

FOR OFFICIAL USE

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Total  
Section B

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**X273/12/02**

NATIONAL THURSDAY, 28 MAY  
QUALIFICATIONS 1.00 PM – 3.30 PM  
2015

CHEMISTRY  
HIGHER (REVISED)

Fill in these boxes and read what is printed below.

Full name of centre

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Town

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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

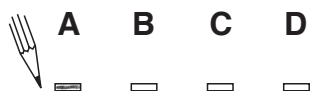
- 1 Check that the answer sheet provided is for **Chemistry Higher (Revised) (Section A)**.
- 2 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.
- 3 Check that the answer sheet you have been given has **your name, date of birth, SCN** (Scottish Candidate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

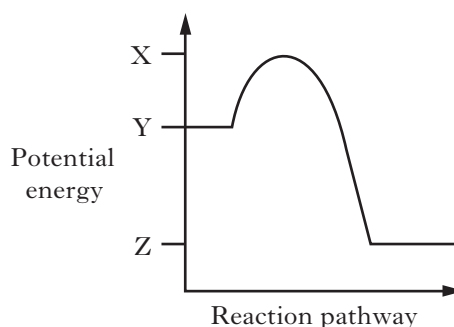
If you decide to change your answer, carefully erase your first answer and using your pencil, fill in the answer you want. The answer below has been changed to **D**.



1. The elements nitrogen, oxygen, fluorine and neon
- A can form negative ions
  - B are made up of diatomic molecules
  - C have single bonds between the atoms
  - D are gases at room temperature.
2. As the atomic number of the alkali metals increases
- A the first ionisation energy decreases
  - B the atomic size decreases
  - C the electronegativity increases
  - D the melting point increases.
3. Which of the following equations represents the first ionisation energy of fluorine?
- A  $F^-(g) \rightarrow F(g) + e^-$
  - B  $F^-(g) \rightarrow \frac{1}{2}F_2(g) + e^-$
  - C  $F(g) \rightarrow F^+(g) + e^-$
  - D  $\frac{1}{2}F_2(g) \rightarrow F^+(g) + e^-$
4. Which line in the table shows the successive ionisation energies of a group 3 element?

	Ionisation energy/ $\text{kJ mol}^{-1}$			
	1st	2nd	3rd	4th
A	900	1800	15 000	20 000
B	600	1800	2800	12 000
C	600	1200	5000	6500
D	500	1000	4000	5000

5. A reaction has the following potential energy diagram.



The activation energy for the forward reaction is

- A  $X - Y$
  - B  $Y - X$
  - C  $Y - Z$
  - D  $Z - Y$ .
6. Which of the following will react with  $\text{Br}_2$  but **not** with  $\text{I}_2$ ?
- A  $\text{OH}^-$
  - B  $\text{SO}_3^{2-}$
  - C  $\text{Fe}^{2+}$
  - D  $\text{Mn}^{2+}$
7. 4.6 g of sodium is added to 4.8 litres of oxygen to form sodium oxide.
- When the reaction is complete, which of the following statements will be true?
- (Take the volume of 1 mole of oxygen to be 24 litres.)
- A 0.10 mol of oxygen will be left unreacted.
  - B 0.10 mol of sodium will be left unreacted.
  - C 0.15 mol of oxygen will be left unreacted.
  - D 0.20 mol of sodium oxide will be formed.

[Turn over

8. Which of the following is the structure for 2-methylpentan-2-ol?

- A
- $$\begin{array}{cccc} & \text{H} & \text{CH}_3 & \text{H} & \text{H} \\ & | & | & | & | \\ \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & | & | & | & | \\ & \text{H} & \text{H} & \text{OH} & \text{H} \end{array}$$
- B
- $$\begin{array}{ccccc} & \text{H} & \text{CH}_3 & \text{H} & \text{H} & \text{H} \\ & | & | & | & | & | \\ \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & | & | & | & | & | \\ & \text{H} & \text{H} & \text{H} & \text{OH} & \text{H} \end{array}$$
- C
- $$\begin{array}{cccc} & \text{H} & \text{H} & \text{CH}_3 & \text{H} \\ & | & | & | & | \\ \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & | & | & | & | \\ & \text{H} & \text{H} & \text{OH} & \text{H} \end{array}$$
- D
- $$\begin{array}{ccccc} & \text{H} & \text{H} & \text{H} & \text{CH}_3 & \text{H} \\ & | & | & | & | & | \\ \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & | & | & | & | & | \\ & \text{H} & \text{H} & \text{H} & \text{OH} & \text{H} \end{array}$$

