AN ROINN OIDEACHAIS

4724

LEAVING CERTIFICATE EXAMINATION, 1997

CHEMISTRY — ORDINARY LEVEL

WEDNESDAY, 25 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, O = 16, Na = 23. Molar volume at STP = 22.4 l (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*) What is the oxidation number of phosphorus in H_3PO_4?

(*b*) Write down the chemical formula for iron(III) oxide.

(*c*) What is the pH of **0.01 M** H_2SO_4?

(*d*) State *Le Chatelier's principle.*

(*e*) What is an *aromatic* compound? Give an example.

(*f*) What is the systematic (IUPAC) name for $CH_3CH{=}CH_2$?

(*g*) Identify the conjugate acid-base pairs in the following: $HNO_3 + H_2O \rightleftharpoons H_3O^+ + NO_3^-$.

(*h*) Give an example of a chemical reaction which is catalysed and name the catalyst involved.

(*i*) State <u>two</u> of the principal activities carried out in an oil refinery.

(*j*) Oxides are classified as *acidic, basic, amphoteric* or *neutral*. Give <u>one</u> example of each of two types of oxide.

(*k*) Mention <u>two</u> operations which are carried out in the purification of water for domestic use.

(*l*) What does *Brownian movement* demonstrate?

(*m*) State *Avogadro's law*.

(*n*) Write the equilibrium constant expression for:

$$2SO_2 + O_2 \rightleftharpoons 2S0_3.$$

(*o*) State the shapes of <u>two</u> of the following molecules: BF_3, NH_3, BeH_2. (11 x 6)

2. In a titration experiment to determine the concentration of sodium hydroxide in a solution, 30 cm^3 of a 0.1 mol $^{-1}$ (dm^{-3}) solution of sulphuric acid were needed to neutralise 25 cm^3 of the sodium hydroxide solution. The equation for the reaction is:

$$2NaOH + H_2SO_4 = Na_2SO_4 + 2H_2O$$

The sulphuric acid solution had been previously standardised using a standard solution of sodium carbonate.

(*a*) Describe how a 250 cm^3 standard solution of sodium carbonate containing 0.1 mol^{-1} is made up. (15)

(*b*) How should the 25 cm^3 of sodium hydroxide solution be transferred during the titration? (9)

(*c*) Name a suitable indicator for use in the titration and state its colour before and after the end point has been reached. (9)

(*d*) Give two precautions which should be taken to ensure that the burette readings are accurate. (12)

(*e*) Why is a conical flask, rather than a beaker, used in the experiment? (6)

(*f*) Calculate the concentration of the sodium hydroxide solution in (i) mol l^{-1}, (ii) g l^{-1}(dm^{-3}). (15)

3. The following five statements were taken from different experiments in a student's laboratory notebook:

(i) "The impure product was recrystallised and its melting point measured."

(ii) "Paper chromatography was used to determine the different dyes in a food sample. **Fig. 1** shows a paper chromatogram of known food dyes **A, B, C, D** and an unknown dye **Q** from a food sample."

(iii) "A flame test indicated that the unknown compound was a potassium salt. Another test confirmed that it was a sulphate."

(iv) "Water was added to the solid in the flask and a hydrocarbon gas was produced."

(v) "This test distinguished between an aldehyde and a ketone."

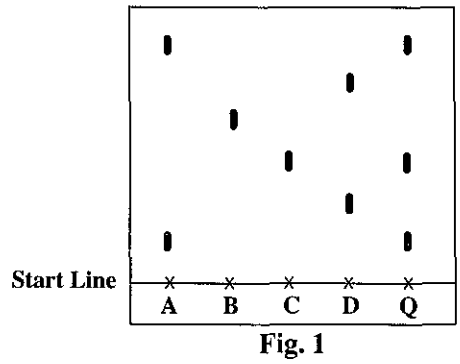

Fig. 1

Answer any <u>four</u> of the following items. **(Each item carries equal marks):**

(*a*) Name a crystalline substance and describe, how you would carry out the melting point determination mentioned in (i) above.

(*b*) With reference to **Fig. 1**, which dyes are indicated to be in the food sample? Describe how paper chromatography is carried out.

(*c*) What flame colour was observed in (iii) above? Describe how the flame test could be carried out. Give details of a test that would confirm that the unknown compound was a sulphate.

