1979

SCOTTISH CERTIFICATE OF EDUCATION

CHEMISTRY

Higher Grade—PAPER II

Thursday, 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.

1. How is a very reactive metal likely to be obtained commercially?

   A The native metal would be purified.

   B The ore would be roasted in air.

   C The ore would be melted and electrolysed.

   D The ore would be heated with coke.

2. When fast-moving alpha-particles are projected at thin gold foil as shown below, a few of them undergo a considerable deflection.
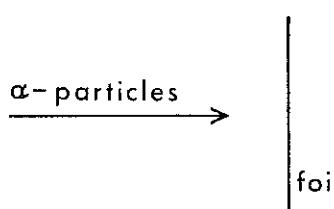
   Which of the following most precisely describes what happens?

   A They bounce off the surface of the foil.

   B They collide with other alpha-particles.

   C They are deflected by ions in the gold.

   D They are deflected by the atomic nuclei in the gold.

3. Consider the following.

Particle	Protons	Neutrons	Electrons
P	26	30	23
Q	26	30	24
R	26	31	24
S	27	31	25

   Which two are different oxidation (valency) states of the same isotope?

   A P and Q

   B Q and R

   C R and S

   D P and R

4. Which one of the following statements **must** be correct concerning the number of neutrons in an atom of **any** element?

   A It is the same as the atomic number of the element.

   B It is the same for all atoms of the element.

   C It is less than the mass number of any atom of the element.

   D It is less than the number of electrons in an atom of the element.

5. A positively charged particle with electronic configuration 2,8 could be

   A a fluoride ion

   B an aluminium ion

   C a sodium atom

   D a neon atom.

6. In the diagram below each sphere represents a particle about the size of an atom and the sign indicates the charge on the particle.
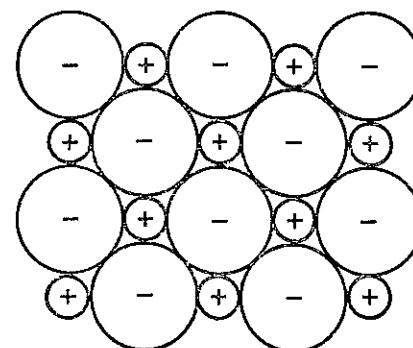
   In which one of the following substances would the above model be a reasonable representation of the way the fundamental particles are arranged in the crystal?

   A Diamond

   B Carbon tetrabromide

   C Calcium fluoride

   D Lithium bromide

7. The electrical conductivities of which pair of solutions shown below should be measured in order to compare the mobilities of $H^+(aq)$ and $Na^+(aq)$?

A   M/2 hydrochloric acid and M sodium chloride

B   M hydrochloric acid and M sodium hydroxide

C   M nitric acid and M sodium nitrate

D   M/2 sulphuric acid and M sodium sulphate

8. A metal (melting point 98 °C, density 0·97 g cm^{-3}) was obtained by electrolysis of its molten chloride (melting point 804 °C, density 2·2 g cm^{-3}). During the electrolysis, in which of the following states would the metal occur?

A   As a solid on the surface of the electrolyte

B   As a liquid on the surface of the electrolyte

C   As a solid at the bottom of the electrolyte

D   As a liquid at the bottom of the electrolyte

9. 64 g of copper is added to 1 litre of M silver nitrate solution. Which one of the following statements represents one of the results of this action?

A   The resulting solution is colourless.

B   All the copper dissolves.

C   64 g of silver is displaced.

D   1 mole of silver is displaced.

10. Which one of the following statements about hydrogen chloride is true?

A   It is a weak acid in dilute solution.

B   Its molecules are polar covalent.

C   It is insoluble in organic solvents.

D   It is used industrially to produce sodium chloride.

11. An element conducts electricity. When it is burned in oxygen and the product is added to water the resulting solution has a pH greater than 7.

The element could be

A   carbon

B   sodium

C   sulphur

D   aluminium.

12. What minimum volume of 4 M hydrochloric acid is required to dissolve 0·1 mole of magnesium according to the following equation?

$$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$$

A   25 cm^3

B   50 cm^3

C   100 cm^3

D   200 cm^3

13. Which one of the following reactions would **NOT** produce sulphur dioxide?

A   Burning sulphur in air

B   Adding dilute sulphuric acid to sodium sulphate

C   Adding dilute hydrochloric acid to sodium sulphite

D   Roasting iron sulphide in air

14. If one mole of sodium hydroxide was added to one mole of sulphurous acid the salt formed would be

A   sodium sulphite

B   sodium sulphide

C   sodium hydrogensulphate

D   sodium hydrogensulphite.

15. An aqueous solution X was tested as follows.
(*a*) Adding dil. HCl produced no visible reaction.

(*b*) Adding $BaCl_2$ + HCl produced a white precipitate.

Which of the following conclusions best fits these observations?
Solution X contains

A   chloride but no sulphate ions

B   sulphate but no chloride ions

C   chloride but no carbonate ions

D   sulphate but no carbonate ions.

16. Dilute sulphuric acid (2 M) is dropped on to a mixture of magnesium and magnesium carbonate. Which one of the following would be the most likely composition of the gas evolved?

A   Carbon dioxide only

B   Hydrogen only

C   Hydrogen and carbon dioxide

D   Carbon dioxide and sulphur dioxide

[Turn over

17. If 0·1 mole of equally fine granules of the following metals were reacted with equal volumes of excess 2 M hydrochloric acid, which one should give off the most hydrogen?

A Aluminium

B Magnesium

C Lithium

D They should all give off the same volume.