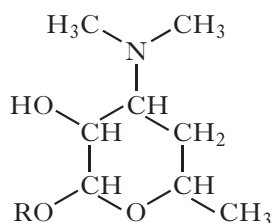
9. Which of the following mixtures will form when NaOH(aq) is added to a mixture of propanol and ethanoic acid?

- A Propanol and sodium ethanoate  
 B Ethanoic acid and sodium propanoate  
 C Sodium hydroxide and propyl ethanoate  
 D Sodium hydroxide and ethyl propanoate

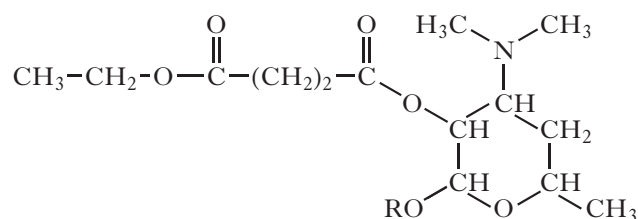
10. Which of the following is **not** true for an essential oil?

- A They are widely used in cleaning products.  
 B They contain aroma compounds.  
 C They contain volatile compounds.  
 D They are water soluble.

11. The antibiotic, erythromycin, has the following structure.



To remove its bitter taste, the erythromycin is reacted to give the compound with structure shown below.



Which of the following types of compound has been reacted with erythromycin to produce the new compound?

- A Alcohol  
 B Aldehyde  
 C Carboxylic acid  
 D Ketone

12. Oils contain carbon to carbon double bonds which can undergo addition reactions with iodine.

The iodine number of an oil is the mass of iodine in grams that will react with 100 g of oil.

Which line in the table shows the oil that is likely to have the lowest melting point?

	Oil	Iodine number
A	corn	123
B	linseed	179
C	olive	81
D	soya	130

13. Fats are formed by the condensation reaction between glycerol molecules and fatty acid molecules.

In the reaction, the mole ratio of glycerol molecules to fatty acid molecules is

- A 1 : 2  
 B 2 : 1  
 C 1 : 3  
 D 3 : 1.

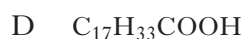
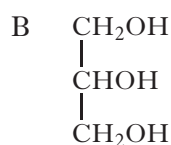
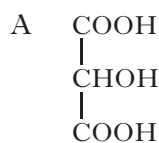
14. Which of the following pairs of molecules could be formed by hydrolysis of a protein?



15. Which of the following is a secondary alcohol?

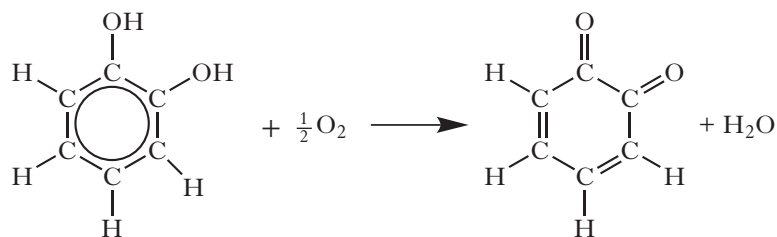
- A Butan-2-ol  
 B Butane-1,4-diol  
 C 2-Methylpropan-1-ol  
 D 2-Methylpropan-2-ol

16. When an oil is hydrolysed, which of the following molecules is always produced?



17. Enzymes are involved in the browning of cut fruit.

One reaction taking place is:



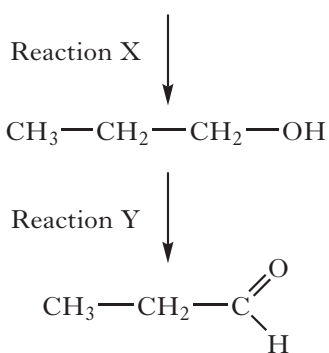
Which of the following correctly describes the above reaction?

