

0500/201

SCOTTISH
CERTIFICATE OF
EDUCATION
1996

WEDNESDAY, 15 MAY
1.30 PM – 3.10 PM

CHEMISTRY
HIGHER GRADE
Paper I

Check that the answer sheet provided is for Chemistry Higher I.

Fill in the details required on the answer sheet.

Reference may be made to the Chemistry (Revised) Higher Grade and Certificate of Sixth Year Studies Data Booklet (1992 edition).

Rough working, if required, should be done only on this question paper, or on the rough working sheet provided—**not** on the answer sheet.

Instructions for the completion of **Part 1** and **Part 2** are given on pages two and nine respectively.



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.

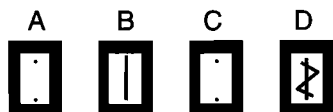
SAMPLE QUESTION

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**.

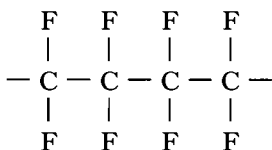
If, after you have recorded your answer, you decide that you have made an error and wish to make a change, you should cancel the original answer and put a vertical stroke in the box you now consider to be correct. Thus, if you want to change an answer **D** to an answer **B**, your answer sheet would 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. A part of the formula for PTFE is shown.



This polymer is classed as a

- A synthetic addition polymer
 B synthetic condensation polymer
 C natural condensation polymer
 D natural addition polymer.
2. Which of the procedures would be best for obtaining sodium chloride from a mixture of sodium chloride and silver chloride?
- A Add water, filter and collect residue.
 B Add water, filter, and evaporate filtrate.
 C Add hydrochloric acid, filter and collect residue.
 D Add sodium hydroxide solution, filter and evaporate residue.
3. Which gas would react with an acid solution?
- A SO_2
 B NH_3
 C CO_2
 D CH_4
4. On analysis, a compound was found to have the following percentage composition by mass.

Tin 78.8 % Oxygen 21.2 %

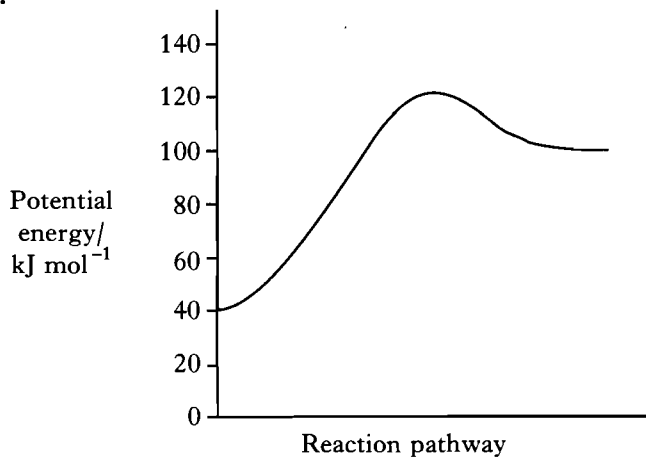
This compound has the formula

- A Sn_2O
 B SnO
 C SnO_2
 D Sn_2O_3 .

5. What volume of sodium hydroxide solution, concentration 0.4 mol l^{-1} , is needed to neutralise 50 cm^3 of sulphuric acid, concentration 0.1 mol l^{-1} ?

- A 25 cm^3
 B 50 cm^3
 C 100 cm^3
 D 200 cm^3

6.



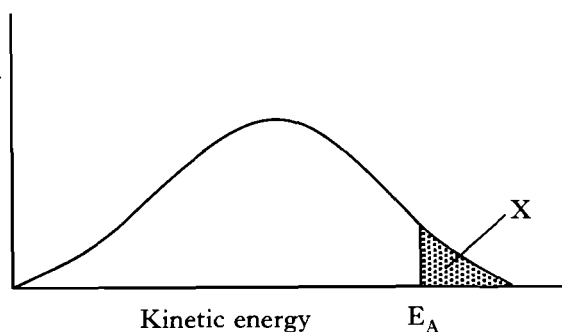
Which set of data applies to the above reaction?

	Enthalpy change	Activation energy/ kJ mol^{-1}
A	Exothermic	60
B	Exothermic	80
C	Endothermic	60
D	Endothermic	80

[Turn over

7.

Number of molecules

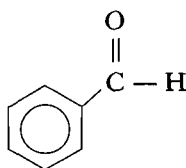


In area X

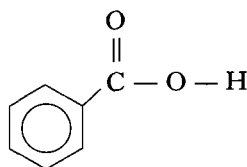
- A molecules always form an activated complex
- B no molecules have the energy to form an activated complex
- C collisions between molecules are always successful in forming products
- D all molecules have the energy to form an activated complex.
8. Liquefied petroleum gas (LPG) is generally a mixture of
- A methane and ethane
- B ethane and propane
- C propane and butane
- D butane and octane.

9. Which of the following is an aldehyde?

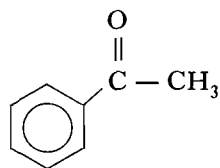
A



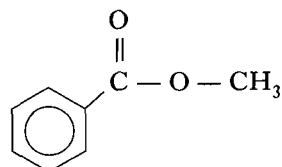
B



C



D



10. Which of the alcohols can be oxidised to give a ketone?

- A 2-methylbutan-1-ol
- B 2, 3-dimethylpentan-1-ol
- C 3-methylbutan-2-ol
- D 2-methylbutan-2-ol

11. The conversion of linoleic acid, $C_{18}H_{32}O_2$, into stearic acid, $C_{18}H_{36}O_2$, is likely to be achieved by

- A hydrogenation
- B hydrolysis
- C hydration
- D dehydrogenation.

12. The number of moles of ions in 1 mol of copper(II) phosphate is

- A 1
- B 2
- C 4
- D 5.

13. Which of the following has the same volume as 14 g of nitrogen gas?

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

- A 14 g of ethane gas
- B 20 g of neon gas
- C 22 g of carbon dioxide gas
- D 28 g of carbon monoxide gas

14. Potassium nitrate decomposes on heating to give potassium nitrite and oxygen.



What volume of oxygen would be obtained by the decomposition of 0.05 mol of potassium nitrate in such a reaction?

(The molar volume of oxygen under these conditions is 24 litres mol^{-1} .)

- A 0.3 litres
- B 0.6 litres
- C 0.9 litres
- D 1.2 litres

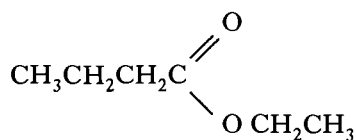
15. The mass of 1 mol of sodium is 23 g.
What is the mass of one sodium atom?

A 6×10^{23} g
B 6×10^{-23} g
C 3.8×10^{-23} g
D 3.8×10^{-24} g

16. The Avogadro Constant is the same as the number of

A molecules in 16 g of oxygen
B ions in 1 litre of sodium chloride solution, concentration 1 mol l^{-1}
C atoms in 24 g of carbon
D molecules in 2 g of hydrogen.

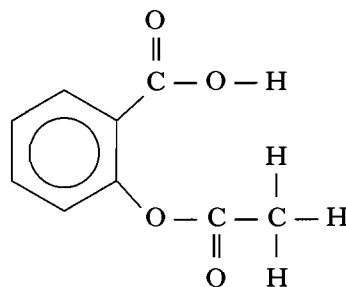
17. Rum flavouring is based on the compound with the formula shown.



It can be made from

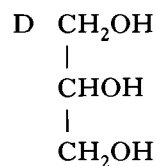
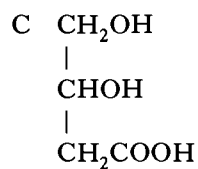
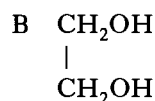
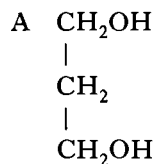
- A ethanol and butanoic acid
B propanol and ethanoic acid
C butanol and methanoic acid
D propanol and propanoic acid.
18. The production of fatty acids and glycerol from fats in foods is an example of
- A hydrolysis
B hydrogenation
C dehydration
D dehydrogenation.

