[0500/200] 1994

SCOTTISH CERTIFICATE OF EDUCATION

CHEMISTRY (REVISED)

Higher Grade—PAPER I

Friday, 20th May—9.30 a.m. to 11.10 a.m.

READ CAREFULLY

1. **Check that the answer sheet provided is for Chemistry (Revised) Higher I.**
2. **Fill in the details required on the answer sheet.**
3. **Reference may be made to the Chemistry (Revised) Higher Grade and Certificate of Sixth Year Studies Data Booklet (1992 edition).**
4. **Rough working, if required, should be done only on this question paper, or on the rough working sheet provided—NOT on the answer sheet.**
5. **Instructions for the completion of PART 1 and PART 2 are given on pages two and eleven respectively.**

ES 0500/200 6/3/3/3/19810

PART 1

In questions 1 to 40 of this part of the paper, an answer is given by indicating the choice A, B, C or D by a stroke made in INK in the appropriate place in Part 1 of the answer sheet—see the sample question below.

For each question there is only ONE correct answer.

This part of the paper is worth 40 marks.

SAMPLE QUESTION

To show that the ink in a ball-pen consists of a mixture of dyes, the method of separation would be

A fractional distillation

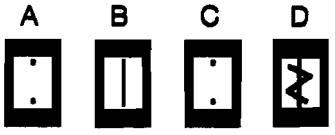
B chromatography

C fractional crystallisation

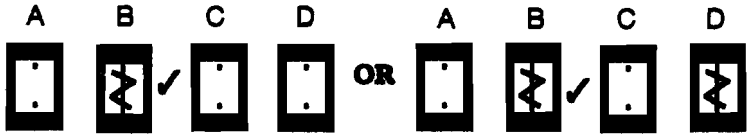
D filtration.

The correct answer is B—chromatography. A **heavy** vertical line should be drawn joining the two dots in the appropriate box in the column headed **B** as shown **in the example on the answer sheet.**

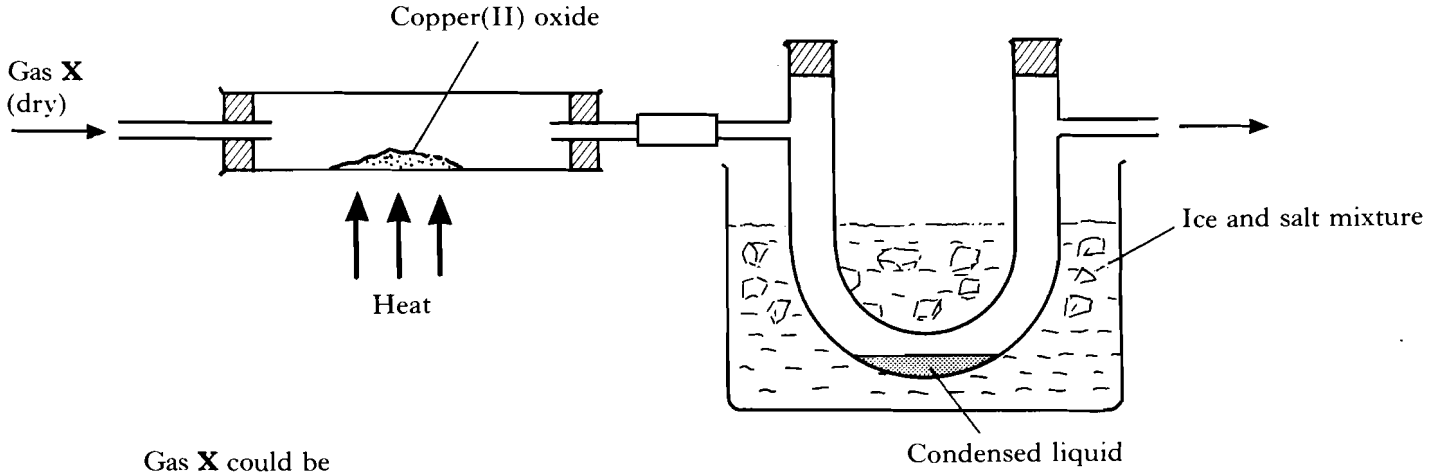
If after you have recorded your answer you decide that you have made an error and wish to make a change, you should cancel the original answer and put a vertical stroke in the box you now consider to be correct. Thus, if you want to change an answer **D** to an answer **B**, your answer sheet would look like this:



If you want to change back to an answer which has already been scored out, you should **enter a tick (✔)** to the RIGHT of the box of your choice, thus;



1. Gas **X** was dried and passed through the apparatus as shown.



Gas **X** could be

A carbon dioxide

B carbon monoxide

C hydrogen

D air.

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2. The instruction card shown below was used by pupils when they were preparing a sample of a salt.

INSTRUCTION CARD

SALT PREPARATION

1. Mix 20 cm^3 of solution **X** with 20 cm^3 of solution **Y**.
2. Stir the mixture.
3. Remove the salt by filtration.
4. Dry the salt in an oven at 100 °C for 30 minutes.

A barium salt prepared by this method could be a

A bromide

B chloride

C nitrate

D sulphate.

3. In which of the following structures would the nails corrode before the roof itself?

A Zinc roof with iron nails

B Iron roof with copper nails

C Copper roof with iron nails

D Zinc roof with copper nails

4. Particles with the same electron arrangement are said to be isoelectronic.

Which of the following compounds contains ions which are isoelectronic?

A Na_2S

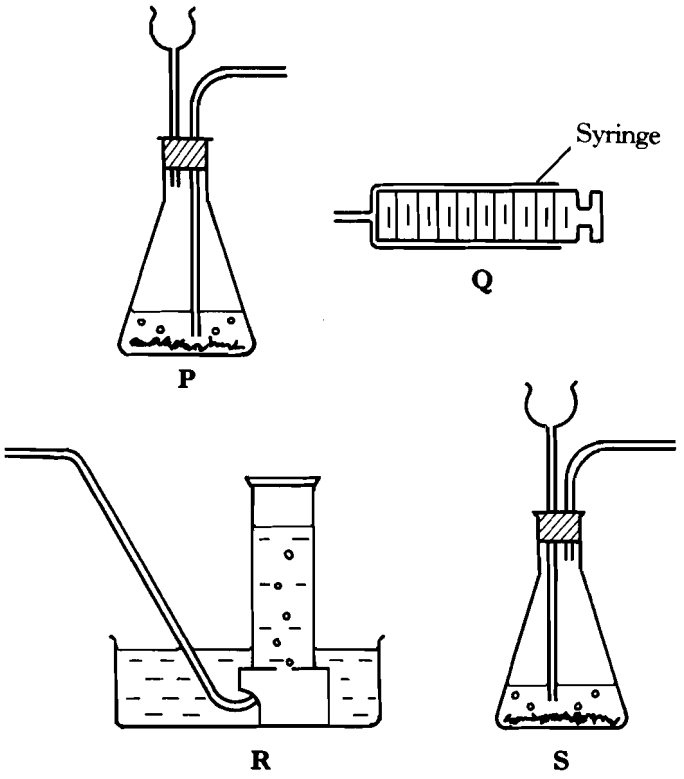
B $MgCl_2$

C KBr

D $CaCl_2$

[Turn over

5. Some pieces of equipment are shown below.



You are asked to measure accurately the volume of carbon dioxide produced every minute when chalk and acid react together.

Which of the following combinations of pieces of equipment is the **best** one to use?

