0500/201

SCOTTISH CERTIFICATE OF EDUCATION 1998

MONDAY, 18 MAY
1.00 PM – 2.40 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.

SCOTTISH QUALIFICATIONS AUTHORITY

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

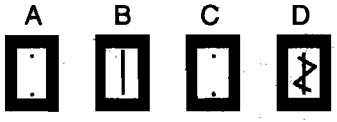
B chromatography

C fractional crystallisation

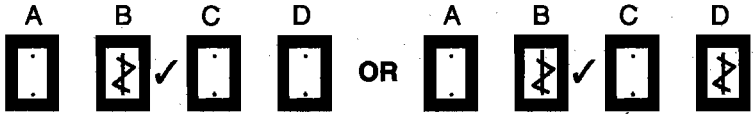
D filtration.

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. Which compound contains **both** a halide ion and a transition metal ion?

   A Iron oxide

   B Silver bromide

   C Potassium permanganate

   D Copper iodate

2. In which of the following compounds do **both** ions have the same electron arrangement as argon?

   A Magnesium oxide

   B Sodium sulphide

   C Calcium bromide

   D Calcium sulphide

3. A carbohydrate did not give a colour change either when added to iodine or when warmed with Benedict's solution.

   The carbohydrate could be

   A maltose

   B sucrose

   C glucose

   D starch.

4. When copper is added to a solution containing zinc nitrate and silver nitrate

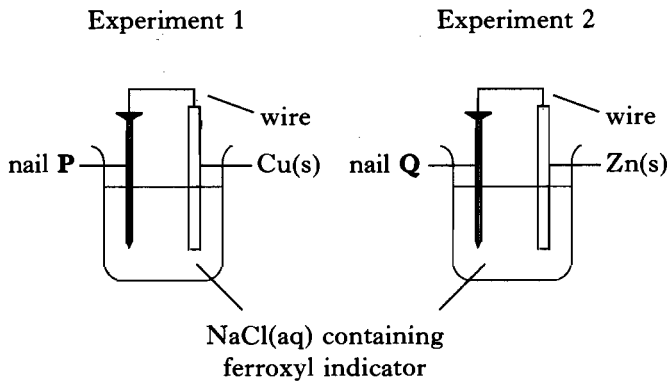
   A deposits of both zinc and silver form

   B a deposit of zinc forms

   C a deposit of silver forms

   D no new deposit forms.

5. Two experiments are set up to study the corrosion of an iron nail.



   Ferroxyl indicator turns blue when $Fe^{2+}(aq)$ ions are present.

   After a short time, a blue colour will have appeared at

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

   B neither **P** nor **Q**

   C **P** but not at **Q**

   D **Q** but not at **P**.

6. The data shown is from the analysis of an organic compound found in meteorite rocks.

   C – 37·5 % H – 12·5 % O – 50%

   The empirical (simplest) formula for the compound is

   A CH_4O

   B C_3HO_4

   C $C_3H_{12}O_3$

   D CH_2O_2.

7. For any chemical, the temperature is a measure of

   A the average kinetic energy of the particles which react

   B the average kinetic energy of all the particles

   C the activation energy

   D the minimum kinetic energy required before reaction occurs.

[Turn over

8. An experiment was carried out at four temperatures. The table shows the times taken for the reaction to occur.

Temperature/°C	20	30	40	50
Time/s	60	30	14	5

The results show that

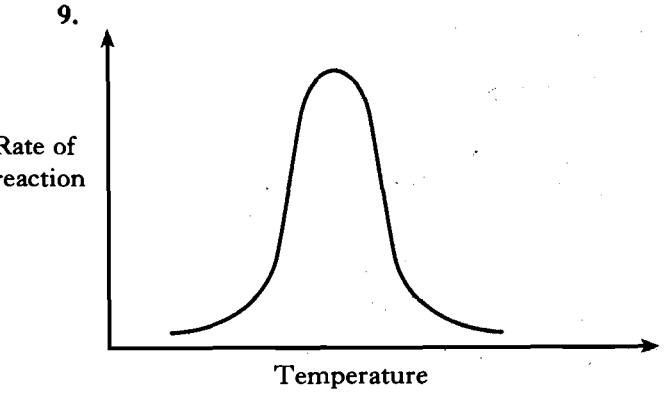
A the reaction is endothermic

B the activation energy increases with increasing temperature

C the rate of the reaction is directly proportional to the temperature

D a small rise in temperature results in a large increase in reaction rate.

9.



The above diagram could represent

A the fermentation of sucrose

B neutralisation of an acid by an alkali

C the combustion of sucrose

D the reaction of a metal with acid.

10. Liquefied petroleum gas consists mainly of

A methane and ethane

B methane and butane

C propane and butane

D hexane and heptane.

11. Which mixture of gases is known as synthesis gas?

A Methane and oxygen

B Carbon monoxide and oxygen

C Carbon dioxide and hydrogen

D Carbon monoxide and hydrogen

12. Which process is used to convert methanol to methanal?

A Hydrogenation

B Condensation

C Hydration

D Oxidation

13. Oxidation of 4-methylpentan-2-ol to the corresponding ketone results in the molecule

A losing 2 g per mole

B gaining 2 g per mole

C gaining 16 g per mole

D not changing in mass.

14. Which equation could represent an industrial cracking process?

A $CH_3(CH_2)_6CH_3 \rightarrow CH_3(CH_2)_4CH_3 + CH_2{=}CH_2$

B $CH_3(CH_2)_6CH_2OH \rightarrow CH_3(CH_2)_5CH{=}CH_2 + H_2O$

C $CH_3(CH_2)_6CH_3 \rightarrow CH_3C(CH_3)_2CH_2CH(CH_3)_2$

D $4CH_2{=}CH_2 \rightarrow -(CH_2CH_2)_4-$

15. In which reaction is the volume of products less than the volume of reactants?

A $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

B $2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$

C $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$

D $2CO(g) + O_2(g) \rightarrow 2CO_2(g)$

16. In which of the following pairs do the gases contain the same number of atoms of oxygen?

A 1 mol of oxygen and 1 mol of carbon monoxide

B 1 mol of oxygen and 0·5 mol of carbon dioxide

C 0·5 mol of oxygen and 1 mol of carbon dioxide

D 1 mol of oxygen and 1 mol of carbon dioxide

17. A one carat diamond used in a ring contained approximately 1×10^{22} carbon atoms.

The mass of the diamond is

A 0·1 g

B 0·2 g

C 1·0 g

D 1·2 g.

18. $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$

How many litres of nitrogen dioxide gas could theoretically be obtained by mixing 5 litres of nitrogen monoxide gas and 2 litres of oxygen gas?

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

A 2

B 3

C 4

D 5

19. The equation shows the reaction between magnesium ribbon and dilute hydrochloric acid.

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

What volume of hydrogen will be produced when 1 g of magnesium is added to excess acid?