18. Which one of the following does **NOT** apply to carbon monoxide? (You may wish to refer to page 36 of the Data Book.)

A It is easily liquefied.

B It is less dense than air.

C It is a powerful reducing agent.

D It combines with haemoglobin in blood.

19. Hydrochloric acid solution and nitric acid solution are poured into separate beakers. Which one of the following substances will react with only **ONE** of the two acid solutions?

A Magnesium

B Copper

C Lead carbonate

D Calcium oxide

20. Sparks were passed through some ammonia gas which had been collected in a tube over liquid paraffin. What happened to the level of the liquid paraffin?

A It rose because the products occupied a smaller volume than the ammonia.

B It fell because the products occupied a larger volume than the ammonia.

C It remained at the same level.

D It rose because one of the products dissolved in the liquid paraffin.

21. When a certain gas is bubbled through dilute hydrochloric acid the pH increases. The gas could be

A hydrogen

B ammonia

C carbon monoxide

D sulphur dioxide.

22. The reaction

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

is an example of

A photosynthesis

B hydrolysis

C combustion

D hydration.

23. The action of digestive enzymes on fats is an example of

A hydrolysis

B hydrogenation

C dehydration

D dehydrogenation.

24. Which one of the following compounds would liberate 1 mole of hydrogen gas when 1 mole of it reacts with 2 moles of sodium?

A C_2H_5OH

B CH_2OHCH_2OH

C CH_3COOH

D CH_3CHO

25. Which one of the following properties identifies a substance as a thermosetting polymer?

A It is resoftened on heating.

B It is a straight chain hydrocarbon.

C It is formed by addition polymerisation.

D None of these.

Questions 26 and 27 refer to the following four classes of polymers.

A Natural addition polymers

B Natural condensation polymers

C Synthetic addition polymers

D Synthetic condensation polymers

Place each of the following in its appropriate class.

26. Glycogen.

27. Polypropene.

28. Hydrogen has two main isotopes.

| Isotope	Symbol	Mass number	Atomic number
Hydrogen	H	1	1
Deuterium	D	2	1

In a mass spectrometer, hydrogen gas containing the isotope deuterium produced five gaseous ions:
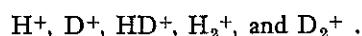
$$H^+, \; D^+, \; HD^+, \; H_2^+, \; \text{and} \; D_2^+ \;.$$

Which pair of lines in the spectrum will overlap?

A H^+ and D^+

B H_2^+ and D_2^+

C H_2^+ and D^+

D H_2^+ and HD^+

29. Naturally occurring nitrogen consists of two isotopes ^{14}N and ^{15}N. How many types of stable nitrogen molecules will occur in the air?

A   1

B   2

C   3

D   4

30. Radioactive $^{14}_{6}C$ decays by beta-particle emission. Which statement is true of the new nucleus produced?

A   It has mass number 13.

B   It has 6 protons.

C   It has 7 neutrons.

D   It is a carbon nucleus.

31. Which has the largest volume at s.t.p.?

A   1 g hydrogen

B   14 g nitrogen

C   20 g neon

D   35·5 g chlorine

32. If a steady current of 0·4 A was passed through molar silver nitrate solution for 40 minutes how many moles of silver would be liberated?

A   0·001

B   0·01

C   0·1

D   1

33. Which one of the following properties of the Group VI elements, or their compounds, would most likely be represented by the graph below?
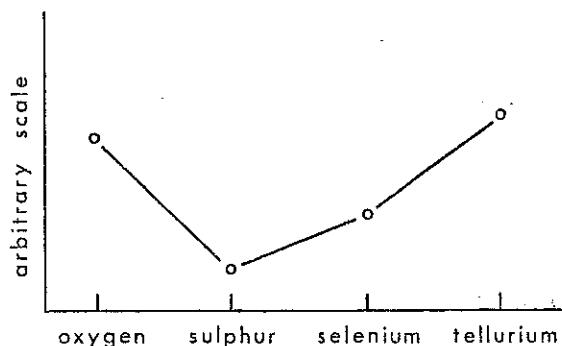
A   Natural abundance of the element

B   Ease of formation of chains of atoms of the element

C   The melting point of the element

D   The boiling point of the hydride

34. From the information given below

$$C(s) + O_2(g) \rightarrow CO_2(g);$$
$$\triangle H = -395 \text{ kJ mol}^{-1}$$

$$CO(g) + \tfrac{1}{2}O_2(g) \rightarrow CO_2(g);$$
$$\triangle H = -282 \text{ kJ mol}^{-1}$$
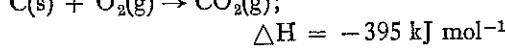
what is the heat of formation of carbon monoxide?

A $+113$ kJ mol^{-1}

B -113 kJ mol^{-1}

C -677 kJ mol^{-1}

D $-197·5$ kJ mol^{-1}

35. When 25 cm³ of 2·0 M HCl was added to 25 cm³ of 1·0 M NaOH, a rise in temperature of 5 °C was noted.

Which one of the following would give a greater rise in temperature?