(*d*) Suggest names for the solid and the hydrocarbon gas referred to in (iv) above. Draw a sketch of the apparatus used to prepare and collect the gas. Name one impurity likely to be present in the gas.

(*e*) Describe and explain the chemical test you would use for (v) above. (66)

4. A student carried out an experiment to investigate the rate at which hydrogen gas was produced from the reaction of excess zinc granules with dilute hydrochloric acid. The volume (cm^3) of hydrogen gas produced was measured at 10 second intervals. The results obtained are shown in **Fig. 2** below. However, the student neglected to label the axes of the graph.

(*a*) Give suitable labels for the X-axis and the Y-axis. (12)

(*b*) Describe, with the aid of a sketch of the apparatus used, how this experiment could have been carried out. (9)

(*c*) Use the graph to determine:

(i) the volume of hydrogen produced after 40 seconds.

(ii) the time taken to produce 40 cm^3 of hydrogen.

(iii) the time at which the reaction was 90% complete. (18)

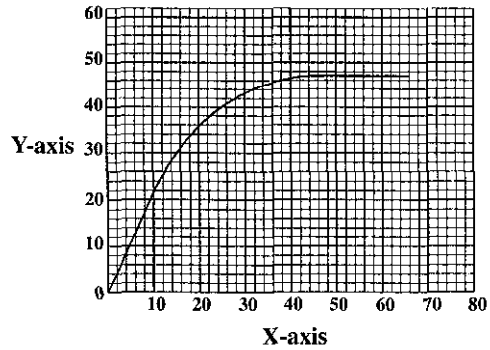

Fig. 2

(*d*) If the experiment was repeated exactly as before, except that more concentrated hydrochloric acid was used, how would you expect the graph obtained to differ from that shown above? (6)

(*e*) How would each of the following affect the rate of this reaction <u>and</u> the total volume of gas produced: (i) the use of the same mass of zinc powder rather than granules and (ii) a higher temperature? (12)

(*f*) Generally, ionic reactions differ in reaction rate from covalent reactions. Which type of reaction is usually the quicker? Give an explanation. (9)

5. (*a*) Write down in your answer book the missing words and/or numbers in the following passage:

Thermochemistry is the study of ___(1)___ changes which occur during chemical reactions. A reaction which liberates heat to the surroundings is an ___(2)___ reaction and has a ___(3)___ ΔH value. The heat of combustion is the amount of heat liberated when ___(4)___ of a substance is burned in ___(5)___ oxygen. In the laboratory the heat of combustion of a substance is determined by burning it and absorbing the heat produced in a ___(6)___. The value of the heat of combustion of methanol is found to be 715 kJ mol^{-1}. The kilogram calorific value of methanol is the heat liberated when ___(7)___ of it is burned. Its value can be calculated using the heat of combustion value above, giving the answer ___(8)___. (8 x 3)

(*b*) Describe with the aid of a sketch, an experiment to determine *the heat of combustion of methanol.* (5 x 3)

(*c*) 1 mole of ethanol reacts with 3 moles of oxygen forming carbon dioxide and water. Write a balanced equation for this reaction and calculate the heat change which occurs on burning 1 mole of ethanol given the following data:

$$C + O_2 = CO_2 \qquad \Delta H = -394\ kJ\ mol^{-1}$$
$$2H_2 + O_2 = 2H_2O \qquad \Delta H = -572\ kJ\ mol^{-1}$$
$$2C + 3H_2 + {}^1/_2O_2 = C_2H_5OH \qquad \Delta H = -279\ kJ\ mol^{-1}$$ (27)

6. Study the following reaction scheme, **Fig. 3**, and then answer the questions below:

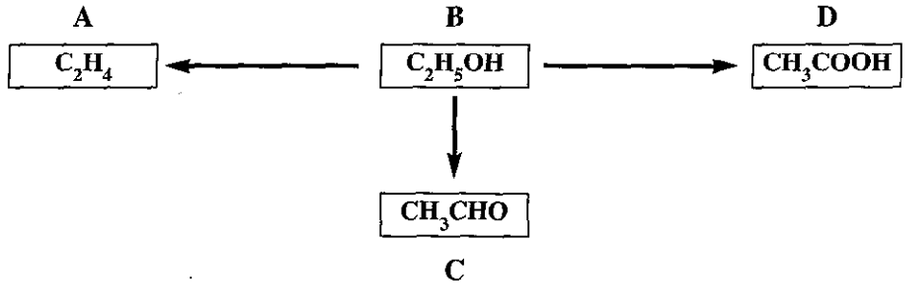

Fig. 3

(*a*) In the case of each of the compounds, **A, B, C** and **D**.
(i) write down its name.
(ii) state the homologous series to which it belongs.
(iii) draw its structural formula. (21)