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

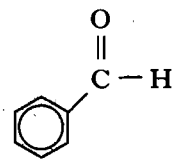
A 1·0 litre

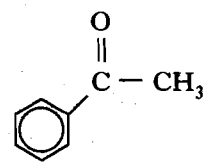
B 2·0 litres

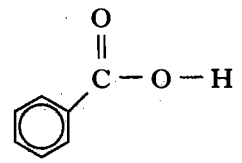
C 2·4 litres

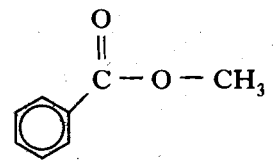
D 24·0 litres

20. Which of the following is an ester?

A 

B 

C 

D 

21. In the formation of "hardened" fats from vegetable oils, the hydrogen

A causes cross-linking between chains

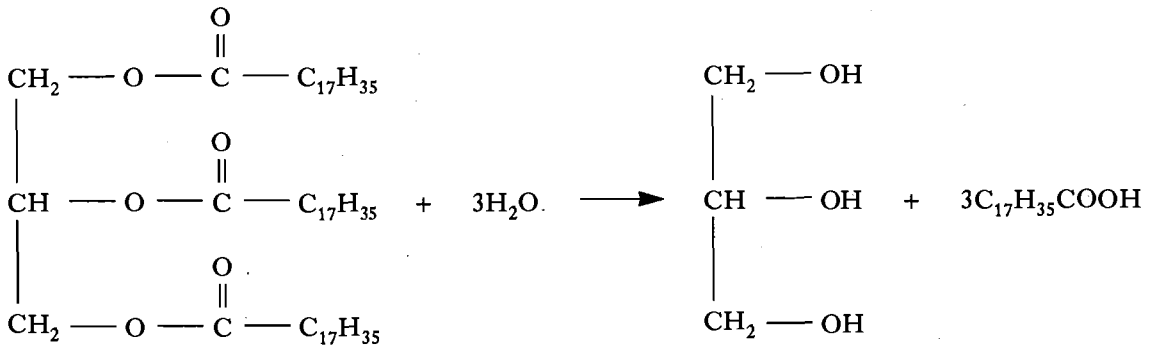
B causes hydrolysis to occur

C increases the carbon chain length

D reduces the number of carbon-carbon double bonds.

[Turn over

22.



Which process is represented by the equation?

A Condensation

B Hydrolysis

C Oxidation

D Dehydration

23. What type of bond is broken when ice is melted?

A Ionic

B Polar covalent

C Hydrogen

D Non-polar covalent

24. Which element is a solid at room temperature and consists of discrete molecules?

A Carbon

B Silicon

C Sulphur

D Boron

25. Which element would require the most energy to convert one mole of gaseous atoms into gaseous ions carrying two positive charges?

(You may wish to use the data booklet.)

A Scandium

B Titanium

C Vanadium

D Chromium

26. Which compound contains hydride ions?

A HCl

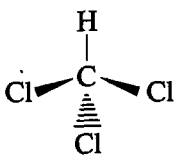
B NaH

C NH_3

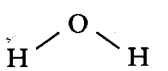
D H_2O

27. The shapes of some common molecules are shown below and each contains at least one polar bond.

Which of these molecules is non-polar?

A 

B H—Cl

C 

D O=C=O

28. Which oxide would be a solid at room temperature (298 K) and a gas at 600 K?

(You may wish to use the data booklet.)

A Fluorine oxide

B Phosphorus oxide

C Magnesium oxide

D Boron oxide

29. Which element has the greatest attraction for bonding electrons within a bond?

A Caesium

B Oxygen

C Fluorine

D Iodine

30. What is the relationship between a, b, c and d?

$$S(s) + H_2(g) \rightarrow H_2S(g) \quad \Delta H = a$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) \quad \Delta H = b$$

$$S(s) + O_2(g) \rightarrow SO_2(g) \quad \Delta H = c$$

$$H_2S(g) + 1\tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) + SO_2(g) \quad \Delta H = d$$

A $a = b + c - d$

B $a = d - b - c$

C $a = b - c - d$

D $a = d + c - b$

31. A group of students added 6 g of ammonium chloride crystals to $200\,cm^3$ of water at a temperature of 25 °C.

The enthalpy of solution of ammonium chloride is $+13{\cdot}6\ kJ\,mol^{-1}$.

After dissolving the crystals, the temperature of the solution would most likely be

A 23 °C

B 25 °C

C 27 °C

D 30 °C.

32. Which equation illustrates an enthalpy of combustion?

A $C_2H_6(g) + 3\tfrac{1}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(\ell)$

B $C_2H_5OH(\ell) + O_2(g) \rightarrow CH_3COOH(\ell) + H_2O(\ell)$

C $CH_3CHO(\ell) + \tfrac{1}{2}O_2(g) \rightarrow CH_3COOH(\ell)$

D $CH_4(g) + 1\tfrac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(\ell)$

33. In the presence of bright light, hydrogen and chlorine react explosively. One step in the reaction is shown below.

$H_2(g) + Cl(g) \rightarrow HCl(g) + H(g)$

Using page 11 of the data booklet, the enthalpy change, in $kJ\,mol^{-1}$, for this step is calculated as

A 5

B 193

C 679

D 867.

34. When a reversible chemical reaction is at equilibrium,

A the concentrations of reactants and products remain equal

B the forward reaction is unable to continue

C the concentrations of reactants and products remain constant

D the forward and reverse reactions proceed at different rates.

35. A catalyst is added to a reaction at equilibrium.

Which of the following does **not** apply?

A The rate of the forward reaction increases.

B The rate of the reverse reaction increases.

C The position of equilibrium remains unchanged.

D The position of equilibrium shifts to the right.

[Turn over

36. A liquid has a pH value of 10.

What is the concentration of $H^+(aq)$ ions present, in $mol\,l^{-1}$?

A 10^{-10}

B 1

C 100

D 10^{10}

37. Excess marble chips (calcium carbonate) were added to $100\,cm^3$ of $1\,mol\,l^{-1}$ hydrochloric acid. The experiment was repeated using the same mass of the marble chips and $100\,cm^3$ of $1\,mol\,l^{-1}$ ethanoic acid.

Which would have been the same for both experiments?

A The time taken for the reaction to be completed

B The rate at which the first $10\,cm^3$ of gas is evolved

C The mass of marble chips left over when reaction has stopped

D The average rate of the reaction

38. The half-life of 1 g bismuth oxide compared to 1 g bismuth sulphate will be

A greater because the percentage of bismuth is greater

B less because of the greater stability of the smaller oxide ion

C the same because the half-life is independent of the percentage of bismuth

D impossible to predict.

39. 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

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 nuclear reaction would **not** give the product nucleus indicated?