A   25 cm³ 1·0 M HCl + 25 cm³ 1·0 M NaOH

B   25 cm³ 4·0 M HCl + 25 cm³ 1·0 M NaOH

C   25 cm³ 1·0 M HCl + 25 cm³ 2·0 M NaOH

D   25 cm³ 2·0 M HCl + 25 cm³ 2·0 M NaOH

[Turn over

36. Given the equations:

$$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$$
$$\triangle H = a \text{ J mol}^{-1}$$

$$Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$$
$$\triangle H = b \text{ J mol}^{-1}$$

$$Mg(s) + Zn^{2+}(aq) \rightarrow Mg^{2+}(aq) + Zn(s)$$
$$\triangle H = c \text{ J mol}^{-1}$$
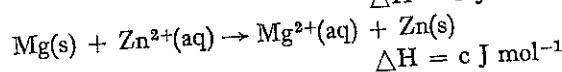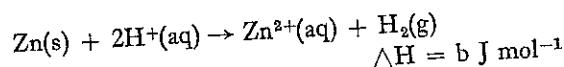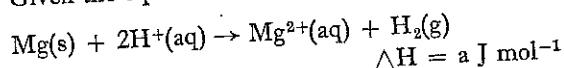
then, according to Hess's Law

A $a - b = c$

B $a + b = c$

C $a + c = b$

D $-a - c = b$

Questions 37 and 38 refer to the following types of structure:

A   Three dimensional ionic lattice

B   Three dimensional covalently linked structure

C   Three dimensional structure of molecules linked by hydrogen bonds

D   Linear polymeric structure, linked by van der Waal's forces

Which of these best describes the structure of

37. Ice.

38. Silicon dioxide.

39. Excess of 1 M hydrochloric acid is added to one of two identical samples of copper carbonate and an equal volume of 1 M sulphuric acid is added to the other. All other conditions are the same. Which of the following is different for the two reactions?

A   The mass of copper carbonate dissolved

B   The volume of gas liberated

C   The mass of water formed

D   The hydrogen ion concentration of the remaining solution

40.
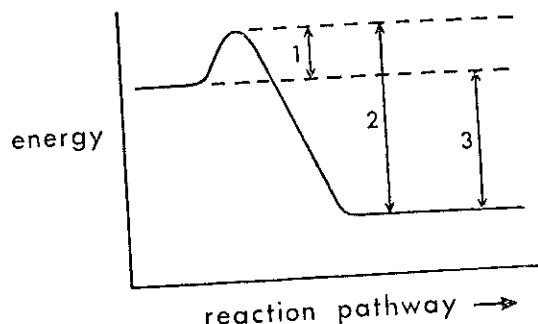
Which of the following correctly represents the activation energy (E_a) and the enthalpy change ($\triangle H$) in the diagram above?

	E_a	$\triangle H$
A	2	3
B	1	2
C	1	3
D	2	1

41. Excess sodium chloride was shaken with water, giving a saturated solution with some solid sodium chloride on the bottom of the container. This system is in equilibrium, thus:

$$NaCl(s) \rightleftharpoons Na^+(aq) + Cl^-(aq)$$
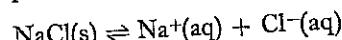
What will happen if HCl(g) is passed through the solution?

A   Chlorine gas will form.

B   The pH will rise.

C   Some sodium chloride will crystallise out.

D   Some solid sodium chloride will dissolve.

42. The results of an experiment carried out at 19°C involving the reaction between equal volumes of 0·5 M nitric acid and sodium thiosulphate solution of different concentrations are shown below:

Concentration of sodium thiosulphate solution	$\frac{M}{2}$	$\frac{M}{4}$	$\frac{M}{8}$	$\frac{M}{16}$
Time in seconds for the appearance of sulphur	13	25	51	104

On the evidence of these results alone, which of the following is correct?

A   The more concentrated the thiosulphate solution, the longer the time before the sulphur appears.

B   The more concentrated the nitric acid, the faster the reaction proceeds.

C   The more concentrated the thiosulphate solution, the faster the reaction proceeds.

D   The higher the temperature, the faster the reaction proceeds.

43. Which one of the following compounds is **NOT** an isomer of heptane?

A   2-methylhexane

B   2,2-dimethylpentane

C   2,3-dimethylbutane

D   2,3-dimethylpentane

44. Which hydrocarbon is **NOT** a member of the same homologous series as the others?

formula weight

A   44

B   72

C   84

D   100

45. Which of the following when added to water will **NOT** give a solution of pH greater than 7?

A   Chloroethane

B   Calcium hydride

C   Ethylamine

D   Sodium hydroxide

46. Which one of the following statements is true?

A   Benzene has the same empirical formula as ethyne.

B   Benzene contains more elements than ethyne.

C   Benzene is more volatile than ethyne.

D   Benzene undergoes addition reactions more readily than ethyne.

47. During the addition of magnesium granules to an excess of dilute hydrochloric acid, each of the following were measured and plotted against time on a graph.

A   Temperature of solution

B   Volume of hydrogen produced

C   pH of solution

D   Conductivity of solution

If the reaction is complete in five minutes, which of the above, when plotted against time, would give a graph like the one below?

time in minutes
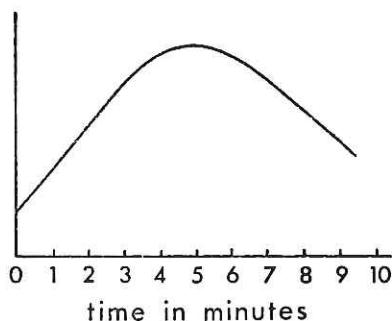
48. Three unlabelled bottles contain samples of 0·5 M hydrochloric, sulphuric and nitric acids. Which of the following procedures will positively identify them?

A   Test with pH paper.

B   Electrolyse and test the gases evolved.

C   Add each to barium chloride solution, then add silver nitrate solution to acids which give no positive reaction.

D   Measure the volume of 1 M sodium hydroxide solution required to neutralise 20 cm³ samples of each acid.