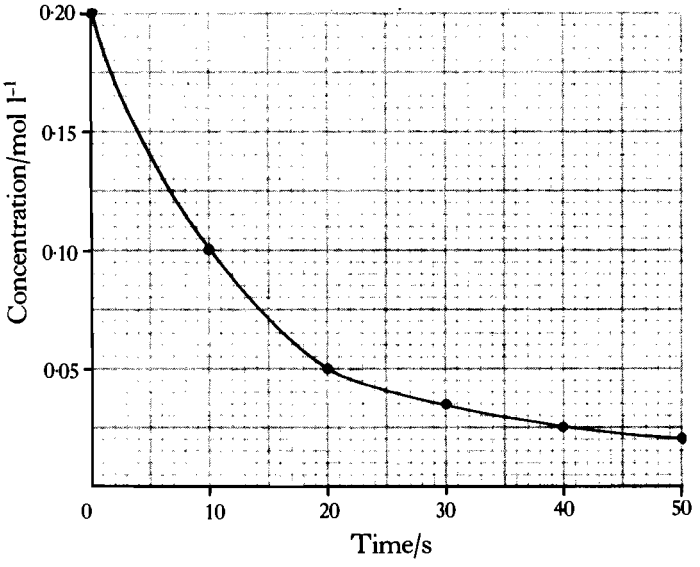
A **P** and **Q**

B **S** and **Q**

C **P** and **R**

D **S** and **R**

6. The graph below shows the variation of concentration of a reactant with time as a reaction proceeds.



The average reaction rate, in mol $l^{-1}s^{-1}$, during the first 20 s is

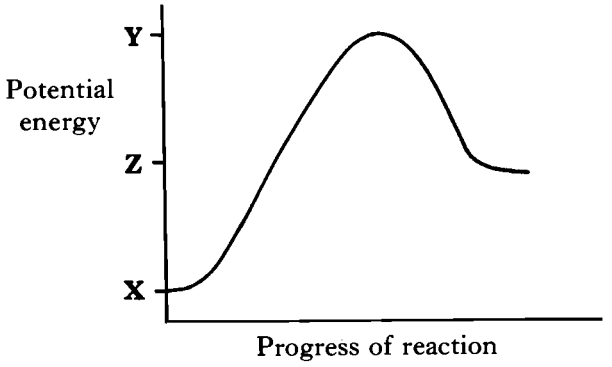
A 0·0025

B 0·0036

C 0·0075

D 0·0090.

7. Refer to the potential energy diagram below.



The energy of activation (E_A) for the forward reaction is given by

A **Y**

B **Z − X**

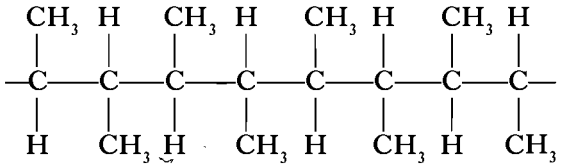
C **Y − X**

D **Y − Z.**

8. Which set of results would be obtained if methanol is analysed by mass?

	Mass of carbon	Mass of hydrogen	Mass of oxygen
A	3 g	1 g	4 g
B	3 g	2 g	8 g
C	6 g	8 g	16 g
D	12 g	8 g	32 g

9. Part of a polymer molecule is represented below.



The monomer which gives rise to this polymer is

A but-2-ene

B but-1-ene

C methylpropene

D buta-1,3-diene.

10. Which equation represents an addition reaction?

A $CH_3OH + O_2 \rightarrow HCOOH + H_2O$

B $CH_3CH_2OH \rightarrow CH_2CH_2 + H_2O$

C $CH_2CH_2 + H_2O \rightarrow CH_3CH_2OH$

D $CH_3CH_3 \rightarrow CH_2CH_2 + H_2$

11. Bacterial oxidation of a solution of ethanol will result in the production of

A ethanoic acid

B ethene

C ethyl ethanoate

D ethane.

12. The dehydration of butan-2-ol can produce two isomeric alkenes, but-1-ene and but-2-ene.

Which one of the following alkanols can similarly produce, on dehydration, a pair of isomeric alkenes?

A propan-2-ol

B pentan-3-ol

C hexan-3-ol

D heptan-4-ol

13. In comparison to petrol, diesel

A evaporates more readily at room temperature

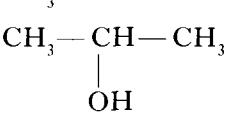
B contains smaller molecules

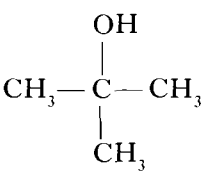
C ignites more readily in air when a flame is applied

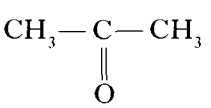
D self-ignites at a lower temperature.

14. Which compound will produce a carboxylic acid on oxidation?

A CH_3-OH

B 

C 

D 

15. Which of the following molecules is **most** likely to be found in petrol?

A CH_4

B C_3H_8

C C_8H_{18}

D $C_{14}H_{30}$

16. What volume of oxygen, in litres, is required for complete combustion of 1 litre of butane?

A 1

B 4

C 6·5

D 13

17. Which of the following has the same volume as 16 g of sulphur dioxide gas?

(All volumes are measured under the same conditions of temperature and pressure.)

A 1 g of helium gas

B 1 g of hydrogen gas

C 10 g of neon gas

D 16 g of oxygen gas

18. The mass of one mole of sodium is 23 g. What is the mass of one sodium atom?

A $6{\cdot}02 \times 10^{23}$ g

B $6{\cdot}02 \times 10^{-23}$ g

C $3{\cdot}82 \times 10^{-23}$ g

D $3{\cdot}82 \times 10^{-24}$ g

19. A solution of nickel(II) sulphate is electrolysed using nickel electrodes.

The passage of 96 500 coulombs results in

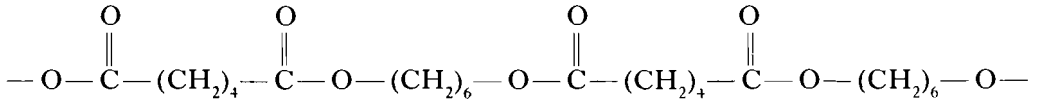
A the positive electrode gaining 29·5 g

B the negative electrode gaining 29·5 g

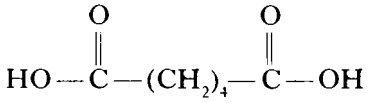
C the positive electrode gaining 59 g

D the negative electrode gaining 59 g.

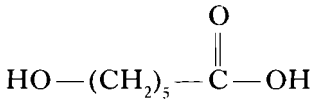
20. Part of a polyester chain is shown below.



Which compound, when added to the reactants during polymerisation, would stop the polyester chain from getting too long?

A 

B $HO-(CH_2)_6-OH$

C 

D CH_3-OH

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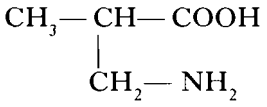
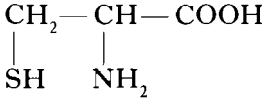
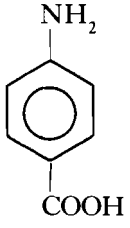
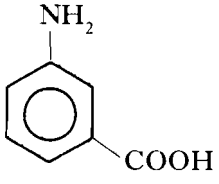
21. Essential amino acids come from the food we eat. Some of these are also called α-amino acids because the amino group is on the carbon atom adjacent to the acid group.