19. Aspirin is one of the most widely used pain relievers in the world. It has the structure:



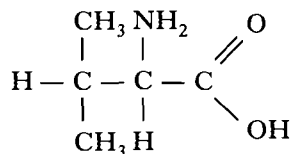
Which two functional groups are present in an aspirin molecule?

- A Hydroxyl and carboxyl
B Aldehyde and ketone
C Carboxyl and ester
D Ester and aldehyde
20. What is the structural formula for glycerol?



[Turn over

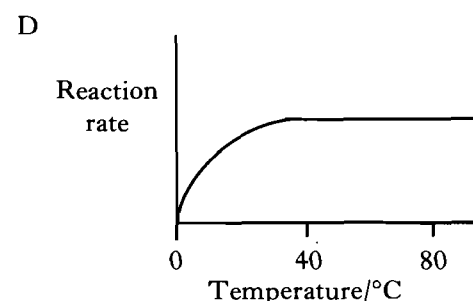
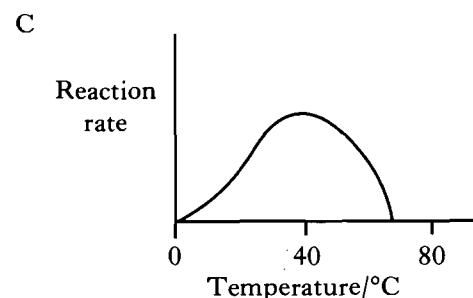
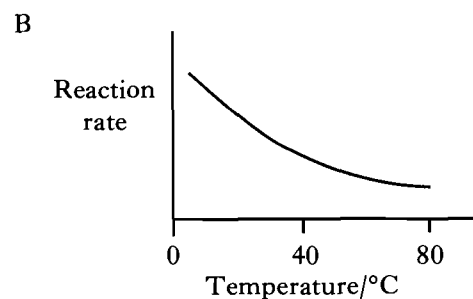
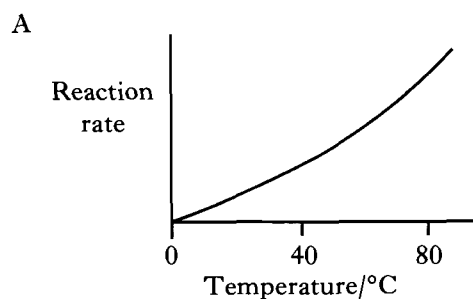
21.



The above molecule can be classified as

- A an amino acid
- B an ester
- C a peptide
- D a protein.

22. The rate of hydrolysis of a protein, using an enzyme, was studied at different temperatures. Which graph would be obtained?



23. The melting points of the Group 7 elements increase on descending the group because the

- A covalent bond lengths increase
- B mean bond energies increase
- C van der Waals attractions increase
- D nuclear charges increase.

24. The difference between the covalent radius of sodium and silicon is mainly due to the difference in the

- A number of electrons
- B number of protons
- C number of neutrons
- D mass of each atom.

25. Which of the elements is most likely to have a covalent network structure?

Element	Melting point/K	Boiling point/K	Density/ g cm ⁻³	Conduction when solid?
A	317	553	1.82	No
B	933	2740	2.70	Yes
C	1683	2628	2.32	No
D	387	457	4.93	No

26. In which of the substances, in the solid state, would van der Waals attractions be a significant "intermolecular force"?

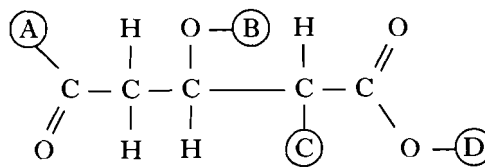
- A Sodium chloride
- B Carbon dioxide
- C Magnesium
- D Ice

27. Tetrachloromethane, CCl₄, is considered to be a non-polar substance because

- A the polar bonds are arranged symmetrically
- B the C—Cl bonds are non-polar
- C a covalent network structure exists
- D only linear molecules are polar.

28. Silicon carbide can be used as
- a lubricant
 - a tip for cutting/grinding tools
 - a substitute for pencil "lead"
 - an electrical conductor.
29. Which of the processes represents the second ionisation energy of magnesium?
- $\text{Mg}^+(\text{g}) \rightarrow \text{Mg}^{2+}(\text{g}) + \text{e}$
 - $\text{Mg}(\text{g}) \rightarrow \text{Mg}^{2+}(\text{g}) + 2\text{e}$
 - $\text{Mg}(\text{s}) \rightarrow \text{Mg}^{2+}(\text{g}) + 2\text{e}$
 - $\text{Mg}^+(\text{s}) \rightarrow \text{Mg}^{2+}(\text{s}) + \text{e}$
30. Which of the following represents an exothermic change?
- $\text{O}_2(\text{g}) \rightarrow 2\text{O}(\text{g})$
 - $\text{CH}_4(\text{g}) \rightarrow \text{C}(\text{g}) + 4\text{H}(\text{g})$
 - $2\text{N}(\text{g}) \rightarrow \text{N}_2(\text{g})$
 - $\text{H}_2\text{O}(\text{g}) \rightarrow 2\text{H}(\text{g}) + \text{O}(\text{g})$
31. The mean bond enthalpy of the C—H bond is 414 kJ mol^{-1} .
From this information, it can be calculated that 1656 kJ of energy is
- evolved when 1 mol of methane is burned in excess oxygen
 - required to dissociate 1 mol of methane into free carbon and hydrogen atoms
 - required for the complete combustion of 1 mol of methane
 - evolved when 1 mol of graphite combines with 2 mol of hydrogen gas.
32. $\text{H}_2\text{O}_2(\ell) \rightarrow \text{H}_2\text{O}(\ell) + \frac{1}{2}\text{O}_2(\text{g})$
 $\Delta\text{H} = -52 \text{ kJ mol}^{-1}$
 $\text{H}_2(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\ell)$
 $\Delta\text{H} = -286 \text{ kJ mol}^{-1}$
- What is the enthalpy of formation of hydrogen peroxide (H_2O_2)?
- -234 kJ mol^{-1}
 - $+234 \text{ kJ mol}^{-1}$
 - -338 kJ mol^{-1}
 - $+338 \text{ kJ mol}^{-1}$

33. Which equation represents the enthalpy of formation of magnesium chloride?
- $\text{Mg}(\text{g}) + \frac{1}{2}\text{Cl}_2(\text{g}) \rightarrow \text{MgCl}(\text{s})$
 - $\text{Mg}(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow \text{MgCl}_2(\text{s})$
 - $\text{Mg}(\text{g}) + 2\text{Cl}(\text{g}) \rightarrow \text{MgCl}_2(\text{s})$
 - $\text{Mg}(\text{s}) + \frac{1}{2}\text{Cl}_2(\text{g}) \rightarrow \text{MgCl}(\text{g})$
34. Ethanol ($\text{C}_2\text{H}_5\text{OH}$) has a different enthalpy of combustion from dimethyl ether (CH_3OCH_3). This is because the compounds have different
- molecular masses
 - bonds within the molecules
 - products of combustion
 - boiling points.
35. On the structure shown, four hydrogen atoms have been replaced by the letters A, B, C and D.

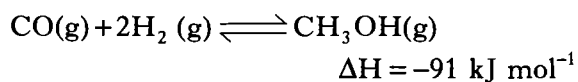


Which letter corresponds to the hydrogen atom which can ionise most easily in aqueous solution?

36. $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
- In the Haber Process, illustrated by the equation, the reaction never reaches equilibrium because
- the ammonia is constantly removed
 - an iron catalyst is used
 - high pressure is used
 - the temperature is held at about 500°C .

[Turn over

37. The equation refers to the preparation of methanol from synthesis gas.



The formation of methanol is favoured by

- A high pressure and low temperature
B high pressure and high temperature
C low pressure and low temperature
D low pressure and high temperature.
38. Which of the following dissolves in water to give an alkaline solution?
- A Sodium nitrate
B Potassium ethanoate
C Ammonium chloride
D Lithium sulphate

39. A radioactive atom of a Group 5 element emits one β -particle. The decay product will be an atom of an element in

- A Group 3
B Group 4
C Group 5
D Group 6.

