

FOR OFFICIAL USE

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Total  
Section B

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**X273/12/02**

NATIONAL FRIDAY, 31 MAY  
QUALIFICATIONS 1.00 PM – 3.30 PM  
2013

CHEMISTRY  
HIGHER (REVISED)

Fill in these boxes and read what is printed below.

Full name of centre

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Town

--

Forename(s)

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Surname

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Date of birth

Day Month Year

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Scottish candidate number

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Number of seat

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Reference may be made to the Chemistry Higher and Advanced Higher Data Booklet.

**SECTION A—Questions 1–30 (30 marks)**

Instructions for completion of **Section A** are given on page two.

For this section of the examination you must use an **HB pencil**.

**SECTION B (70 marks)**

- 1 All questions should be attempted.
- 2 The questions may be answered in any order but all answers are to be written in the spaces provided in this answer book, **and must be written clearly and legibly in ink**.
- 3 Rough work, if any should be necessary, should be written in this book and then scored through when the fair copy has been written. If further space is required, a supplementary sheet for rough work may be obtained from the Invigilator.
- 4 Additional space for answers 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 book.
- 5 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.
- 6 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.



## SECTION A

### Read carefully

- 1 Check that the answer sheet provided is for **Chemistry Higher (Revised) (Section A)**.
- 2 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.
- 3 Check that the answer sheet you have been given has **your name, date of birth, SCN** (Scottish Candidate Number) and **Centre Name** printed on it.

Do not change any of these details.

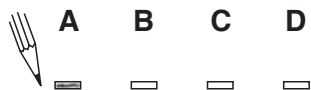
- 4 If any of this information is wrong, tell the Invigilator immediately.
- 5 If this information is correct, **print** your name and seat number in the boxes provided.
- 6 The answer to each question is **either** A, B, C or D. Decide what your answer is, then, using your pencil, put a horizontal line in the space provided (see sample question below).
- 7 There is only **one correct answer** to each question.
- 8 Any rough working should be done on the question paper or the rough working sheet, **not** on your answer sheet.
- 9 At the end of the examination, put the **answer sheet for Section A inside the front cover of your answer book**.

### Sample Question

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

- A chromatography
- B fractional distillation
- C fractional crystallisation
- D filtration.

The correct answer is **A**—chromatography. The answer **A** has been clearly marked in **pencil** with a horizontal line (see below).



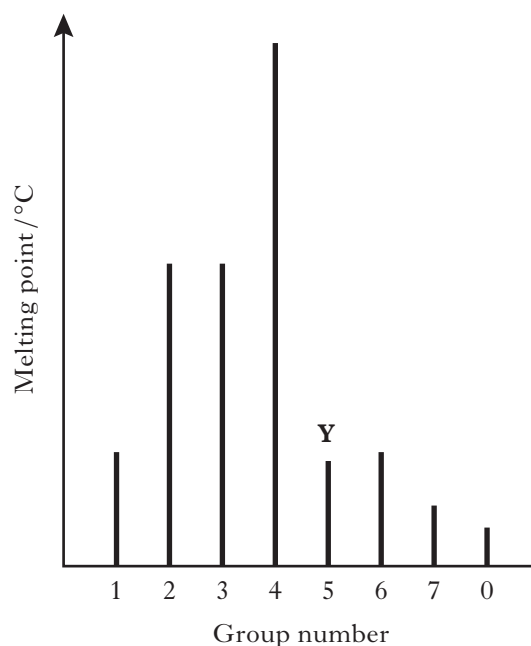
### Changing an answer

If you decide to change your answer, carefully erase your first answer and using your pencil, fill in the answer you want. The answer below has been changed to **D**.



1. Which of the following elements has the greatest attraction for bonding electrons?
- A Lithium  
B Chlorine  
C Sodium  
D Bromine
2. Which of the following elements exists as discrete molecules?
- A Boron  
B Carbon (diamond)  
C Silicon  
D Sulfur
3. Which of the following statements is true?
- A The potassium ion is larger than the potassium atom.  
B The chloride ion is smaller than the chlorine atom.  
C The sodium atom is larger than the sodium ion.  
D The oxygen atom is larger than the oxide ion.
4. Which type of bonding is **never** found in elements?
- A Metallic  
B London dispersion forces  
C Polar covalent  
D Non-polar covalent

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



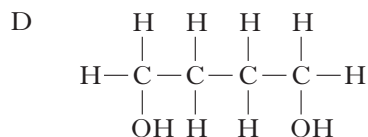
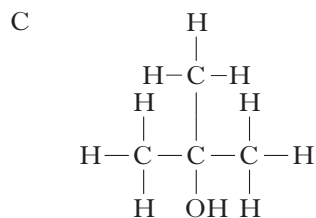
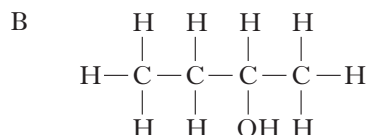
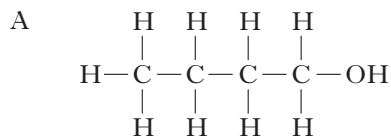
Which of the following is a correct reason for the low melting point of element **Y**?

- 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.

[Turn over

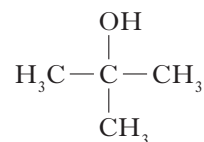
6. The structures for molecules of four liquids are shown below.

Which liquid will be the most viscous?



7. Which of the following elements is the strongest reducing agent?
- A Lithium  
B Bromine  
C Fluorine  
D Aluminium

8.



Which of the following compounds is an isomer of the structure shown above?

- A Butanal  
B Butanone  
C Butan-1-ol  
D Butanoic acid

9. A compound with molecular formula  $\text{C}_6\text{H}_{12}\text{O}_2$ , could be

- A hexanal  
B hexan-2-ol  
C hexan-2-one  
D hexanoic acid.

10. An ester has the following structural formula



The name of this ester is

- A propyl propanoate  
B ethyl butanoate  
C butyl ethanoate  
D ethyl propanoate.

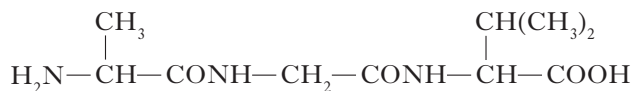
11. Esters are formed by the reaction between which **two** functional groups?