- A Oxidation
- B Reduction
- C Dehydration
- D Condensation

18. Which of the following arrangements of atoms shows a peptide link?

- A  $\begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ -\text{C}-\text{O}-\text{N}- \\ | \\ \text{H} \end{array}$
- B  $\begin{array}{c} \text{H} \quad \text{O} \quad \text{H} \\ | \quad || \quad | \\ -\text{C}-\text{C}-\text{N}- \\ | \\ \text{H} \end{array}$
- C  $\begin{array}{c} \text{H} \quad \text{OH} \\ | \quad | \\ -\text{C}-\text{C}=\text{N}- \\ | \\ \text{H} \end{array}$
- D  $\begin{array}{c} \text{H} \quad \text{O} \quad \text{H} \\ | \quad || \quad | \\ -\text{C}-\text{C}-\text{O}-\text{N}- \\ | \\ \text{H} \end{array}$

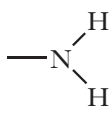
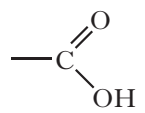
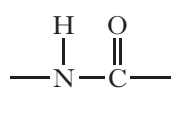
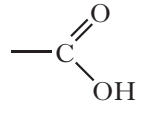
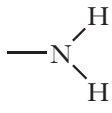
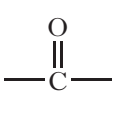
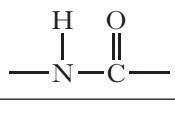
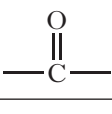
19.  $\text{CH}_3-\text{CH}=\text{CH}_2$



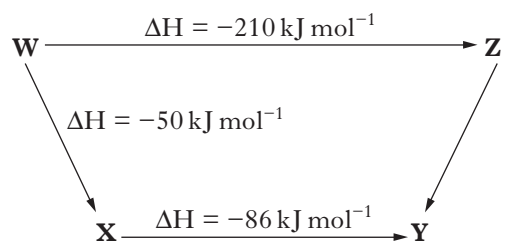
Which line in the table correctly describes reactions **X** and **Y**?

	Reaction X	Reaction Y
A	hydration	oxidation
B	hydration	reduction
C	hydrolysis	oxidation
D	hydrolysis	reduction

20. Which line in the table shows correctly categorised functional groups?

	Amino group	Carbonyl group
A		
B		
C		
D		

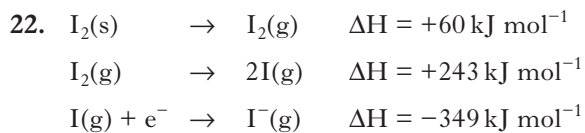
21. Consider the reaction pathway shown below.