40. Which particle will be formed when an atom of ${}_{83}^{211}\text{Bi}$ loses an α -particle and the decay product then loses a β -particle?

- A ${}_{79}^{210}\text{Au}$
B ${}_{80}^{209}\text{Hg}$
C ${}_{81}^{208}\text{Tl}$
D ${}_{82}^{207}\text{Pb}$

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 ₂ H ₆	F N ₂

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

A	B	C
Ⓓ	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.

Ⓐ	B	C
D	Ⓔ	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	Ⓒ
D	E	Ⓕ

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:

Ⓐ	B	C
Ⓓ	E	F

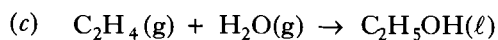
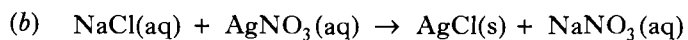
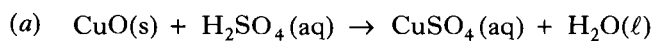
If you want to change back to an answer which has already been scored out, you should enter a tick (✓) in the box of the answer of your choice, thus:

Ⓐ	B	C
✓ Ⓓ	E	F

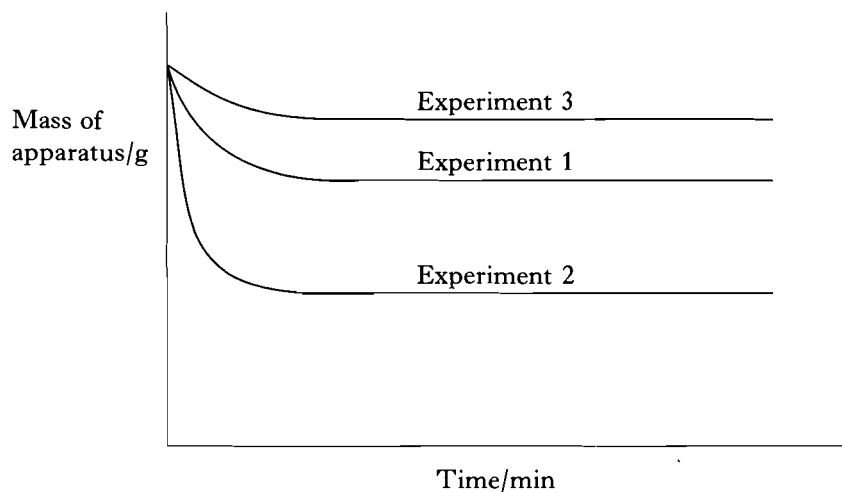
41.

A		B		C	
Condensation		Dehydration		Hydration	
D		E		F	
Hydrolysis		Neutralisation		Precipitation	

Identify the kind of reaction which is represented by each of the equations.



42. A pupil carried out three experiments involving the reaction of excess metal with dilute acid. The results of the three experiments are plotted on the graph.



Excess zinc was added to 100 cm^3 of 0.1 mol l^{-1} sulphuric acid in experiment 1.

A		B		C	
iron/ 100 cm^3 of 0.1 mol l^{-1} sulphuric acid		iron/ 200 cm^3 of 0.1 mol l^{-1} sulphuric acid		iron/ 100 cm^3 of 0.1 mol l^{-1} hydrochloric acid	
D		E		F	
magnesium/ 100 cm^3 of 0.1 mol l^{-1} sulphuric acid		magnesium/ 200 cm^3 of 0.2 mol l^{-1} hydrochloric acid		magnesium/ 100 cm^3 of 0.2 mol l^{-1} hydrochloric acid	

(a) Identify the reactants in Experiment 2.

(b) Identify the reactants in Experiment 3.

43.

A		B		C	
	NH_4^+		Mg^{2+}		OH^-
D		E		F	
	I^-		Br^-		F^-

Identify the **two** ions which

- react to form an alkaline gas,
- can be displaced from solution by chlorine gas,
- do **not** contain 6.02×10^{24} electrons in one mole of ions.

44. The first twenty elements in the Periodic Table can be categorised according to their bonding and structure.

A		B		C	
	Boron		Chlorine		Nitrogen
D		E		F	
	Phosphorus		Sodium		Sulphur

- Identify the element which exists as a covalent network solid.
- Identify the **two** elements which exist as discrete covalent molecular solids.
- Identify the **two** elements which react to form the compound with the most ionic character.

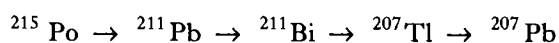
45. There are different families of oxygen-containing carbon compounds.

A		B		C	
	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3 - \text{C} - \text{O} - \text{CH}_3 \end{array}$		$\begin{array}{c} \text{O} \\ // \\ \text{CH}_3 - \text{CH}_2 - \text{C} \\ \backslash \\ \text{OH} \end{array}$		$\text{CH}_3 - \text{CH}_2 - \text{O} - \text{CH}_3$
D		E		F	
	$\begin{array}{c} \text{CH}_3 - \text{CH}_2 - \text{C} = \text{O} \\ \\ \text{H} \end{array}$		$\begin{array}{c} \text{OH} \\ \\ \text{CH}_3 - \text{CH} - \text{CH}_3 \end{array}$		$\begin{array}{c} \text{O} \\ \\ \text{CH}_3 - \text{C} - \text{CH}_3 \end{array}$

Propan-1-ol is a primary alcohol.

- Identify the **two** isomers of propan-1-ol.
- Identify the compound(s) which could be formed by the oxidation of propan-1-ol.

46. The last five isotopes in a natural radioactive decay series are shown.



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

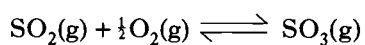
A	^{207}Tl and ^{207}Pb have the same atomic number.
B	^{211}Pb and ^{207}Pb have the same electron arrangement.
C	When ^{215}Po undergoes α -emission, the immediate product is ^{211}Bi .
D	^{211}Pb and ^{211}Bi are isotopes.
E	The nucleus of a ^{215}Po isotope contains 135 neutrons.
F	When ^{207}Tl undergoes β -emission, the immediate product is ^{207}Pb .

47. Metals can be obtained at the negative electrode during electrolysis of molten salts.

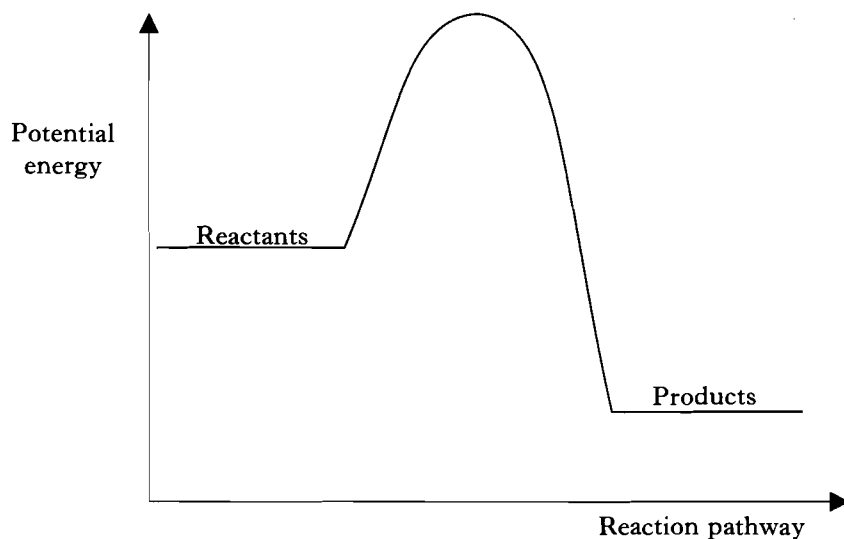
Identify the **true** statement(s).

A	Two moles of electrons are required to produce 20 g of calcium.
B	The quantity of electricity required to produce 27 g of aluminium and 23 g of sodium is the same.
C	2.0×10^{23} electrons are required to produce 3 g of aluminium.
D	96 500 coulombs are required to produce 80 g of calcium.
E	The quantity of electricity required to produce 40 g of calcium is twice that required to produce 23 g of sodium.

48. A vanadium(V) oxide catalyst is used in the production of sulphur trioxide.



The potential energy diagram for the uncatalysed reaction is shown.



