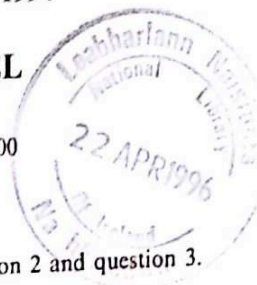AN ROINN OIDEACHAIS

LEAVING CERTIFICATE EXAMINATION, 1994

CHEMISTRY — ORDINARY LEVEL

MONDAY, 20 JUNE — AFTERNOON, 2.00 to 5.00

Question 1 and **five** other questions must be answered.

These questions *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, Na = 23, P = 31, S = 32, Cl = 35.5, Ca = 40.

Molar volume at S.T.P. = 22.4 l(dm³).

Avogadro constant = 6 × 10²³ 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*) Write down the electronic configuration (s, p etc.) of aluminium (atomic number 13).

    (*b*) What type of compound is formed when metals, bases and metal carbonates react with acids?

    (*c*) What is an *aromatic compound?*

    (*d*) Give an example of (i) a molecular crystal (ii) a covalent crystal.

    (*e*) Name the chemical manufactured in the *Contact Process.*

    (*f*) What happens when iron is added to an aqueous solution of copper(II) sulphate?
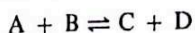
    (*g*) Write down the structural formula of 1-chloro-2-methylbutane.

    (*h*) Give an example of (i) an acidic oxide (ii) an amphoteric oxide.

    (*i*) What is the oxidation number of manganese in $KMnO_4$?

    (*j*) What is the pH of a 0.01 M solution of hydrochloric acid?

    (*k*) The following equation represents an exothermic reaction:

    $$A + B \rightleftharpoons C + D$$

    What would be the effect of increasing the temperature?

    (*l*) What mass of sodium chloride would be required to make up 500 cm³ of a 5% (w/v) solution?

    (*m*) What is meant by the *relative atomic mass* of an element?

   (*n*) Name two materials that are added to the top of the blast furnace.

    (*o*) What is meant by the *eutrophication* of water?

    (11 × 6)

2. The following extract was taken from a student's practical notebook:

"The concentration of a hydrochloric acid solution was found by titration with a standard 0.1 M solution of sodium carbonate. 25.0 cm³ of the sodium carbonate solution, followed by a few drops of indicator, were added to a conical flask. The acid solution was added in small volumes until the indicator changed colour."

Further titrations were carried out and the results are summarized in the table which follows:

TITRATION	FIRST	SECOND	THIRD
INITIAL READING/cm³	0.0	21.5	0.0
FINAL READING/cm³	21.5	41.5	20.0

The equation for the reaction is:

$$Na_2CO_{3(aq)} + 2HCl_{(aq)} = 2NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$
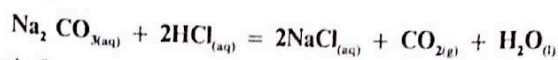
(a) What is a *standard solution*? (6)

(b) Describe how you would make up 250 cm³ of a standard solution of 0.1 M sodium carbonate. (12)

(c) What piece of apparatus was used to (i) measure the 25.0 cm³ of sodium carbonate solution (ii) add the known volumes of acid to the conical flask? (12)

(d) Give one precaution, in each case, for the accurate use of both of the pieces of apparatus in (c) above. (The two precautions should be different). (12)

(e) Name a suitable indicator for the experiment and state its colour (i) before and (ii) after the end point has been reached. (9)

(f) Calculate the concentration of the hydrochloric acid solution in (i) mol ℓ⁻¹ (dm⁻³) and (ii) g ℓ⁻¹ (dm⁻³). (15)