(*b*) Which one of the compounds:
(i) is contained in vinegar?
(ii) can be polymerised to form a substance in everyday use?
(iii) is the main substance present in methylated spirits? (9)

(*c*) Compound **A** may be used to prepare each of the other three compounds **B, C** and **D**, in the laboratory. In the case of any two of these preparations.
(i) draw a sketch of the apparatus used. (12)
(ii) name the reagents and conditions required. (12)
(iii) state how the product is collected. (12)

7. (*a*) State <u>two</u> ways in which the modern Periodic Table differs from Mendeleev's Table. (12)

(*b*) **Fig. 4** shows a portion of the periodic table divided into four sections labelled **A, B, C** and **D**.

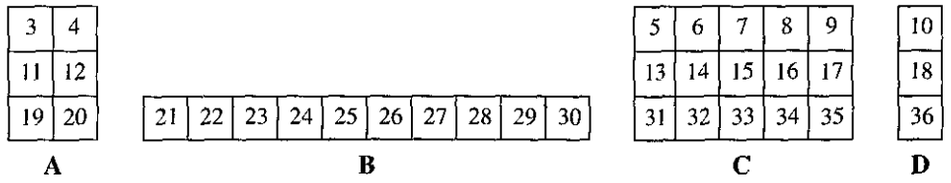

Fig. 4

Select from **A** to **D**, the section in which you would find:

(i) a gas which has no naturally occurring compounds.

(ii) an element which produces hydrogen when added to water.

(iii) the most reactive non-metal.

(iv) an element which forms coloured ions.

(v) a metal which floats on water.

(vi) the element with the electron configuration $\mathbf{1s^2 2s^2 2p^6 3s^1}$.

(vii) an element which forms an ion with a double negative charge.

(viii) a monatomic gas. (8 x 3)

(*c*) The table below gives information about four elements **V, W, X** and **Y** which are in the same group in the Periodic Table.

Element	Atomic Number	Melting Point/°C	Boiling Point/°C
V	9	–220	–188
W	17	–101	–33
X	35	–7	58
Y	53	114	183

(i) Using the melting points and boiling points given write down the letters of <u>all</u> the elements in the table which, at room temperature and atmospheric pressure, are:

(*a*) solids (*b*) liquids (*c*) gases. (12)

(ii) The next element in this group after **Y** is **Z**.

(*a*) Would you expect **Z** to be a solid, liquid or gas? (3)

(*b*) How many electrons will be in the outer shell of a **Z** atom? (3)

(*c*) Using the symbol **Z**, write down the formula of the most stable ion of **Z**. (6)

(*d*) How many atoms are present in a molecule of **Z**? (6)

8. (*a*) This item concerns the following metals:

Magnesium, zinc, sodium, iron.

(i) Arrange the metals in order of chemical reactivity, placing the most reactive metal first. (6)

(ii) Which metal is used to galvanise iron? (3)

(iii) Which metal shows variable valency or oxidation state? (3)

(iv) Which metal gives a yellow colour to a bunsen flame? (3)

(v) In the case of any <u>one</u> of the metals above, show by means of an equation how it reacts with (*a*) water or steam (*b*) dilute hydrochloric acid. (12)

(*b*) **Fig. 5** shows apparatus used for the purification of impure copper by electrolysis.

(i) Using the letters **X, Y** and **Z**, identify (*a*) the cathode, (*b*) the electrolyte, (*c*) the anode. (9)

(ii) Name the electrolyte used. (3)

(iii) Which electrode is made from impure copper? (3)

(iv) In which parts of the apparatus does the conduction of electric current take place by (*a*) movement of electrons, (*b*) movement of ions. (6)

(v) Write an equation for the reaction occurring at the cathode. (6)

(vi) At which electrode does reduction take place? (6)

(vii) Give another example of an electrolysis reaction stating:

(*a*) the electrolyte used.