Which of the following is an α-amino acid?

A 

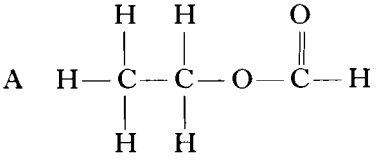
B 

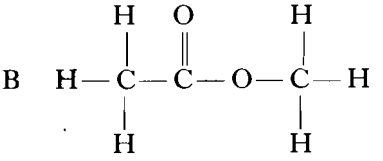
C 

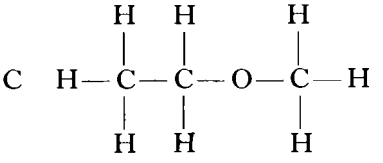
D 

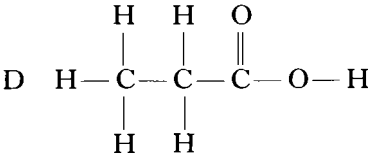
22. An ester is prepared from methanoic acid and ethanol.

Which of the following is the full structural formula for the ester produced?

A 

B 

C 

D 

23. Which of the following **must** contain nitrogen?

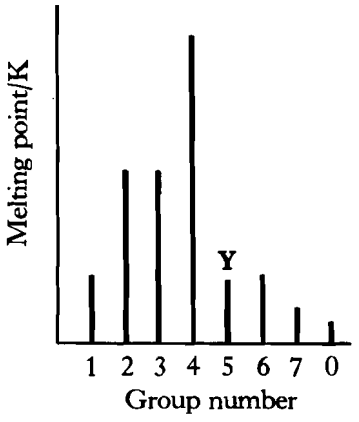
A An enzyme

B An oil

C A polyester

D A carbohydrate

24. The diagram shows the melting points of successive elements across a period in the Periodic Table.



Which of the following is a correct reason for the low melting point of element **Y**?

A It has weak ionic bonds.

B It has weak covalent bonds.

C It has weakly-held outer electrons.

D It has weak forces between molecules.

25. Carbon dioxide is a gas at room temperature while silicon dioxide is a solid because

A van der Waals' forces are much weaker than covalent bonds

B carbon dioxide contains double covalent bonds and silicon dioxide contains single covalent bonds

C carbon-oxygen bonds are less polar than silicon-oxygen bonds

D the relative formula mass of carbon dioxide is less than that of silicon dioxide.

26. Which statement concerning the radii of atoms and ions is correct?

The radius of

A Cl^- is less than that of Cl

B H^- is greater than that of H^+

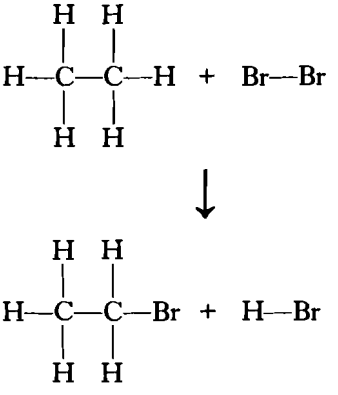
C Na^+ is greater than that of Na

D Fe^{3+} is greater than that of Fe^{2+}.

27. Consider the following bond enthalpies.

Bond	Enthalpy/kJ mol^{-1}
Br— Br	194
H— Br	366
C— H	414
C— Br	280

What is the enthalpy change, in kJ mol^{-1}, for the following reaction?



A +38

B −38

C −1254

D +1254

28. In which of the following changes is energy released?

A $F_2(g) \rightarrow 2F(g)$

B $Na(g) \rightarrow Na^+(g) + e$

C $Na(s) \rightarrow Na(\ell)$

D $Cl(g) + e \rightarrow Cl^-(g)$

29. The enthalpy of combustion of methanol is −715 kJ mol^{-1}.

The mass of methanol which has to be burned to produce 71·5 kJ is

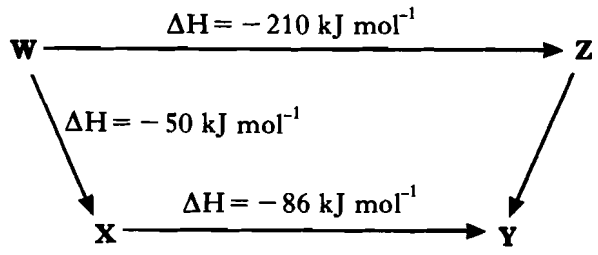
A 3·2 g

B 32 g

C 71·5 g

D 715 g.

30. Consider the reaction pathway shown below.



According to Hess' Law, the ΔH value, in kJ mol^{-1}, for reaction **Z** to **Y** is

A +74

B −74

C +346

D −346.

31. Which entry in the table shows the effect of a catalyst on the reaction rates and position of equilibrium in a reversible reaction?

	Rate of forward reaction	Rate of reverse reaction	Position of equilibrium
A	increased	unchanged	moves right
B	increased	increased	unchanged
C	increased	decreased	moves right
D	unchanged	unchanged	unchanged

32. What is the pH of 50 cm^3 of a 1×10^{-2} mol l^{-1} solution of hydrochloric acid?

A −2

B −1

C 1

D 2

33. Which of the following is the best description of a 0·1 mol l^{-1} solution of nitric acid?

A Dilute solution of a weak acid

B Dilute solution of a strong acid

C Concentrated solution of a weak acid

D Concentrated solution of a strong acid

34. Which solution will react with magnesium?

A Sodium chloride

B Lithium chloride

C Potassium chloride

D Ammonium chloride

35. Pure water has a pH of 7.

Which of the following is true?

A $[H^+(aq)] = 10^{-7}$ and $[OH^-(aq)] = 0$

B $[H^+(aq)] = 0$ and $[OH^-(aq)] = 10^{-7}$

C $[H^+(aq)] = [OH^-(aq)] = 10^{-7}$

D $[H^+(aq)] + [OH^-(aq)] = 10^{-7}$

36. Radioactive calcium would differ from ordinary (non-active) calcium in its

A atomic mass

B chemical properties

C atomic number

D electronic configuration.

37. What is the result of an atom losing a β-particle?

	Atomic number	Mass number
A	increased	no change
B	decreased	no change
C	no change	increased
D	no change	decreased

38. ${}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$

The above process represents

A nuclear fission

B nuclear fusion

C proton capture

D beta emission.

39. Which of the following needs to be known to calculate the relative atomic mass of an element?

A The number of protons and the number of neutrons in each isotope

B The identities of the isotopes present and their relative abundance

C The number of neutrons in each isotope

D The number of protons, neutrons and electrons in each isotope

40. Induced nuclear reactions can be described in a shortened form

T (*x*, *y*) P

where the participants are the target nucleus (**T**), the bombarding particle (***x***), the ejected particle (***y***) and the product nucleus (**P**).

Which of the following nuclear reactions would **not** give the product nucleus suggested?

A ${}^{14}_{7}N\ (\alpha, p)\ {}^{17}_{8}O$

B ${}^{242}_{96}Cm\ (n, \alpha)\ {}^{239}_{94}Pu$

C ${}^{10}_{5}B\ (\alpha, n)\ {}^{13}_{7}N$

D ${}^{236}_{93}Np\ (p, \alpha)\ {}^{238}_{92}U$

PART 2

In questions 41 to 48 of this part of the paper, an answer is given by circling the appropriate letter (or letters) in the answer grids provided on Part 2 of the answer sheet.