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

A	The enthalpy change for the forward reaction is positive.
B	At equilibrium, the energy of activation for the forward reaction is equal to the energy of activation for the reverse reaction.
C	The catalyst decreases the enthalpy change of the reaction.
D	Increasing the pressure increases the yield of sulphur trioxide.
E	The enthalpy change in the forward reaction represents the enthalpy of formation of sulphur trioxide.
F	The catalyst increases the rate of the reverse reaction.

[END OF QUESTION PAPER]

FOR OFFICIAL USE

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

Total

0500/202

SCOTTISH
CERTIFICATE OF
EDUCATION
1996

WEDNESDAY, 15 MAY
9.30 AM - 12.00 NOON

CHEMISTRY
HIGHER GRADE
Paper II

Fill in these boxes and read what is printed below.

Full name of school or college

Town

First name and initials

Surname

Date of birth

Day Month Year

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Candidate number

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Number of seat

All questions should be attempted.

Necessary data will be found in the Chemistry (Revised) Higher Grade and Certificate of Sixth Year Studies Data Booklet (1992 Edition) which is provided.

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.

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.

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.

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.

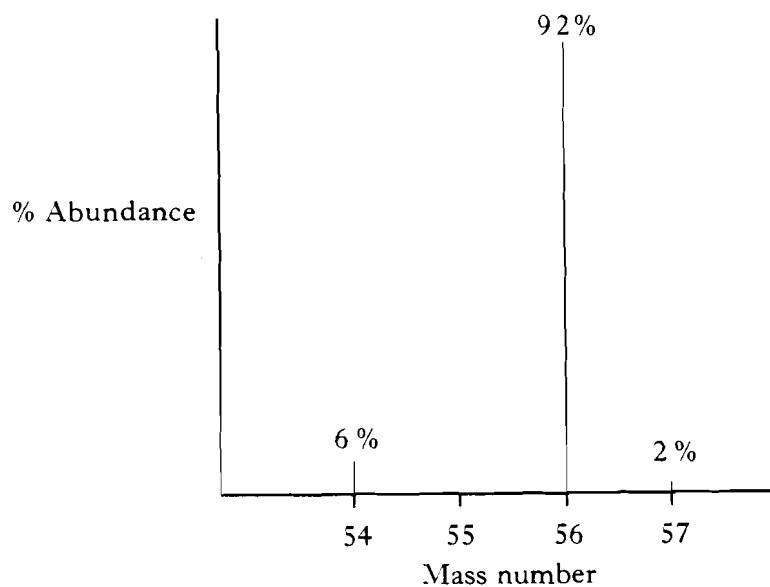
Before leaving the examination room, you must give this book to the invigilator. If you do not, you may lose all the marks for this paper.



Marks

1. When samples of elements are placed in the mass spectrometer, the charts obtained provide important information.

(a) The relative atomic mass of iron can be calculated from the information in the following chart.



Calculate the relative atomic mass of iron.

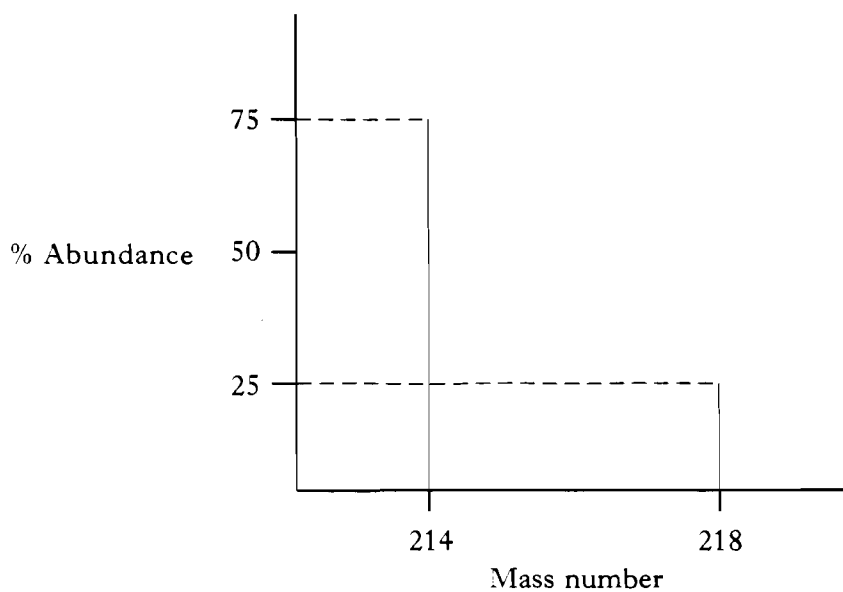
(Show your working clearly.)

2

Marks

1. (continued)

- (b) Polonium-218 is an α -emitting radioisotope. The following chart is for a sample which is six minutes old. The half-life of the sample can be found from the chart.



- (i) Write a balanced nuclear equation to show the decay of polonium-218.

1

- (ii) What is meant by the half-life of the radioisotope?

1

- (iii) Calculate the half-life of the radioisotope.

1

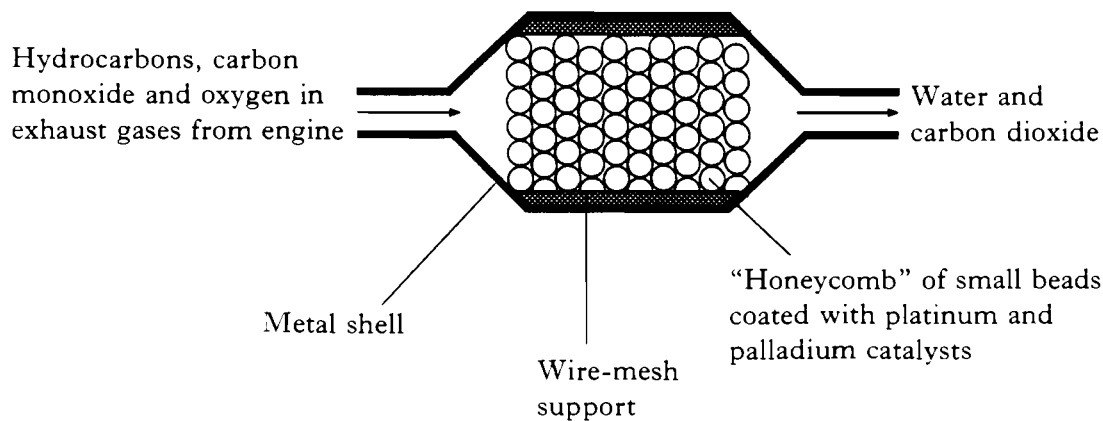
(5)

[Turn over

Marks

2. Catalysts are an important part of everyday-life.

(a) Catalytic converters are fitted in the exhaust systems of modern cars. These cars use unleaded petrol.



(i) Why are the platinum and palladium catalysts coated on to small beads?

1

(ii) How would the use of leaded petrol affect the catalyst?

1

Marks

2. (continued)

- (iii) Explain what happens to the molecules in the gas from the engine during the catalytic conversion to water and carbon dioxide.

You may wish to draw labelled diagrams.

2

- (b) Enzymes are biological catalysts.

- (i) Use labelled diagrams to show why an enzyme can only catalyse a specific reaction.