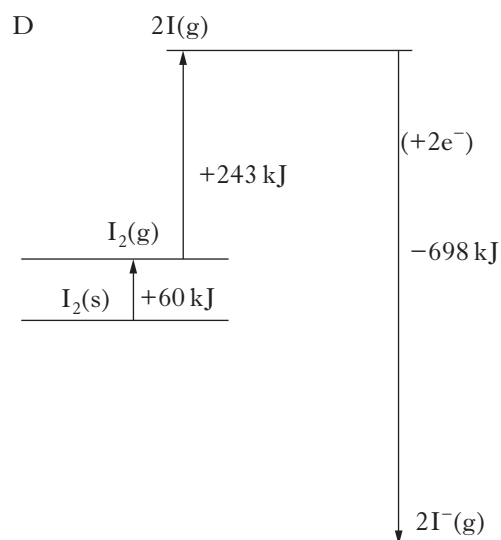
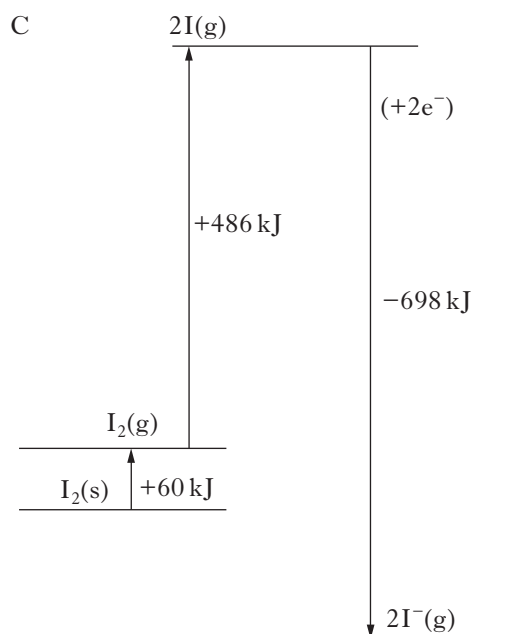
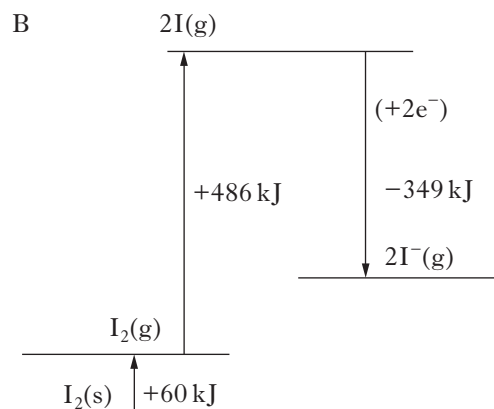
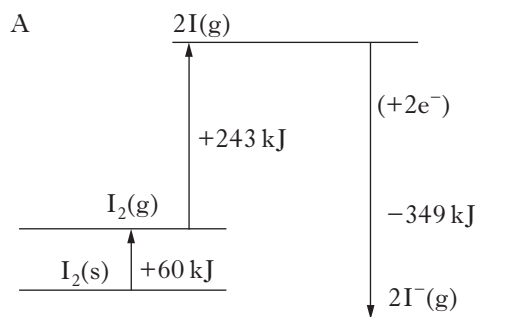
According to Hess's Law, the  $\Delta H$  value, in  $\text{kJ mol}^{-1}$ , for reaction **Z** to **Y** is

- A +74
- B -74
- C +346
- D -346.

**[Turn over**



Which of the following would show the energy diagram for  $\text{I}_2(\text{s}) + 2\text{e}^- \rightarrow 2\text{I}^-(\text{g})$ ?



23. Which of the following statements regarding a chemical reaction at equilibrium is always true?

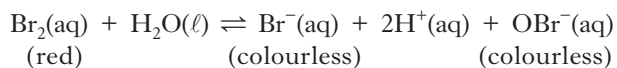
- A The rates of the forward and reverse reactions are equal.
- B The concentration of reactants and products are equal.
- C The forward and reverse reactions have stopped.
- D The addition of a catalyst changes the position of equilibrium.

24. In which of the following systems will the equilibrium be **unaffected** by a change in pressure?

- A  $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$
- B  $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$
- C  $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$
- D  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$



25. The following equilibrium exists in bromine water.



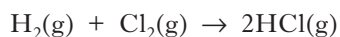
The red colour of bromine water would fade on adding a few drops of a concentrated solution of

- A HCl
- B KBr
- C AgNO<sub>3</sub>
- D NaOBr.

26. In which of the following reactions would the products have a lower volume than the reactants?

- A  $2\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{CO}(\text{g})$
- B  $\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$
- C  $\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\ell)$
- D  $\text{Ca}(\text{OH})_2(\text{aq}) + 2\text{CO}_2(\text{g}) \rightarrow \text{Ca}(\text{HCO}_3)_2(\text{aq})$

27. Hydrogen and chlorine react to form hydrogen chloride.



Bond	Bond enthalpy/kJ mol <sup>-1</sup>
H-H	432
Cl-Cl	243
H-Cl	428

What is the enthalpy change, in kJ mol<sup>-1</sup>, for the above reaction?