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

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

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

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

PART 2

In questions 41 to 47 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 may 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.

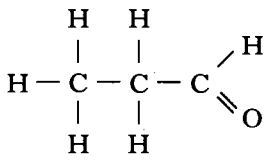
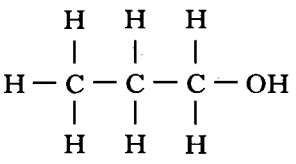
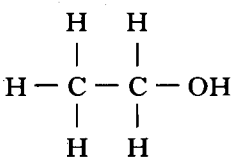
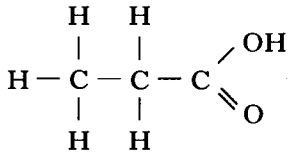
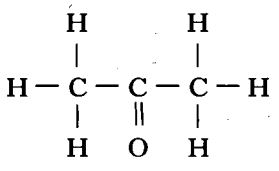
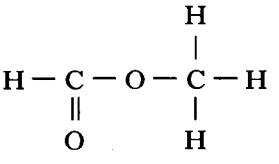
If, after you have recorded your answer, you decide that you have made an error and wish to make a change, you should cancel the original answer and circle the answer you now consider to be correct. Thus, in part (*a*), if you want to change an answer **D** to an answer **A**, your answer sheet would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

(A)	B	C
⊘	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. Many organic functional groups contain oxygen.

A 	B 	C 
D 	E 	F 

(*a*) Identify the aldehyde.

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

(*c*) Identify the **two** compounds which could be oxidised to produce the compound shown in box **D**.

(*d*) Identify the **two** isomers.

42. Nuclear transformations involve different processes.

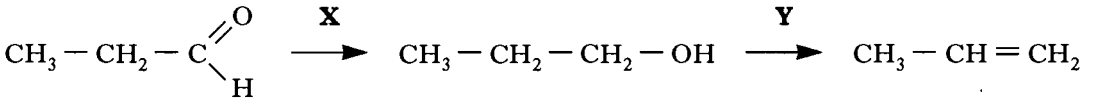
A alpha emission	B beta emission	C neutron capture
D proton capture	E nuclear fusion	F nuclear fission

Identify the process taking place in each of the transformations.

(*a*) $^{23}_{11}\text{Na} + x \rightarrow {}^{24}_{11}\text{Na}$

(*b*) $^{2}_{1}\text{H} + {}^{3}_{1}\text{H} \rightarrow {}^{4}_{2}\text{He} + y$

43.



A Oxidation	B Reduction	C Hydrogenation
D Dehydrogenation	E Dehydration	F Condensation

(*a*) Identify the name which could be applied to reaction **Y**.

(*b*) Identify the name(s) which could be applied to reaction **X**.

44. The properties of oxides are related to their bonding and structures.

A Na_2O	B P_4O_{10}	C H_2O
D Al_2O_3	E Fe_2O_3	F CuO

(*a*) Identify the **two** oxides which are made up of discrete molecules.

(*b*) Identify the oxide which would dissolve in water to produce a solution with pH greater than 7.

(*c*) Identify the oxide(s) which would react with sodium hydroxide solution.

45. Changes in concentration can alter the position of an equilibrium.

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

A KCl(s)	B KOH(s)	C $Na_2SO_4(s)$
D $AgNO_3(s)$	E KF(s)	F $NaNO_3(s)$

(*a*) Identify the compound which if added to the equilibrium mixture would move the equilibrium to the left.

(*b*) Identify the compound(s) which if added to the equilibrium mixture would move the equilibrium to the right.

[Turn over for Questions 46 and 47 on *Page twelve*

46. Lithium hydride is produced by the reaction of lithium with hydrogen.

$$Li(s) + \tfrac{1}{2}H_2(g) \rightarrow LiH(s) \qquad \Delta H = -90kJ\,mol^{-1}$$

Identify the true statement(s).

A	The reaction is endothermic.
B	The reaction to produce lithium hydride is a redox action.
C	The energy change in the reaction represents the enthalpy of formation of lithium hydride.
D	Lithium hydride has metallic bonding.
E	Lithium hydride has hydrogen bonding.
F	The electrolysis of lithium hydride melt produces hydrogen at the negative electrode.

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

Identify the true statement(s).

A	There are $6{\cdot}02 \times 10^{23}$ atoms in 0·5 mol of neon gas.
B	There are $6{\cdot}02 \times 10^{23}$ electrons in 0·5 mol of hydrogen gas.
C	There are $6{\cdot}02 \times 10^{23}$ molecules in 0·5 mol of oxygen gas.
D	There are $6{\cdot}02 \times 10^{23}$ hydrogen atoms in 0·5 mol of water.
E	There are $6{\cdot}02 \times 10^{23}$ oxide ions in 0·5 mol of potassium oxide.
F	There are $6{\cdot}02 \times 10^{23}$ sodium ions in 0·5 mol of sodium chloride.

[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 1998

MONDAY, 18 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

Candidate number

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.

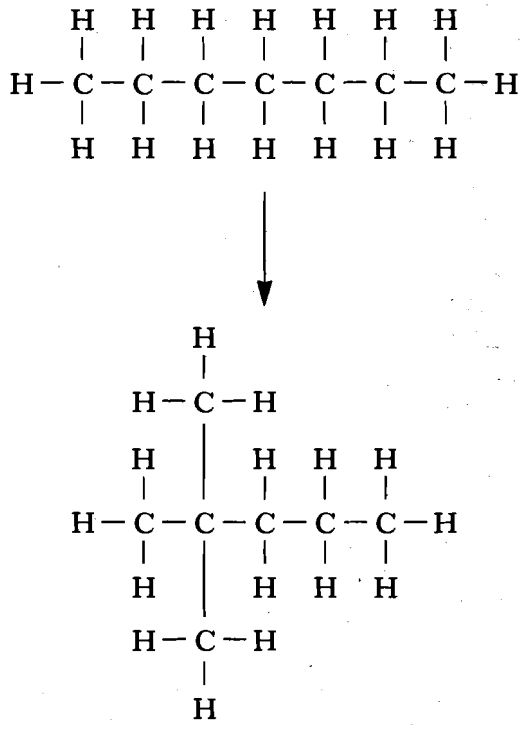
Before leaving the examination room, you must give this book to the invigilator. If you do not, you may lose all the marks for this paper.

SCOTTISH QUALIFICATIONS AUTHORITY

Candidate must not write in this margin

Marks

1. (*a*) Hydrocarbons which are suitable for unleaded petrol are produced in oil refineries. An example of one of the reactions which takes place is shown.



(i) What name is given to the industrial process in which reactions like the above occur?

1

(ii) State the systematic name for the product of the reaction shown.

1

(iii) What structural feature of the product makes it suitable for use in unleaded petrol?

1

(*b*) Oil refineries also produce diesel fuel.