[Turn over

In questions **49 and 50** more than one response may be correct.

Answer

A   if responses 1, 2 and 3 are correct,

B   if responses 1 and 3 are correct,

C   if responses 2 and 4 are correct,

D   if response 4 only is correct,

E   if some other response or combination of responses is correct.

49. Radioactive calcium would differ from ordinary (non-radioactive) calcium in its

1   chemical properties

2   atomic number

3   electronic configuration

4   atomic weight.

50. In which of the following reaction(s) will the volume of the gaseous products be half that of the reactants, all measurements being made at s.t.p.?

1    $C + O_2 \rightarrow CO_2$

2    $N_2 + O_2 \rightarrow 2NO$

3    $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

4    $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

[END OF QUESTION PAPER]

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.

$$H-\overset{\displaystyle H}{\underset{\displaystyle H}{\overset{|}{\underset{|}{C}}}}-\overset{\displaystyle H}{\underset{\displaystyle H}{\overset{|}{\underset{|}{C}}}}-O-\overset{\displaystyle H}{\underset{\displaystyle H}{\overset{|}{\underset{|}{C}}}}-\overset{\displaystyle H}{\underset{\displaystyle H}{\overset{|}{\underset{|}{C}}}}-H$$
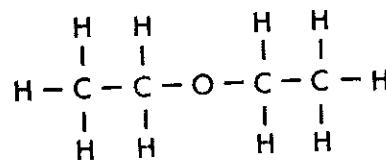
(a) Draw the extended structural formula for a secondary alcohol which is an isomer of the above.

(b) Name the isomer you have drawn.

(2)

2. The following represents an industrial method of producing hydrogen:

STEP 1 HOT COKE + STEAM ──────→ HYDROGEN + GAS "X"
(volumes of products in ratio 1:1)

STEP 2 HYDROGEN + GAS "X" + STEAM $\xrightarrow{\text{catalyst}}$ HYDROGEN + GAS "Y"
(volumes of products in ratio 2:1)

(a) What are gases "X" and "Y"?   2

(b) How would gas "Y" be separated from the hydrogen?   1

(3)

3. A mixture of liquid hydrocarbons was heated at a steady rate in a distillation apparatus. The temperature was recorded every minute until the mixture had all distilled.

The following graph shows the results:
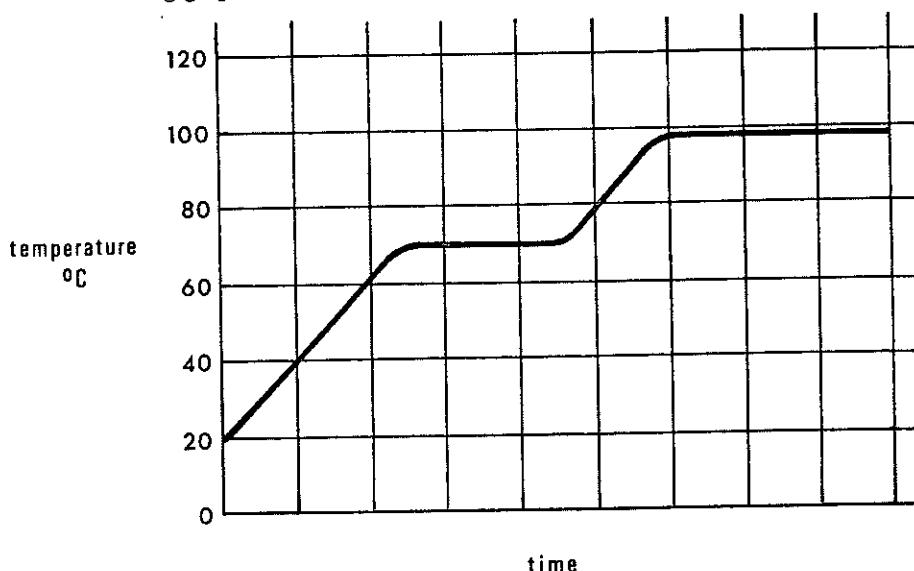
(a) How many liquids were in the mixture?   1

(b) What are the apparent boiling points of the liquids?   2

(3)

4. Answer **EITHER A OR B.**

   A. Examine the following scheme:

$$H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-Br \xrightarrow{\text{reagent } X} H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-O-H$$

reagent Z ↙   ↘ reagent Y

$$\overset{H}{\underset{H}{\diagdown}}C = C\overset{H}{\underset{H}{\diagup}}$$
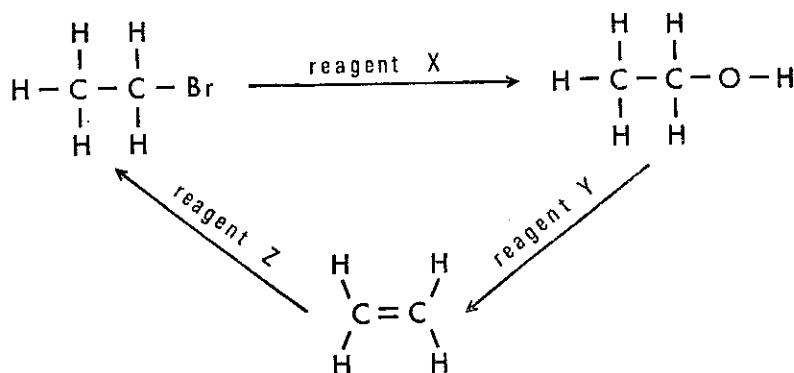
   Identify the reagents X, Y and Z. (3)

