

1976

Chemistry

Higher II

SCOTTISH CERTIFICATE OF EDUCATION

CHEMISTRY

Higher Grade—Paper II

Monday, 10th May—1.30 p.m. to 4.00 p.m.

Marks may be deducted for bad spelling, and bad punctuation, and for writing that is difficult to read.

Working should be shown in all answers involving calculations.

Necessary data will be found in the book of Mathematical Tables and Science Data.

[173]

PART A

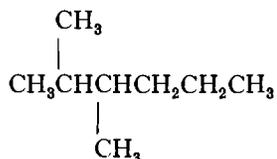
All questions should be attempted. It should be noted, however, that some questions contain a choice.

It is suggested that about one hour be spent on this part of the paper.

Marks

1. Answer EITHER A OR B.

A. Write down the systematic name of the following compound. (2)



OR

B. Draw the structural formula of 3,4-dimethylheptane. (2)

2. $a\text{Cu} + b\text{HNO}_3 \rightarrow c\text{Cu}(\text{NO}_3)_2 + d\text{NO} + e\text{H}_2\text{O}$

Balance the equation and write down the values for a, b, c, d and e. (2)

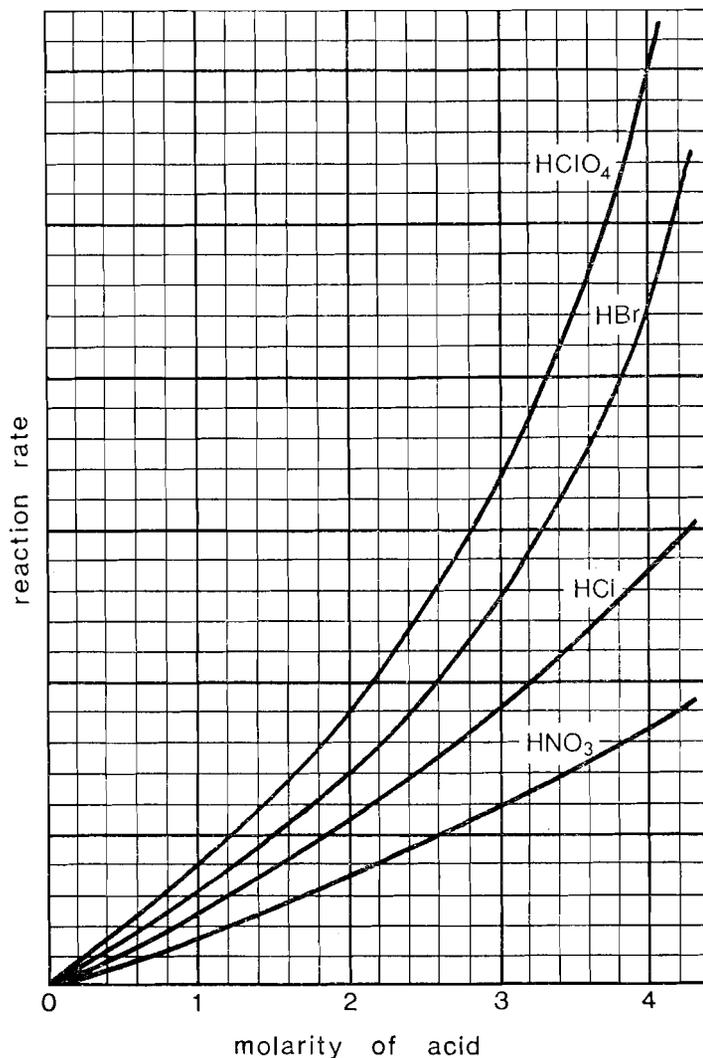
3. ${}^{10}_5\text{B} + {}^1_0\text{n} \rightarrow {}^p_q\text{X} + 2{}^4_2\text{He}$

What are the values of p and q in the above equation? What is element X? (2)

4. Use the information in your Data Book to calculate the mass of 1 molecule of bromine. (3)

5. Answer EITHER A OR B.

A.



Sucrose is hydrolysed to glucose and fructose using an acid catalyst. The graph shows the relative efficiencies of some acids of different strengths at different concentrations. Nitric acid is the weakest acid shown and perchloric acid is the strongest.

