L 30

11701

AN ROINN OIDEACHAIS

LEAVING CERTIFICATE EXAMINATION, 1994

CHEMISTRY — HIGHER LEVEL

MONDAY, 20 JUNE — AFTERNOON, 2.00 to 5.00

Question 1 and **five** other questions must be answered. These five *must* include question 2 or question 3 but may include *both* question 2 and question 3.

All questions carry the same number of marks.

Relative atomic masses: H = 1, C = 12, N = 14, O = 16, K = 39, Ca = 40, Zn = 65.

Molar volume at S.T.P. = 22.4 dm^3

Avogadro constant = 6×10^{23} mol^{-1}

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

(*a*) Define (i) atomic number, (ii) mass number.

(*b*) What is the oxidation number of sulphur (i) in SO_2, (ii) in $S_2O_3^{2-}$?

(*c*) How many molecules are there in 3.36 dm^3 of methane at S.T.P.?

(*d*) State the shapes of the following molecules: (i) beryllium hydride, (ii) hydrogen sulphide.

(*e*) Write the electronic configuration (s,p) of the Al^{3+} ion. What neutral atom has the same configuration?

(*f*) What is the systematic (IUPAC) name of $(CH_3)_2C = C(CH_3)_2$?

(*g*) What reagents would you use to test for the presence of chloride ions in aqueous solution?

(*h*) In writing their chemical formulae, why is it usual (i) to put the chlorine first in Cl_2O, (ii) to put the magnesium first in $MgCl_2$?

(*i*) A volume of 600 cm^3 of water was found to contain 0.03 grams of dissolved solids. Express the concentration of dissolved solids in parts per million.

(*j*) Give *two* benefits of the cracking of hydrocarbons in the oil refining process.

(*k*) Give the name *and* formula of a compound that could supply both nitrogen and phosphorus in the making of a fertiliser.

(*l*) A solution of potassium hydrogencarbonate was labelled 12% (w/v). What was the concentration of the solution in mol dm^{-3}?

(*m*) Balance the equation: $AsCl_3 + H_2O \rightarrow H_3AsO_3 + HCl$

(*n*) How does a water deioniser (i) remove positive ions, (ii) remove negative ions, from water?

(*o*) The main purpose of the tertiary treatment of sewage is to lower the levels of species containing one or other of two elements. Identify the two elements.

(11 × 6)

2. A mass of 1.60 grams of impure calcium hydroxide was dissolved in 100 cm^3 of a 1.0 mol dm^{-3} solution of hydrochloric acid. The solution was then made up to 500 cm^3 with deionised water in a volumetric flask. It was found by titration that 18.75 cm^3 of this solution exactly neutralised 25.00 cm^3 of a 0.090 mol dm^{-3} solution of sodium hydroxide. The reactions that took place may be represented:

$$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$$
$$HCl + NaOH \rightarrow NaCl + H_2O$$

(i) Outline the procedure involved in weighing the impure calcium hydroxide and dissolving it in the hydrochloric acid solution. (9)

(ii) In carrying out titrations involving sodium hydroxide solution, why is it not usual to put the sodium hyroxide solution in the burette? (6)

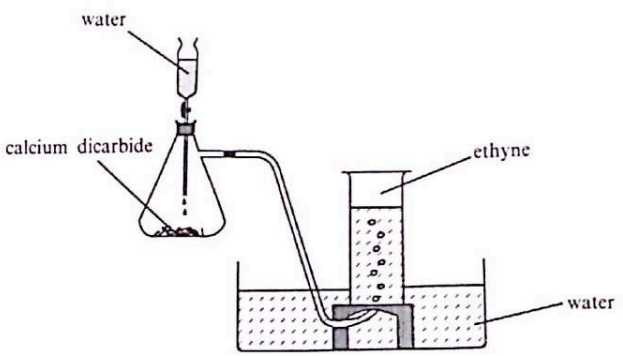
(iii) Name *two* indicators that could have been used in the titration and, in the case of either one of them, state the colour change at the end-point. (12)

(iv) Calculate the concentration of the hydrochloric acid solution in the volumetric flask in mol dm^{-3}. Find (*a*) the number of moles of hydrogen chloride in 500 cm^3 of this solution, (*b*) the number of moles of hydrogen chloride in the 100 cm^3 of hydrochloric acid solution present at the start of the experiment. How many moles of hydrogen chloride were used up in the reaction with the calcium hydroxide? (15)

(v) Calculate (*a*) the number of moles, (*b*) the mass, of calcium hydroxide present in the 1.60 grams of impure compound. What was the percentage purity of the calcium hydroxide? (12)

(vi) Calcium hydroxide is slightly soluble in water. By what name is this solution commonly known and for what purpose is it used in chemical analysis? Write an equation for the reaction that takes place when the solution is used for this purpose. (12)

3. A group of students prepared and collected ethyne using the apparatus shown in the diagram. They tested the product for unsaturation (i) using bromine solution, (ii) using acidified potassium manganate(VII) solution.