1

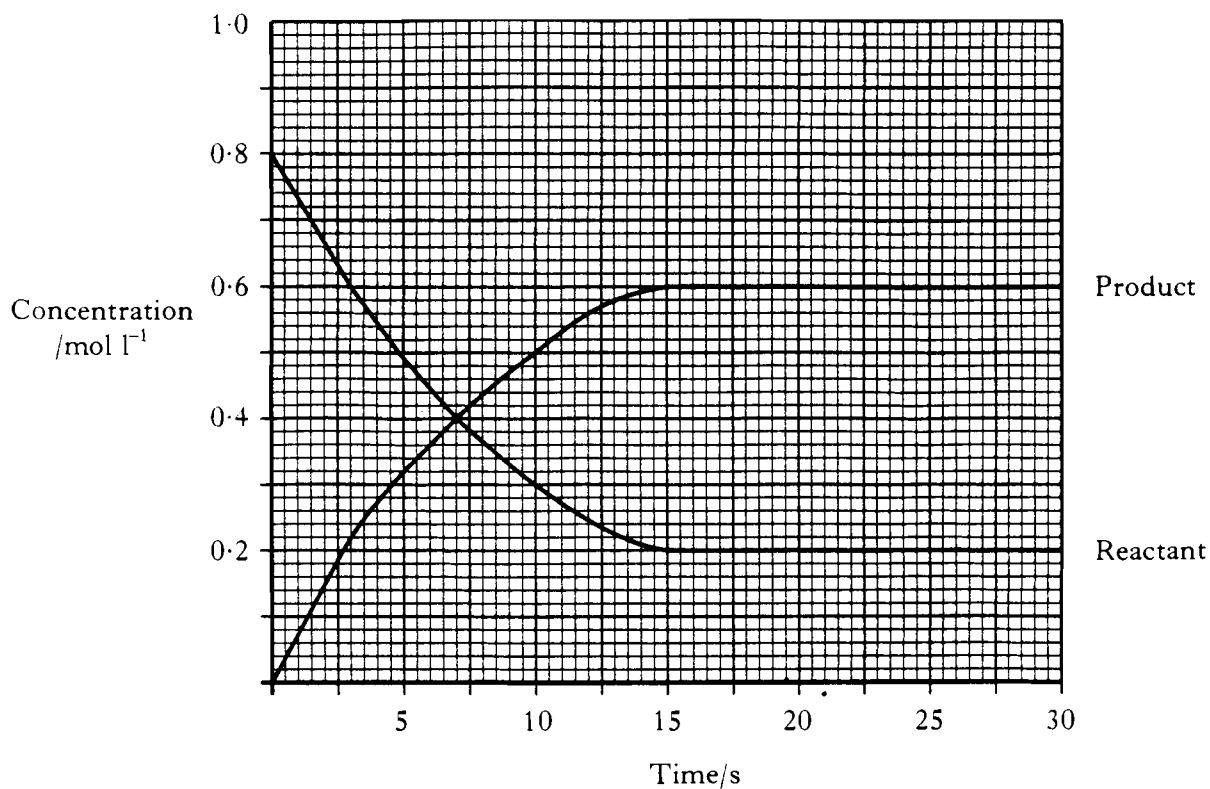
- (ii) State **one** factor which can affect the efficiency of an enzyme.

1
(6)

[Turn over

Marks

3. The graph shows the concentrations of reactant and product as equilibrium is established in a reaction.



- (a) Calculate the average rate of reaction over the first 10 s.
(Show your working clearly.)

1

Marks

3. (continued)

- (b) The equilibrium constant for a reaction is given the symbol K . In this reaction K is given by:

$$K = \frac{\text{equilibrium concentration of product}}{\text{equilibrium concentration of reactant}}$$

Calculate the value of K for this reaction.

1

- (c) The reaction is repeated using a homogeneous catalyst.

(i) What is meant by a **homogeneous** catalyst?

1

(ii) What effect would the introduction of the catalyst have on the value of K ?

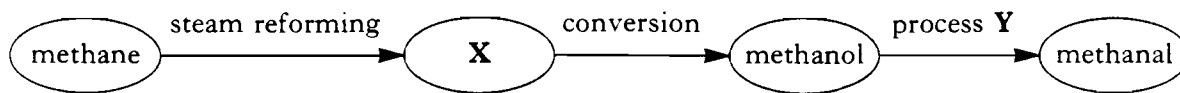
1

(4)

[Turn over

Marks

4. The chemical industry uses methane as a feedstock in the production of methanal.



- (a) Draw the full structural formula for methanal.

1

- (b) Name gas mixture **X**.

1

- (c) Name process **Y**.

1

- (d) Give an industrial use for methanal.

1

(4)

Marks

5. Aluminium oxide, aluminium chloride and aluminium sulphate are three compounds of aluminium.

(a) Aluminium oxide is an amphoteric oxide.

What is meant by an amphoteric oxide?

1

(b) Aluminium chloride can be hydrolysed.

Name the gas produced in this reaction.

1

(c) Aluminium sulphate has the formula $\text{Al}_2(\text{SO}_4)_3$.

Calculate the number of aluminium ions in 3.42 g of aluminium sulphate.

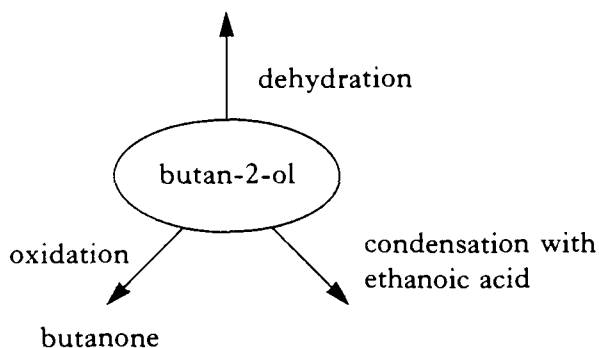
2

(4)

[Turn over

Marks

6. Butan-2-ol reacts in different ways.



(a) Name the **two** products formed by the dehydration of butan-2-ol.

1

(b) Name a reagent which could be used to oxidise butan-2-ol to butanone.

1

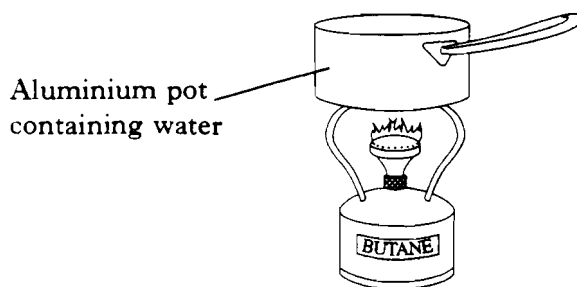
(c) Draw the full structural formula for the ester produced by the condensation of butan-2-ol with ethanoic acid.

1

(3)

Marks

7. A pupil used a cylinder of camping gas to measure the enthalpy of combustion of butane. The experimental set-up is shown.



The pupil found that 2.8 g of butane burned to give out 72.4 kJ of energy.

- (a) Write a balanced equation to show the reaction which corresponds to the enthalpy of combustion of butane.

1

- (b) Apart from the mass of the butane cylinder at the start and the end of the experiment, state **three** measurements which the pupil would have made.

2

- (c) Calculate the experimental value for the enthalpy of combustion of butane.
(Show your working clearly.)

1
(4)

Marks

8. The American scientist Linus Pauling devised a scale to compare the attraction of atoms for bonded electrons. This scale is called the electronegativity scale. Some electronegativity values are shown on page 12 of the data booklet.

(a) Which group of the Periodic Table contains elements with no quoted values for electronegativity?

1

(b) Use the electronegativity values to explain why carbon disulphide contains pure covalent bonds.

1

(c) Explain the trend in the electronegativity values of the Group 7 elements.

2
(4)

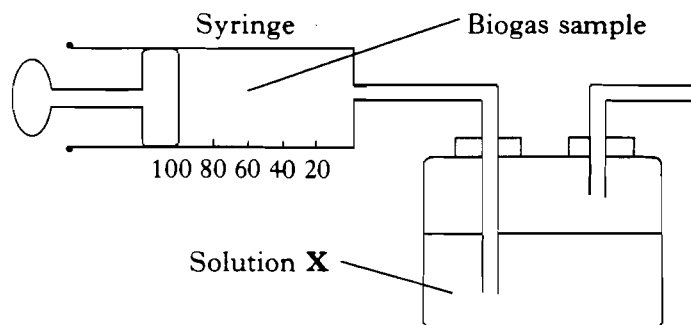
Marks

9. In some countries, cow dung is fermented and the mixture of gases produced, known as biogas, is used as a fuel. The mixture contains a small amount of carbon dioxide.

(a) Name the main component of the biogas mixture.

1

(b) The percentage of carbon dioxide in a biogas sample can be estimated by experiment. Part of the apparatus is shown in the diagram.



(i) Solution **X** is used to absorb the carbon dioxide.
Give a name for solution **X**.

1

(ii) Complete the diagram to show all of the apparatus which could be used to carry out the experiment.