- A A hydroxyl group and a carboxyl group  
B A hydroxyl group and a carbonyl group  
C A hydroxide group and a carboxyl group  
D A hydroxide group and a carbonyl group

12. Oils are generally

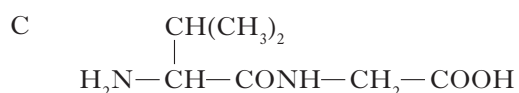
- A solid at room temperature and contain a high proportion of unsaturated molecules  
B solid at room temperature and contain a high proportion of saturated molecules  
C liquid at room temperature and contain a high proportion of unsaturated molecules  
D liquid at room temperature and contain a high proportion of saturated molecules.

13. A tripeptide **X** has the structure

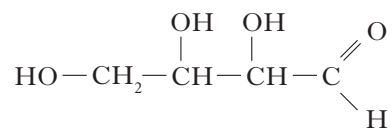


Partial hydrolysis of **X** yields a mixture of dipeptides.

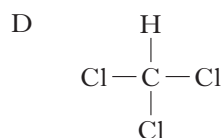
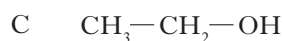
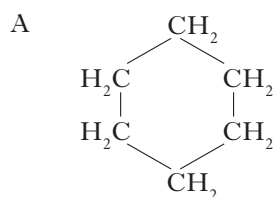
Which of the following dipeptides could be produced on hydrolysing **X**?



14. Erythrose can be used in the production of a chewing gum that helps prevent tooth decay.



Which of the following compounds will be the **best** solvent for erythrose?

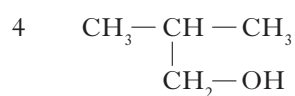
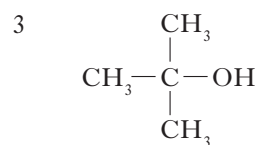
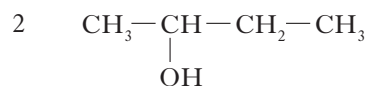
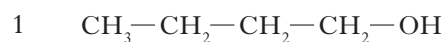


15. When a protein is denatured

- A its overall shape is distorted
- B its amide links are hydrolysed
- C it is broken into separate peptide fragments
- D it decomposes into amino acids.

[Turn over

16. Which **two** isomers would each produce an acid when warmed with acidified potassium dichromate solution?

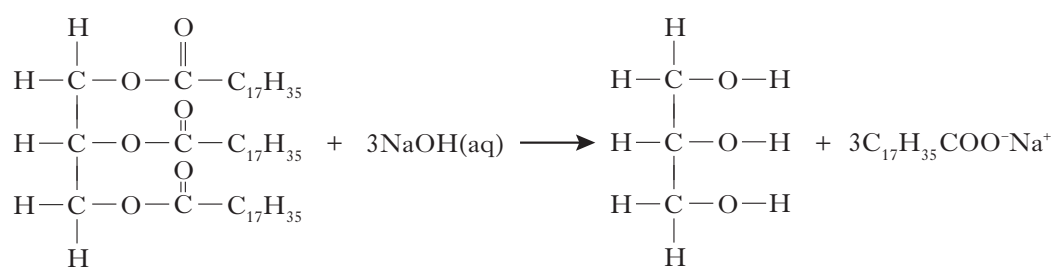


- A 1 and 2  
B 2 and 3  
C 1 and 4  
D 3 and 4

17. Which of the following organic compounds is an isomer of hexanal?

- A 2-Methylbutanal  
B 3-Methylpentan-2-one  
C 2,2-Dimethylbutan-1-ol  
D 3-Ethylpentanal

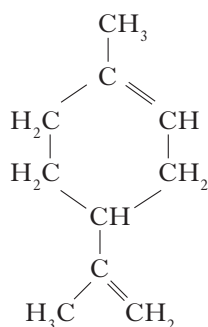
18. Soaps are produced by the following reaction.



This reaction is an example of

- A condensation  
B esterification  
C hydrolysis  
D oxidation.

19. Limonene is one of the terpene molecules responsible for the flavour of lemons.



How many isoprene units are used in the production of one limonene molecule?

- A 1  
B 2  
C 3  
D 4
20. A mixture of magnesium bromide and magnesium sulfate is known to contain 3 mol of magnesium and 4 mol of bromide ions.  
How many moles of sulfate ions are present?  
A 1  
B 2  
C 3  
D 4
21.  $2\text{C}_2\text{H}_2(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 4\text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\ell)$   
ethyne

What volume of gas would be produced by the complete combustion of  $100\text{ cm}^3$  of ethyne gas?

All volumes were measured at atmospheric pressure and room temperature.

- A  $200\text{ cm}^3$   
B  $300\text{ cm}^3$   
C  $400\text{ cm}^3$   
D  $800\text{ cm}^3$

22.  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$

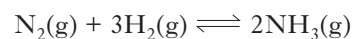
The equation represents a mixture at equilibrium.

Which line in the table is true for the mixture after a further 2 hours of reaction?

	Rate of forward reaction	Rate of back reaction
A	decreases	decreases
B	increases	increases
C	unchanged	decreases
D	unchanged	unchanged

23. In which of the following would an increase in pressure result in the equilibrium position being moved to the left?
- A  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$   
B  $\text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + \text{H}_2(\text{g})$   
C  $\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + 3\text{H}_2(\text{g})$   
D  $\text{Fe}_2\text{O}_3(\text{s}) + 3\text{CO}(\text{g}) \rightleftharpoons 2\text{Fe}(\text{s}) + 3\text{CO}_2(\text{g})$

24. Ammonia is made by the Haber Process.



The equilibrium position lies to the left.

Which line in the table is correct?

	Atom Economy	Percentage Yield
A	high	high
B	high	low
C	low	high
D	low	low

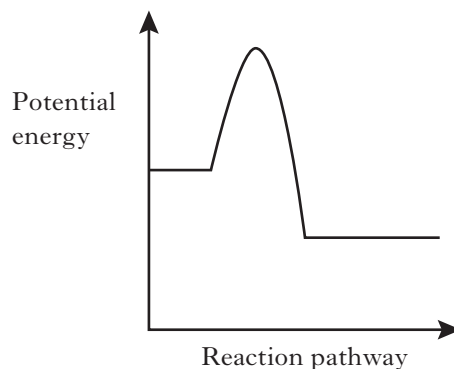
[Turn over

25. In which of the following will **both** changes result in an increase in the rate of a chemical reaction?

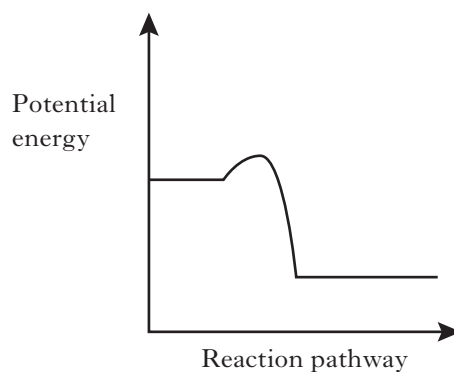
- A A decrease in activation energy and an increase in the frequency of collisions.
- B An increase in activation energy and a decrease in particle size.
- C An increase in temperature and an increase in the particle size.
- D An increase in concentration and a decrease in the surface area of the reactant particles.