In some questions, two letters are required for full marks.

If more than the correct number of answers is given, marks will be deducted.

In some cases the number of correct responses is NOT identified in the question.

This part of the paper is worth 20 marks.

SAMPLE QUESTION

A CH_4	B H_2	C CO_2
D CO	E C_2H_6	F N_2

(*a*) Identify the diatomic **compound(s).**

A	B	C
(D)	E	F

The one correct answer to part (*a*) is D. This should be circled.

(*b*) Identify the **two** substances which burn to produce **both** carbon dioxide **and** water.

(A)	B	C
D	(E)	F

As indicated in this question, there are **two** correct answers to part (*b*). These are A and E.
Both answers are circled.

(*c*) Identify the substance(s) which can **not** be used as a fuel.

A	B	(C)
D	E	(F)

There are **two** correct answers to part (*c*). These are C and F.
Both answers are circled.

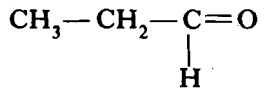
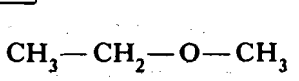
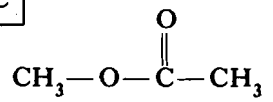
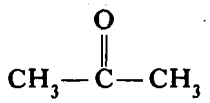
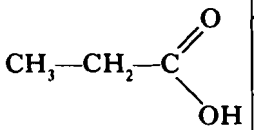
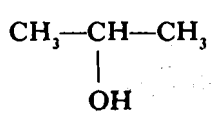
If, after you have recorded your answer, you decide that you have made an error and wish to make a change, you should cancel the original answer and circle the answer you now consider to be correct. Thus, in part (*a*), if you want to change an answer **D** to an answer **A**, your answer sheet would look like this:

(A)	B	C
~~(D)~~	E	F

If you want to change back to an answer which has already been scored out, you should enter a tick (✓) in the box of the answer of your choice, thus:

~~(A)~~	B	C
✓ ~~(D)~~	E	F

41. Many organic compounds contain oxygen.

A 	**B** 
C 	**D** 
E 	**F** 

(*a*) Identify the ketone.

(*b*) Identify the compound which could be oxidised to form the compound shown in box **E**.

(*c*) Identify the compound which could be hydrolysed when warmed with sodium hydroxide solution.

42. Many processes take place in the petrochemical industry.

A blending	**B** hydration	**C** reforming
D polymerisation	**E** cracking	**F** oxidation

(*a*) Identify the process taking place in the production of ethanol from ethene.

(*b*) Identify the process taking place in the production of diesel from gas oil fractions.

(*c*) Identify the process(es) taking place in the production of poly(ethene) from naphtha.

43. There are a number of different enthalpy changes.

A combustion	B formation	C hydration
D neutralisation	E lattice-breaking	F sublimation

(*a*) Identify the enthalpy change which would be associated with the following reaction.

$$C(s) + 2H_2(g) \rightarrow CH_4(g)$$

(*b*) Identify the enthalpy change(s) which would be associated with the dissolving of an ionic salt in water.

44. Identify the trend(s) which would occur as the relative atomic mass of the halogens increases.

A	The covalent radius decreases.
B	The density decreases.
C	The ionisation energy decreases.
D	The boiling point decreases.
E	The van der Waals' forces become stronger.

45. Isomers have the same molecular formula but different structural formulae.

Identify the compound(s) with isomeric forms.

A methanol	B glucose	C propane
D C_2HCl_3	E $C_2H_4Cl_2$	F C_2H_5Cl

[Turn over

46. An industrial gas mixture is produced by the catalytic steam reforming of methane.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \quad \Delta H = +206 \text{ kJ mol}^{-1}$$

Identify the change(s) which would move the equilibrium to the right.

A increasing temperature	B increasing the concentration of hydrogen	C increasing pressure
D adding more catalyst	E decreasing pressure	F decreasing temperature

47. Fats and oils are naturally occurring esters.

Identify the **true** statement(s).

A	Fats and oils in the diet can supply the body with energy.
B	Fats and oils are a less concentrated source of energy than carbohydrates.
C	Fats are likely to have relatively low melting points compared to oils.
D	Fats are likely to have a higher degree of unsaturation than oils.
E	Molecules in fats are packed more closely together than molecules in oils.

48. The value for the Avogadro Constant is $6{\cdot}02 \times 10^{23}$ mol^{-1}.

Identify the **true** statement(s).

A	24 g of carbon contains $6{\cdot}02 \times 10^{23}$ atoms.
B	1 g of hydrogen contains $6{\cdot}02 \times 10^{23}$ molecules.
C	500 cm^3 of 2 mol l^{-1} sodium hydroxide solution contains $6{\cdot}02 \times 10^{23}$ sodium ions.
D	6 g of water contains $6{\cdot}02 \times 10^{23}$ atoms.
E	44 g of carbon dioxide contains $6{\cdot}02 \times 10^{23}$ oxygen atoms.

[END OF QUESTION PAPER]

FOR OFFICIAL USE

Presenting Centre No.	Subject No.	Grade	Paper No.	Group No.	Marker's No.
	0500	H	2		

Total Marks

[0500/201] 1994

SCOTTISH CERTIFICATE OF EDUCATION

CHEMISTRY (REVISED)

Higher Grade—PAPER II

Friday, 20th May—1.30 p.m. to 4.00 p.m.

Fill in these boxes and read what is printed below.

Full Name of school or college

Town

Christian Name/First Name, Initial(s) (of other/middle name(s))

Surname

Date of Birth
Day *Month* *Year*

Number of seat occupied at examination

1. **All questions should be attempted.**
2. **Necessary data will be found in the Chemistry (Revised) Higher Grade and Certificate of Sixth Year Studies Data Booklet (1992 Edition) which is provided.**
3. **The questions may be answered in any order but all answers are to be written in this answer book, and must be written clearly and legibly in ink.**
4. **Rough work, if any should be necessary, as well as the fair copy, is to be written in this book.**
   Rough work should be scored through when the fair copy has been written.
5. **Additional space for answers and rough work will be found at the end of the book. If further space is required, supplementary sheets may be obtained from the invigilator and should be inserted inside the *front* cover of this booklet.**
6. **The size of the space provided for an answer should not be taken as an indication of how much to write. It is not necessary to use all the space.**
7. **Before leaving the examination room you must give this book to the invigilator. If you do not, you may lose all the marks for this paper.**

ES 0500/201 6/3/3/17210

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Marks

1. A radioisotope used in a hospital has a half-life of 1·5 hours. It has a count rate of 8000 counts min^{-1} at 9.00 a.m.

(*a*) What would the count rate be at 1.30 p.m. on the same day?

1

(*b*) An aqueous solution of a compound containing the radioisotope was prepared.

What effect would this have on its half-life?

1

(*c*) Give a use for radioisotopes in medicine.

