AN ROINN OIDEACHAIS

LEAVING CERTIFICATE EXAMINATION, 1978

CHEMISTRY—HIGHER LEVEL

MONDAY, 19 JUNE—AFTERNOON, 2 to 4.45

Six questions to be answered.

All questions carry the same number of marks.

Relative atomic masses: H = 1, C = 12, O = 16, Mg = 24, S = 32, Cl = 35.5, Fe = 56, Cu = 63.5, Ag = 108
Molar volume at S.T.P. = 22.4 litres
Avogadro constant (number) = 6×10^{23}
1 faraday = 96,500 coulombs

1. Answer *eleven* of the following items, *(a), (b), (c),* etc. All the items carry the same marks. *Keep your answers short.*

(a) State Pauli's exclusion principle.

(b) Is the shape of the BeH_2 molecule linear, planar or tetrahedral? What type of hybrid orbital accounts for this shape?

(c) Write the equilibrium constant expression for the reaction: $2NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)}$

(d) What atoms are represented by the following structures: (i) $1s^2\ 2s^2\ 2p^3$, (ii) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$?

(e) Write the conjugate base of each of the following acid species: (i) H_3O^+, (ii) HCO_3^-.

(f) What do you understand by the electron affinity of an element?

(g) Which one of the following might exist as *cis—trans* isomers:

$CHCl_3$ $CHCl = CHCl$ $CH_3CHClCOOH$ $C_4H_8Cl_2$ $CH_2 = CHCl$?

(h) State Raoult's law of vapour pressure lowering.

(i) In the reaction $C_{(s)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + H_{2(g)}$ $\Delta H = 132$ kJ what would be the effect on the yield of products ($CO + H_2$) of

(i) increasing the temperature,

(ii) increasing the pressure?

(j) What mass of iron oxide Fe_3O_4 could be obtained from 7 g of iron and excess oxygen?

(k) Define the activation energy of a reaction.

(l) What is the difference between homogeneous and heterogeneous catalysis?

(m) Which one of the following gases would diffuse *fastest* through the same porous plug under the same conditions of temperature and pressure:

Cl_2 CH_3Cl CO_2 C_2H_6 HCl?

(n) How many molecules of hydrogen are formed when 1 g of magnesium reacts with excess of dilute hydrochloric acid?

2. *(a)* What do you understand by

(i) atomic number, (ii) mass number, (iii) isotopes, (iv) relative atomic mass (atomic weight) of an element?

Using a mass spectrometer it was found that boron consisted of 81% $^{11}_{5}B$ and 19% $^{10}_{5}B$. Estimate the relative atomic mass of boron.

(b) Discuss the part played by the emission spectrum of hydrogen in the development of modern ideas of atomic structure.

What do you understand by an orbital?
If a certain atom contains eight electrons with principal quantum number 2, state briefly how these eight electrons would be arranged in orbitals and indicate the shape and relative position of each orbital.

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3. What is an oxidation number?

What are the main rules by which oxidation numbers are assigned?

What is the oxidation number of

(i) bromine in BrF_3, (ii) chromium in $K_2Cr_2O_7$, (iii) sulphur in $H_2S_2O_7$, (iv) nitrogen in NH_4^+?

State Faraday's laws of electrolysis.

A current of 2 amperes was passed for 1930 seconds through an aqueous solution of silver nitrate. The change at the cathode may be represented as:

$$Ag^+ + 1e^- \longrightarrow Ag$$

(i) Explain why the cathode reaction is a reduction.
(ii) How many coulombs of electricity were passed?
(iii) What mass of silver would be deposited on the cathode?
(iv) If the same quantity of electricity were passed through an aqueous solution of copper(II) sulphate what mass of copper would be deposited on the cathode?

4. Explain, mentioning the conditions necessary for the reaction to take place satisfactorily, how ethanol may be converted to

(i) acetaldehyde,
(ii) diethyl ether,
(iii) ethene (ethylene).

Draw a labelled sketch of the apparatus you would set up to prepare and collect a sample of any *one* of the three products above.

Suggest why methanol is completely soluble in water while ethene, which has nearly the same relative molecular mass (molecular weight), is almost insoluble.

Complete the following equations:

(i) $CH_3COOC_2H_5 + NaOH \longrightarrow$

(ii) $C_2H_5COOH + NaOH \longrightarrow$

(iii)  $+ NaOH \longrightarrow$

5. Select any *four* of the following compounds:

$$CaH_2 \quad HBr \quad Li_2O \quad SO_3 \quad MgCl_2 \quad PCl_3$$

In the case of *each* of the four compounds selected state

(i) its appearance at room temperature,
(ii) the type of bonding present,
(iii) its behaviour in water, giving an equation where appropriate,
(iv) whether the aqueous solution is neutral, acidic or alkaline.

The SO_3 molecule is planar, with 12 electrons in the outer shell of sulphur. Suggest an electronic structure for this molecule.

6. 2.235 g of a group I metal chloride were dissolved in distilled water and the solution made up to 250cm^3. For 25 cm^3 of this solution 37.5 cm^3 of 0.08 M (0.08 N) silver nitrate solution were required for complete precipitation of the chloride ion. Potassium chromate (K_2CrO_4) solution was used as an indicator.