26. Which of the following diagrams represents an exothermic reaction which is most likely to take place at room temperature?

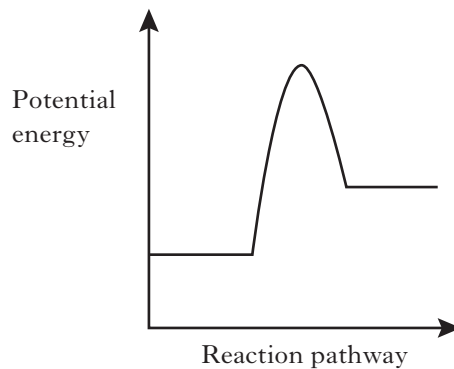
A



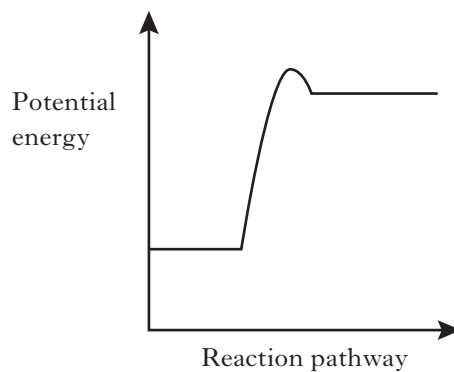
B



C



D



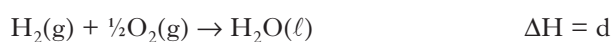
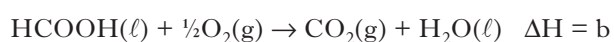


27. The enthalpy of combustion of methanol is  $-727 \text{ kJ mol}^{-1}$ .

What mass of methanol has to be burned to produce  $72.7 \text{ kJ}$ ?

- A  $3.2 \text{ g}$
- B  $32 \text{ g}$
- C  $72.7 \text{ g}$
- D  $727 \text{ g}$

28.



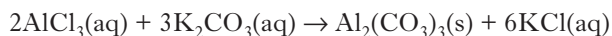
What is the relationship between a, b, c and d?

- A  $a = c + d - b$
- B  $a = b - c - d$
- C  $a = -b - c - d$
- D  $a = c + b + d$

29.  $45 \text{ cm}^3$  of a solution could be most accurately measured out using a

- A  $50 \text{ cm}^3$  beaker
- B  $50 \text{ cm}^3$  burette
- C  $50 \text{ cm}^3$  pipette
- D  $50 \text{ cm}^3$  measuring cylinder.

30. Aluminium carbonate can be produced by the following reaction.



The most suitable method for obtaining a sample of the aluminium carbonate is

- A collection over water
- B distillation
- C evaporation
- D filtration.

**Candidates are reminded that the answer sheet MUST be returned INSIDE the front cover of this answer book.**

**[Turn over**

**[BLANK PAGE]**

Marks

## SECTION B

All answers must be written clearly and legibly in ink.

1. Attempts have been made to make foods healthier by using alternatives to traditional cooking ingredients.

(a) An alternative to common salt contains potassium ions and chloride ions.

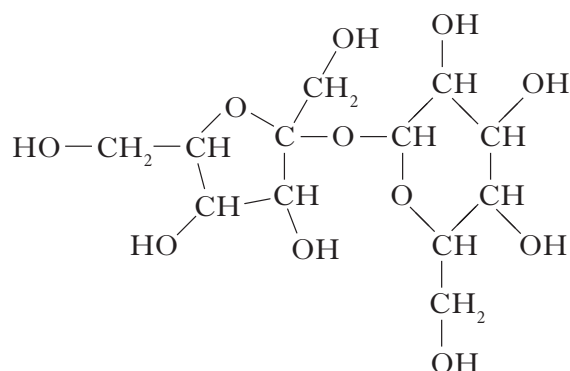
- (i) Write an ion-electron equation for the first ionisation energy of potassium.

1

- (ii) **Explain clearly** why the first ionisation energy of potassium is smaller than that of chlorine.

3

- (b) A calorie-free replacement for fat can be made by reacting fatty acids with the hydroxyl groups on a molecule of sucrose. A structural formula for sucrose is shown.



How many fatty acid molecules can react with one molecule of sucrose?

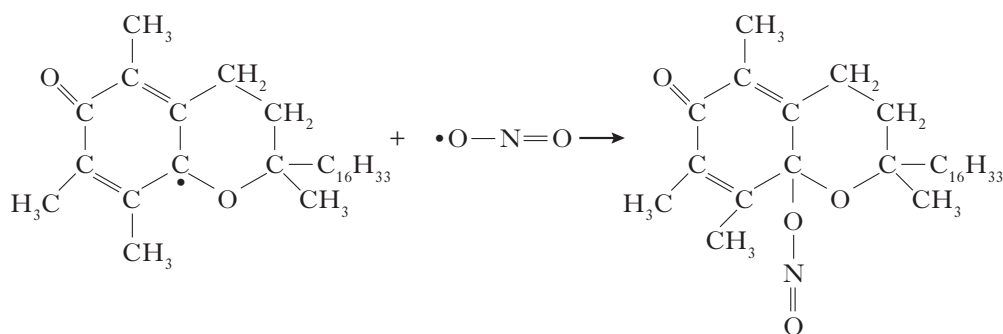
1

(5)

Marks

2. Suncreams contain antioxidants.

- (a) The antioxidant, compound **A**, can prevent damage to skin by reacting with free radicals such as  $\text{NO}_2^\bullet$ .



Compound **A**

Why can compound **A** be described as a free radical scavenger in the reaction shown above?

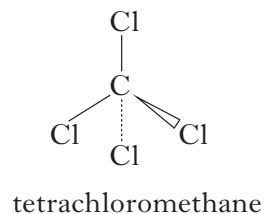
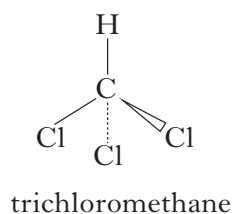
1

- (b) Another antioxidant used in skin care products is vitamin C,  $\text{C}_6\text{H}_8\text{O}_6$ . Complete the ion-electron equation for the oxidation of vitamin C.