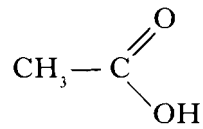
1

(3)

Marks

2. Consider the following substances.

A



B

HCl

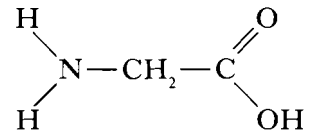
C

NH_3

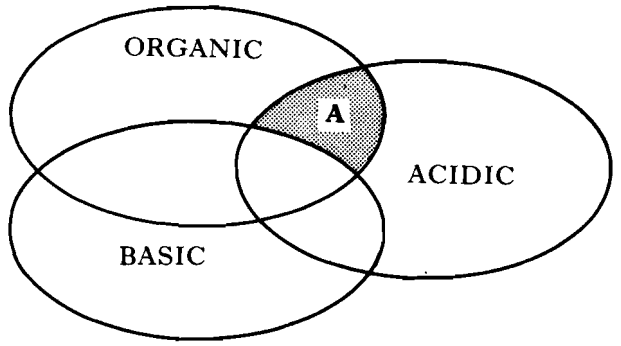
D

$CH_3—CH_2—OH$

E



In the diagram below, the letter **A** has been placed in the shaded area because substance **A** is both **organic** and **acidic**, but has no basic properties.



Write the letters **B** to **E** in their appropriate places on the diagram. **(3)**

[Turn over

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Marks

3. At room temperature, a lump of white phosphorus reacts with air forming phosphorus(V) oxide.

$$4P(s) + 5O_2(g) \longrightarrow P_4O_{10}(s) \quad \Delta H_{formation} = -3000 \text{ kJ mol}^{-1}$$

(*a*) Use this information to calculate the enthalpy of combustion of phosphorus.

1

(*b*) State the effect of using powdered phosphorus in place of lump phosphorus on

(i) the rate of the reaction,

1

(ii) the enthalpy change for the reaction.

1

(3)

Candidates must not write in this margin

Marks

4. Both fats and oils are mixtures of triglycerides.

Each triglyceride molecule contains three ester linkages and the majority of the molecules contain carbon-carbon double bonds.

(*a*) Why does the triglyceride molecule contain **three** ester linkages?

1

(*b*) Oils can be converted into fats by a process called hardening.

What happens to the triglyceride molecules when oils are hardened?

1

(*c*) On exposure to air, oils turn rancid more rapidly than fats.

In this process, the triglyceride molecules are broken up into smaller, "foul-smelling" molecules.

At what functional group within the triglyceride molecule is the breaking likely to occur?

1
(3)

[Turn over

Marks

5. The properties of hydrochloric acid (a strong acid) were compared with those of ethanoic acid (a weak acid). Equal volumes of solutions of the same concentration were used in each test. The actual results for hydrochloric acid are shown in the following table.

Test	Hydrochloric	Ethanoic
(i) pH	2	lower same higher
(ii) Conductivity/mA	97	lower same higher
(iii) Speed of reaction with magnesium/cm^3 gas min^{-1}	57	lower same higher
(iv) Volume of strong alkali required for neutralisation/cm^3	50	lower same higher

(*a*) Circle the appropriate words in the table to show how the test results for ethanoic acid compare with those for hydrochloric acid. **2**

(*b*) The sodium hydroxide solution used in test (iv) had a concentration of 0·01 mol l^{-1}.

Calculate its pH. **1**

(*c*) Given 100 cm^3 of hydrochloric acid with a pH of 1, describe in detail how you would prepare accurately 250 cm^3 of the same acid, but with a pH of 2. **2**

(5)

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Marks

6. The elements sodium to argon make up the third period of the Periodic Table.

(*a*) Complete the following table.

Element	Melting point/K	Bonds (or forces) broken at the melting point
sodium	371	metallic
silicon	1683	
phosphorus	317	

2

(*b*) (i) Name the **two** elements in the third period which form the compound with the greatest degree of ionic character.

1

(ii) Name the element in the third period which forms an oxide which can react with both acids and bases.

1

(*c*) (i) The first ionisation energy of sulphur is 1010 kJ mol^{-1}.

Write the equation for this process.

1

(ii) On crossing the third period from left to right, there is a general increase in the first ionisation energy of the elements.

Explain this trend.

1
(6)

Candidates must not write in this margin

Marks

7. (*a*) The enthalpy of formation of propan-1-ol is the enthalpy change for the reaction shown in the following equation.

$$3C(s) + 4H_2(g) + \tfrac{1}{2}O_2(g) \longrightarrow \underset{\text{propan-1-ol}}{C_3H_7OH(\ell)}$$

Calculate the enthalpy of formation of propan-1-ol using the enthalpies of combustion of carbon, hydrogen and propan-1-ol given on page 11 of the data booklet.

(Show your working clearly.)

3

(*b*) Propan-1-ol is produced in industry by the following reaction.

$$C_3H_6(g) + H_2O(g) \longrightarrow \underset{\text{propan-1-ol}}{C_3H_7OH(\ell)}$$

Why is the enthalpy change for this reaction different from the enthalpy of formation of propan-1-ol?

1

(4)

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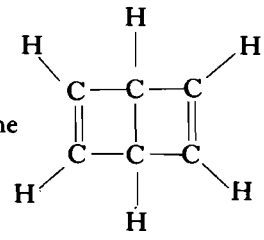
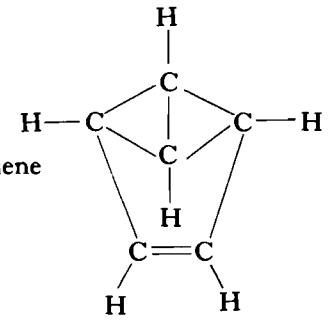
Marks

8. Dewar benzene and benzvalene are isomers of benzene.

Dewar benzene



Benzvalene



(*a*) The skeletal structural formula for Dewar benzene is:

Draw the skeletal structural formula for benzvalene.

1

(*b*) Describe a chemical test which could be used to distinguish between benzene and Dewar benzene.

1

(*c*) Benzene molecules, like graphite, contain free (delocalised) electrons.
Why then does benzene **not** conduct electricity?

1

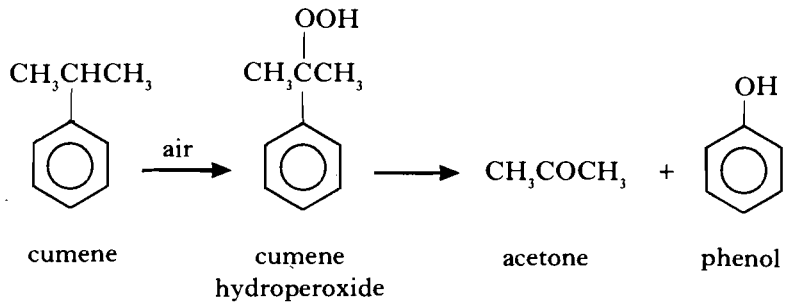
(3)

Candidates must not write in this margin

Marks

9. Acetone, widely used as a solvent, is manufactured from cumene.

Cumene is oxidised by air and the cumene hydroperoxide product is then cleaved.

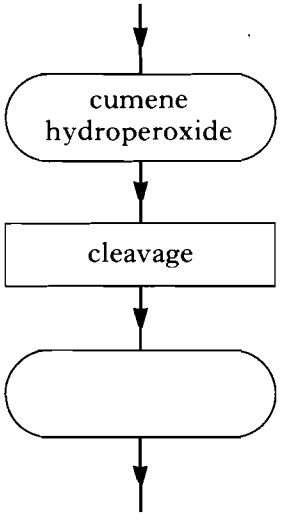


The mixture of acetone and phenol is separated by distillation.

(*a*) Complete the flow chart to summarise the manufacture of acetone from cumene.

In your flow chart use ⬭ to represent chemicals

and ▭ to represent processes.