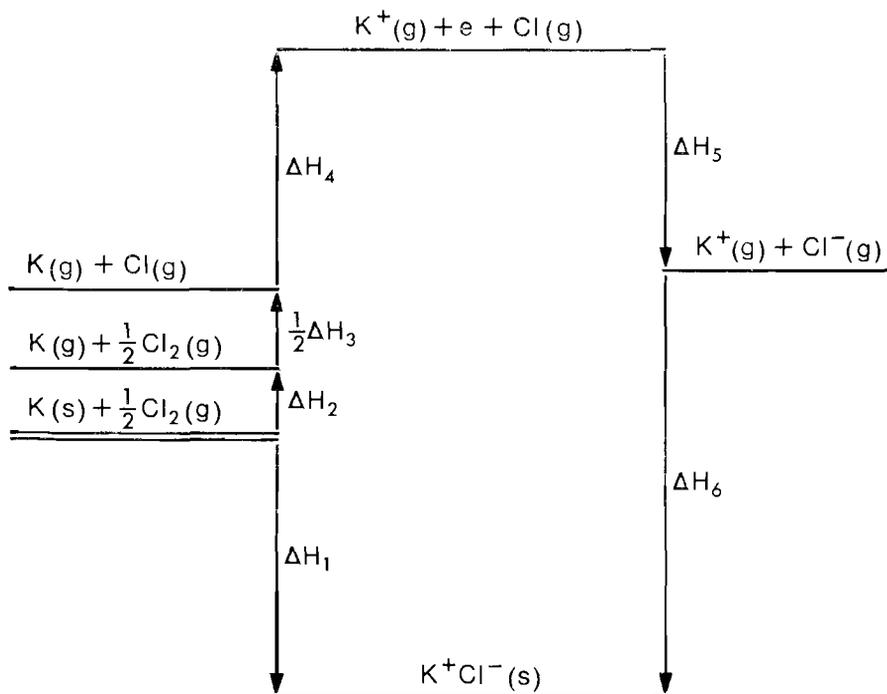
- What species is the **actual** catalyst in the hydrolysis? (1)
- Would 4 M ethanoic acid be a better or worse catalyst than those acids shown? Explain. (2)
- Draw two axes on your answer book; copy the curves for HBr and HCl roughly as shown. Now indicate by **dotted** lines where you think the curves for HI and HF would fit in. What does this suggest about the relative strengths of hydrogen-halogen bonds? (3)

[Turn over

OR

- B. The energy level diagram below shows the enthalpy changes associated with the formation of solid potassium chloride from its elements in their standard states. Upward arrows indicate endothermic processes and downward arrows indicate exothermic processes.

ΔH_1 , the Heat of Formation of potassium chloride, is the net result of all the other enthalpy changes.



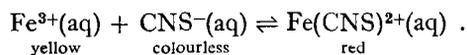
- (a) ΔH_1 is the Heat of Formation of solid potassium chloride and ΔH_6 is the Lattice Energy of potassium chloride. What names are given to the enthalpy changes ΔH_2 , ΔH_3 , ΔH_4 , and ΔH_5 ? (2)

- (b) Given that $\Delta H_1 = -436 \text{ kJ mol}^{-1}$
 $\Delta H_2 = +90 \text{ kJ mol}^{-1}$
 $\Delta H_5 = -356 \text{ kJ mol}^{-1}$

make use of your Data Book to calculate the Lattice Energy of KCl(s). (4)

6. 280 cm^3 of a gas were found to weigh 0.55 g at s.t.p. Calculate the molecular weight of the gas. (3)

7. $\text{Fe}^{3+}(\text{aq})$ ions react with thiocyanate ions, $\text{CNS}^{-}(\text{aq})$ according to the equation:



- (a) When ammonium thiocyanate solution is added the red colour deepens. Explain why this change takes place.
- (b) When ammonium chloride solution is added the chloride ions form a complex with the $\text{Fe}^{3+}(\text{aq})$ ions.

What would you expect to happen to the colour of the red solution? Explain your answer. (4)

8. Explain each of the following:

- (a) n-propanol and n-butane have almost the same molecular weight but n-propanol has a boiling point of 97°C and n-butane has a boiling point of -0.5°C .
- (b) Potassium chloride dissolves readily in water but not in benzene.