1  
(2)

Marks

3. The structures below show molecules that contain chlorine atoms.



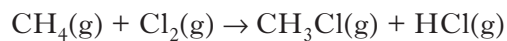
- (a) The compounds shown above are not very soluble in water. Trichloromethane is around ten times more soluble in water than tetrachloromethane.

**Explain clearly** why trichloromethane is more soluble in water than tetrachloromethane.

Your answer should include the names of the intermolecular forces involved.

3

- (b) Chloromethane can be produced by the reaction of methane with chlorine.



Using bond enthalpies from the data booklet, calculate the enthalpy change, in  $\text{kJ mol}^{-1}$ , for this reaction.

2

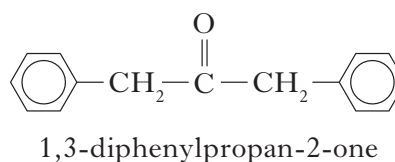
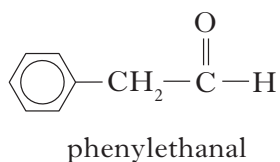
(5)

Marks

4. Chocolate contains various compounds.

- (a) Many of the flavour and aroma molecules found in chocolate are aldehydes and ketones.

Two examples are shown below.



Phenylethanal can be easily oxidised but 1,3-diphenylpropan-2-one cannot.

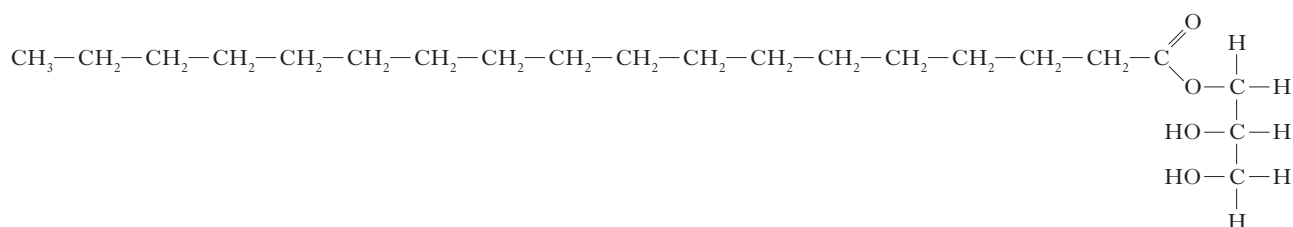
- (i) Name a chemical that could be used to distinguish between these two compounds.

1

- (ii) Name the type of organic compound formed when phenylethanal is oxidised.

1

- (b) Glycerol monostearate is an emulsifier used in chocolate.



- (i) Why is glycerol monostearate added to chocolate?

1

- (ii) Draw a structural formula for glycerol.

1

Marks

**4. (continued)**

- (c) Theobromine, a compound present in chocolate, can cause illness in dogs and cats.

To decide if treatment is necessary, vets must calculate the mass of theobromine consumed.

1.0 g of chocolate contains 1.4 mg of theobromine.

Calculate the mass, in mg, of theobromine in a 17 g biscuit of which 28% is chocolate.

**Show your working clearly.**

2

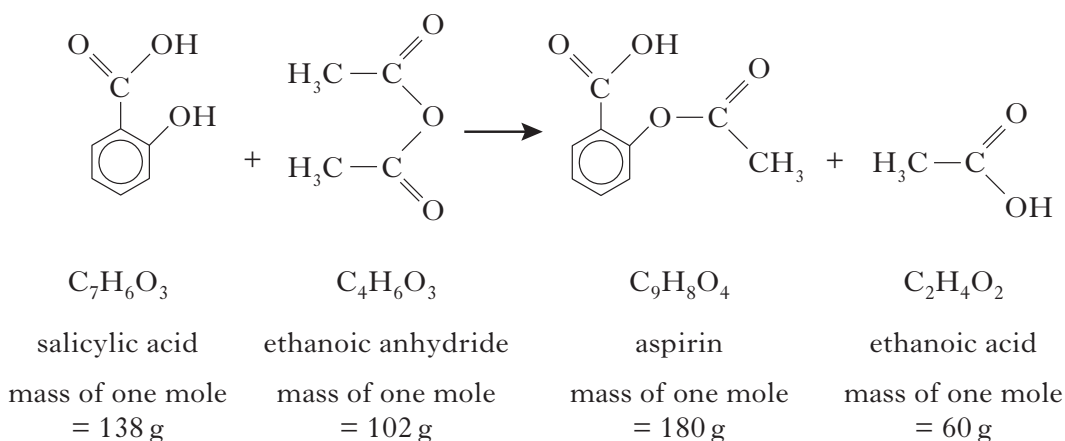
- (d) The flavour and texture of chocolate comes from a blend of compounds.

**Using your knowledge of chemistry**, describe how you could show that there are ionic compounds and covalent compounds present in chocolate.

3  
(9)

Marks

5. Aspirin, a common pain-killer, can be made by the reaction of salicylic acid with ethanoic anhydride.



- (a) Calculate the atom economy for the formation of aspirin using this method.

**Show your working clearly.**

2

- (b) In a laboratory preparation of aspirin, 5.02 g of salicylic acid produced 2.62 g of aspirin.

Calculate the percentage yield of aspirin.

**Show your working clearly.**

2

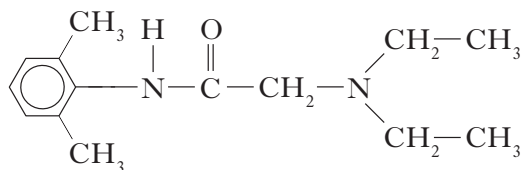
(4)



Marks

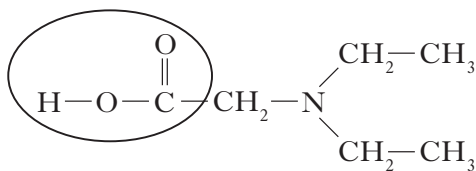
6. Dental anaesthetics are substances used to reduce discomfort during treatment.

(a) Lidocaine is a dental anaesthetic.



Lidocaine causes numbness when applied to the gums. This effect wears off as the lidocaine is hydrolysed.

One of the products of the hydrolysis of lidocaine is compound **C**.



compound **C**

(i) Name the functional group circled above.

1

(ii) Draw a structural formula for the other compound produced when lidocaine is hydrolysed.