OR

   B. Examine the following scheme:

$$Cu(s) \xrightarrow{\text{reagent } P} Cu(NO_3)_2\,(aq) \xrightarrow{\text{reagent } Q} CuCO_3\,(s)$$

reagent R ↖   ↗ heat

$$CuO\,(s)$$
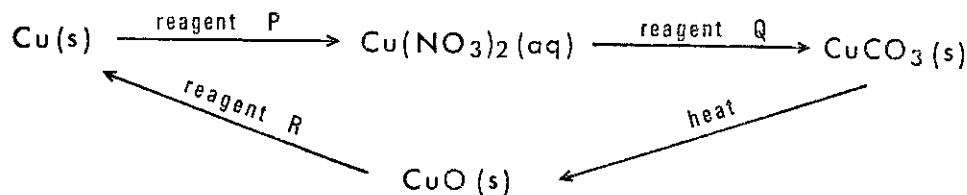
   Identify the reagents P, Q and R. (3)

5. The Standard Electrode Potential for the reduction of the vanadate(IV) ion, $VO^{2+}(aq)$, to the vanadium(III) ion, $V^{3+}(aq)$, in acid solution is $+0.36$ volt.

   (a) Write the balanced ion-electron half reaction equation for this reduction. 2

   (b) Which of the following ions could theoretically reduce the VO^{2+} ion to V^{3+}? $Sn^{2+}(aq)$, $Sn^{4+}(aq)$, $Fe^{2+}(aq)$, $Fe^{3+}(aq)$. 1

   (Use your data book in answering the question: see page 30). (3)

6.

$$a\,Al + b\,Mn_3O_4 \longrightarrow c\,Al_2O_3 + d\,Mn$$

   Balance the above equation and find the values of a, b, c and d. (2)

7. Polonium-210 is radioactive, emitting alpha (α) particles. Calculate the number of alpha particles emitted by 1 mole of polonium-210 in a time equal to two half-lives. (3)

8.

$$H-C\equiv C-H$$

HCl ↗ Compound I $\xrightarrow{\text{HCl}}$ Compound II

reagent A ↘ Compound III

reagent B ↗ 1,2-dichloroethane

reagent C ↘ monochloroethane
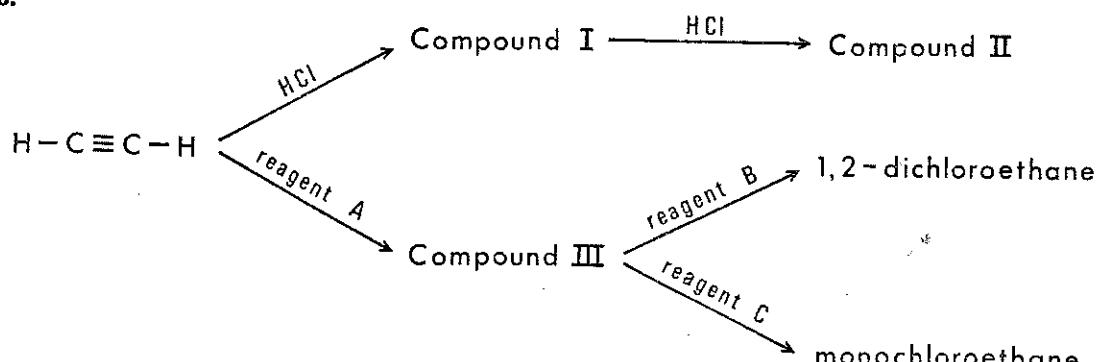
   ALL COMPOUNDS IN THE ABOVE DIAGRAM HAVE DIFFERENT STRUC-
   TURES, AND THE REAGENT AND COMPOUND ARE IN THE RATIO OF
   1 MOLE:1 MOLE IN EVERY CASE.

   (a) Draw the extended structural formulae for compounds I, II and III. 3

   (b) Name reagents A, B and C. 3

   (6)

9. Answer **EITHER A OR B.**

    A. Calculate the Heat of Formation of 1 mole of hydrogen fluoride, from the elements, using mean bond dissociation energies given in the data book on page 31.   **(5)**

    OR

    B. Calculate the Heat of Formation of 1 mole of methane using Heats of Combustion given in the data book on pages 33 and 35. Show that the calculated value is in reasonable agreement with the data book value (page 35).   **(5)**

10.

| PROPERTY	COMPOUND		
	$CH_3-C\overset{O}{\underset{O-H}{}}$	$CH_3-C\overset{O}{\underset{O-CH_3}{}}$	$CH_3-C\overset{O}{\underset{O^-\ Na^+}{}}$
Boiling point	118 °C	(a)	(b)
Solubility in water	(c)	(d)	(e)
Bonds broken at melting point	(f)	(g)	(h)

List the letters (a) to (h) in your answer book and beside each write the appropriate term from the following list:

57 °C;	190 °C;	decomposes above 450 °C;	
soluble giving neutral solution;	soluble giving acid solution;	soluble giving alkaline solution;	insoluble;
van der Waals;	hydrogen;	covalent;	ionic.