Calculate (i) the molarity (or normality) of the chloride solution,
(ii) the formula weight of the metal chloride,
(iii) the relative atomic mass (atomic weight) of the metal.

Mention all the precautions you would take in the course of the experiment to ensure that the final value taken (i.e. 37.5 cm^3) was correct.

Explain how potassium chromate acts as an indicator in this case.

Describe how you would carry out one chemical test in each case to confirm the presence of (i) the chloride ion, (ii) the nitrate ion, in aqueous solutions.

7. Define (i) heat of reaction, (ii) heat of combustion, (iii) heat of solution.

560 cm^3 of propane (measured at S.T.P.) were compressed with excess oxygen in a suitable calorimeter and ignited. It was found that 55 kJ of heat were evolved. Calculate the heat of combustion of propane.

Explain what is meant by bond energy.

Outline the main energy changes involved in the following reactions:

(i) $H_2 + Cl_2 \longrightarrow 2HCl$,

(ii) $HCl + H_2O + aq \longrightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

Calculate the bond energy of the H–Cl bond, i.e. E(H–Cl), from the following data:

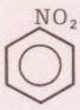
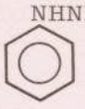
$E(H–H) = 436 \text{ kJ mol}^{-1}$

$E(Cl–Cl) = 242 \text{ kJ mol}^{-1}$

$H_2 + Cl_2 \longrightarrow 2HCl \quad \Delta H = -184 \text{ kJ}$

8. The formulae of five compounds are given as follows:

A. $CH_3CH = CH_2$ **B.** $CH_3\,CH(OH)\,COOH$

C. CH_3COCH_3 **D.**  **E.** 

(i) Name the compounds **A** to **E**.

(ii) Which one of the compounds **A** to **E** would be most likely to give a polymer of high relative molecular mass (molecular weight)? Suggest a structure for the polymer showing two repeating units.

(iii) With which one of the compounds **A** to **D** does **E** form a solid compound? Write the name and structural formula for this solid compound.

(iv) Which one of the compounds **A** to **E** would be most likely to decolourise bromine water? Give the name and structural formula for the product and state what type of reaction has taken place.

(v) Which one of the compounds **A** to **E** could be formed directly from a hydrocarbon by substitution? Name the reagents used and suggest why the reaction mixture should not be allowed to rise above 323 K (50°C) during the reaction.

(vi) Which one of the compounds **A** to **E** shows stereoisomerism? Explain briefly how isomerism occurs in this case and how it is detected.

9. What is meant by (i) a weak base, (ii) hydrolysis, (iii) the pH of a solution?
Show how hydrolysis occurs in aqueous solutions of *(a)* sodium acetate, *(b)* iron (III) chloride, explaining in each case the part played by water molecules in determining whether the final equilibrium solution is acidic, alkaline or neutral.

The dissociation of the weak base, ammonia, in aqueous solution may be represented as

$$NH_{3(aq)} \rightleftharpoons NH_4^+ + OH^-$$

Find the pH of a 0.01 M (0.01 N) solution of ammonia in water, given that its dissociation constant (K) is 1.8×10^{-5}.

10. Answer any *two* of the following.

(a) Describe how the elevation of boiling-point of a pure solvent by a non-volatile solute may be found experimentally.
When 3.64 g of an organic compound were dissolved in 80 g of acetone the boiling-point was raised by 0.43 K. If the boiling-point constant for acetone is 1.72 K mol^{-1} kg^{-1} find the relative molecular mass (molecular weight) of the compound.

(b) Define the solubility of a solute in water.
The solubility of sodium nitrate (in g per 100 g water) at different temperatures is shown in the table below.

Temperature (K)	273	293	313	333	353
Solubility	73	88	105	125	149

Draw a solubility curve for sodium nitrate in water and from your graph find the solubility of sodium nitrate at (i) 303 K, (ii) 348 K.
If a saturated solution of sodium nitrate in 50 g water at 348 K were cooled to 303 K what mass of sodium nitrate would be deposited?

(c) Describe, with the aid of a labelled diagram, how *either* hydrogen sulphide *or* sulphur dioxide could be prepared and collected in the laboratory. Give a balanced equation for the reaction described.
140 cm^3 of sulphur dioxide, measured at S.T.P., was reduced completely by hydrogen sulphide according to the equation

$$2H_2S + SO_2 \longrightarrow 3S + 2H_2O$$

(i) What volume of hydrogen sulphide would be required to react completely with 140 cm^3 of sulphur dioxide, both measured at S.T.P.?

(ii) What mass of sulphur would be formed in this reaction?

(d) Define the first ionisation energy of an element.
Discuss the factors which account for the general increase in first ionisation energies across a typical period e.g. Na to Ar.
Explain why the general trend is reversed on passing from magnesium to aluminium and from phosphorus to sulphur.
How do you account for (i) the decrease in first ionisation energies down a group e.g. Li to Cs, (ii) the similarity of the first ionisation energies of iron, cobalt, nickel and copper?
(Refer to table of first ionisation energies, Mathematics Tables, page 45.)