2

Marks

9. (continued)

(*b*) For every 10 tonnes of acetone produced in this industrial process, calculate the mass of phenol (C_6H_5OH) produced.

(Show your working clearly.)

2

(*c*) Acetone can also be manufactured by oxidising propan-2-ol.

In industry, several factors influence the decision as to which route might be used.

Suggest **two** of these factors.

1

(5)

[Turn over

Candidates must not write in this margin

Marks

10. Organic compounds can undergo different oxidation reactions to produce molecules with different functional groups.

(*a*) Ethanoic acid can be produced by oxidising ethanol.

$$\text{ethanol} \xrightarrow{\text{oxidation}} \text{ethanal} \xrightarrow{\text{oxidation}} \text{ethanoic acid}$$

(i) Name a reagent which can be used to carry out the oxidation of ethanol to ethanal. **1**

(ii) Outline an industrial method for making ethanoic acid which does **not** involve ethanol. **1**

(*b*) $$\text{glycerol} \xrightarrow{\text{oxidation}} \text{methanoic acid} + \underset{\mathbf{X}}{\begin{matrix} H \\ \diagdown \\ C{=}O \\ \diagup \\ H \end{matrix}}$$

(i) Draw the full structural formula for methanoic acid. **1**

(ii) Name compound **X**. **1**

Candidates must not write in this margin

Marks

10. (continued)

(*c*) but-2-ene $\xrightarrow{\text{oxidation}}$ butane-2,3-diol

(i) Draw the full structural formula for butane -2,3-diol.

1

(ii) Diols can be used in the manufacture of polymers.

Name the type of condensation polymer for which a diol is one of the monomers.

1

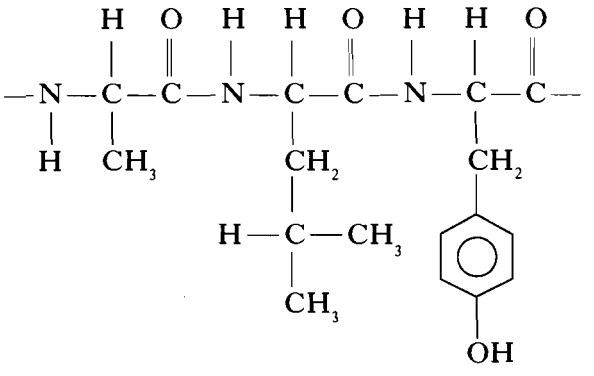
(6)

[Turn over

Candidates must not write in this margin

Marks

11. The structure shown is part of a protein molecule.



(*a*) Circle a peptide (amide) link in the structure. **1**

(*b*) Draw the structural formula for **one** of the molecules which would be formed if the protein was hydrolysed.

1

(*c*) Enzymes are proteins.

(i) Why does the enzyme maltase catalyse the hydrolysis of maltose, but not the hydrolysis of sucrose?

1

(ii) Maltase has optimum activity in alkaline conditions.

Why does maltase lose its ability to act as a catalyst in acid conditions?

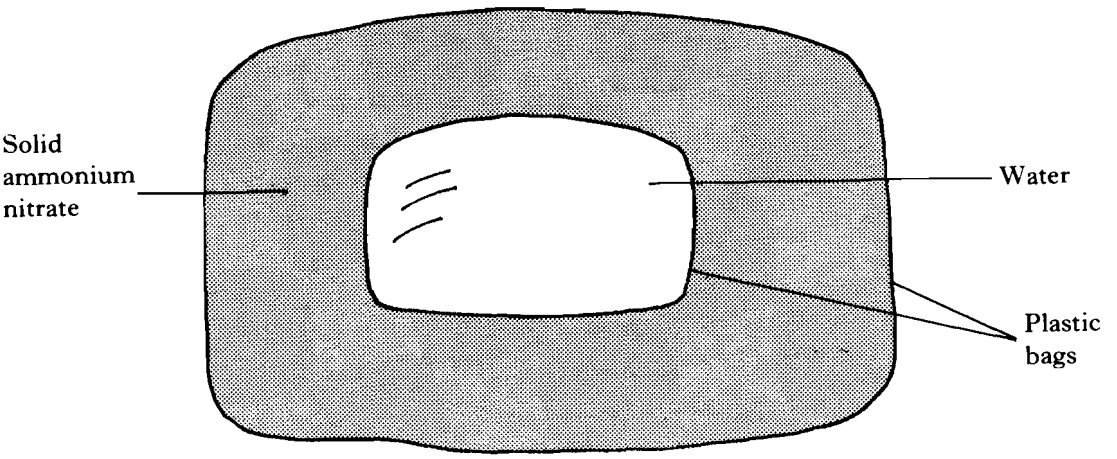
1

(4)

Candidates must not write in this margin

Marks

12. A simplified diagram of a portable cold pack is shown.



When the pack is given a sharp knock, the inner bag bursts. As the ammonium nitrate dissolves in the water, the temperature drops.

(*a*) Name the type of reaction which results in a fall in temperature.

1

(*b*) A laboratory experiment was carried out on a smaller scale. 10 g of ammonium nitrate (NH_4NO_3) was dissolved in 400 cm^3 of water.

Calculate the change in temperature.

(Take $\Delta H_{solution}$ for ammonium nitrate to be +26 kJ mol^{-1}.)

(Show your working clearly.)

3
(4)

[Turn over

Candidates must not write in this margin

Marks

13. The reaction between propanone and iodine is catalysed by $H^+(aq)$ ions.

$$CH_3COCH_3(aq) + I_2(aq) \longrightarrow CH_3COCH_2I(aq) + HI(aq)$$

(*a*) Why is the hydrogen ion described as a **homogeneous** catalyst in this reaction?

1

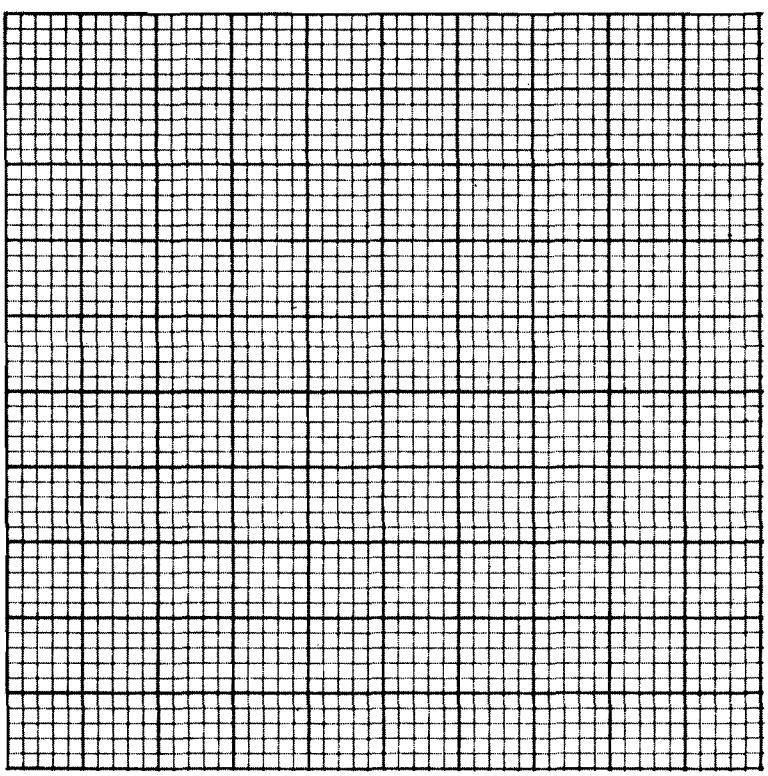
(*b*) The reaction can be followed by monitoring the concentration of iodine. This is done by removing samples from the reaction mixture and analysing them.