(i) Write a balanced equation for the reaction between calcium dicarbide and water. (6)

(ii) What change was observed in the appearance of the calcium dicarbide when the drops of water fell on it? What caused this change in appearance? (6)

(iii) The ethyne obtained by the students was impure. Name *one* possible impurity other than air or water vapour. What substance present in the calcium dicarbide could have given rise to this impurity? Suggest a method of removing impurities from the ethyne. (12)

(iv) What was observed when the ethyne was tested with the bromine solution? The reaction gave rise to an unsaturated product and then to a saturated product. Give the names *and* structural formulae of these two products. (18)

(v) What was observed when the ethyne was tested with the acidified potassium manganate(VII) solution? In this reaction an organic acid of molecular formula $C_2H_2O_4$ is produced. Give the name *or* structural formula of this acid. (12)

(vi) When 1.25×10^{-3} moles of an unsaturated hydrocarbon, an alkene, were burned completely in oxygen, 112 cm^3 of carbon dioxide (measured at S.T.P.) were produced. Find the molecular formula of the alkene. (12)

4. Define (i) heat of combustion, (ii) kilogram calorific value, (iii) bond energy. (18)

Outline simple laboratory experiments that would allow you to compare the heats of combustion (or the kilogram calorific values) of two organic liquids. (12)

The kilogram calorific value of pentane (C_5H_{12}) is 48,750 kJ. Calculate the heat of combustion. (9)

Heats of combustion may also be calculated using bond energy values. Use the three bond energy values below to calculate the heat of combustion of butan-l-ol, given that the sum of the bond energy values involved in breaking all the bonds in one mole of butan-l-ol is 5575 kJ, and that the equation for the combustion of butan-l-ol is

$$C_4H_9OH_{(l)} + 6\tfrac{1}{2}O_{2(g)} \rightarrow 4CO_{2(g)} + 5H_2O_{(g)}$$

$$E(O = O) = 496 \text{ kJ mol}^{-1}; E(C = O) = 743 \text{ kJ mol}^{-1}; E(O - H) = 463 \text{ kJ mol}^{-1}$$

(21)

Though pentane and butan-l-ol have about the same relative molecular mass, there is a considerable difference in their boiling points. Which of the two liquids would you expect to have the higher boiling point? Give a reason for the choice you have made. (6)

5. Define (i) pH, (ii) acid dissociation constant (K_a), (iii) base in the Bronsted-Lowry theory. (15)

What do you understand by the strength of an acid or base? (6)

Nitrous acid is a weak acid. The equation for its dissociation in aqueous solution is

$$HNO_2 + H_2O \rightleftharpoons H_3O^+ + NO_2^-$$

(i) Indicate the species acting as bases in the dissociation of nitrous acid in aqueous solution. (6)

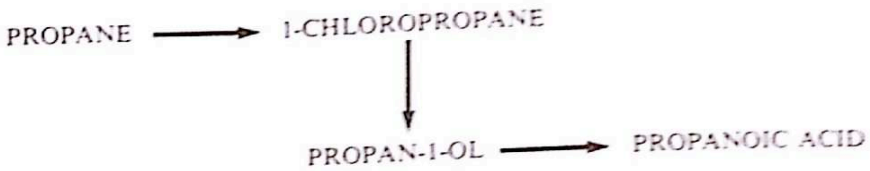
(ii) Write the expression for the acid dissociation constant (K_a) of nitrous acid. (6)

(iii) If nitrous acid is 4.9% dissociated in a 0.20 mol dm^{-3} aqueous solution at 25 °C, show clearly that the approximate value of the acid dissociation constant (K_a) is 5.0×10^{-4}. (15)

(iv) Calculate the approximate pH of the 0.20 mol dm^{-3} aqueous solution of nitrous acid at 25 °C. (9)

(v) The concentration of a nitrous acid solution can be found by titrating it against a suitable base. If standard solutions of strong and weak bases were available, which would you choose for the titration? Explain clearly the reason for your choice. (9)

6. Study the following reaction scheme and answer the questions which follow.



(i) What is a homologous series? To which homologous series does propane (C_3H_8) belong? (9)