    (4)

11. The Heat of Neutralisation of hydrochloric acid by sodium hydroxide is given by

$$HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l); \quad \triangle H = -\ 57 \cdot 3\ kJ$$
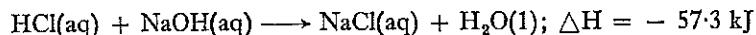
Write a balanced equation in each case for the partial neutralisation of 1 mole of phosphoric acid (H_3PO_4) by sodium hydroxide when the Heat of Neutralisation is

$$(a) - 57 \cdot 3\ kJ, \quad (b) - 114 \cdot 6\ kJ. \qquad \textbf{(2)}$$

12.

$$\text{ALCOHOL} \xrightarrow{\ \ A\ \ } CH_3COCH_3$$
$$\text{(I)} \qquad\qquad\qquad \text{(II)}$$

    (a) Name alcohol (I).   **1**

    (b) Name a reagent which could be used at A.   **1**

    (c) Give one chemical test, with the result, which when applied to compounds (I) and (II) would enable you to state which was which.   **2**

    (4)

13. (a) Why is the first ionisation energy of lithium smaller than that of beryllium?   **2**

    (b) Why is the second ionisation energy of lithium greater than the second ionisation energy of beryllium?   **2**

    (4)

14. Answer **EITHER A OR B.**

A. When 100 cm³ of a gaseous hydrocarbon are burned in excess oxygen 400 cm³ of carbon dioxide and 400 cm³ of water vapour are produced. (All measurements are at a temperature above 100 °C and at 1 atmosphere pressure.)

  (*a*) What is the molecular formula of the hydrocarbon?   **3**

  (*b*) The hydrocarbon does not decolourise bromine water.

    Draw a possible structural formula for the hydrocarbon.   **1**
                                        (4)

OR

B. 1 g of a hydrogen halide is neutralised by 50 cm³ of 1 M sodium hydroxide solution. Show from these figures that the hydrogen halide is HF. (You may wish to consult page 29 of the data book.)   **(4)**

15.
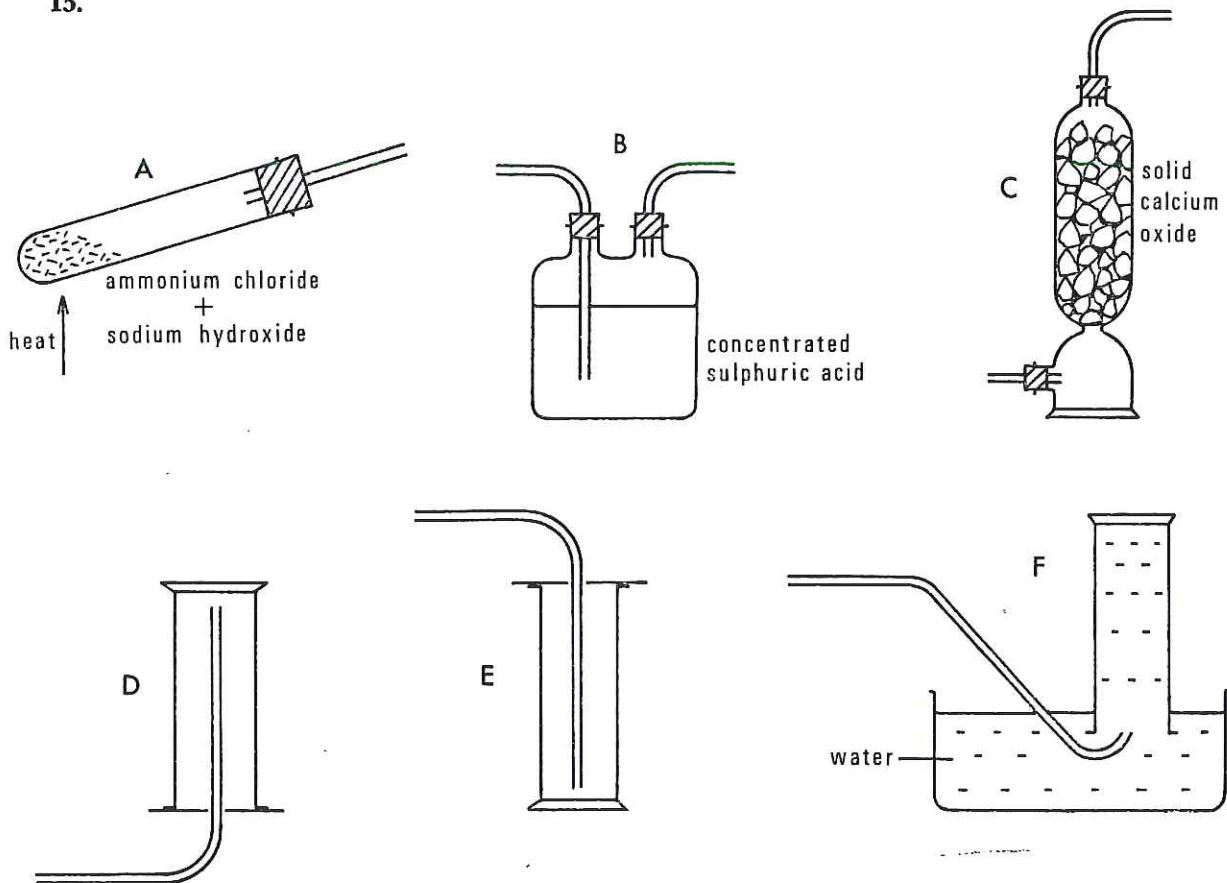
List, in order, those pieces of apparatus which you would arrange together if you were attempting to prepare and collect a dry sample of ammonia.

Do not draw the apparatus but answer by putting the appropriate letters in order.   **(2)**

[Turn over

PART B

All three questions should be attempted. Each question contains a choice. Candidates are advised to spend about 1½ hours on this part.

Marks

16. Answer **EITHER A OR B**.

A. (I) Ethyl ethanoate, b.p. 77 °C, can be made by condensing together ethanol, b.p. 78·5 °C, and ethanoic acid, b.p. 118 °C. The reaction is reversible and can be catalysed by the addition of acid.

