LEAVING CERTIFICATE EXAMINATION, 1974

CHEMISTRY—HIGHER LEVEL

THURSDAY, 20 JUNE—AFTERNOON, 2 to 4.45

Six questions to be answered.

All questions carry the same number of marks.

Atomic Weights: H = 1, C = 12, N = 14, O = 16, Fe = 56
Molar volume at S.T.P. = 22·4 litres.

1. Answer *eleven* of the following items, (*a*), (*b*), (*c*), . . . etc. All the items carry the same marks. *Keep your answers short.*
   (*a*) What are isotopes?
   (*b*) How many moles of Al^{3+} are there in 3 moles of $Al_2(SO_4)_3$?
   (*c*) Why do carbon dioxide and propane (C_3H_8) diffuse at the same rate under the same conditions?
   (*d*) What is the conjugate acid of the base $C_2H_5NH_2$?
   (*e*) Write the following elements in the order in which they occur in the electrochemical series: zinc, sodium, copper, hydrogen.
   (*f*) What do you understand by the electron affinity of an element?
   (*g*) Write an equation for the reaction of lithium hydride with water.
   (*h*) What type of crystal is generally soluble in non-polar solvents?
   (*i*) Why does the atomic radius decrease across a period in the periodic table?
   (*j*) Give the equation for a reaction which can be used as a test for the sulphate ion.
   (*k*) What type of isomerism would you expect to find in compounds of formula COOH CH = CH COOH?
   (*l*) Which of the following molecules has zero dipole moment:
   $$HCl, \quad CO_2, \quad NH_3, \quad CH_3Cl, \quad H_2O?$$
   (*m*) Mention one test for a double bond C = C in a hydrocarbon.
   (*n*) What is the volume at S.T.P. of one gram of nitrogen gas?

2. "An electron within an atom is specified by four quantum numbers: principal, azimuthal, magnetic and spin". Discuss this statement.
   State Pauli's exclusion principle.
   Write the electronic configuration (*s*, *p*, etc. . . .) for oxygen, argon and scandium.

3. Write the structural formula for (i) ethanol, (ii) ethyl acetate, (iii) phenol.
   Describe, using a labelled diagram of the apparatus, how you would prepare and collect a sample of ethyl acetate.
   Show by equations how ethanol reacts with (i) sodium, (ii) phosphorus pentachloride. Name the products.
   Show how (i) acetic acid, (ii) di-ethyl ether, may be obtained from ethanol.
   How does a solutian of phenol react with bromine water?

4. Answer the following questions by referring to the first thirty six elements of the periodic table (Mathematical Tables, p. 44) and to the table of electronegativities (Mathematical Tables, p. 46.)
   (i) Name one non-metal which exists as single atoms and one which exists as giant molecules at room temperature.
   (ii) Give the formula of an ionic compound formed by an element in group II and show the charge on each ion.
   (iii) Give the formula of a covalent compound formed by an element in group V and show clearly the electronic structure of the molecule.
   (iv) What do you understand by electronegativity?
   (v) Comment on the nature of the bonds you would expect in each of the compounds MgS and PH_3.
   (vi) Which two of the first thirty six elements would form the compound you would expect to have the greatest ionic character?
   (vii) Mention the uses of radioactive isotopes, giving two examples.

5. Define (i) heat of formation, (ii) heat of combustion, (iii) heat of solution of a substance.
   Outline the main energy changes involved when
   (i) sodium chloride crystals dissolve in water,
   (ii) charcoal burns in oxygen.
   Calculate the heat change ($\triangle H$) for the reaction
   $$C_{(s)} + \tfrac{1}{2}O_{2(g)} + 2H_{2(g)} \rightarrow CH_3OH_{(l)}$$
   from the following data:
   $$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} \qquad \triangle H = -393 \text{ kJ}$$
   $$H_{2(g)} + \tfrac{1}{2}O_{2(g)} \rightarrow H_2O_{(g)} \qquad \triangle H = -286 \text{ kJ}$$
   $$2CH_3OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 4H_2O_{(g)} \qquad \triangle H = -1424 \text{ kJ}$$
   Name and state the law you made use of in this calculation.

6. What do you understand by oxidation number?
Give a brief summary of the rules for oxidation numbers.

What is the oxidation number of (i) nitrogen in NO_3^-, (ii) nitrogen in NH_3, (iii) chromium in $K_2Cr_2O_7$, (iv) chlorine in $KClO_4$?