3. (a) Indicate by letter (A, B, C, D) the apparatus, shown in Fig. 1, which may be used in an experiment to:
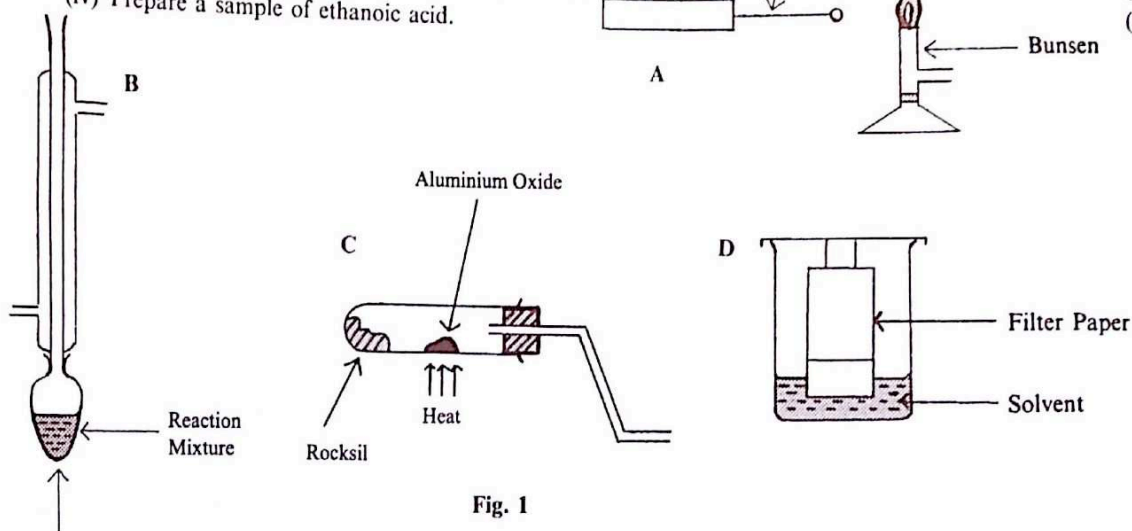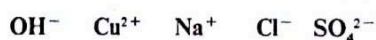
   (i) Separate the different coloured dyes in an ink. (6)
   (ii) Prepare a sample of ethene. (6)
   (iii) Identify the metallic ions present in a substance. (6)
   (iv) Prepare a sample of ethanoic acid. (6)

Fig. 1

(b) Describe how you would carry out any one of the experiments referred to in (a). (12)

(c) From the following list of ions:

$$OH^- \quad Cu^{2+} \quad Na^+ \quad Cl^- \quad SO_4^{2-}$$

Write down the formula of an ion which:

   (i) gives a blue colour in aqueous solution. (6)

   (ii) gives a white precipitate with aqueous silver nitrate in the presence of excess dilute nitric acid. (6)

   (iii) will give a yellow colour to a bunsen flame. (6)

   (iv) is present in all aqueous solutions. (6)

   (v) gives a white precipitate with acidic aqueous barium chloride. (6)

4. Answer the following questions with reference to the periodic table and to the six elements labelled j to o in the part of the periodic table shown below:

											1 (j)	2					
3	4	5									6 (k)	7	8	9	10		
11 (ℓ)	12	13									14	15	16	17 (m)	18		
19	20	21	22	23	24	25	26 (n)	27	28	29 (o)	30	31	32	33	34	35	36

(a) Which element has the electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^1$? (3)

(b) How does the reactivity of elements change as you go down a group? (3)

(c) Which element is the most reactive metal shown in the table? (3)

(d) What is the name of the block of elements that includes **n** and **o**? State one way in which the properties of elements in this block differ from those in Group I. (3)

(e) Write down the formula of a compound formed by each of the following pairs of elements:

(i) elements ℓ and **m**, (ii) elements **k** and **j**. (6)

(f) With reference to one of the compounds in part (e) above, state:

(i) the bonding present, justifying your answer by referring to electronegativity values.

(ii) what happens to the outer electrons of each of the combining elements when the bond is formed? (12)

(g) In the following table state which of the substances numbered **1** to **3** represents:

(i) the element ℓ?

(ii) the compound formed by ℓ combining with **m**?

(iii) the compound formed by **k** combining with **j** ? (18)

SUBSTANCE	1	2	3
MELTING POINT/°C	801	98	− 183
BOILING POINT/°C	1465	883	− 162
ELECTRICAL CONDUCTIVITY when **SOLID** when **MOLTEN** when in **AQUEOUS SOLUTION**	none good good	good good reacts with water	none none insoluble

5. Calcium carbonate reacts with dilute nitric acid according to the equation:

$$CaCO_3 + 2HNO_3 = Ca(NO_3)_2 + H_2O + CO_2$$

(6)
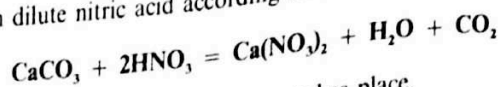
(i) Describe what you would see when the above reaction takes place.