How does the method of ignition of diesel in a car engine differ from that of ignition of petrol?

1

(4)

Candidate must not write in this margin

Marks

2. In spacecraft, the total mass carried and the air quality are important. Lithium hydroxide has been used to absorb carbon dioxide produced by astronauts. The equation for the reaction is:

$$LiOH + CO_2 \longrightarrow LiHCO_3$$

(*a*) 6·0 g of lithium hydroxide absorbs 5·9 litres of carbon dioxide.
Use this information to calculate the molar volume of carbon dioxide.
(Show your working clearly.)

2

(*b*) Lithium hydroxide is more expensive and less common than sodium hydroxide.
Suggest why lithium hydroxide is still preferred to sodium hydroxide for use in spacecraft.

1

(3)

[Turn over

Candidate must not write in this margin

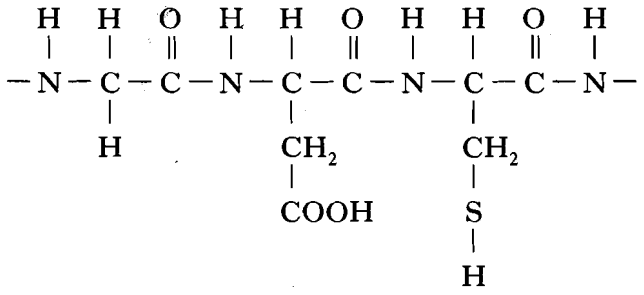
Marks

3. Proteins are polymers found in the human body in tissues such as hair, finger nails and skin.

(*a*) Name the type of compound produced by hydrolysis of a protein.

1

(*b*) Part of a protein molecule is shown.



Draw the structural formula for **one** of the monomers produced by hydrolysis of this protein fragment.

1

(*c*) Proteins can be denatured by heat.
What is meant by denatured?

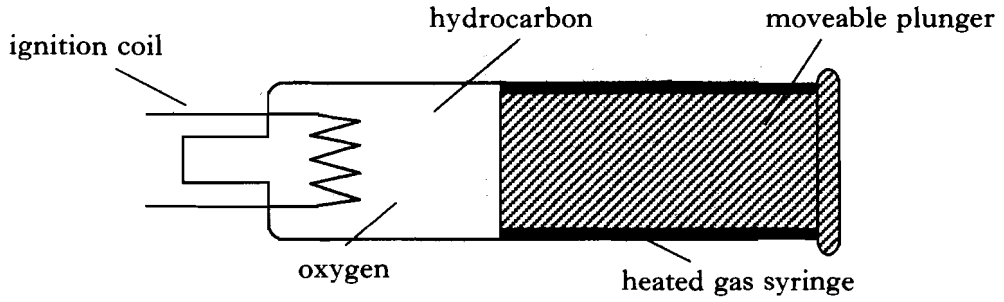
1

(3)

Candidate must not write in this margin

Marks

4. The syringe shown was used to study the reactions of hydrocarbons with oxygen at a constant temperature of 120 °C.



In one experiment, 20 cm^3 of a hydrocarbon gas containing six carbon atoms per molecule was ignited in excess oxygen gas. Carbon dioxide and water vapour were produced.

(*a*) Calculate the volume of carbon dioxide gas produced.

1

(*b*) 100 cm^3 of water vapour was produced.
What is the molecular formula for the hydrocarbon?

1

(2)

[Turn over

Candidate must not write in this margin

Marks

5. Hydrogen peroxide can be used to clean contact lenses. In this process, the enzyme catalase is added to break down hydrogen peroxide.

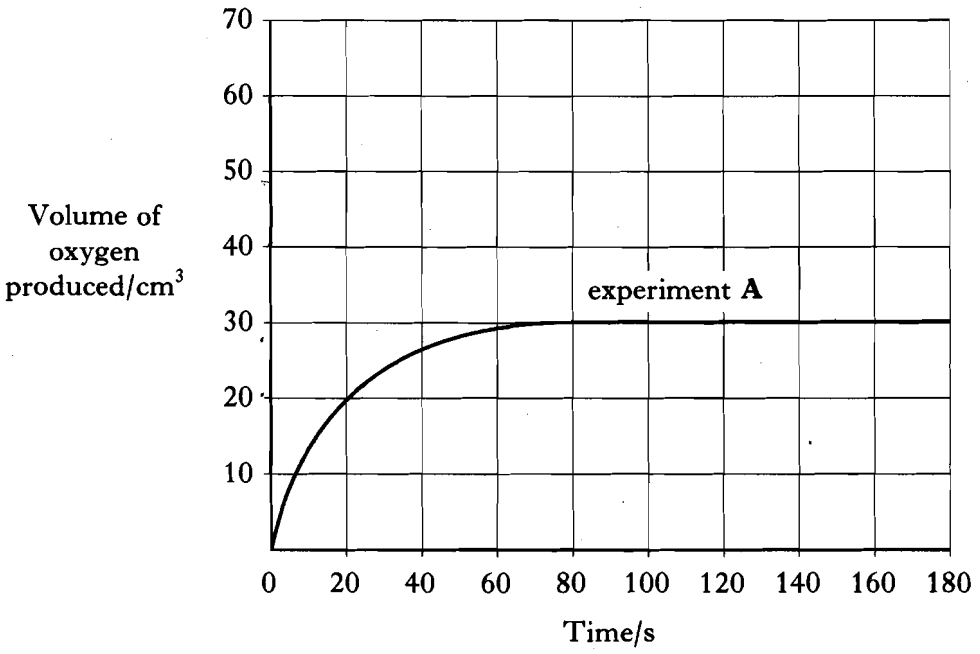
The equation for the reaction is:

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

The rate of oxygen production was measured in three laboratory experiments using the same volume of hydrogen peroxide at the same temperature.

Experiment	Concentration of H_2O_2/mol l^{-1}	Catalyst used
A	0·2	yes
B	0·4	yes
C	0·2	no

The curve obtained for experiment **A** is shown.



(*a*) Calculate the average rate of the reaction over the first 40 s.

1

Candidate must not write in this margin

Marks

5. (continued)

(*b*) Add curves to the graph to show the results of experiments **B** and **C**. Label each curve clearly. **2**

(*c*) Draw a labelled diagram of assembled laboratory apparatus which could be used to carry out these experiments. **1**

(4)

[Turn over

Candidate must not write in this margin

Marks

6. Esters are important and useful compounds. They occur in nature and can also be made in the laboratory.

(*a*) An ester can be made from ethanol and methanoic acid.
Draw the full structural formula for this ester.

1

(*b*) Name the catalyst used in the laboratory preparation of an ester.

1

(*c*) How can this ester be separated from unreacted ethanol and methanoic acid?

1

(*d*) Unless the ester is removed from the reaction mixture as it forms, 100% conversion of reactants to ester is never achieved.
Give a reason for this.