(2)

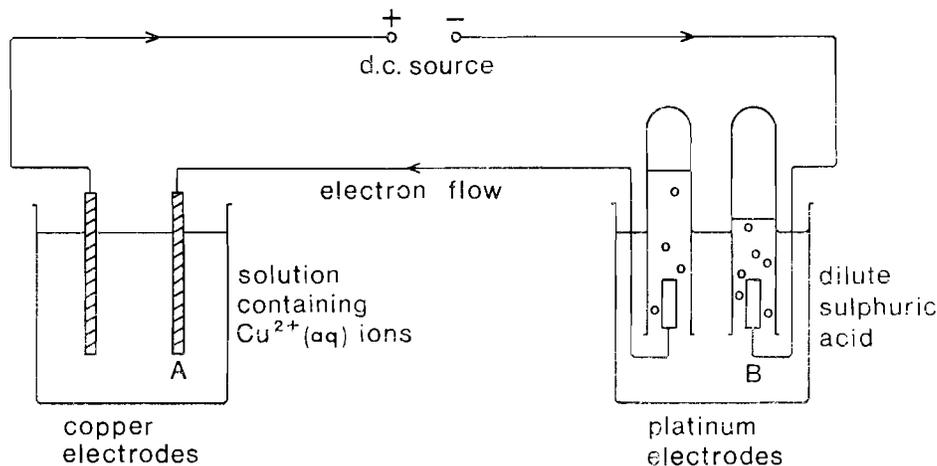
9.

Bond	Bond energy kJ mol^{-1}
N—H	391
N \equiv N	941
H—H	435

Use the values of bond energy given in the table to calculate the Heat of Formation of 1 mole of ammonia from its elements. Show all your working and indicate clearly whether the reaction is exothermic or endothermic.

(5)

10.

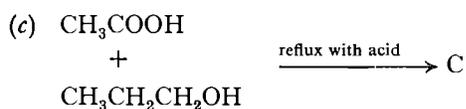


During an electrolysis experiment the apparatus was set up as shown in the diagram. It was found at the end of the experiment that the copper electrode A had increased in weight by 0.64 g . (Use the data on page 39 of the Data Book.)

- (a) Write an equation for the reaction occurring at electrode A.
- (b) What volume of gas at s.t.p. is liberated at electrode B?

(5)

[Turn over



Write down the structural formulae of the organic products A, B and C. (3)

12. (a) Write down the formula of aluminium selenide.

(b) What substances do you think would be formed when copper is warmed gently with concentrated selenic acid?

(c) Write an ionic equation for the reaction occurring when barium chloride solution is added to a solution of potassium selenate. (4)

13. 4 g sodium hydroxide were dissolved in about 100 cm³ of water. What volume of 2 M hydrochloric acid would be required to neutralise the solution? (4)

14. Answer **EITHER A OR B**

A. You are supplied with the following apparatus and chemicals: two glass beakers, a magnesium rod, a silver rod, connecting wires, molar solutions of silver nitrate, potassium chloride and magnesium sulphate, a packet of filter papers, a bulb holder and three bulbs (6 V, 3.5 V and 0.5 V respectively).

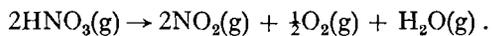
(a) Draw a labelled diagram of an apparatus which uses the above materials to light a bulb. (2)

(b) State clearly or indicate on the diagram the direction of the flow of electrons in the external circuit. (1)

(c) Explain which bulb you choose to light, ignoring the possibility of internal resistance within the cell. (2)

OR

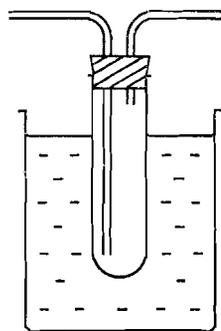
B. When nitric acid vapour is heated strongly it decomposes according to the equation:



(a) Arrange the following pieces of apparatus so that the decomposition can be carried out, and optimum separation of the products obtained in one operation.