(ii) Powdered calcium carbonate reacts at a different rate to large pieces. Explain this difference. (12)

(iii) State two other changes that could be made to change the rate of the reaction indicating clearly whether these changes increase or decrease the rate. (18)

(iv) Copy and complete the following diagram, **Fig. 2**, to show how you would measure the volume of carbon dioxide produced in the reaction. (15)
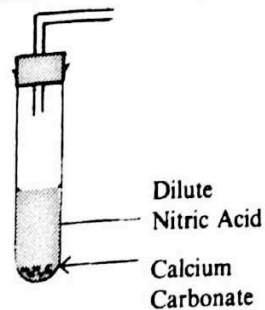
Fig. 2

Dilute
Nitric Acid

Calcium
Carbonate

(v) A student measured the volume of carbon dioxide produced at minute intervals until the evolution of carbon dioxide ceased. Draw a sketch, in your answer book, of the graph you would expect to obtain when the volume of carbon dioxide produced was plotted against time. (15)

6. The formulae of four organic compounds are given in the table below:

(i) Copy the table below into your answer book and complete it.

COMPOUND	NAME	HOMOLOGOUS SERIES	FUNCTIONAL GROUP	STRUCTURAL FORMULA
C_2H_4(A)	ethene	alkenes		
C_2H_5OH(B)			– OH	
CH_3CHO(C)				(see figure)
CH_3COOH(D)				

(24)

(6)

(ii) What reagent may be used to convert **B** to **A**?

(iii) State what colour changes are observed when:

   (a) Compound A reacts with a solution of bromine in 1,1,1-trichloroethane,

   (b) Compound B reacts with acidified potassium dichromate(VI) solution,

   (c) Compound C reacts with Fehling's solution.

(18)

(iv) One of the four compounds **A, B, C, D** has the following composition by weight: 40 % carbon, 6.7 % hydrogen and 53.3 % oxygen. Identify the compound showing how you reached your conclusion. (18)
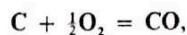
7. (a) Define (i) heat of combustion, (ii) kilogram calorific value. (12)

The hydrocarbon butane, C_4H_{10}, releases 49.6 kJ of heat energy when 1.0 g is burned in oxygen. Calculate:
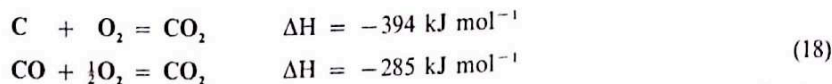
(i) the kilogram calorific value of butane, (6)

(ii) the heat of combustion of butane. (6)

(b) State Hess's law. (9)

Calculate the heat change for the reaction

$$C + \tfrac{1}{2}O_2 = CO,$$

given the following data:

$$C + O_2 = CO_2 \qquad \Delta H = -394 \text{ kJ mol}^{-1}$$
$$CO + \tfrac{1}{2}O_2 = CO_2 \qquad \Delta H = -285 \text{ kJ mol}^{-1}$$

(18)

(c) Describe an experiment to measure either the heat of combustion of a substance **or** the heat of neutralization of an acid. (15)

8. (a) Write down in your answer book the missing words or phrases in the following passage:

Ammonia is manufactured by a process called the _____ (1) _____ process in which _____ (2) _____ and _____ (3) _____ react together in the presence of a catalyst of finely divided _____ (4) _____. The reactant raw materials (2) and (3) are obtained from _____ (5) _____ and _____ (6) _____ respectively. (18)

Fig. 3

(b) Use the information from the graphs opposite, **Fig. 3**, to determine how the amount of ammonia produced is affected by:
(i) an increase in temperature,
(ii) an increase in pressure. (12)
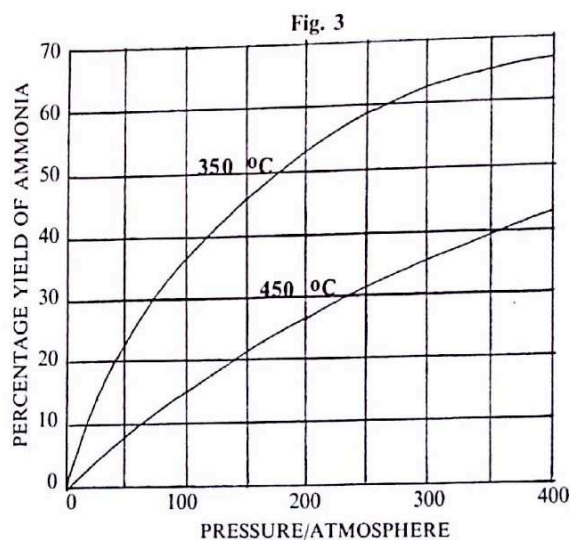
(c) What approximate percentage yield would you expect to obtain if the reaction was carried out at 450 °C and 300 atmospheres pressure? (9)

(d) Ammonia is used in the manufacture of fertilizers labelled as NPK fertilizers. Which two of the compounds in the table below, when mixed, would produce such a fertilizer?