- A +181
- B -181
- C +247
- D -247

28.  $\text{HCl}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\ell)$

A student recorded the following temperatures when reacting 20 cm<sup>3</sup> dilute hydrochloric acid with 20 cm<sup>3</sup> dilute sodium hydroxide solution.

Solution	Temperature/°C
HCl(aq)	18
NaOH(aq)	20
NaCl(aq)	27

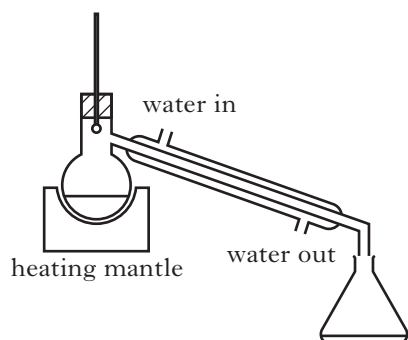
ΔT for this reaction will be

- A 2°C
- B 7°C
- C 8°C
- D 9°C.

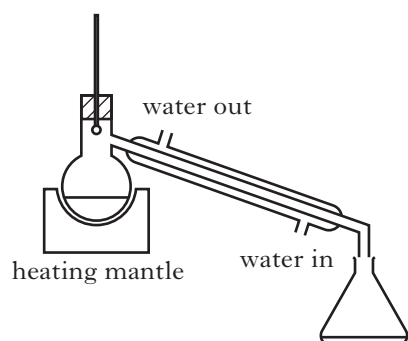
**[Turn over**

29. Which of the following diagrams shows the correct set up for the separation of ethanol from ethanoic acid?

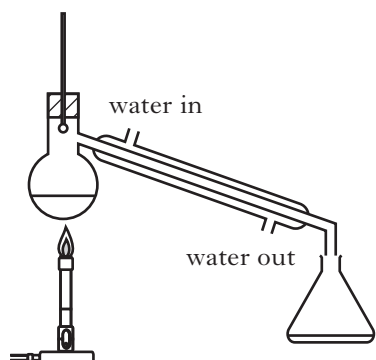
A



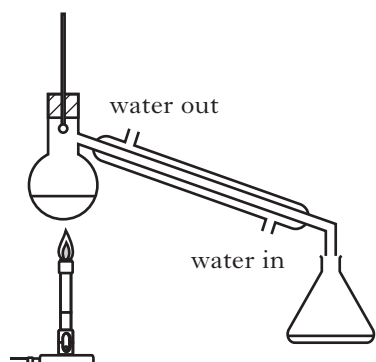
B



C



D



30. Which of the following would **not** help a student determine the end point of a titration accurately?

A Swirling the flask.

B Using a white tile.

C Adding the solution dropwise near the end-point.

D Repeating the titration.

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

## SECTION B

All answers must be written clearly and legibly in ink.

1. Volcanoes produce a variety of molten substances, including sulfur and silicon dioxide.

- (a) Complete the table to show the strongest type of attraction that is broken when each substance melts.

Substance	Melting point (°C)	Strongest type of attraction broken when substance melts.
sulfur	113	
silicon dioxide	1610	

2

- (b) Volcanic sulfur can be put to a variety of uses. One such use involves reacting sulfur with phosphorus to make a compound with formula  $P_4S_3$ .

- (i) Draw a possible structure for  $P_4S_3$ .

1

- (ii) Explain why the covalent radius of sulfur is smaller than that of phosphorus.

1

- (iii) The melting point of sulfur is much higher than that of phosphorus.

**Explain fully**, in terms of the structures of sulfur and phosphorus molecules and the intermolecular forces between molecules of each element, why the melting point of sulfur is much higher than that of phosphorus.