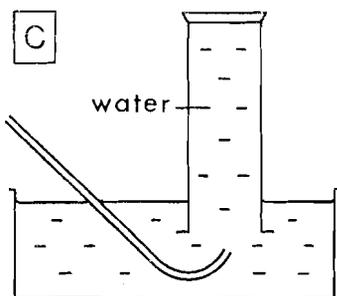
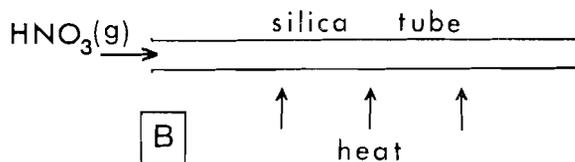
Assume that inert connecting tubing is available.

There is no need to draw the apparatus. Answer using the box/letter symbol for each piece. (2)



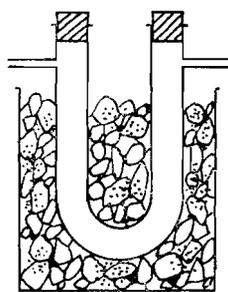
cold water

A



C

water



freezing mixture

D

(b) Indicate clearly where each product will be collected. (2)

(c) Why will the water collected not be pure? (1)

[Turn over

PART B

All three questions should be attempted. Each question contains a choice.

Candidates are advised to spend about $1\frac{1}{2}$ hours on this part.

15. Answer EITHER A OR B

Marks

A. The following is an extract from a lecture given by F. Soddy to a meeting of Nobel Prize-winners in Bavaria in 1952. (Modern Science Memoirs No. 33.)

“At that time, the turn of the century, the rare-earth elements had nearly all been separated from one another, a sequence, spread over no less than 40 units of atomic weight, of over a dozen different chemical elements, in point-blank contradiction to the chemical principle of the Periodic Law, so closely alike in chemical character that it is the work of a lifetime still to separate them. This, had we known it, was a curious foreshadowing of one feature at least of isotopes, but in itself sufficient to contradict the original idea that it was the atomic weight that determined chemical character. Also showing the same thing was the fact, quite well established by the turn of the century, that there were definite exceptions to the Periodic Law, three pairs of elements being transposed, of which the most glaring was tellurium, at wt. 127.6 preceding, not following, iodine, 126.9. At that time too it had been recognised that such a large proportion of the elements have atomic weights so nearly integral in terms of that of oxygen as 16—though there are plenty of others, like chlorine 35.453, straddling integers—that this could not be due to chance. This recalled Prout’s then notorious but now famous hypothesis of 1815, that the elements were compounded of hydrogen, since many had nearly integral atomic weights in terms of that of hydrogen, and which the more exact atomic weight determinations of Stas and later atomic weight chemists had been considered completely to disprove.”

(a) Why does Soddy suggest that the rare-earth elements are so difficult to separate? (1)

(b) What evidence is there in the passage that atomic weight does not determine chemical character? (2)

(c) In modern periodic tables iodine atomic weight 126.9 is placed after tellurium atomic weight 127.6.
Explain why this arrangement is **chemically** correct. (2)

(d) Why was it reasonable in 1815 for Prout to suggest that elements were composed of hydrogen? (1)

(e) What experimental evidence is given in the passage which might disprove Prout’s suggestion? (1)

(f) How would modern atomic theory account for the atomic weight of chlorine as 35.453? (2)

(g) Explain why Prout’s hypothesis can be viewed favourably in the light of modern ideas on atomic theory. (3)

(h) In the passage atomic weights are compared to oxygen as 16. What standard is now used for atomic weight determinations? (1)

(i) Name an apparatus used today to determine atomic weights. (1)

(j) In the determination of the atomic weight of element X the following analysis was obtained:

$$92.2\% \text{ } ^{28}_{14}\text{X}; 4.7\% \text{ } ^{29}_{14}\text{X}; 3.1\% \text{ } ^{30}_{14}\text{X}$$