Use oxidation numbers to determine whether or not each of the following is an oxidation/reduction reaction and if so indicate which species is being oxidised and which is being reduced:

(i) $Mg + Cl_2 \rightarrow MgCl_2$

(ii) $ZnCO_3 \rightarrow ZnO + CO_2$

(iii) $Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O$

Using oxidation numbers, or otherwise, balance the following equation:

$$MnO_4^- + H_2S + H^+ \rightarrow Mn^{2+} + S + H_2O$$

7. What do you understand by (i) the rate of a chemical reaction, (ii) the activation energy of a reaction?
For each of the following statements explain briefly why the rate of the reaction alters, stating the factor, or factors, involved:

(i) Silver nitrate crystals do not seem to react with sodium chloride crystals but in solution an immediate white precipitate is formed.

(ii) If hydrogen and oxygen are mixed at room temperature no reaction can be detected but if a spark is passed through the mixture a violent reaction occurs.

(iii) When hydrogen is being collected from the reaction of excess zinc with 2M sulphuric acid it takes longer to fill a gas-jar of a given size as the reaction proceeds.

(iv) When a mixture of ethylene and hydrogen is heated to 410 K no reaction can be detected but when the mixture is passed over finely divided nickel at this temperature ethane is formed.

8. (*a*) Name one of each of the following types of oxide (i) basic, (ii) acidic, (iii) amphoteric, (iv) neutral.
Explain what you mean by an amphoteric oxide.
On reduction 11·6 g of an oxide of iron gave 8·4 g of the metal. What is the formula of the oxide?

(*b*) The following are chlorides of elements in the same period, together with their melting-points:

	$NaCl$	$MgCl_2$	$SiCl_4$	PCl_3
m.p.	1081 K	987 K	205 K	161 K

(i) What general information about the bonding is indicated by the melting-points?

(ii) Select one metallic and one non-metallic chloride from the given list and explain what happens when each of these two is placed in water.

(iii) Phosphorus forms another chloride of empirical formula PCl_5 and melting-point about 433 K. Suggest a reason why this melting-point is higher than might be expected.

9. (*a*) Write equations for any **four** of the following reactions and name the products:

(i) the nitration of benzene,

(ii) the reaction of benzaldehyde with phenylhydrazine,

(iii) the reaction of methylamine with methyl iodide,

(iv) the bromination of propene,

(v) the hydrolysis of an amide.

(*b*) What is polymerisation? For any **two** of the following polymers
polythene, polystyrene, nylon.

(i) draw a section of the molecule showing the units present and the bonding between them,

(ii) state one important use.

10. Formic acid is a weak monobasic acid which is soluble in water, ionising slightly according to the equation

$$HCOOH \rightleftharpoons H^+ + HCOO^-$$

(i) Write an expression for its dissociation constant (K_a).

(ii) Find the pH of a 0·1 M (0·1 N) solution of formic acid given that K_a for this acid is $2{\cdot}1 \times 10^{-4}$.

(iii) The dissociation constant for acetic acid (0·1 M) in water is $1{\cdot}8 \times 10^{-5}$. Is it a stronger or a weaker acid than formic acid? Explain your reasoning.

(iv) What volume of 0·1 M (0·1 N) formic acid would be needed to neutralise completely 25 cm^3 of 0·108 M (0·108 N) sodium hydroxide solution?

(v) Name a suitable indicator for this titration.

(vi) Assuming that the indicator you choose is a weak acid explain briefly how it works.

11. Answer any **three** of the following:

(i) Show clearly the electron changes taking place (*a*) at the cathode, (*b*) at the anode, when molten lead bromide is electrolysed.
What anode would you use in this experiment? Why?
Explain why this is an oxidation/reduction reaction.

(ii) Describe and discuss the shape of the acetylene molecule in terms of hybrid orbitals.

(iii) An organic compound was found to consist of 62·05% carbon, 10·35% hydrogen and 27·60% oxygen. Find the simplest possible formula for the compound.
The compound, of molecular weight 58, was difficult to oxidise but it gave a precipitate with phenylhydrazine. Suggest a name and structural formula for the compound.

(iv) Explain, using a suitable example, how optical isomerism can arise in a compound. How can the isomers be recognised by experiment?