1

(c) Name **one** other fuel which can be made by fermentation.

1

(4)

[Turn over

Marks

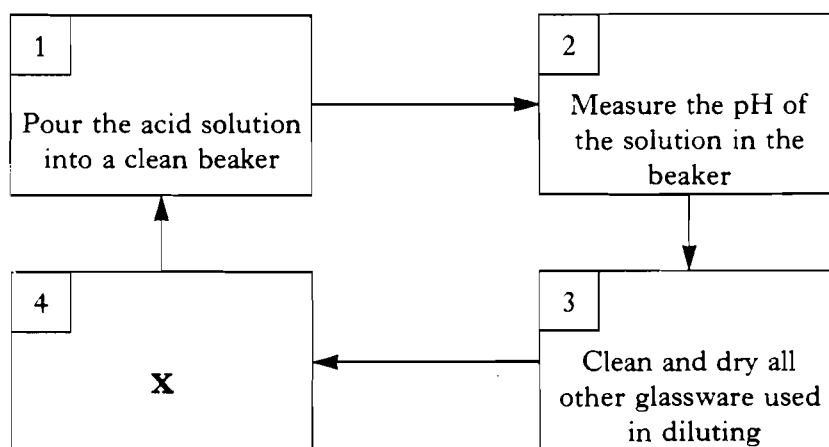
10. A pupil is asked to investigate the relationship between the pH of solutions of hydrochloric acid and the concentration of the hydrogen ions when the acid is repeatedly diluted.

(a) (i) Complete this table to show the result of the first dilution.

Concentration of		pH
acid/mol l ⁻¹	H ⁺ ions/mol l ⁻¹	
1	1	0
0.1	0.1	

1

(ii) Instructions for the experiment are given in a flow diagram.



Marks

10. (continued)

Describe in detail what the pupil should do at the stage marked **X**.
The description should include the volumes and the names of the apparatus used.

3

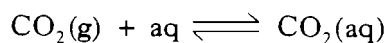
(b) Calculate the concentration of hydroxide ions in a solution of hydrochloric acid with a concentration of 0.001 mol l^{-1} .

1
(5)

[Turn over

Marks

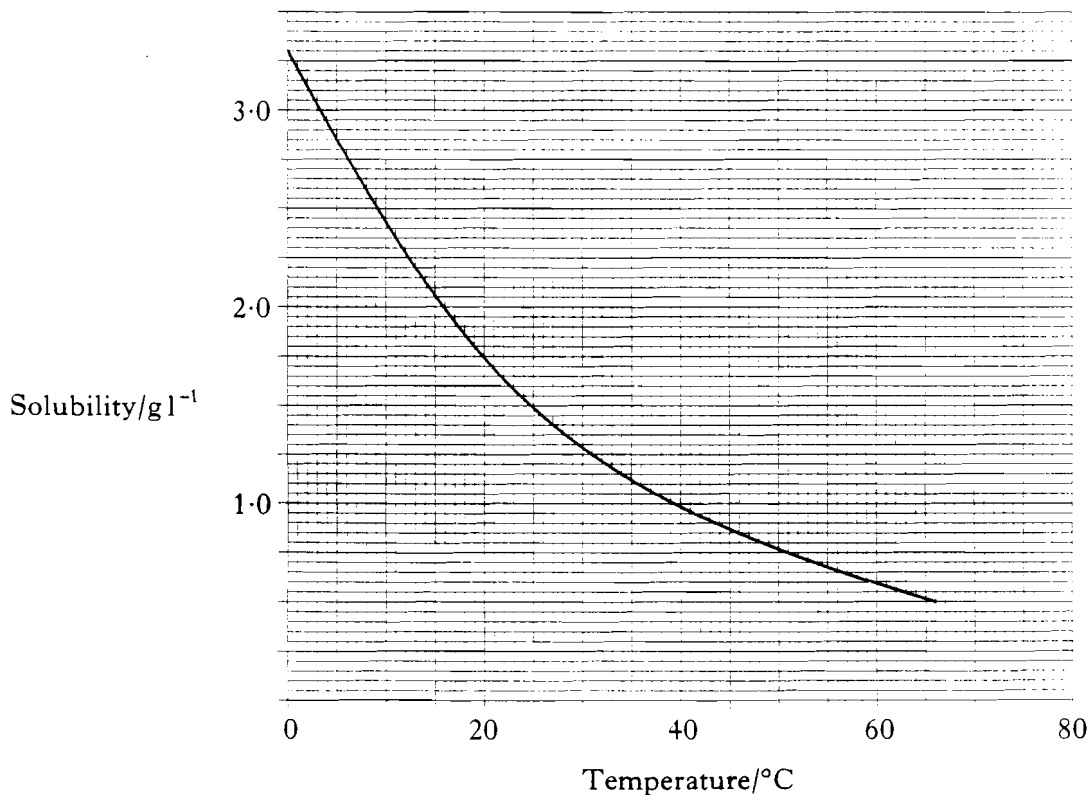
11. Soda water is made by dissolving carbon dioxide in water, under pressure.



- (a) When the stopper is taken off a bottle of soda water, the carbon dioxide gas escapes. Explain why the drink eventually goes **completely** flat.

2

- (b) This graph shows the solubility of carbon dioxide in water at different temperatures.



What does the graph indicate about the enthalpy of solution of carbon dioxide in water?

1

Marks

11. (continued)

- (c) When all of the carbon dioxide is removed from one litre of soda water at 0°C , the gas is found to occupy 1.7 litres.

Use information in the graph to calculate the molar volume of carbon dioxide at this temperature.

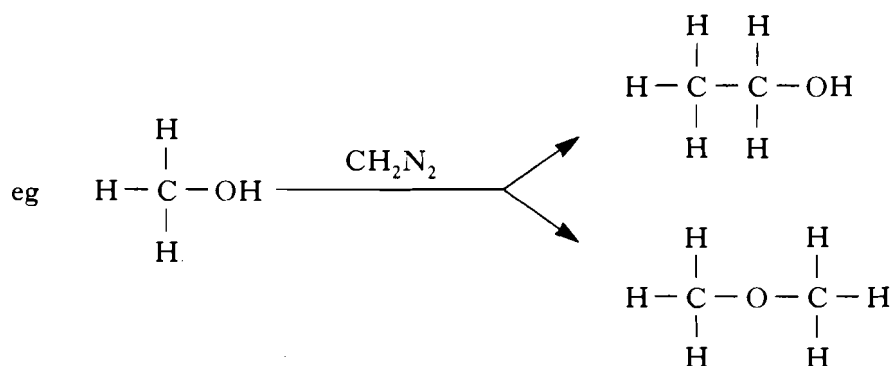
(Show your working clearly.)

2
(5)

[Turn over

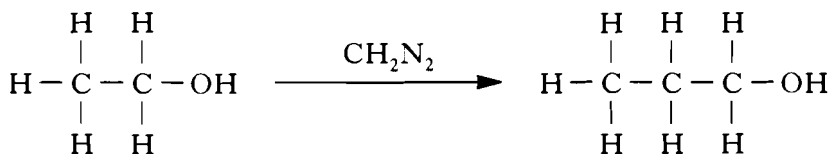
Marks

12. The compound diazomethane, CH_2N_2 , undergoes an unusual reaction called **insertion**. Under certain experimental conditions, the CH_2 group produced can insert itself into **any** bond which includes an atom of hydrogen.



Nitrogen is a product in every reaction.

One of the products for the reaction of diazomethane with ethanol is shown below.



- (a) Name the product shown.