1
(4)

Candidate must not write in this margin

Marks

7. Radioisotopes are used in the treatment of patients suffering from cancer.

(*a*) The isotope $^{60}_{27}Co$ has a half-life of 5·3 years and is used to supply gamma radiation from outside the body of the patient.

Give **two** reasons why this isotope would **not** be suitable for use inside the body.

2

(*b*) $^{32}_{15}P$, a beta-emitting isotope with a half-life of 14 days, is used in the treatment of skin cancer.

(i) Show, **by calculation**, how the proton to neutron ratio is changed by the decay of this isotope.

1

(ii) 3 g of the isotope was used to treat cancer over a period of 56 days.
Calculate the mass of the isotope which decayed during this time.

1

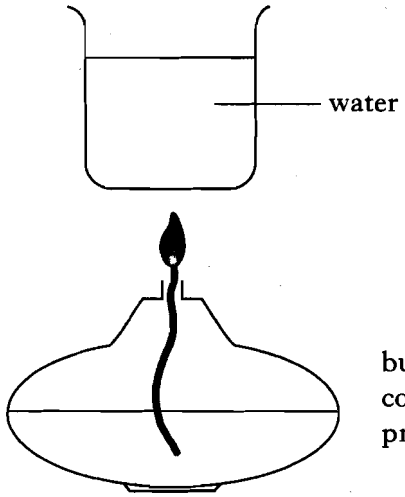
(4)

[Turn over

Candidate must not write in this margin

Marks

8. A pupil found the enthalpy of combustion of propan-1-ol using the following apparatus.



(*a*) In addition to the initial and final temperatures of the water, what other measurements would the pupil have made?

2

(*b*) The table shows enthalpies of combustion of three alcohols.

Compound	Enthalpy of combustion/kJ mol^{-1}
methanol	–715
ethanol	–1371
propan-1-ol	–2010

Why is there a **regular** increase in enthalpies of combustion from methanol to ethanol to propan-1-ol?

1

Candidate must not write in this margin

Marks

8. (continued)

(*c*) The equation for the enthalpy of formation of propan-1-ol is:

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

Use information on enthalpies of combustion from the data booklet to calculate the enthalpy of formation of propan-1-ol.

(Show your working clearly.)

3

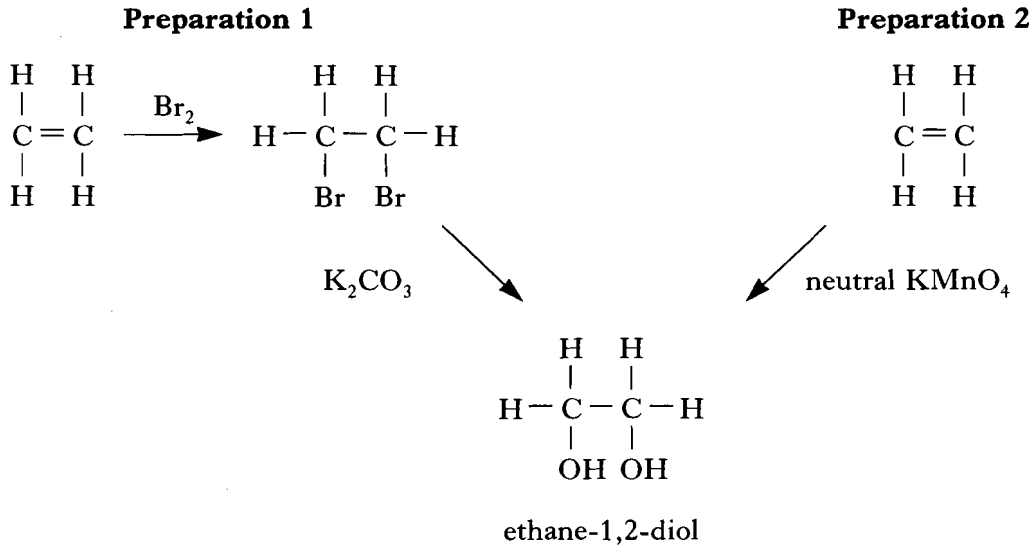
(6)

[Turn over

Candidate must not write in this margin

Marks

9. Ethane-1,2-diol is a colourless liquid used as anti-freeze in car radiators. It can be made in the laboratory from ethene.



(*a*) Give the traditional name for ethane-1,2-diol.

1

(*b*) In preparation 1, the reaction of K_2CO_3 produces the salt potassium bromide and carbon dioxide as by-products.

Give the formula for another compound, **not containing carbon**, which would react with K_2CO_3 to produce the same salt and carbon dioxide.

1

(*c*) In preparation 2, the $KMnO_4$ oxidises ethene in **neutral** aqueous solution.

Complete the balancing of the ion-electron equation shown.

$$MnO_4^-(aq) \longrightarrow MnO_2(s) + 4OH^-(aq)$$

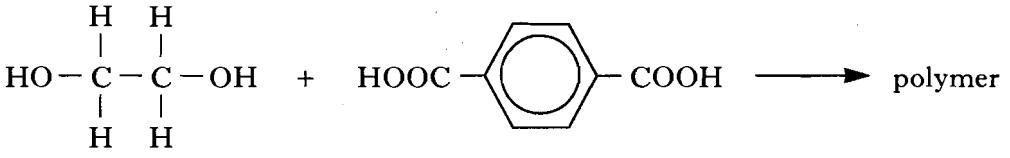
1

Candidate must not write in this margin

Marks

9. (continued)

(*d*) Ethane-1,2-diol can be polymerised with terephthalic acid to form a condensation polymer.



terephthalic acid

(i) Write the molecular formula for terephthalic acid.

1

(ii) Draw a section of polymer showing **one** molecule of each monomer joined together.

1

(iii) Why would this polymer be formed as a fibre and **not** a resin?

1

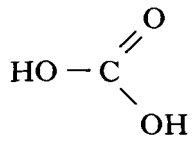
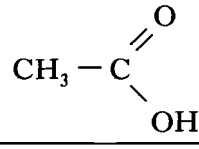
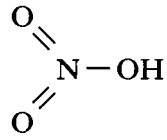
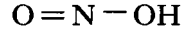
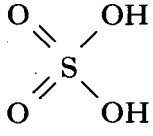
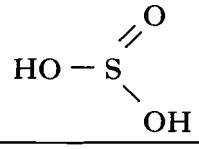
(6)

[Turn over

Candidate must not write in this margin

Marks

10. The structural formulae for some acids containing oxygen are shown.

Acid	Strength	Structure
carbonic	weak	
ethanoic	weak	
nitric	strong	
nitrous	weak	
sulphuric	strong	
sulphurous	weak	

(*a*) (i) Describe **two** tests to distinguish between a weak acid and a strong acid, stating clearly the result of each test.