    (*a*) Write a balanced equation for the formation of ethyl ethanoate from ethanol and ethanoic acid. **2**

    (*b*) How would the addition of the catalyst affect

        (i) the rate of the forward reaction;

        (ii) the rate of the reverse reaction;

        (iii) the amount of ester formed? **3**

    (*c*) In an **uncatalysed** reaction at **equilibrium**:

        (i) How does the rate of the forward reaction compare with that of the reverse reaction? **1**

        (ii) How could you slow down the rate of the forward and reverse reactions? **1**

        (iii) Supposing both forward and reverse reactions are stopped, how could you estimate the quantity of acid in the equilibrium mixture? **2**

    (*d*) In an attempt to measure the quantity of ester in the equilibrium mixture a pupil tried to remove the ester from the equilibrium mixture by distillation.

        (i) Make a diagram of a suitable apparatus for the distillation. **2**

        (ii) Why is the pupil's answer likely to be inaccurate? **1**

        (iii) Suggest another method of separating the ester from the mixture. **1**

(II) The pH of an aqueous solution of ethanoic acid is 3. Would the pH increase or decrease if some solid sodium ethanoate is added? Explain your answer. **4**

(17)

OR

B. (I) In a class experiment it is found that 100 cm^3 of hydrogen gas are produced when 0·3 g of zinc react with excess dilute sulphuric acid.

   (a) Draw a diagram of the assembled apparatus you would use in this experiment.   **2**

   (b) Pure zinc reacts slowly with dilute sulphuric acid. Adding a few drops of copper(II) sulphate solution produces the following results:

   the blue colour of the Cu^{2+}(aq) ion fades rapidly, dark brown particles appear on the zinc and the production of hydrogen gas becomes rapid.

   Using the apparatus you have assembled in (a), you are asked to compare the rates of reaction of:

   Experiment 1: zinc + sulphuric acid

   and Experiment 2: zinc + sulphuric acid + a few drops of copper(II) sulphate solution.

   You are further asked to plot your results in graphical form to show the difference in rate.

   (i) Which of the species, Cu^{2+}(aq) or Cu(s), is likely to be acting as a catalyst?   **1**

   (ii) Give a reason for your choice in (i)   **2**

   (iii) State **four** conditions which must be kept the same in experiments 1 and 2.   **2**

   (iv) What do you measure during the course of the reactions which will enable you to compare reaction rates?   **2**

   (v) On the same set of labelled axes sketch the two graphs, labelled (1) and (2), which would result. (There is no need to use graph paper.)   **2**

(II) When ethanol is passed over different substances at 350 °C, different compounds are produced:

$$CH_3CH_2OH \nearrow^{nickel} CH_3-C\overset{H}{\underset{O}{\lessgtr}} + H_2 \quad \boxed{dehydrogenation}$$

$$\searrow_{aluminium\ oxide} CH_2 = CH_2 + H_2O \quad \boxed{dehydration}$$
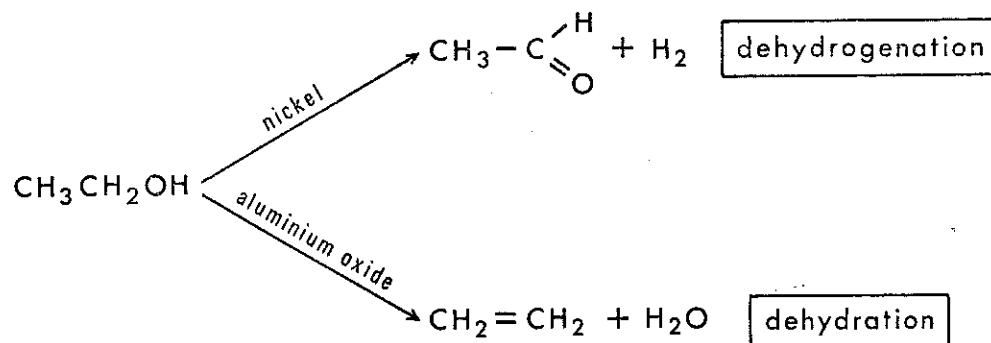
Devise a school laboratory experiment to find out which of the two organic products results when ethanol is passed over hot zinc oxide. Your answer should include

(a) a diagram of the apparatus;   **2**

(b) tests for ethanal and ethene, one test for each, to establish which one is formed.   **4**

   (17)

17. Answer **EITHER A OR B.**

A. Brass is an alloy of the metals copper and zinc with small amounts of tin and lead. An analysis to determine the percentage of each metal in a sample of brass is outlined in the flow-chart.

The analysis is based on selective precipitation of each metal as an insoluble PRECIPITATE. Thus the metals can be extracted separately from the brass.

```
BRASS                         PRECIPITATE              METAL WEIGHED AS

 A │ Treat with conc.
   │ nitric acid.
   ↓
SOLUTION 1

 B │ Add water.
   ↓                          Hydrated      dry and      ┌─────────┐
SOLUTION 2      ─────────→     tin(IV)   ─────────────→  │ TIN(IV) │
                               oxide     heat strongly   │ OXIDE   │
   │ Add excess conc.                                    └─────────┘
   │ sulphuric acid;
 C │ heat to evaporate
   │ to small volume;
   │ add water.
   ↓                          Lead(II)      dry and      ┌──────────┐
SOLUTION 3      ─────────→    sulphate  ─────────────→   │ LEAD(II) │
                                         heat strongly   │ SULPHATE │
   │ Electrolyse between                                 └──────────┘
 D │ weighed platinum
   │ electrodes.
   ↓                          Copper deposited           ┌──────────┐
SOLUTION 4      ─────────→    on negative     dry        │ COPPER   │
                             electrode  ─────────────→   │   on     │
   │ Add diammonium                                      │ electrode│
 E │ hydrogenphosphate                                   └──────────┘
   │ solution.
   ↓                          Zinc ammonium  dry and     ┌───────────┐
SOLUTION 5      ─────────→    phosphate  ─────────────→  │ ZINC      │
                                         heat strongly   │PYROPHOSPHATE│
                                                         │$(Zn_2P_2O_7)$│
                                                         └───────────┘
```