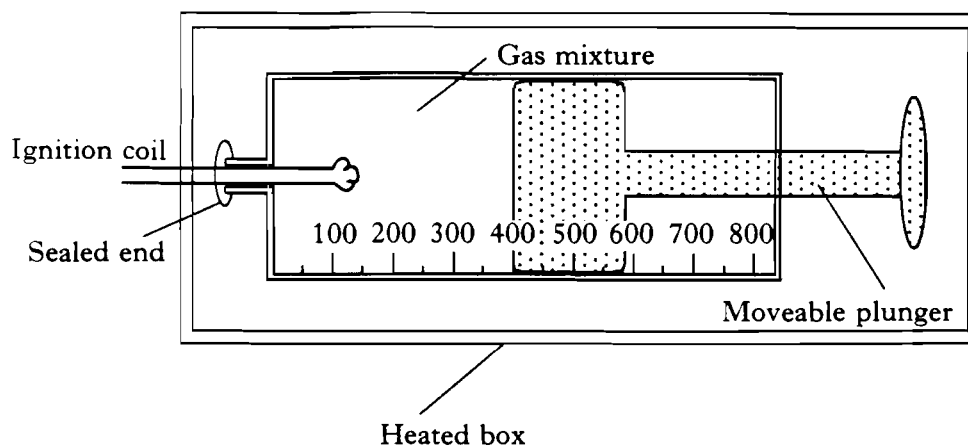
1

- (b) Draw the full structural formula for the other **two** organic products which could be formed in this reaction.

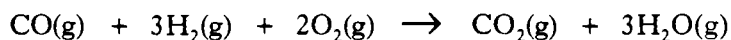
2
(3)

Marks

13. Gas syringes are graduated to allow the volumes of gases to be measured.



The heated box kept the syringe at a temperature greater than 100°C . The syringe contained 150 cm^3 of hydrogen and 50 cm^3 of carbon monoxide mixed with 200 cm^3 of oxygen. When ignited, the gases reacted as shown.



- (a) Name the reactant gas which was in excess and give the remaining volume of this gas.

1

- (b) What was the volume and composition of the products of the reaction?

1

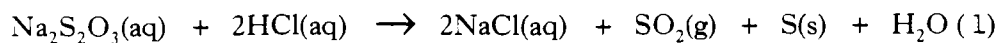
- (c) What would have been the reading on the gas syringe if, at the end of the reaction, the gases had been allowed to cool to room temperature?

1

(3)

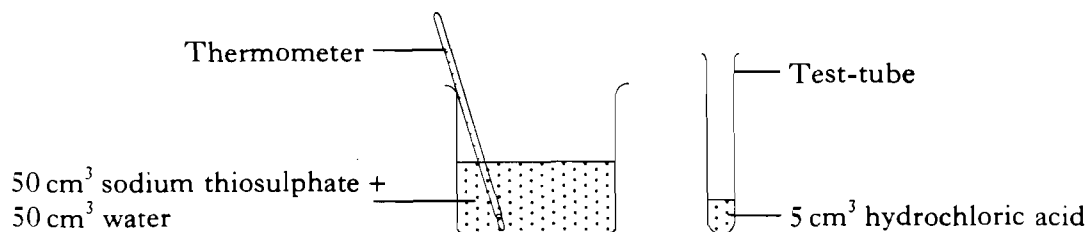
Marks

14. (a) A pupil was investigating the effect of temperature on the rate of reaction. A reaction which produces sulphur and sulphur dioxide from dilute hydrochloric acid and sodium thiosulphate solution was used.

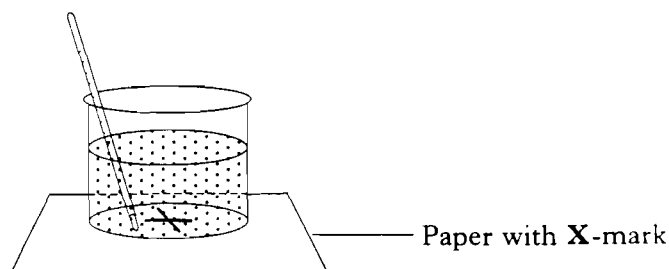


This is what was done.

- The following solutions were measured out.



- The beaker was heated in a water bath to approximately 30 °C.
- The beaker was then placed on a card with an **X** on it and the exact temperature of the sodium thiosulphate solution noted.



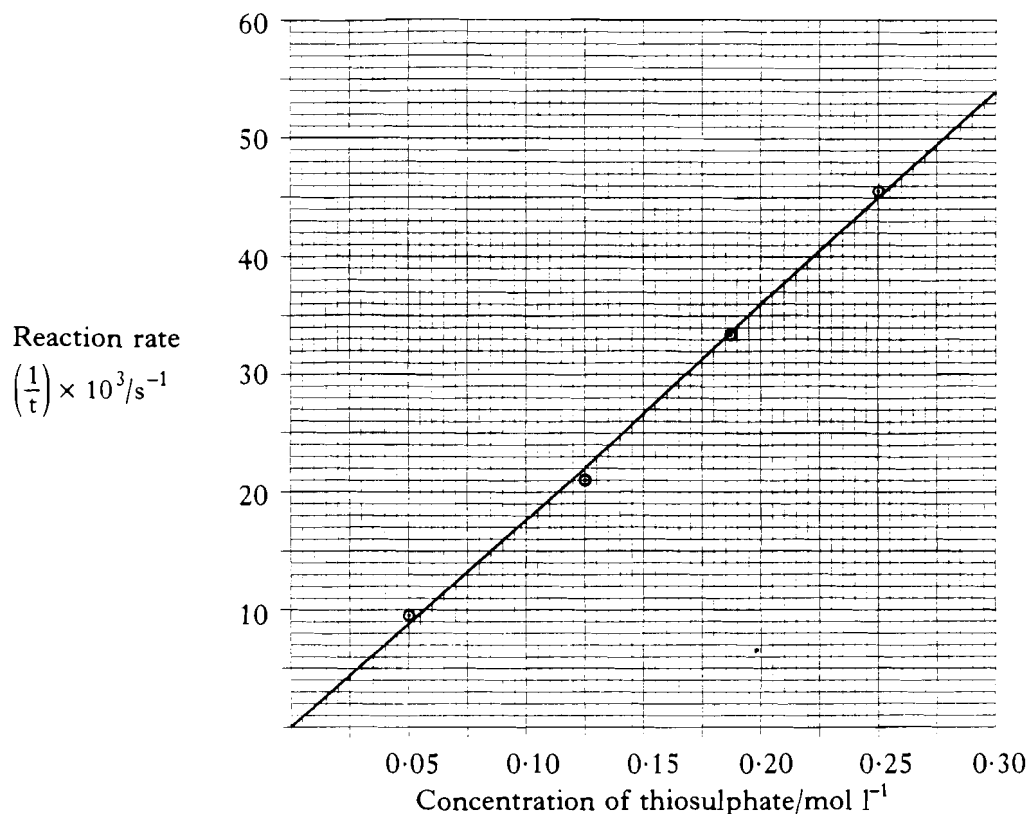
- The acid was added to the sodium thiosulphate solution and the time for the **X** to be obscured by the sulphur formed was noted.
- The apparatus was thoroughly washed out.
- The experiment was repeated once at a temperature of approximately 40 °C.

State **three** ways of improving the above investigation procedure.

Marks

14. (continued)

- (b) The graph below shows the effect of variation in the concentration of sodium thiosulphate solution when it reacts with hydrochloric acid.



- (i) One of the reactions was completed in 55.9 seconds.
What concentration of sodium thiosulphate solution was used in this reaction?

(Show your working clearly.)

1

- (ii) Why does increasing the concentration result in an increase in the reaction rate?

1

(5)

[Turn over

Marks

15. Ionisation energies can be found by applying an increasing voltage across test samples of gases until the gases ionise.

The results below were obtained from experiments using hydrogen atoms and then helium atoms.

Element	Voltage at which an atom of gas ionises/V	
hydrogen	13.6	no further change
helium	24.6	54.5

- (a) Why are there two results for helium but only one for hydrogen?

1

- (b) (i) Write an equation which would represent the first ionisation energy of helium gas.

1

- (ii) Why is the first ionisation energy of helium higher than that of hydrogen?

1

Marks

15. (continued)

(c) The ionisation energy, I.E., can be found from:

$$\text{I.E.} = \text{voltage} \times 1.6 \times 10^{-19} \text{ J}$$

Calculate a value for the first ionisation energy of helium.

(Show your working clearly.)

2

(5)

[Turn over

Marks

16. The Group 5 hydrides are covalent compounds.

Compound	Enthalpy of formation/ kJ mol^{-1}	Boiling point/K
NH_3	-46	240
PH_3	+6	185
AsH_3	+172	218

(a) What is the trend in the stability of the Group 5 hydrides?