COMPOUND	FORMULA	RELATIVE MOLECULAR MASS
Ammonium sulphate	$(NH_4)_2SO_4$	132
Potassium nitrate	KNO_3	101
Urea	$CO(NH_2)_2$	60
Ammonia phosphate	$(NH_4)_3PO_4$	149

(12)

(e) Which of the two compounds, ammonium sulphate and ammonium phosphate, contains the greater percentage of nitrogen? Show your calculations. (15)

9. (a) In Ireland, drinking water is taken from rivers and lakes. Outline the treatments carried out on this water to make it fit for human consumption. (18)

(b) A one litre (dm³) sample of water was filtered and then evaporated to dryness in a beaker. The following experimental readings were obtained:

Mass of filter paper before filtering took place   0.5 g
Mass of filter paper after filtration and drying   0.7 g
Mass of beaker   136.8 g
Mass of beaker + solids remaining after drying   138.0 g

Calculate (i) the total suspended solids, (ii) the total dissolved solids in the water. Express each answer in mg ℓ⁻¹ (dm⁻³) or ppm. (18)

(c) Soap solution was added to three samples of water, **A**, **B** and **C**, of equal volume. The volume of soap solution required to produce a lather was noted in each case. Three further samples of the same volume were then boiled and the volume of soap required to produce a lather was again found. The following table shows the data obtained:

WATER SAMPLE	VOLUME OF SOAP SOLUTION NEEDED/cm³	
	before boiling	after boiling
A	24	x
B	21	y
C	2	z

(i) If sample **A** exhibits temporary hardness, sample **B** permanent hardness and sample **C** is distilled water, write down the values of x, y and z. (18) (12)

(ii) Name one compound in each case which might have caused the hardness in **A** and **B**.

10. Answer any **two** of the following (*A*), (*B*), (*C*), (*D*).

(*A*) The reaction of calcium dicarbide and water can be represented by the equation:

$$CaC_2 + 2H_2O = C_2H_2 + Ca(OH)_2$$ (6)
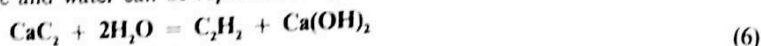
(i) Write the name and structural formula for C_2H_2.

(ii) If 6.4 g of calcium dicarbide was used, calculate:

    (a) the mass of C_2H_2 produced,

    (b) the volume of C_2H_2 produced at STP, (18)

    (c) the number of molecules of C_2H_2 produced, (9)

(iii) Draw a sketch of the apparatus used to prepare, purify and collect C_2H_2 in the laboratory.

(*B*) From the following list:

oxidation, electrolysis, neutralization, polymerization,
catalytic cracking, precipitation, decomposition,
esterification, condensation, vaporization and reduction.

select the one which best describes the process which occurs when each of the following changes takes place:

(i) magnesium → magnesium oxide

(ii) silver ion$_{(aq)}$ + chloride ion$_{(aq)}$ → silver chloride$_{(s)}$

(iii) lead bromide$_{(l)}$ → lead + bromine

(iv) calcium carbonate → calcium oxide + carbon dioxide

(v) hydrochloric acid + sodium hydroxide → sodium chloride + water

(vi) ethanol + ethanoic acid → ethyl ethanoate + water

(vii) iodine$_{(s)}$ → iodine$_{(g)}$

(viii) water$_{(g)}$ → water$_{(l)}$

(ix) copper(II) oxide → copper

(x) hexadecane → heptane + propene + ethene

(xi) ethene → poly(ethene) (11 × 3)

(*C*) (i) Water, with some dilute sulphuric acid added, can be electrolysed. Describe with the aid of a sketch how this electrolysis can be carried out in the laboratory. (12)

(ii) Explain the shape of the water molecule in terms of electron pair repulsion theory. (9)

(iii) The following dissociation takes place in water:

$$H_2O + HCl \longrightarrow H_3O^+ + Cl^-$$
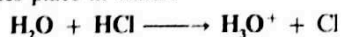
In terms of Brønsted-Lowry theory, indicate the acid, base, conjugate acid and conjugate base in the above equation. (12)

(*D*) Describe a laboratory experiment to determine **either** the relative molecular mass of a volatile liquid **or** the chemical formula of a named compound. (33)