Test 1

Test 2

2

Candidate must not write in this margin

Marks

10. (*a*) (continued)

(ii) State the **two** variables which must be controlled in **both** tests to make the tests fair.

1

(*b*) What structural feature appears to determine the strength of these acids?

1

(*c*) Chloric acid, $HClO_3$, is a strong acid.
Draw its full structural formula.

1

(*d*) Estimate the pH of 0·008 mol l^{-1} nitric acid solution.

1

(*e*) Carbonic acid forms a salt, sodium carbonate.
Explain why sodium carbonate solution is alkaline.

2

(8)

[Turn over

Candidate must not write in this margin

Marks

11. Ammonia is made by the Haber Process.

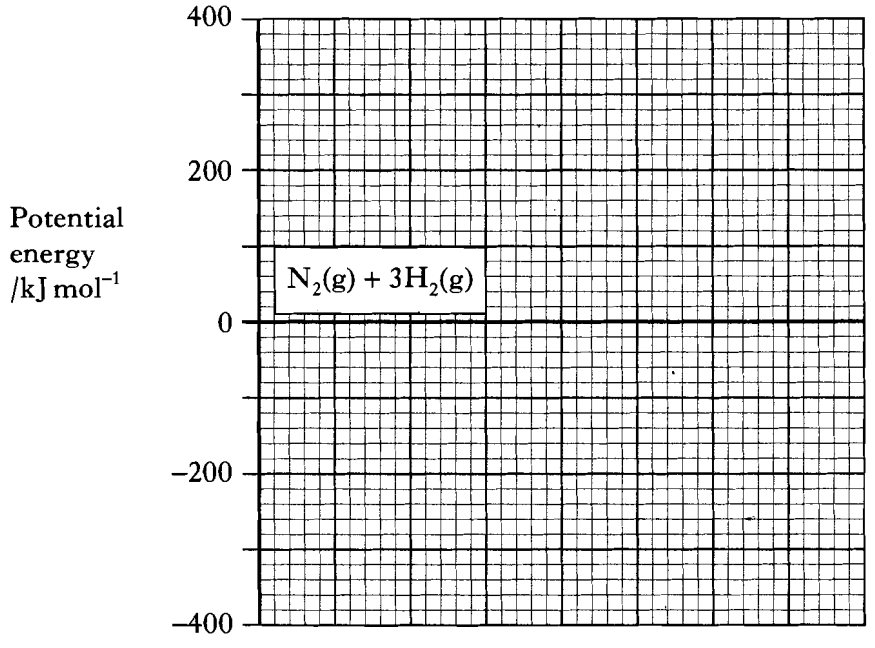
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(*a*) The Haber Process is normally carried out at 200 atmospheres pressure.
Suggest **one** advantage and **one** disadvantage of increasing the pressure in the Haber Process beyond 200 atmospheres.

1

(*b*) The activation energy (E_A) and enthalpy change (ΔH) for this reaction are 236 kJ mol^{-1} and −92 kJ mol^{-1} respectively.

(i) Use this information to draw the potential energy diagram for the reaction.



1

(ii) Calculate the activation energy for the reverse reaction.

1

Candidate must not write in this margin

Marks

11. (continued)

(*c*) Over a period of time, 120 tonnes of hydrogen produced 88·4 tonnes of ammonia by the Haber Process.

Calculate the percentage yield of ammonia.

(1 tonne = 1000 kg)

(Show your working clearly.)

2

(5)

[Turn over

Candidate must not write in this margin

Marks

12. Methanol and ethanol can be used as alternative fuels in car engines.

(*a*) **Methanol**

Methanol can be made as follows.

$$\mathbf{X} + H_2O \xrightarrow{\text{steam reforming}} \underbrace{CO + 3H_2}_{\text{synthesis gas}} \longrightarrow CH_3OH$$

(i) Identify **X**.

1

(ii) Methanol is less volatile than petrol and less likely to explode in a car accident.

Explain why methanol is less volatile than petrol.

2

(*b*) **Ethanol**

In some countries, ethanol for fuel is made by fermentation.

(i) Why is ethanol considered to be a "renewable" fuel?

1

(ii) To meet market demand, ethanol is also made by a method other than fermentation.

What is this method?

1

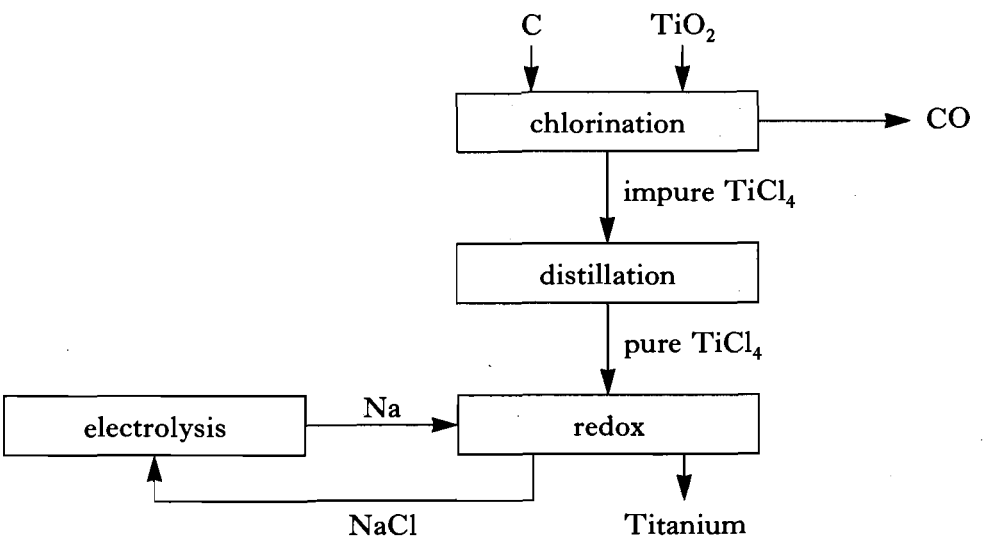
(5)

Candidate must not write in this margin

Marks

13. Titanium is a very useful metal. It has many uses, from components of spacecraft to spectacle frames.

The diagram shows steps in the manufacture of titanium.



(*a*) In this diagram, sodium is recycled.

Add a labelled arrow to the diagram to show how another chemical is recycled.

1

(*b*) $TiCl_4$ can be separated from impurities by fractional distillation because it is volatile.

What does this suggest about the type of bonding in $TiCl_4$?

1

(*c*) During the distillation step, care must be taken to ensure that no water enters the reaction chamber.

What type of reaction is this designed to prevent?

1

(*d*) Give another name for the redox reaction to produce titanium.

1

(4)

Candidate must not write in this margin

Marks

14. For people who suffer from bronchitis, even low concentrations of ozone, O_3, irritate the lining of the throat and can cause headaches.