The following results were obtained.

Time/s	40	180	320	540	820
Concentration of iodine/mol l^{-1}	0·0084	0·0071	0·0058	0·0038	0·0012

(i) Draw a graph of these results.

Use appropriate scales to fill most of the graph paper.



2

Marks

13. (continued)

(ii) What does the graph indicate about the effect of iodine concentration on the reaction rate?

1

(iii) As each sample for analysis is removed it is added to sodium carbonate solution.

Why does this reduce the rate of the catalysed reaction in the sample?

1

(*c*) The experiment was repeated at a higher temperature.

With the help of an energy distribution diagram, explain why the rate of the reaction would have increased.

2

(7)

[Turn over

Candidates must not write in this margin

Marks

14. Chlorine and sodium hydroxide are important industrial chemicals. Both are produced by the electrolysis of sodium chloride solution.

(*a*) The ion-electron equation for the formation of chlorine is:

$$2Cl^-(aq) \longrightarrow Cl_2(g) + 2e$$

Calculate the volume of chlorine produced when a current of 350 000 A flows for 1 hour.

(Take the molar volume to be 24 litres mol^{-1}.)

(Show your working clearly.)

3

(*b*) Bromine can be obtained by bubbling chlorine gas through a solution of bromide ions.

$$Cl_2(g) + 2Br^-(aq) \longrightarrow Br_2(aq) + 2Cl^-(aq)$$

Name this type of reaction.

1

Marks

14. (continued)

(*c*) The hypochlorite ion, $ClO^-(aq)$, acts as a bleaching agent in solution.

(i) Most household bleaches are made by reacting sodium hydroxide with chlorine. Sodium hypochlorite, sodium chloride and water are formed.

Write a balanced equation for the reaction.

2

(ii) When chlorine is added to water, the following equilibrium is set up.

$$Cl_2(aq) + H_2O(\ell) \rightleftharpoons 2H^+(aq) + ClO^-(aq) + Cl^-(aq)$$

Why does the addition of sodium hydroxide increase the bleaching efficiency of the solution?

1

(iii) When $ClO^-(aq)$ acts as a bleach, it reacts to produce the $Cl^-(aq)$ ion.

$$ClO^-(aq) \longrightarrow Cl^-(aq)$$

Complete the above to form the ion-electron equation.

1

(8)

[Turn over

Candidates must not write in this margin

Marks

15. The label shows the ingredients found in a plum jam.

PLUM JAM

plums – flavour
glucose and sucrose – sweeteners
citric acid – fruit acid
sodium citrate – acidity regulator
water – solvent

(*a*) Describe a chemical test which could be used to distinguish between glucose and sucrose.

1

(*b*) Citric acid is a weak acid.

What is meant by a weak acid?

1

(*c*) Sodium citrate is a salt of a weak acid and a strong base.

What happens to the pH of water when sodium citrate is dissolved in it?

1

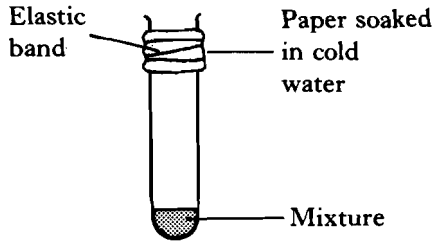
Marks

15. (continued)

(*d*) The flavour in plums comes from naturally-occurring esters. Part of a workcard outlining the laboratory preparation of an ester is shown below.

PREPARATION OF AN ESTER

1. Mix 1 cm^3 of the alkanol with 1 cm^3 of the alkanoic acid in a test tube.
2. Wrap a piece of paper soaked in cold water around the top of the test tube and hold in place as shown in the diagram.



3.

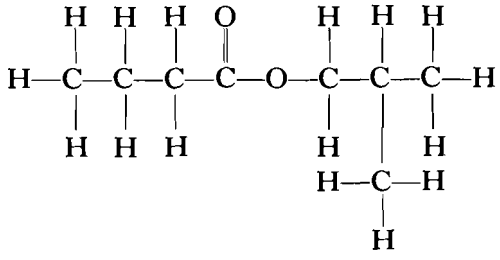
4.

5. After 20 minutes, pour the contents of the test tube into a beaker containing sodium hydrogen carbonate solution.

(i) Complete the workcard by adding appropriate instructions for steps 3 and 4. **2**

(ii) Why is paper soaked in cold water put around the test tube? **1**

(iii) The full structural formula for a plum-flavoured ester is shown below.



Give the systematic name of the alkanol used in making this ester. **1**

(7)

Candidates must not write in this margin

Marks

16. (*a*) A half-litre glass is filled with water.

Calculate the number of **atoms** in this volume of water.

(Take the density of water to be $1{\cdot}0\ g\,cm^{-3}$.)

(Show your working clearly.)

500 cm^3

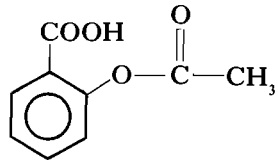
2

(*b*) When a headache tablet is added to water, two of the ingredients, citric acid and sodium hydrogencarbonate, react to form carbon dioxide. No such reaction takes place when the tablet is dry.

(i) Suggest why the tablet will release carbon dioxide only when it is added to water.

1

(ii) Another ingredient in the tablet has the following structure.



Headache tablets which are kept for many months, especially in hot and humid climates, often smell of vinegar (ethanoic acid).

Suggest why this happens.

1

Candidates must not write in this margin

Marks

16. (continued)

(*c*) The bonds in both water and carbon dioxide molecules are polar.

Why is water a polar substance but carbon dioxide a non-polar substance?

1

(5)

[Turn over

Candidates must not write in this margin

Marks

17. Hydrogen peroxide is a colourless liquid with the formula H_2O_2. Its solution can be used as an antiseptic.

(*a*) Work out the structural formula for the hydrogen peroxide molecule and draw it below.

1

(*b*) A hospital technician was checking the concentration of a hydrogen peroxide solution. She titrated 25·0 cm^3 portions of the solution against an acidified potassium permanganate solution.

The reaction taking place during the titrations is:

$$2MnO_4^-(aq) + 6H^+(aq) + 5H_2O_2(aq) \longrightarrow 2Mn^{2+}(aq) + 8H_2O(\ell) + 5O_2(g)$$

(purple) (colourless)

The technician's results are shown in the table below.

Titration	1	2	3
Titre volume/cm^3	16·5	15·8	15·8

(i) How would the technician know that the end-point of the titration had been reached?

1

(ii) Why would the technician ignore the result of the first titration when calculating the mean titre volume?

1

Candidates must not write in this margin

Marks

17. (continued)

(iii) The concentration of the potassium permanganate solution was 0·101 mol l^{-1}.

Use the technician's results to calculate the concentration of the hydrogen peroxide solution.

(Show your working clearly.)

3

[Turn over

Candidates must not write in this margin

Marks

17. (continued)

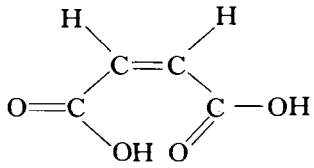
(*c*) The picture shows a trainee technician taking a burette reading while carrying out a permanganate titration.