(*a*) (i) What is the purpose of the nitric acid at A?   1

    (ii) Why use nitric rather than hydrochloric acid at A?   1

(*b*) At C heating is continued until white acid fumes are given off to ensure that all the nitric acid is expelled.

    (i) Which property of sulphuric acid is used at this stage?   1

    (ii) Suggest a reason for ensuring that **all** the nitric acid is removed.   1

(*c*) What general method would be used to separate the precipitates from the solutions?   1

(*d*) Why does tin(IV) oxide form rather than tin(II) oxide?   1

(e) Tin(IV) oxide dissolves in both concentrated sulphuric acid and in hot concentrated potassium hydroxide solution.

    (i) In view of these reactions what type of oxide is tin(IV) oxide?   **1**

    (ii) Write the formula for tin(IV) oxide.   **1**

    (iii) Write a balanced equation for the reaction between tin(IV) oxide and potassium hydroxide.   **2**

(f)   (i) Write an ion-electron half reaction equation for the deposition of copper on the negative platinum electrode.   **1**

    (ii) If the brass sample contains 64% by mass of copper, calculate the number of coulombs which will deposit **all** the copper from a 1·000 g sample of the brass.   **3**

    (iii) Suggest a method of checking that all the copper had been deposited by electrolysis at D.   **1**

(g) A 1·000 g sample of brass produces 0·608 g of zinc pyrophosphate ($Zn_2P_2O_7$). What is the mass of the zinc in the sample?   **3**

    (18)

OR

B. In 1894 Lord Rayleigh measured the density of nitrogen obtained from two sources. In one case, he took dry air and extracted from it carbon dioxide, then oxygen, leaving behind atmospheric nitrogen. His other samples of nitrogen were produced from nitric acid or ammonia. When he came to weigh a litre of nitrogen prepared in these two ways he found that atmospheric nitrogen was 0·0064 gram per litre heavier than nitrogen derived from pure chemicals.

Rayleigh believed his results could best be explained by the assumption that nitrogen existed in two polymorphic (allotropic) forms, one containing N_2 molecules, the other N_3 molecules—in the same way as oxygen (O_2) differs from ozone (O_3).

Ramsay, on the other hand, attributed the higher density of the atmospheric nitrogen to the presence in the sample of some hitherto unknown heavier element. To settle the question Ramsay passed and repassed atmospheric nitrogen over heated magnesium. When no further reaction would take place, the gas left was found to have a density of almost 20 times that of hydrogen. Further experiment confirmed that the gas was a new element.

(a) How could carbon dioxide have been removed from the air by Rayleigh?   **1**

(b) How could you prepare and collect a sample of nitrogen from ammonia?   **3**

(c) How could Rayleigh's assumption have explained the results obtained?   **1**

(d) How many molecules of oxygen (O_2) could be obtained from 1 mole of ozone (O_3) molecules?   **2**

(e) Magnesium reacts with nitrogen to form magnesium nitride (Mg_3N_2) as follows:

$$3Mg(s) + N_2(g) \longrightarrow Mg_3N_2(s)$$
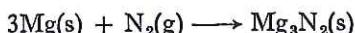
What mass of magnesium would be needed to react with 1·0 litre of nitrogen? (measured at standard temperature and pressure)   **3**

(f) When water is added to magnesium nitride a strong smell of ammonia is produced. Write a balanced equation for this reaction.   **2**

(g) What in the passage suggests that the new element isolated by Ramsay is chemically inactive?   **1**

(h) What is the molecular weight of the new element?   **2**

(i) Which new element had Ramsay isolated?   **1**

(j) How would this gas be produced on an industrial scale today?   **1**

(k) Give one use for this gas.   **1**

    (18)

[Turn over

18. Answer **EITHER A OR B**.

   A. Write an essay on "The Mineral Acids" (hydrochloric, nitric and sulphuric).

   Divide your essay into three main sections:

   (*a*) an **outline** of their industrial preparations;

   (*b*) a discussion of the properties of the acids and their uses in the chemical laboratory;

   (*c*) a discussion of some of their industrial uses.

   Your essay should make reference to the headings listed above. Where possible you should include examples and equations to illustrate the points you wish to make. **(15)**

   OR

   B. Write an essay on "The Atomic Nucleus".

   Divide your essay into two main sections:

   (*a*) "The mass aspect of the nucleus":

       (i) nuclear particles, atomic mass, isotopes and atomic weight;

       (ii) a modern instrumental method of determining atomic weight.

   (*b*) "Unstable atomic nuclei":

       (i) nature of emitted radiations;

       (ii) effect of radiation loss on parent nucleus;

       (iii) man-made radioisotopes;

       (iv) uses of radioisotopes.

   Your essay should make reference to the headings listed above. Where possible you should include examples and nuclear equations to illustrate the points you wish to make.

   (15)

[END OF QUESTION PAPER]