AN ROINN OIDEACHAIS

LEAVING CERTIFICATE EXAMINATION, 1973

CHEMISTRY—HIGHER LEVEL

FRIDAY, 15 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, O = 16, S = 32, Cl = 35·5, Mn = 55.
Molar volume at S.T.P. = 22·4 litres.
Avogadro number = 6×10^{23}.

1. Compare ionic, molecular, metallic and covalent crystals under the following headings, giving a suitable example of each type of crystal:—(i) the units present and the binding forces between them, (ii) hardness, (iii) melting point, (iv) electrical conductivity, (v) solubility in water and non-polar media.

2. What is (i) an acid, (ii) a base, in terms of the Brønsted-Lowry theory? Why is it considered to be an advance on earlier theories?
   Indicate which species in the following examples are acting as acids:

$$NH_4^+ + CO_3^{2-} \rightleftharpoons HCO_3^- + NH_3$$
$$O^{2-} + H_2O \rightleftharpoons OH^- + OH^-.$$

   Show what you understand by a conjugate acid-base pair by reference to either of the above reactions.
   What is the pH of the solution made by diluting 1 cm³ of 1 M hydrochloric acid with pure water to one litre (1,000 cm³)?

3. Describe how you would measure the molecular weight (relative molecular mass) of a non-volatile compound. Discuss briefly the limitations of the method.
   The boiling point of benzene is 353·26 K. The addition of 0·625 g of sulphur to 125 g of benzene raised the boiling point to 353·31 K. Calculate the molecular weight of sulphur and comment on the result.
   (The boiling point constant for benzene = 2·56 for 1,000 g benzene.)

4. Potassium permanganate in acid solution oxidises oxalate ions according to the equation

$$2\,MnO_4^- + 5\,C_2O_4^{2-} + 16\,H^+ \rightarrow 2\,Mn^{2+} + 10\,CO_2 + 8\,H_2O$$

   In a titration 20 cm³ of an oxalic acid solution required 24 cm³ of 0·02 molar (0·10 normal) potassium permanganate solution for complete oxidation.

   (i) What is the reducing agent in this reaction?

   (ii) Why is an indicator unnecessary?

   (iii) What condition other than the addition of acid is necessary for this titration?

   (iv) Explain why the first drop of the potassium permanganate solution added decolorises slowly while succeeding drops are rapidly decolorised.

   (v) Define oxidation in terms of electron transfer and show that the change from $C_2O_4^{2-}$ to CO_2 is an oxidation.

   (vi) Define oxidation in terms of change in oxidation number and show that the change from MnO_4^- to Mn^{2+} is a reduction.

   (vii) Calculate the concentration of the oxalic acid solution (*a*) in terms of molarity (or normality), (*b*) in grams of oxalic acid crystals $(COOH)_2.2H_2O$ per litre (1,000 cm³).

5. Write the structural formula for (i) ethylene, (ii) acetylene, (iii) ethanol, (iv) acetaldehyde.
   Show, giving essential conditions, how acetylene may be converted to (i) acetaldehyde, (ii) sodium acetylide.
   Use a labelled diagram to show how ethylene may be prepared from ethanol. Under what conditions might diethyl ether be obtained from the same reagents?
   Discuss a possible mechanism for the bromination of ethylene.

6. Acetic acid and propanol react according to the equation

$$CH_3COOH + C_3H_7OH \rightleftharpoons CH_3COOC_3H_7 + H_2O.$$

Write the expression for the equilibrium constant for this reaction.

In an experiment 210 g of acetic acid and 210 g of propanol were heated together at a certain temperature until a state of equilibrium was reached. It was shown by titration that 60 g of acetic acid remained. Calculate the equilibrium constant for the reaction.

State Le Chatelier's principle.

In the case of each of the following reactions

$$2\,NO_{(g)} \rightleftharpoons N_{2(g)} + O_{2(g)} \qquad \triangle H = -180\ kJ$$
$$2\,NH_{3(g)} \rightleftharpoons N_{2(g)} + 3\,H_{2(g)} \qquad \triangle H = +92\ kJ,$$

what would be the effect on the dissociation of (*a*) increasing the pressure, (*b*) increasing the temperature?

7. Describe (i) the general appearance at room temperature, (ii) the type of bonding, in each of any **four** of the following:

$$Na_2O,\ SO_2,\ NaH,\ H_2S,\ LiCl,\ PCl_3.$$

Comment on the relation between (i) and (ii).

Discuss, using equations where appropriate, the behaviour in water of the four compounds you selected. In each case indicate whether the solution is acidic, basic or neutral.

8. (*a*) What is (i) atomic number, (ii) mass number?

What are isotopes? Illustrate your answer by referring to $^{20}_{10}Ne$ and $^{22}_{10}Ne$.

What is the relative atomic mass (atomic weight) of an element? On what scale is it measured?

It was found, using a mass spectrometer, that neon consists of 90% $^{22}_{10}Ne$ and 10% $^{22}_{10}Ne$. Calculate the relative atomic mass of neon.

(*b*) In a reaction 4·35 g of manganese dioxide reacted completely with concentrated hydrochloric acid according to the equation

$$MnO_2 + 4\,HCl \rightarrow MnCl_2 + Cl_2 + 2\,H_2O.$$

(i) How many moles of MnO_2 does 4·35 g represent?

(ii) How many moles of HCl are needed to react with this weight of MnO_2?

(iii) What weight of anhydrous $MnCl_2$ could be obtained from this reaction?

(iv) Calculate the volume at S.T.P. of the chlorine obtained.

(v) Calculate the number of molecules of chlorine obtained.

9. Show, by means of a suitable equation in each case, what is meant by any **five** of the following terms as used in organic chemistry:—(i) addition, (ii) substitution, (iii) polymerisation, (iv) condensation, (v) acetylation, (vi) nitration, (vii) hydrolysis. The names of the reactants and the products should be given, together with any essential conditions.

Complete the following equation and state which of the above terms would best describe the reaction:

$$CH_3CHO + C_6H_5.NH.NH_2 \rightarrow$$

10. Answer any **three** of the following:—

(i) Describe and discuss the shape of the methane molecule in terms of hybrid orbitals.

(ii) Explain why an aqueous solution of aluminium sulphate is acidic while an aqueous solution of potassium carbonate is alkaline.

(iii) Compare and contrast the properties of the hydroxyl group as found in ethanol, phenol and acetic acid. How could one of the differences between them be demonstrated using a solution of sodium carbonate and a solution of sodium hydrogen carbonate?

(iv) Discuss the effect of increase in temperature on the rate of a chemical reaction. Why does a small increase in temperature often result in a large increase in the rate of a reaction?