Identify **four** points of bad practice in his technique.

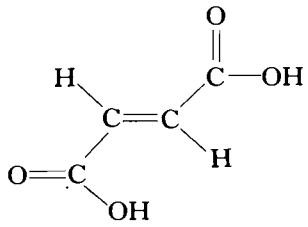
2
(8)

Marks

18. Maleic acid and fumaric acid have the same molecular formula. Their structures are different because rotation is not possible about the carbon-carbon double bond.



maleic acid
mp 430 K



fumaric acid
mp 560 K

(*a*) The molecular mass of octane (mp 216 K) is almost the same as that of the two acids.

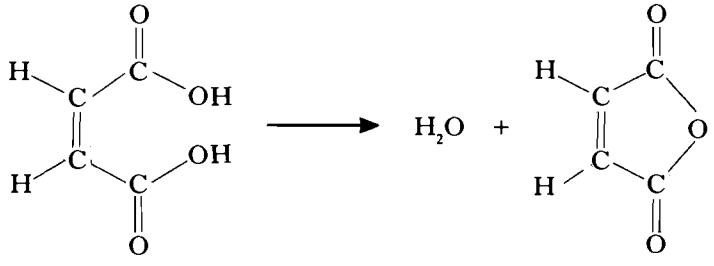
Why is its melting point lower than the melting point of the acids?

1

(*b*) Why is the melting point of fumaric acid higher than that of maleic acid?

1

(*c*) On heating to 440 K, maleic acid can change shape and undergo the following reaction.



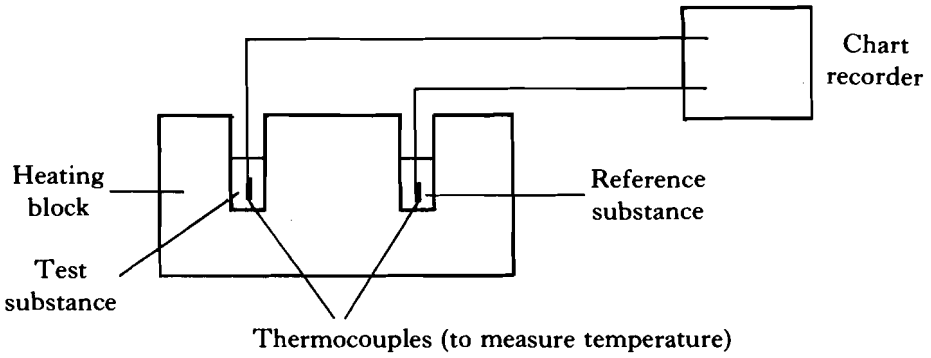
Name the type of reaction taking place.

1

(3)

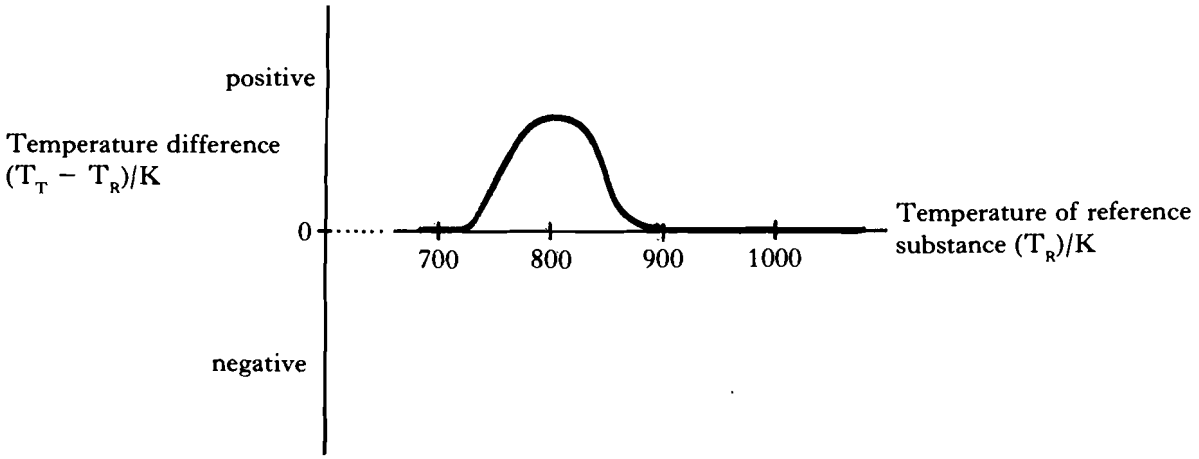
Marks

19. Differential thermal analysis (DTA) is a technique used to investigate changes which occur in substances when they are heated. This technique involves measuring the **temperature difference** between a test substance and a reference substance when both are heated.



As soon as a change occurs in the test substance, its temperature (T_T) will differ from that of the reference substance (T_R).

The following DTA curve was obtained when using calcium oxalate (CaC_2O_4) as the test substance.



The peak corresponds to the change:

$$CaC_2O_4 \longrightarrow CaCO_3 + CO$$

This change occurs at 725 K.

(*a*) Why can it be concluded that the **rise** in the DTA curve is due to the change being exothermic?

1

Marks

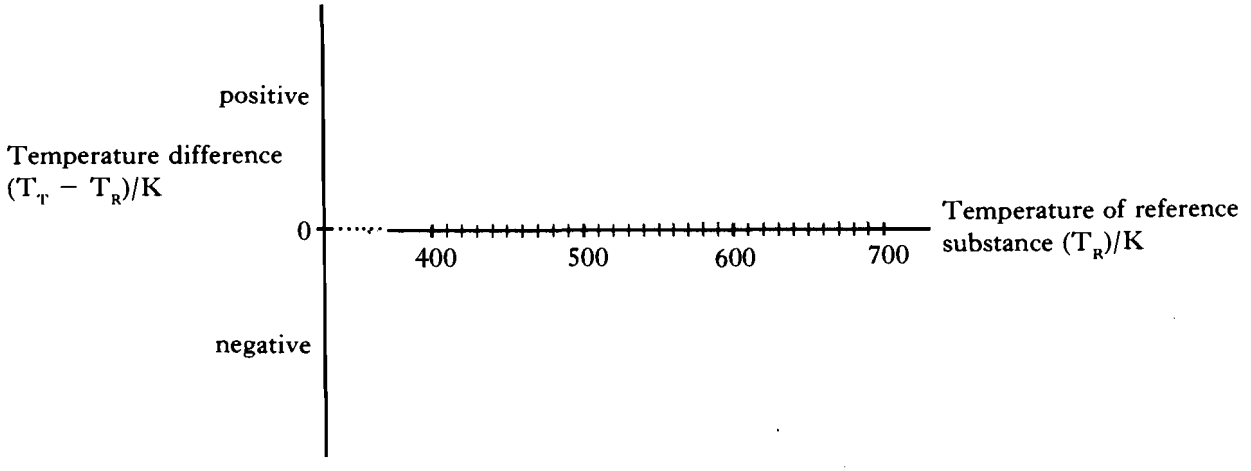
19. (continued)

(*b*) Suggest a property which a substance must have to make it suitable as a reference substance in DTA analysis.

1

(*c*) Selenium melts at 490 K.

Draw the DTA curve which would be expected if selenium was heated in the DTA apparatus in the range 400 K to 700 K.



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(3)

[END OF QUESTION PAPER]