1

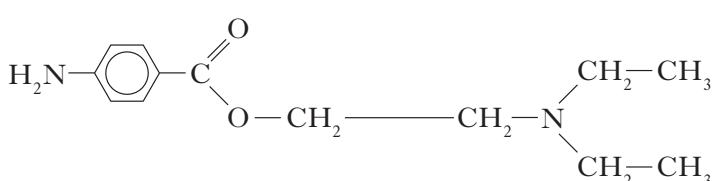
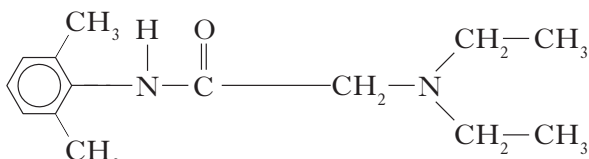
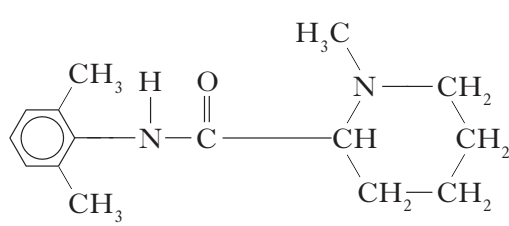
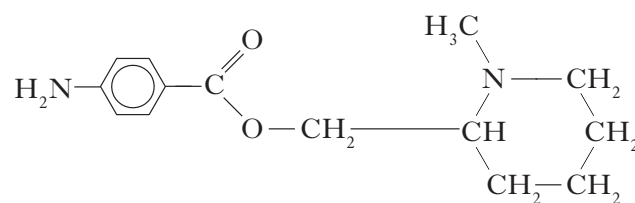
(iii) Draw a structural formula for the organic compound formed when compound **C** reacts with NaOH(aq).

1

Marks

## 6. (continued)

(b) The table below shows the duration of numbness for common anaesthetics.

Name of anaesthetic	Structure	Duration of numbness/ minutes
procaine		7
lidocaine		96
mepivacaine		114
anaesthetic X		

Estimate the duration of numbness, in minutes, for anaesthetic X.

1

*Marks***6. (continued)**

- (c) The maximum safe dose of lidocaine for an adult is 4.5 mg of lidocaine per kg of body mass.

1.0 cm<sup>3</sup> of lidocaine solution contains 10 mg of lidocaine.

Calculate the maximum volume of lidocaine solution that could be given to a 70 kg adult.

**Show your working clearly.**

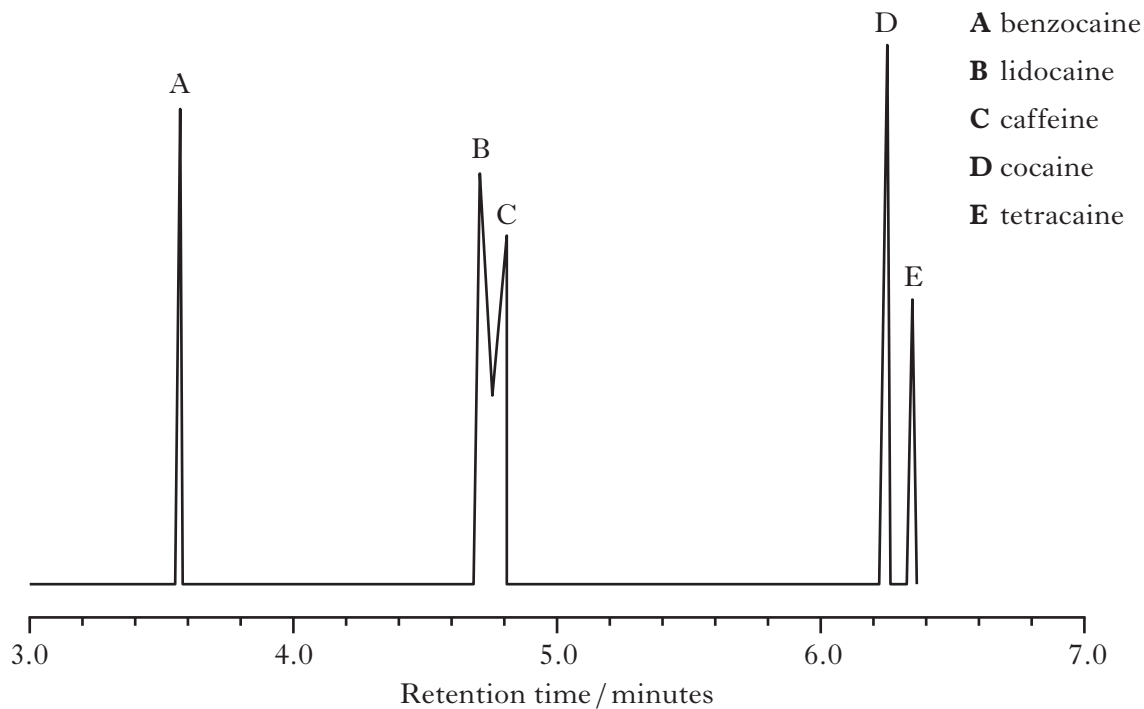
**3****[Turn over]**

Marks

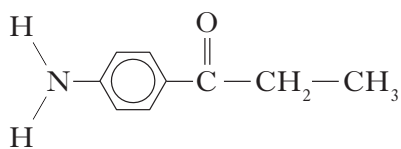
## 6. (continued)

- (d) When forensic scientists analyse illegal drugs, anaesthetics such as lidocaine are sometimes found to be present.

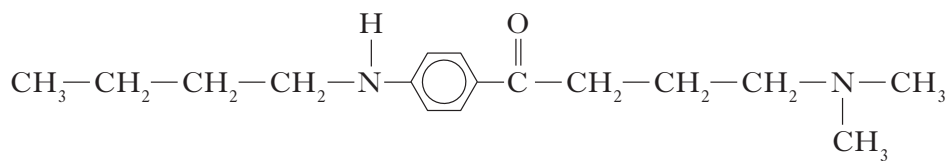
The gas chromatogram below is from an illegal drug.



- (i) The structures of benzocaine and tetracaine are shown below.



benzocaine



tetracaine

Suggest why benzocaine has a shorter retention time than tetracaine.