NO_2 gas from car exhausts reacts with oxygen to form ozone as follows.

$$O_2(g) + NO_2(g) \rightleftharpoons NO(g) + O_3(g)$$

Car exhaust fumes also contain volatile organic compounds (VOCs), which can combine with NO gas.

(*a*) Explain how a rise in VOC concentration will change the ozone concentration.

1

(*b*) In an experiment to measure the ozone concentration of air in a Scottish city, 10^5 litres of air were bubbled through a solution of potassium iodide. Ozone reacts with potassium iodide solution, releasing iodine.

$$2KI(aq) + O_3(g) + H_2O(\ell) \longrightarrow I_2(aq) + O_2(g) + 2KOH(aq)$$

The iodine formed was titrated with 0·01 mol l^{-1} sodium thiosulphate solution, $Na_2S_2O_3(aq)$, using starch indicator.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \longrightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

The results of three titrations are shown in the table.

Experiment	Volume of thiosulphate/cm^3
1	22·90
2	22·40
3	22·50

(i) What colour change would show that the titration was complete?

1

Candidate must not write in this margin

Marks

14. (*b*) (continued)

(ii) Why was the volume of sodium thiosulphate to be used in the calculation taken to be 22·45 cm^3 although this is **not** the average of the three titres in the table?

1

(iii) Taking the volume of sodium thiosulphate solution to be 22·45 cm^3, calculate the volume of ozone in **one litre** of air.

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

(Show your working clearly.)

3

(6)

[Turn over

Candidate must not write in this margin

Marks

15. The Scottish chemist, Sir William Ramsay, discovered the element argon in air in 1894 by removing all oxygen, carbon dioxide and water vapour from air. He thought that the remaining gas would be pure nitrogen but it was denser than the nitrogen made by the thermal decomposition of ammonium nitrite, NH_4NO_2.

The equation for this decomposition reaction is

$$NH_4NO_2 \longrightarrow N_2 + 2H_2O$$

(*a*) (i) Suggest why argon was not discovered until 1894.

1

(ii) Why was the nitrogen from air denser than that from the decomposition of ammonium nitrite?

1

(*b*) One way of removing water vapour from air involves passing moist air over magnesium nitride. Water reacts with magnesium nitride to form ammonia and magnesium oxide.

Write a balanced equation for this reaction.

1

(*c*) A sample of air contains 23·2% by mass of oxygen.

Calculate the number of oxygen atoms present in 100 g of air.

(Show your working clearly.)

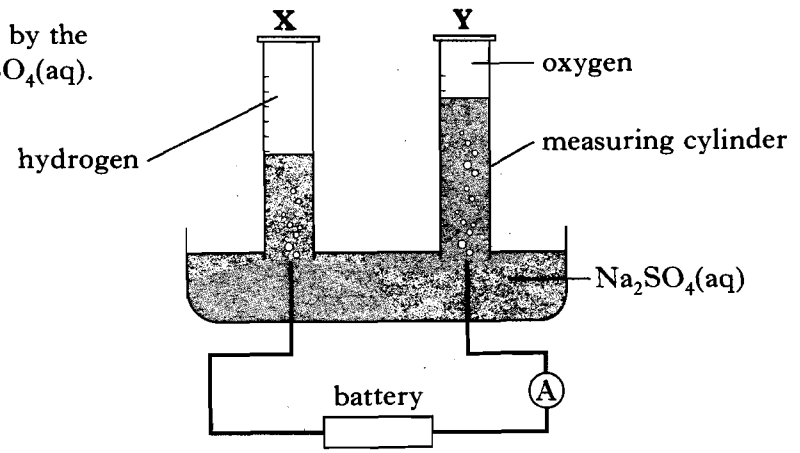
2

(5)

Candidate must not write in this margin

Marks

16. Gases are produced by the electrolysis of $Na_2SO_4(aq)$.



The ion-electron equations are shown.

Electrode **X**: $2H_2O(\ell) + 2e^- \longrightarrow H_2(g) + 2OH^-(aq)$

Electrode **Y**: $H_2O(\ell) \longrightarrow \frac{1}{2}O_2(g) + 2H^+(aq) + 2e^-$

(*a*) Explain what happens to the pH at each electrode.

Electrode **X**:

Electrode **Y**:

1

(*b*) A current of 2A was passed through the apparatus for 5 min and 20 s.
Calculate the volume of hydrogen gas produced.
(Take the molar volume of hydrogen gas to be 24 litres mol^{-1}.)
(Show your working clearly.)

3

(4)

Candidate must not write in this margin

Marks

17. Bond enthalpies and boiling points of some halogens are shown in the table.

Halogen	Bond enthalpy/kJ mol^{-1}	Boiling point/K
Cl — Cl	243	238
Br — Br	194	332
I — I	161	457

(*a*) Why do the boiling points of the halogens increase down the group, although the covalent bonds become weaker?

1

(*b*) Enthalpy of formation values and bond enthalpies for some hydrogen halides are shown in the table.

Halide	Enthalpy of formation /kJ mol^{-1}	Bond enthalpy/kJ mol^{-1}
H — F	−271	569
H — Cl	−92	431
H — Br	−36	366
H — I	+26	299

(i) What do the enthalpy of formation values indicate about the stability of hydrogen halides?

1

(ii) Explain why the value for the enthalpy of formation for HCl is so different from its bond enthalpy.

Your answer must include relevant equations.

2

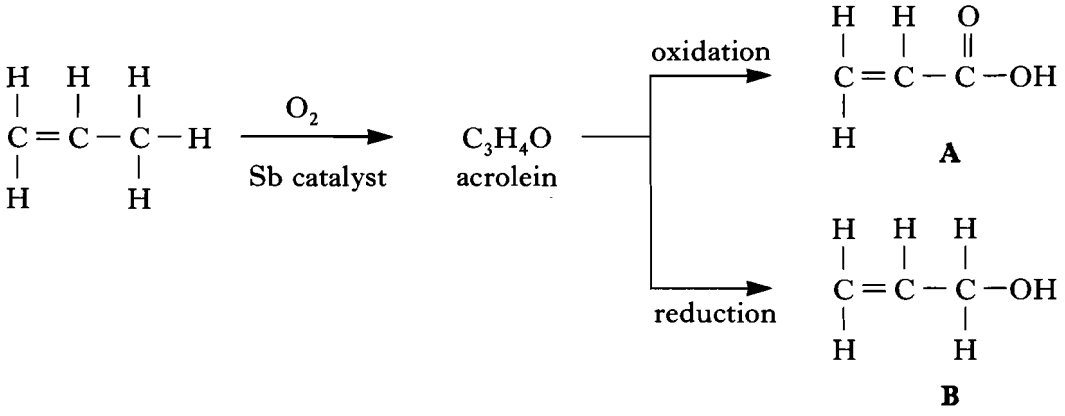
(4)

Candidate must not write in this margin

Marks

18. Acrolein is a feedstock for the production of useful organic compounds, eg acrylic fibres, synthetic rubber and glycerol.