1

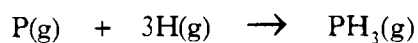
(b) Explain why the boiling point of NH_3 is higher than the boiling point of PH_3 and AsH_3 .

2

Marks

16. (continued)

- (c) The mean bond enthalpy of the P–H bond in $\text{PH}_3(\text{g})$ can be found by using the enthalpy change represented by the equation:



The enthalpy of sublimation of phosphorus is 315 kJ mol^{-1} ;
the enthalpy of formation of phosphorus hydride is given in the table at the top of the opposite page;
the H–H bond enthalpy is given in the data booklet.

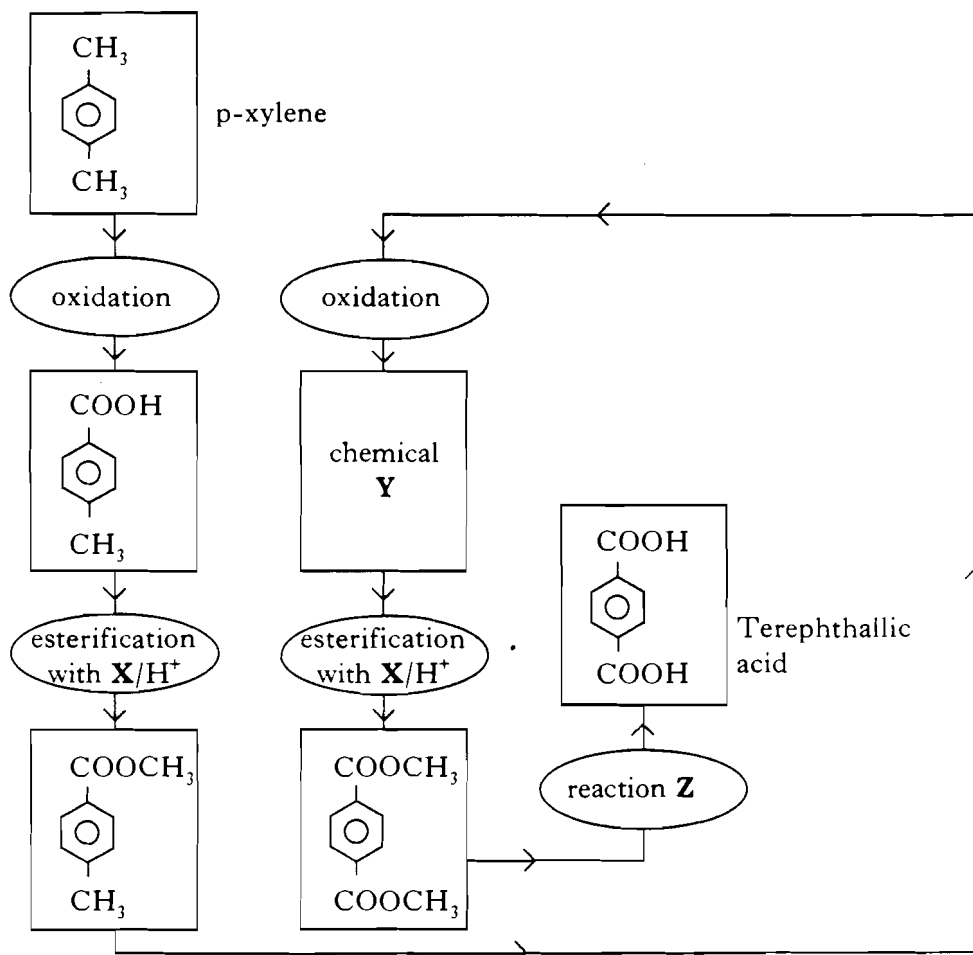
Write equations to represent each of the above enthalpy changes and hence calculate the mean bond enthalpy of the P–H bond.

3
(6)

[Turn over

Marks

17. Terephthalic acid is a commercially important molecule. The feedstock is p-xylene and three simple reactions are involved in the production process.



- (a) (i) Give the systematic name for p-xylene.

1

- (ii) Name the oil fraction likely to provide the source of p-xylene.

1

- (iii) Name the chemical X used in the esterification.

1

Marks

17. (continued)

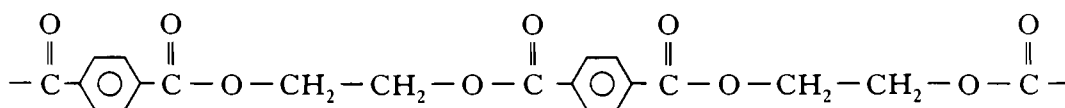
(iv) Draw a structural formula for chemical **Y**.

1

(v) What name is given to reaction **Z**?

1

(b) Terephthalic acid is used in the production of terylene. Terylene is a linear textile fibre commonly known as a polyester.



Part of a terylene molecule

(i) What type of polymerisation has taken place in the formation of terylene from terephthalic acid?

1

(ii) Draw the full structural formula for the other monomer used in terylene manufacture.

1

(iii) How would the structure of a cured polyester **resin** differ from the structure of a linear polyester?

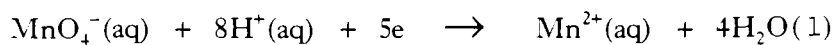
1

(8)

Marks

18. The purity of iron(II) salts can be found by titration with acidified potassium permanganate solution.

Equations:



- (a) This reaction can be described as self-indicating.
How can the end-point be detected?

1

- (b) A pupil was given 1.55 g of impure iron(II) sulphate, $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, and used this to prepare 250 cm^3 of solution for the titration.

It was found that 9.5 cm^3 of 0.01 mol l^{-1} acidified potassium permanganate solution was required to oxidise 25 cm^3 of the iron(II) sulphate solution.

- (i) Use this information to show that the 250 cm^3 solution contained $4.75 \times 10^{-3} \text{ mol}$ of iron(II) sulphate.

(Show your working clearly.)

2

Marks

18. (continued)

(ii) The percentage purity of a salt can be found from the relationship:

$$\text{Percentage purity} = \frac{\text{mass of pure salt}}{\text{mass of impure salt}} \times 100$$

Calculate the mass of pure iron(II) sulphate and thus find the percentage purity of the iron(II) sulphate salt.

(Show your working clearly.)

2
(5)

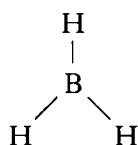
[Turn over

Marks

19. Prefixes can be used to indicate the number of atoms in a molecule.

Term	Number of atoms in the molecule	Example
diatomic	2	hydrogen chloride
triatomic	3	carbon dioxide
tetra-atomic	4	sulphur trioxide
penta-atomic	5	tetrachloromethane
hexa-atomic	6	phosphorus pentachloride

(a) What term is used to describe the following molecule?



1

(b) Name a hexa-atomic molecule, containing carbon, which will decolourise bromine water rapidly.

1

(c) Write the formula for a carbon compound consisting of penta-atomic molecules with a molecular mass of 85.

1
(3)

Marks

20. The idea of **oxidation number** leads to a systematic method of naming inorganic compounds.

The systematic name of KClO_3 is potassium chlorate(V) where the Roman numeral in brackets represents the oxidation number of the chlorine atom.

Simplified rules for working out oxidation numbers are:

all Group 1 metals have an oxidation number of +1;

oxygen has an oxidation number of -2;

the sum of the oxidation numbers of all atoms in the formula of a compound is zero.

- (a) Complete the table below.

Formula	Oxidation number of non-oxygen atom in the negative ion	Systematic name	Charge on the negative ion
KClO_3	+5	potassium chlorate(V)	-1
Na_2SO_4	+6		-2
	+7	potassium iodate(VII)	-1
Na_3PO_4			

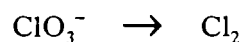
2

- (b) In acid solution, potassium chlorate(V), $\text{KClO}_3(\text{aq})$, oxidises sodium iodide.

- (i) Write an ion-electron equation for the oxidation reaction.

1

- (ii) During the reaction, chlorate(V) ions are reduced to form chlorine.



Complete the above to form the ion-electron equation.

1
(4)

[END OF QUESTION PAPER]