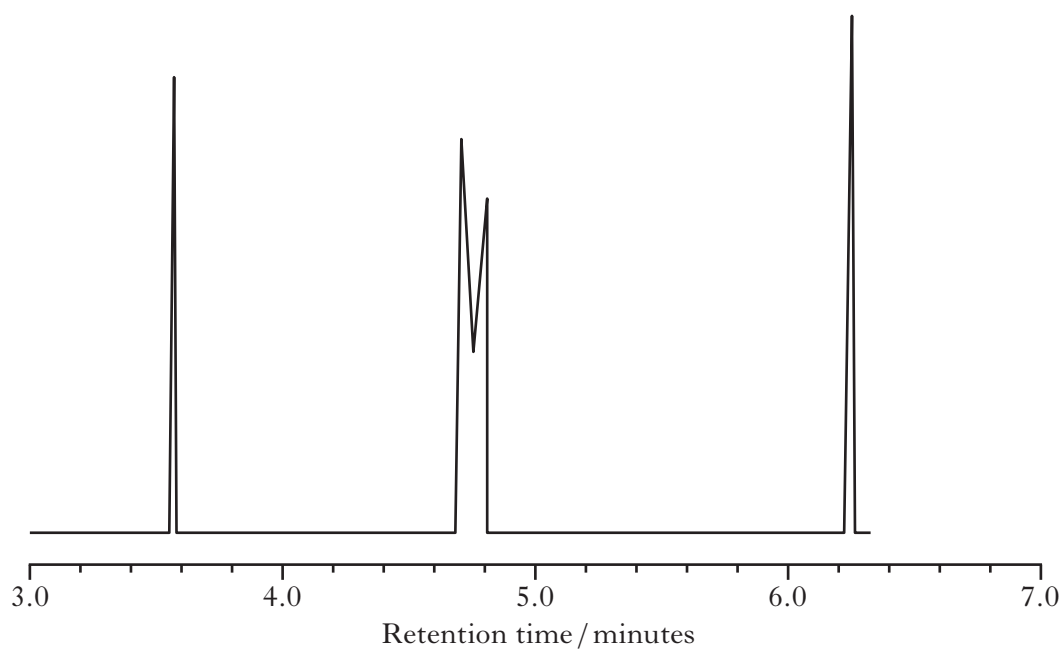
Marks

**6. (d) (continued)**

- (ii) Why is it difficult to obtain accurate values for the amount of lidocaine present in a sample containing large amounts of caffeine?

**1**

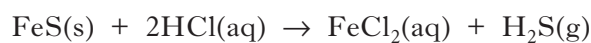
- (iii) Add a peak to the diagram below to complete the chromatogram for a second sample that only contains half the amount of tetracaine compared to the first.

**1  
(10)****[Turn over]**

Marks

7. Hydrogen sulfide is a toxic gas with the smell of rotten eggs.

- (a) Hydrogen sulfide gas can be prepared by the reaction of iron(II) sulfide with excess dilute hydrochloric acid:



- (i) Hydrogen sulfide gas is very soluble in water.

Draw a diagram to show an assembled apparatus that could be used to measure the volume of  $\text{H}_2\text{S}$  gas produced when a sample of iron(II) sulfide reacts with hydrochloric acid.

Your diagram should be labelled and should show the names of any chemicals used.

2

- (ii) Calculate the mass, in g, of iron(II) sulfide required to produce  $79\text{ cm}^3$  of hydrogen sulfide gas.

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

**Show your working clearly.**

3

Marks

**7. (continued)**

(b) Hydrogen sulfide gas produced from iron(II) sulfide is often contaminated with hydrogen gas and gaseous arsenic compounds.

- (i) Arsenic(III) sulfide is an orange-yellow powder which is insoluble in water. Below 310 °C it can sublime, turning from a solid to a gas.

Name the type of bonding and structure present in arsenic(III) sulfide.

**1**

- (ii) To avoid these contaminants, hydrogen sulfide can be made by reacting aluminium sulfide with water. Hydrogen sulfide and aluminium hydroxide are produced.

Write a balanced equation for the production of hydrogen sulfide from aluminium sulfide and water.

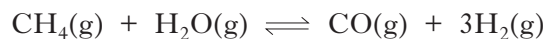
**2****(8)****[Turn over]**

Marks

8. Mobile phones are being developed that can be powered by methanol.

Methanol can be made by a two-stage process.

- (a) In the first stage, methane is reacted with steam to produce a mixture of carbon monoxide and hydrogen.



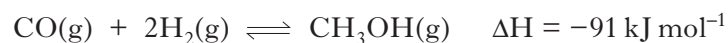
Use the data below to calculate the enthalpy change, in  $\text{kJ mol}^{-1}$ , for the forward reaction.



Show your working clearly.

2

- (b) In the second stage, the carbon monoxide and hydrogen react to produce methanol.



Circle the correct words in the table to show the changes to temperature and pressure that would favour the production of methanol.

(An additional table, if required, can be found on *Page thirty-four*.)

temperature	decrease / keep the same / increase
pressure	decrease / keep the same / increase

1

(3)



Marks

9. Dark blue compounds can be made by reacting ammonia with copper ions. To determine the number of ammonia molecules that react with each copper ion, a student prepared the following mixtures and measured their colour intensity.

Mixture	A	B	C	D	E	F
Volume of $0.1 \text{ mol l}^{-1} \text{ Cu}^{2+}$ solution, $\text{cm}^3$	7.5	5.0	2.5	2.0	1.5	1.0
Volume of $0.1 \text{ mol l}^{-1} \text{ NH}_3$ solution, $\text{cm}^3$	2.5	5.0	7.5	8.0	8.5	
Colour intensity	0.61	1.23	1.83	1.96	1.47	0.98

(An additional table, if required, can be found on *Page thirty-four*.)

- (a) Complete the table to show the volume of  $\text{NH}_3$  solution required for the final experiment.

1

- (b) The number of ammonia molecules that react with each copper ion can be found from the mixture with the greatest colour intensity.

How many ammonia molecules react with each copper ion?

1

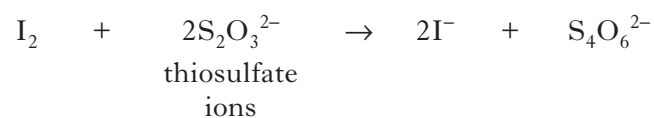
(2)

[Turn over]

Marks

10. Solutions containing iodine are used to treat foot rot in sheep.

The concentration of iodine in a solution can be determined by titrating with a solution of thiosulfate ions.



- (a) Write an ion-electron equation for the reaction of the oxidising agent in the titration.

1

- (b) Three  $20.0 \text{ cm}^3$  samples of a sheep treatment solution were titrated with  $0.10 \text{ mol l}^{-1}$  thiosulfate solution.

The results are shown below.

Sample	Volume of thiosulfate/ $\text{cm}^3$
1	18.60
2	18.10
3	18.20

- (i) Why is the volume of sodium thiosulfate used in the calculation taken to be  $18.15 \text{ cm}^3$ , although this is not the average of the three titres in the table?