3

(7)

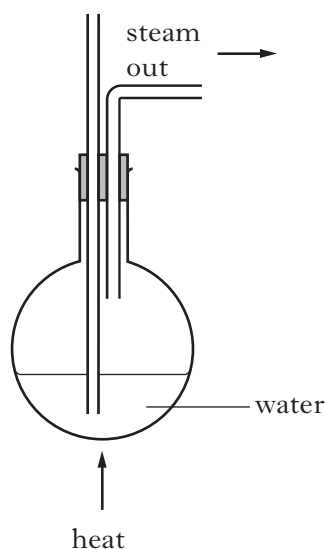
Marks

2. (a) Methyl cinnamate is an ester used to add strawberry flavour to foods. It is a naturally occurring ester found in the essential oil extracted from the leaves of strawberry gum trees.

To extract the essential oil, steam is passed through shredded strawberry gum leaves. The steam and essential oil are then condensed and collected.

- (i) Complete the diagram to show an apparatus suitable for carrying out this extraction.

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



2

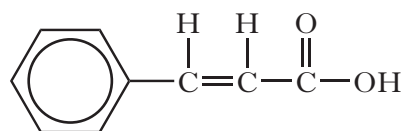
- (ii) The essential oil extracted is a mixture of compounds.

Suggest a technique that could be used to separate the mixture into pure compounds.

1

- (b) Methyl cinnamate can be made from cinnamic acid and methanol.

A structural formula for cinnamic acid is shown.



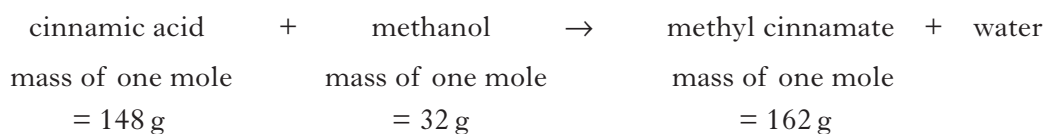
Draw a structural formula for the ester methyl cinnamate.

1

Marks

**2. (continued)**

- (c) A student prepared a sample of methyl cinnamate from cinnamic acid and methanol.



6.5 g of cinnamic acid was reacted with 2.0 g of methanol.

- (i) Show, by calculation, that cinnamic acid is the limiting reactant.  
(One mole of cinnamic acid reacts with one mole of methanol.)

2

- (ii) (A) The student obtained 3.7 g of methyl cinnamate from 6.5 g of cinnamic acid. Calculate the percentage yield.

2

- (B) The student wanted to scale up the experiment to make 100 g of methyl cinnamate.

Cinnamic acid costs £35.00 per 250 g.

Calculate the cost of cinnamic acid needed to produce 100 g of methyl cinnamate.

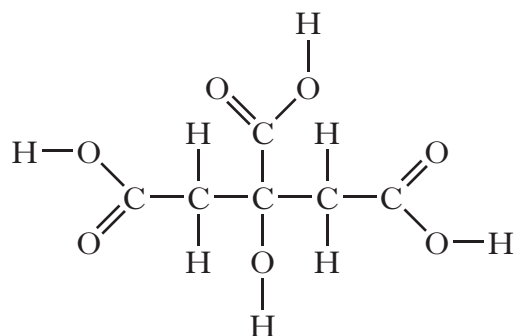
2

**(10)**

Marks

3. Sherbet is a sweet powder that fizzes on the tongue.

(a) A sherbet contains citric acid.

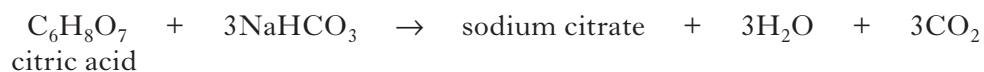


citric acid

Explain why citric acid is very soluble in water.

1

(b) The sherbet also contains sodium hydrogencarbonate. It reacts with citric acid when water is present.



(i) On the citric acid structure shown above, circle a hydrogen atom that is replaced by a sodium ion when the sherbet reacts.