(ii) Define *functional group*. What is the functional group (*a*) in alcohols, (*b*) in carboxylic acids? (12)

(iii) There are two isomeric forms of chloropropane (C_3H_7Cl), 1-chloropropane and 2-chloropropane. Explain what is meant by *isomers*, and show the two isomers of chloropropane by means of structural formulae. (12)

(iv) Outline briefly (*a*) how you would convert 1-chloropropane to propan-1-ol, (*b*) how you would convert propan-1-ol to propanoic acid. (15)

(v) By methods similar to those you have outlined in (iv), 2-chloropropane can be converted to propan-2-ol and then to a ketone. Give the name and structural formula of the ketone and state how you would convert it back to propan-2-ol. Write an equation for the condensation reaction of the ketone with 2,4-dinitrophenylhydrazine. (18)

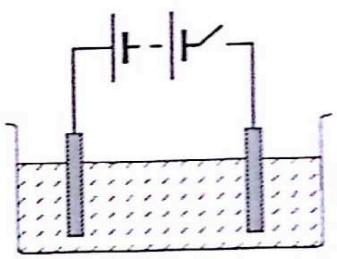
7. Copper is a transition element which, like other transition elements, exhibits variable valence. Though sometimes found free in nature, it is more usually obtained by extraction from its ores and purified by electrolysis.

(i) Explain the underlined terms. (9)

(ii) Copper is usually either monovalent or divalent in its compounds. Explain in terms of electronic configuration (s, p, etc.) how these valences arise. (12)

(iii) Name one of the main ores from which copper is extracted and outline the stages involved in the extraction process. (18)

(iv) The diagram shows a simple apparatus for the purification of the copper obtained from the extraction process in (iii). Name the electrolyte used. In what respect does the anode material differ from the cathode material?



What difference would there be in the reaction taking place at the anode if inert electrodes were used? (15)

(v) Show, by means of balanced equations, the effect of heat (*a*) on copper(II) carbonate, (*b*) on copper(II) nitrate. (12)

8. (*a*) Distinguish between the terms *triad* and *octave* in the history of the classification of the elements, and name the scientists associated with the introduction of these terms into Chemistry. (12)

When the term octave was introduced it was found to apply to only about the first sixteen elements known at that time. Could the term be correctly used for the sixteen elements from lithium to argon in the modern Periodic Table? Give a reason for your answer. (9)

(*b*) Define *first ionisation energy*. (6)

Explain why the value of the first ionisation energy of oxygen is lower than that of fluorine and is also lower than that of nitrogen. (12)

(*c*) The following substances are crystalline solids:

ice iodine diamond sodium fluoride

(i) Which one of the four solids exists as ionic crystals? Show the formation of the ionic bonds by means of suitable diagrams. Explain why the substance does not conduct electricity in the solid state but does act as a conductor when in the molten state or when dissolved in a polar solvent. (18)

(ii) Which one of the four solids exists as molecular crystals held together by Van der Waals' forces? What type of bond holds the atoms together in a molecule of this substance? Explain why the substance is virtually insoluble in water. (9)

9. State Le Chatelier's Principle. (6)

Write down the equation of state for an ideal gas. (6)

The production of ammonia from nitrogen and hydrogen is usually carried out at pressures of around 200 atmospheres and temperatures of about 450 °C. The equation for the reaction is

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

(i) Write the equilibrium constant expression (K_c) for the reaction. (6)

(ii) Explain why high pressures lead to an increased yield of ammonia. Why are very high pressures (e.g. 1000 atmospheres) not normally used? (12)

(iii) Ten moles of nitrogen and thirty moles of hydrogen were mixed and allowed to come to equilibrium in a closed 7.5 dm^3 container at a certain temperature. The equilibrium mixture contained 15 moles of ammonia. Calculate the numbers of moles of nitrogen and hydrogen and also the total number of moles of gas present in the mixture at equilibrium. Calculate also the value of the equilibrium constant (K_c) at that temperature. (18)

(iv) Use the equation of state for an ideal gas to calculate the temperature of the equilibrium mixture in (iii), given that the pressure in the closed container at equilibrium is 2×10^7 N m^{-2} and that the value of R is 8.3 J mol^{-1} K^{-1}. State (*a*) the disadvantage of using this reasonably high temperature, (*b*) the reason why low temperatures are not used. (12)

(v) From the three gases in the equilibrium mixture in (iii) identify the gas that deviates least from ideal behaviour and give a reason for the choice you have made. (6)