1

Marks

## 10. (b) (continued)

- (ii) Calculate the concentration of iodine, in  $\text{mol l}^{-1}$ , in the foot rot treatment solution.

**Show your working clearly.**

3

- (iii) Describe how to prepare  $250 \text{ cm}^3$  of a  $0.10 \text{ mol l}^{-1}$  standard solution of sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3$ .

Your answer should include the mass, in g, of sodium thiosulfate required.

3

(8)

Marks

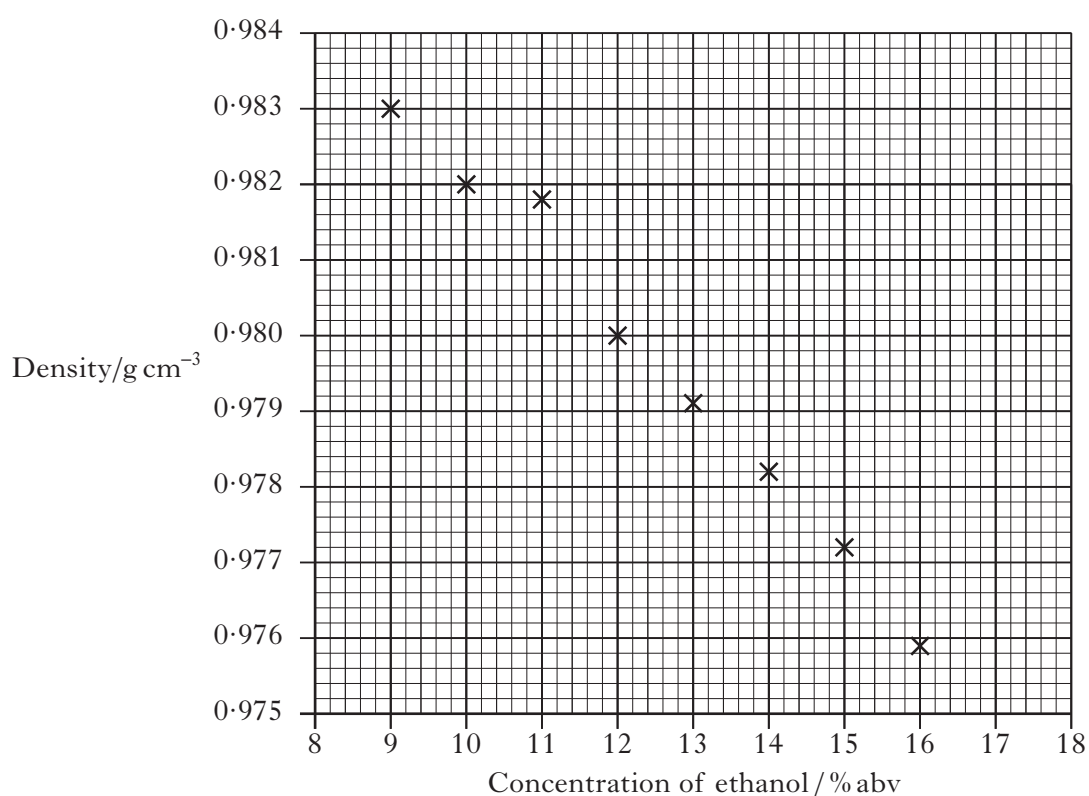
11. Ethanol has many uses.

(a) Ethanol is found at relatively low concentrations in wine.

(i) Name the chemical reaction that produces ethanol in wine.

1

(ii) Standard ethanol solutions were used to produce a graph of density against concentration of ethanol, given as a percentage of alcohol by volume (% abv).



What is the concentration of ethanol, in units of % abv, in a solution of density  $0.9818 \text{ g cm}^{-3}$ ?

1

Marks

**11. (continued)**

(b) Whisky contains a higher concentration of ethanol.

- (i) Before 1980, the concentration of alcohol in drinks was measured in terms of degrees proof.

The concentration of alcohol in two drinks is shown in the table below, both as % abv and degrees proof.

Sample	Alcohol concentration / % abv	Alcohol concentration / degrees proof
Wine	14.0	24.5
Sherry	20.0	35.0

A cask strength whisky has an alcohol concentration of 65% abv.

Calculate the alcohol concentration of this whisky in degrees proof.

1

- (ii) A barrel containing 195 litres of cask strength whisky costs £1300.

The cask strength whisky is diluted with water to reduce the concentration of alcohol from 65% abv to 46% abv before it is bottled.

Calculate the cost of the cask strength whisky needed to produce a 0.70 litre bottle.

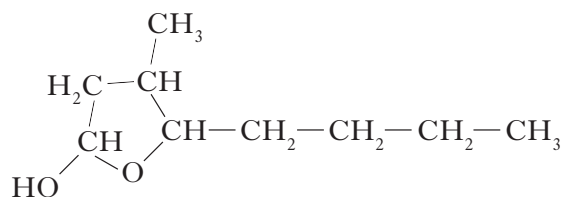
**Show your working clearly.**

2

Marks

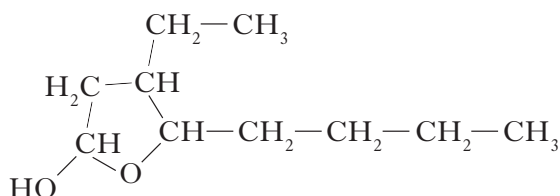
## 11. (b) (continued)

- (iii) 5-Butyl-4-methyltetrahydrofuran-2-ol is a flavour compound found in whisky stored in oak barrels.



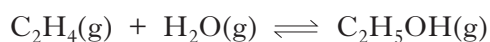
5-butyl-4-methyltetrahydrofuran-2-ol

Write the systematic name for the compound shown below.



1

- (c) Ethanol, for use in industrial processes, can be produced by reacting ethene gas with steam.



- (i) What name is given to this type of chemical reaction?

1

- (ii) What would happen to the equilibrium position if a catalyst was used?

1

(8)

*Marks*

12. Cooking involves many chemical reactions. Proteins, fats, oils and esters are some examples of compounds found in food. A chemist suggested that cooking food could change compounds from being fat-soluble to water-soluble.