1

(ii) Explain why the reaction will only take place when water is present.

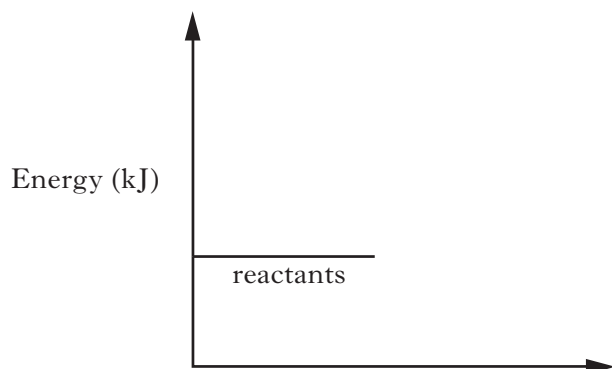
1

## 3. (continued)

- (c) When the sherbet fizzes on the tongue a cold sensation is felt; the reaction is endothermic. Marks

- (i) Complete the potential energy diagram to show the energy pathway for the reaction.

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



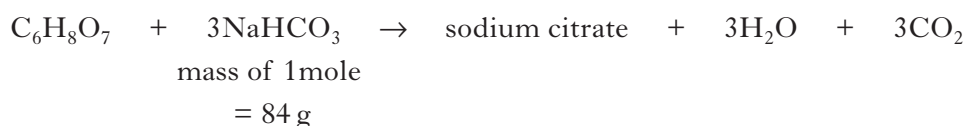
1

- (ii) A student wanted to calculate the enthalpy change when 1 gram of sherbet is added to a small beaker of water.

State the measurements the student should make.

2

- (d) A sherbet is made by mixing 15 g of sodium hydrogencarbonate with excess citric acid.



Calculate the maximum volume of carbon dioxide that would be released from this sherbet.

(Take the volume of 1 mole of carbon dioxide to be 24 litres.)

3

(9)

4. Up to 10% of perfumes sold in the UK are counterfeit versions of brand name perfumes.

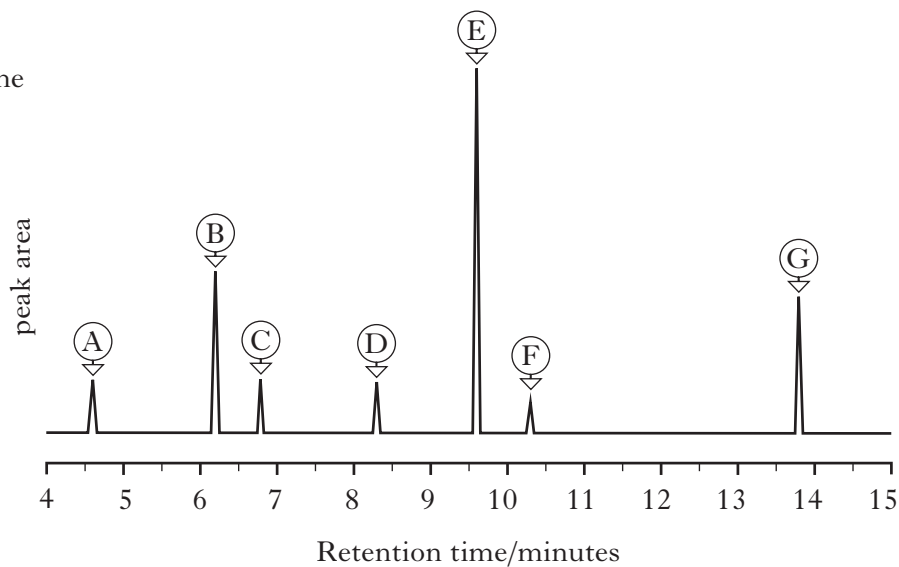
One way to identify if a perfume is counterfeit is to use gas chromatography. The gas chromatograms from a brand name perfume and two counterfeit perfumes, A and B, are shown below. The chromatograms were run under identical conditions.