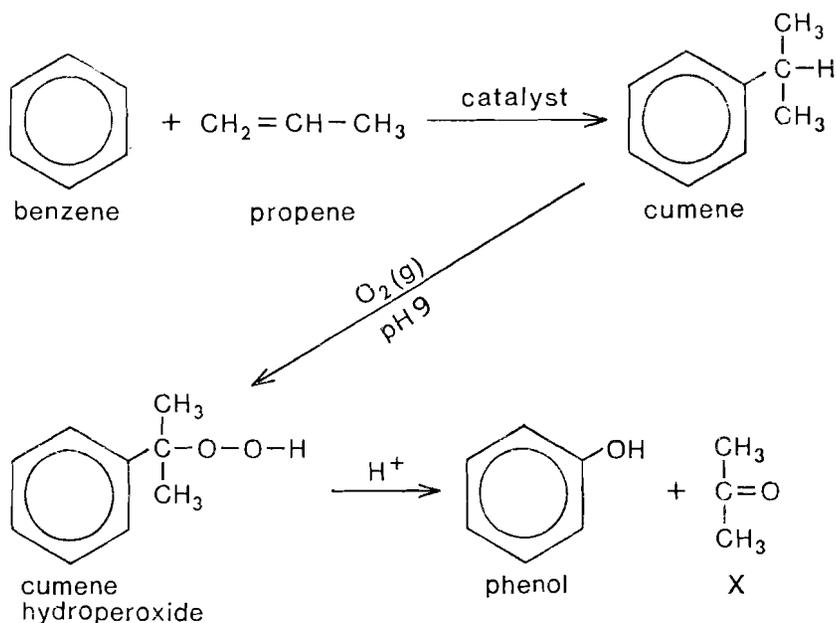
Use these figures to calculate the atomic weight of element X. Show all the steps in your working clearly. (3)

(17)

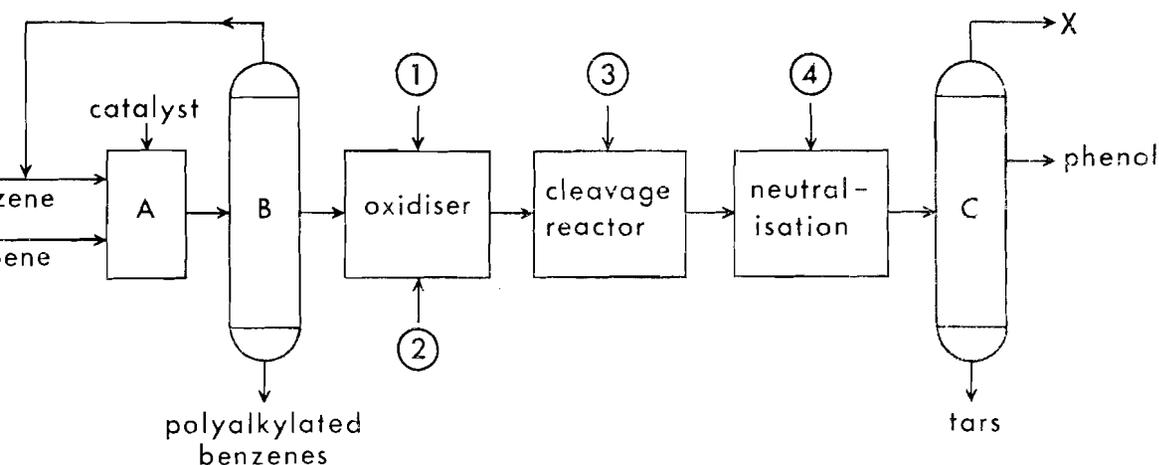
OR

B. *The Production of Phenol (Hydroxybenzene)*

Phenol is widely used in industry for the manufacture of plastics, dyestuffs and other useful products. For many years, coal tar was the major source of phenol, but with increasing demand, new methods of production have had to be found. The most modern method involves the catalytic alkylation of benzene with propene, forming the alkylated benzene known as cumene. The cumene then undergoes air oxidation at $\text{pH} > 7$ to cumene hydroperoxide. This reaction is autocatalytic, so when the plant is operating normally the concentration of cumene hydroperoxide is kept at 10%. The cumene hydroperoxide is then “split” by lowering the pH, the mixture is neutralised and the products are distilled. The reaction sequence is:



A simplified flow diagram is as follows:



Marks

- (a) What is the primary industrial source of propene? (1)
- (b) In the passage, what name is applied to the process occurring in A? (1)
- (c) From the reaction sequence, what alternative name could be given to the process occurring in A? (1)
- (d) From your understanding of the passage and the reaction sequence, what reagents must enter the flow diagram at ①, ②, ③, and ④? (4)
- (e) What distils from the top of column B? (1)
- (f) Does this suggest anything about the relative quantities of benzene and propene in the original feedstock? (2)
- (g) What is meant by the term "autocatalytic"? What statement in the passage confirms your answer? (2)
- (h) The profitability of the process depends upon recovery of the by-product X.
- (i) Name this product. (2)
- (ii) To what class of compound does it belong? (2)
- (i) Draw the structural formula of a simple polyalkylated benzene which could be recovered from the bottom of column B. (2)
- (j) Suggest what might happen to the "tars" from the bottom of column C. (1)

(17)

[Turn over

16. Answer EITHER A OR B

A. As we move horizontally across a period or vertically down a group in the Periodic Table we can observe gradual changes in the physical and chemical properties of the elements. Use your Data Book pp. 34-37 to help you answer the following questions.

- (a) Where, between elements of atomic number 1 and 12 are the most abrupt changes in the chemical properties? (2)
- (b) What **two** factors cause the tendency for the first ionisation energy to increase as we move across a period? (2)
- (c) Within the period sodium to argon write formulae for
- the compound with the highest degree of ionic bonding;
 - the hydride with the highest degree of covalent bonding. (2)
- (d) By means of extended structural formulae show why the group 4 elements carbon and silicon have dioxides which are totally different in character. (2)
- (e) At ordinary temperatures, five distinct structures exist among the elements. These are:
- closely packed molecules;
 - giant covalent structure;
 - giant ionic structure with interstitial electrons;
 - atomic gas;
 - molecular gas.
- Which of these best describe the normal state of sulphur, silicon, argon and aluminium? (4)
- (f) Among simple compounds, the oxides probably show the most regular trends as we move across a period. In what sense can aluminium oxide be said to be intermediate in properties between the oxides of sodium and sulphur? (2)
- (g) Mendeleef was able to predict many properties of elements yet to be discovered. Predict the physical appearance and estimate the melting points of:
- francium;
 - astatine. (4)

(18)

OR

Marks

B. (a) HOH C₃H₇OH NaOH C₆H₅OH

These compounds all contain the OH group. Explain

(i) why a solution of NaOH conducts electricity but a solution of C₃H₇OH does not; (1)

(ii) why a solution of C₆H₅OH has a pH of less than 7 but a solution of NaOH has a pH of more than 7. (2)

(iii) C₃H₇OH and HOH react in a similar way with certain reagents.

Select one such reagent and write an equation for its reaction with each. (2)

(b) Draw simple diagrams to show the shape of the molecules of methane and ethyne. Your diagram should show clearly the positions of the atoms in the molecule. Explain briefly why the molecules have these shapes. (5)

(c) "Some of the reactions of phenylamine (aniline) are those of a substituted ammonia."

(i) What do you understand by this statement?

(ii) Dry hydrogen chloride was bubbled into phenylamine dissolved in ether and a precipitate was obtained. Name the precipitate and write an equation for the reaction. (3)

(d) When 0.16 g of an alcohol were burned in oxygen 0.22 g of carbon dioxide and 0.18 g of water were produced.

(i) From the mass of carbon dioxide produced calculate the mass of carbon in the sample.

(ii) From the mass of water produced calculate the mass of hydrogen in the sample.

(iii) Deduce the mass of oxygen in the sample.

(iv) Find the empirical formula of the alcohol. (5)

(18)

17. Answer **EITHER A OR B**

A. Write an essay on "Water".

Your answer should include reference to the following points:

(a) its anomalous position among the hydrides of light elements and the reasons for this, in terms of bonding;

(b) its role as a solvent;

(c) its role in electrolysis;

(d) its biological importance. (15)

OR

B. Write an essay on "Nitrogen".

Your answer should include reference to the following points:

(a) the natural occurrence and chemical importance of nitrogen and nitrogen-containing compounds, both organic and inorganic;

(b) the industrial importance of the fixation of nitrogen including an outline of the process involved;

(c) the agricultural importance of nitrogen and its compounds. (15)

[END OF QUESTION PAPER]