(*b*) the product at the anode. (6)

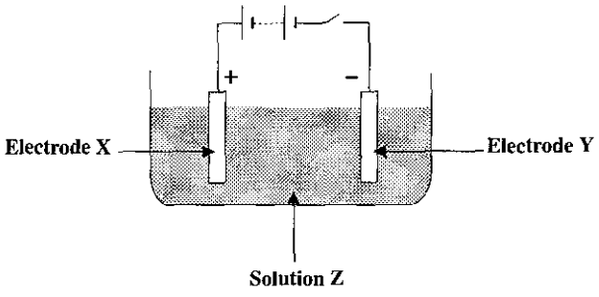

Fig. 5

9. The sketch below represents the label which appeared on a container of bottled mineral water.

BOTTLED WATER		
Composition		**mg l^{-1}**
Hydrogencarbonate	(HCO_3^-)	228.0
Calcium	(Ca^{2+})	68.6
Chloride	(Cl^-)	49.9
Magnesium	(Mg^{2+})	9.7
Nitrate	(NO_3^-)	14.0
Potassium	(K^+)	2.2
Sodium	(Na^+)	23.9
Sulphate	(SO_4^{2-})	10.8
pH = 7.8		

(*a*) Is the mineral water acidic, alkaline or neutral? (3)

(*b*) What is the concentration of hydrogencarbonate ions expressed in parts per million (ppm)? (3)

(*c*) Using the ions listed on the label, write down the name or formula of a compound which causes (i) temporary hardness, (ii) permanent hardness in water. (12)

(*d*) How may (i) temporary, (ii) permanent hardness be removed from water? (12)

(*e*) On boiling a sample of mineral water, a whitish precipitate is obtained which reacts with dilure hydrochloric acid giving off a gas which turns limewater milky (cloudy). Write down the name of:

(i) the gas produced.

(ii) the compound which would be the main part of the white precipitate. (9)

(*f*) Give (i) an advantage, (ii) a disadvantage of hard water. (6)

(*g*) The mineral water contains chloride ions and nitrate ions. Describe a chemical test for (i) chloride ions, (ii) nitrate ions. (12)

(*h*) Describe, briefly, how you would determine the total mass of dissolved solids in a litre of water. (9)

10. Answer any *two* of the following (*a*), (*b*), (*c*), (*d*):

(*a*) Ammonia, sulphuric acid and nitric acid are three important industrial chemicals.

(i) State the raw materials required for the manufacture of each of these

(ii) Write equations for the reactions involving the manufacture of <u>one</u> of th

(iii) Give <u>one</u> important but different use for each of the three industrial chemica.

(*b*) (i) What is a crystal?

(ii) The table below give information about three types of crystal.
Copy the table into your answer book and complete it. (10 x 3)

	TYPES OF CRYSTAL		
	IONIC	**COVALENT**	**MOLECULAR (non-polar)**
EXAMPLE	NaCl		
UNITS IN CRYSTAL	ions		
BINDING FORCE IN CRYSTAL	electrostatic		
MELTING POINT and BOILING POINT		high	
SOLUBILITY IN WATER			insoluble/very low

(*c*) Balance the following equation which represents the burning of natural gas (methane, CH_4). (3)

$$\mathbf{CH_{4(g)} + O_{2(g)} \longrightarrow CO_{2(g)} + H_2O_{(l)}}$$

If 10 moles of methane are completely burned, calculate:

(i) the mass of methane burned. (6)

(ii) the number of moles of oxygen used up. (6)

(iii) the volume of carbon dioxide produced at STP. (9)

(iv) the number of molecules of water formed. (9)

(*d*) A hydrocarbon **X** contains 85.7 % carbon by mass.

(i) Calculate the empirical formula of the hydrocarbon **X**. (9)

(ii) If the relative molecular mass of **X** is 56, write down its molecular formula. (6)

(iii) **X** readily decolorises bromine solution. What information does this give you about the structure of **X**? Write down an equation for this reaction. (9)

(iv) Draw <u>two</u> possible structural formulae for **X** showing all bonds and give the name of the compound represented by <u>either</u> of the structural formulae drawn. (9)