Acrolein was first produced after the Second World War by oxidation of propene using an antimony catalyst as shown in the first stage of the diagram.



(*a*) Draw the full structural formula for acrolein.

1

(*b*) **Four** experiments were carried out on compounds **A** and **B**.

Complete the table to predict the results of these experiments.

Experiment	Compound **A**	Compound **B**
Reaction with sodium		Hydrogen gas given off
Solubility in water		Soluble
pH	Less than seven	
Reaction with magnesium	Hydrogen gas given off	

2

(*c*) Compound **B** has an isomer which belongs to a different homologous series and has **no effect** on Benedict's (or Fehling's) solution.

Draw the full structural formula for this isomer.

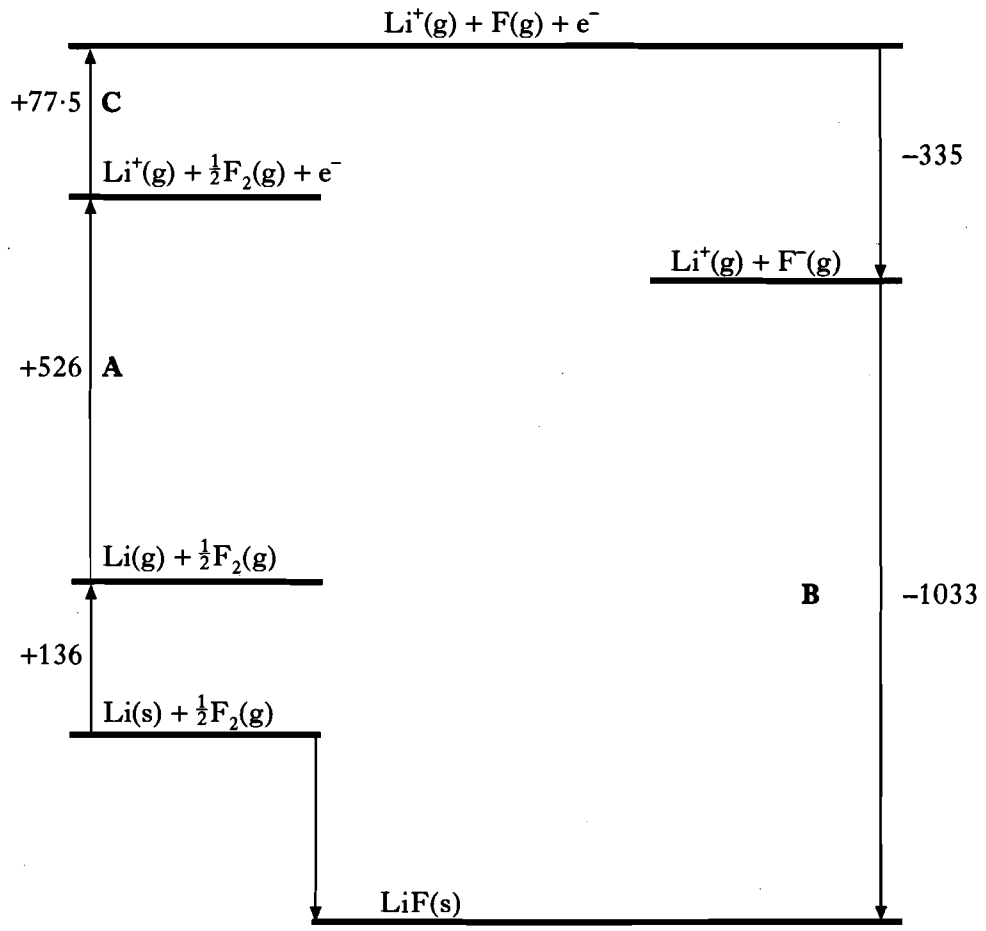
1

(4)

Candidate must not write in this margin

Marks

19. The diagram, **which is not drawn to scale**, can be used to calculate the enthalpy of formation of lithium fluoride. All energy changes are in kJ.



(*a*) Name the energy changes **A** and **B**.

A

B

2

(*b*) Calculate the enthalpy of formation of lithium fluoride.

1

Candidate must not write in this margin

Marks

19. (continued)

(*c*) The F — F bond enthalpy (data booklet page 11), which is used to calculate energy change **C**, is +155 kJ mol^{-1}.

Why is this value **not** described as a "Mean bond enthalpy"?

1

(*d*) The hydration enthalpies of the Li^+ and F^- ions are −519 kJ mol^{-1} and −401 kJ mol^{-1} respectively.

Use this information, together with information from the diagram, to calculate the enthalpy of solution of lithium fluoride.

1

(5)

[Turn over

Candidate must not write in this margin

Marks

20. Both bonded and non-bonded pairs of electrons repel each other and this determines the shape of a molecule.

The following procedure is used to find the total number of pairs of electrons around a central atom.

(i) Note the number of electrons in the outer energy level (shell) of the central atom.

(ii) Note the number of other atoms present—each atom provides one electron for bonding.

(iii) Add (i) and (ii) to give the total number of electrons.

(iv) Divide this total by two to give the number of electron pairs—both bonded pairs and non-bonded pairs.

Example: with ammonia, NH_3, N is the central atom.

(i) 2,5 = 5 electrons

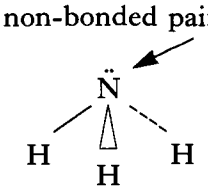
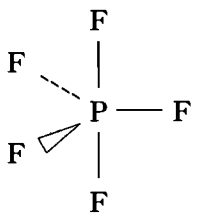
(ii) 3H 3×1 = 3 electrons

(iii) Total = 8 electrons

(iv) 8 electrons give 4 pairs.

Since NH_3 only has 3 bonds there is one non-bonded pair. The 4 pairs of electrons repel each other, giving the pyramidal shape of an ammonia molecule as shown in the first row of the table.

(*a*) Complete the table.

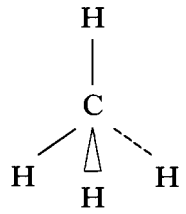
Formula	Outer electrons in central atom	Total number of electrons	Bonded pairs	Non-bonded pairs	Molecular shape
NH_3	5	8	3	1	
CCl_4	4		4	0	
$BeCl_2$	2	4	2		
PF_5		10	5		

3

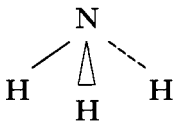
Marks

20. (continued)

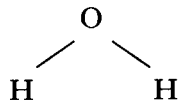
(*b*) The angles between bonds in three molecules are shown.



angle HCH = 109°



angle HNH = 107°



angle HOH = 105°

Suggest a reason for this decrease in bond angles.

1

(4)

[*END OF QUESTION PAPER*]