**Use your knowledge of chemistry** to comment on the accuracy of this statement.

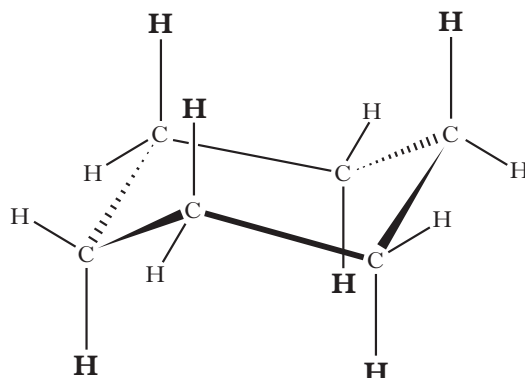
(3)

**[Turn over**

Marks

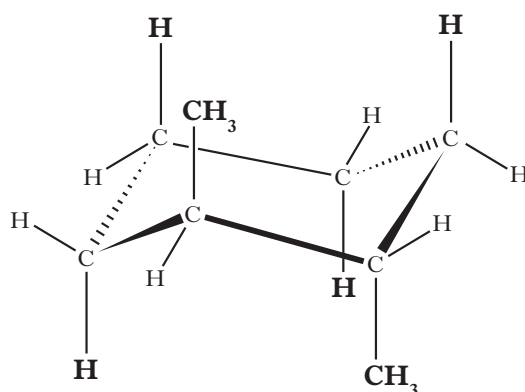
13. Cycloalkanes are found in nature.

A representation of cyclohexane is shown below.



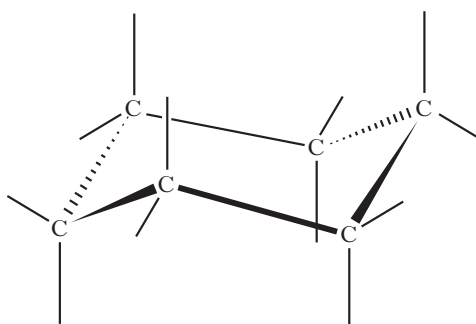
The six hydrogen atoms marked in **bold** are said to be in axial positions.

In the molecule of **1,2**-dimethylcyclohexane shown below, two methyl groups are in axial positions.



- (a) Complete the structure shown below to show a molecule of **1,3**-dimethylcyclohexane in which both the methyl groups are in axial positions.

(An additional diagram, if required, can be found on *Page thirty-four*.)



1



Marks

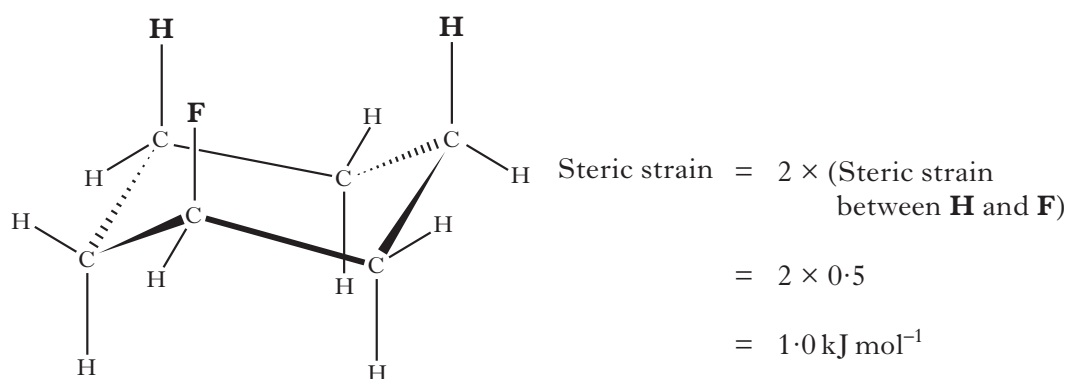
## 13. (continued)

- (b) Axial groups **on the same side** of a cyclohexane ring can repel each other. The strength of the repulsion is known as the “steric strain”.

The table below shows values which allow the steric strain to be calculated.

Axial groups	Steric strain /kJ mol <sup>-1</sup>
H and H	0.0
H and F	0.5
H and Br	1.0
H and CH <sub>3</sub>	3.8
H and (CH <sub>3</sub> ) <sub>3</sub> C	11.4

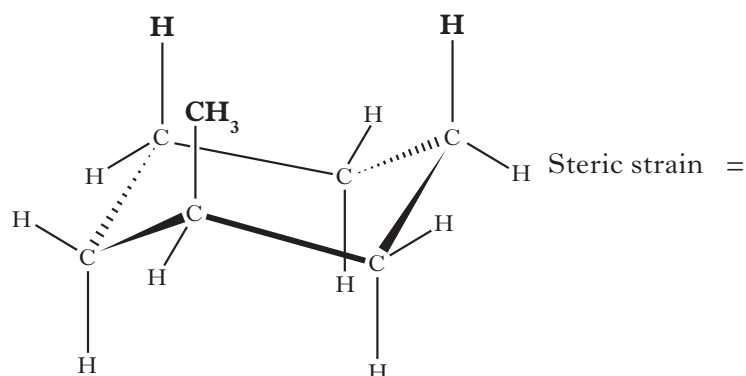
For example:



- (i) Write a general statement, linking the size of the steric strain to the type of axial group present.

1

- (ii) Calculate, in kJ mol<sup>-1</sup>, the steric strain for the molecule shown below.



1

(3)

[END OF QUESTION PAPER]

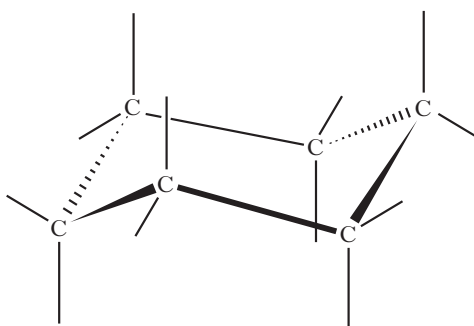
## ADDITIONAL TABLE FOR USE IN QUESTION 8(b)

temperature	decrease / keep the same / increase
pressure	decrease / keep the same / increase

## ADDITIONAL TABLE FOR USE IN QUESTION 9(a)

Mixture	A	B	C	D	E	F
Volume of $0.1 \text{ mol l}^{-1} \text{ Cu}^{2+}$ solution, $\text{cm}^3$	7.5	5.0	2.5	2.0	1.5	1.0
Volume of $0.1 \text{ mol l}^{-1} \text{ NH}_3$ solution, $\text{cm}^3$	2.5	5.0	7.5	8.0	8.5	
Colour intensity	0.61	1.23	1.83	1.96	1.47	0.98

## ADDITIONAL DIAGRAM FOR USE IN QUESTION 13(a)



**ADDITIONAL SPACE FOR ANSWERS**

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