxidation number

B: Chlorine exhibits an oxidation number of +7

(ii) Give the formula of an oxo-acid of chlorine with oxidation number of +5

b.

(i) On the space below sketch a graph to show the variation of acid strength of the hydrogen halides HF

(ii) Explain the shape of the graph

- c. Give balanced equations for the reaction of chlorine with

i. Cold dilute KOH

ii. Hot concentrated KOH

- d. Complete the table below by writing the formulae and names of compounds of Sulphur with the corresponding oxidation states

Oxidation state	Formula of compound	Name of Sulphur compound
+2		
+4		
+6		

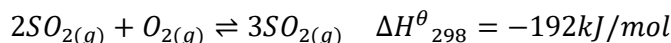
- e. Give equations to show how Sulphur or its compound undergoes

i. Oxidation

ii. Reduction

iii. Disproportionation

- f. The key reaction in the Contact Process for the manufacture of Sulphuric acid is the oxidation of  $\text{SO}_2$  to  $\text{SO}_3$



i. State and explain how the yield of  $\text{SO}_3$  is increased in practice

ii. How is  $\text{SO}_3$  converted to sulphuric acid?

4.

a.

- i. Complete the table by giving the formulae of the simple hydrides of the elements of period 2 to neon

Element	Li	Be	B	C	N	O	F	e
Formula of hybrid								

- ii. Write equations to show the reaction of the hybrids of Li and F with water. Explain the differences in their reactions with water in terms of their structure and bonding
- Equations
  - Explanation
- iii. Suggest a reason why the hybrid of carbon does not react with water
- b. What is the difference between a d-block element and a transition element? Give an example of each
- c. State and explain the variation in atomic radius across the first transition series Scandium to zinc
- d.
- i. Why are transition metal compounds colored?
  - ii. Copper is a transition metal. Explain why some of its compounds are white
- e.
- i. Complete the table below by giving the oxides of manganese in the corresponding oxidation states
- |                                |    |    |    |    |
|--------------------------------|----|----|----|----|
| Oxidation states               | +2 | +4 | +6 | +7 |
| Formula of oxides of manganese |    |    |    |    |
- ii. Explain why manganese exhibits the +7-oxidation state
- f. Give a balanced equation for a reaction in which a transition metal acts as a homogenous catalyst

#### SECTION C: ORGANIC CHEMISTRY

- 5.
- a. State the information about the structure of an organic compound that can be revealed by the following spectroscopic techniques

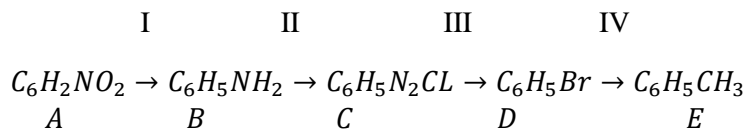
Spectroscopic method	Information obtained
Mass spectroscopy	
Infra-red spectroscopy	
NMR spectroscopy	

- b. An organic compound contained 48.7 percent of carbon and 8.1 percent of hydrogen. Determine its empirical formula
  - c. Using suitable examples in each case state the difference between an electrophile and a nucleophile
  - d. Nitrobenzene is obtained by reacting benzene with a nitrating mixture
    - i. Give the composition of the nitrating mixture
    - ii. What is (are) the condition (s) of the reaction?
    - iii. State and illustrate the mechanism of the nitration of benzene
- e.
- i. What is atomic hybridization?
  - ii. Explain the difference in shape between methane (CH<sub>4</sub>) and ethane (C<sub>2</sub>H<sub>6</sub>)

- 6.
- a. The compound C<sub>4</sub>H<sub>10</sub>O exhibits isomerism
    - i. What is isomerism?
    - ii. Give the structures of two isomers of C<sub>4</sub>H<sub>10</sub>O in each case that show
      - A: Position isomerism
      - B: Optical isomerism
      - C: Functional group isomerism
      - D: Chain isomerism

iii. Given a chemical test to distinguish between the functional group isomers given above

b. Consider the reaction sequence below



i. Give the names of the compounds B and C

B:

C:

ii. State the reagents and reaction conditions represented by I to IV

I:

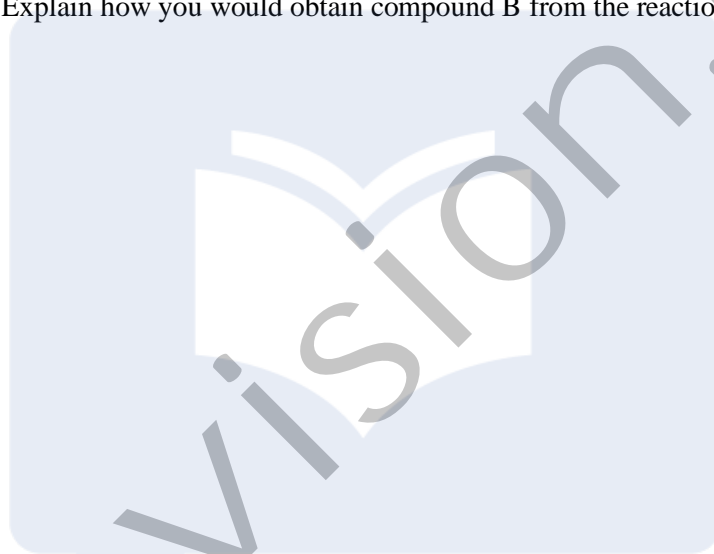
II:

III:

IV:

iii. How could you convert compound c to an azo dye?

iv. Explain how you would obtain compound B from the reaction mixture



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