Marks

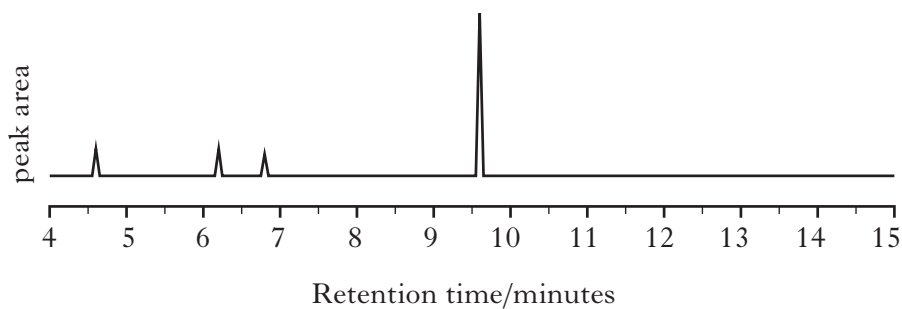
Some of the peaks in the brand name perfume have been identified as belonging to particular compounds.

Brand name perfume

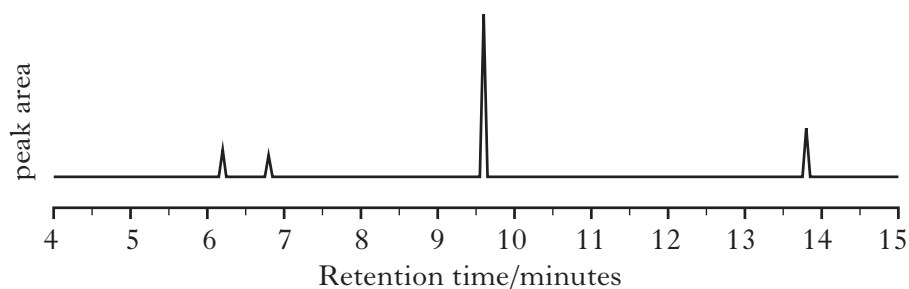
- (A) linalool
- (B) citronellol
- (C) geraniol
- (D) eugenol
- (E) anisyl alcohol
- (F) coumarin
- (G) benzyl salicylate



Counterfeit A



Counterfeit B





*Marks***4. (continued)**

- (a) Identify one compound present in the brand name perfume that appears in both counterfeit perfumes.

**1**

- (b) Some compounds in the brand name perfume are not found in the counterfeit perfumes.

State another difference that the chromatograms show between the counterfeit perfumes and the brand name perfume.

**1**

- (c) The gas used to carry the perfume sample along the chromatography column is helium.

- (i) Suggest why helium is used.

**1**

- (ii) Apart from the polarity of the molecules, what else would affect the retention time of molecules during gas chromatography?

**1****[Turn over**

Marks

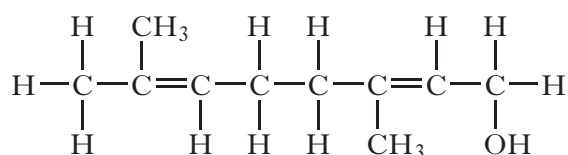
## 4. (continued)

(d) Many of the compounds in perfumes are molecules consisting of joined isoprene units.

(i) What name is given to molecules in perfumes consisting of joined isoprene units?

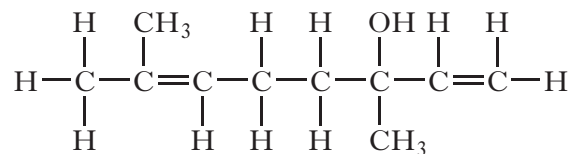
1

(ii) Geraniol is one of the compounds found in the brand name perfume. It has the following structural formula and systematic name.



3,7-dimethylocta-2,6-dien-1-ol

The compound linalool is also present. Its structural formula is shown.



State the systematic name for linalool.

1

(e) Coumarin is another compound found in the brand name perfume. It is present in the spice cinnamon and can be harmful if eaten in large quantities.

The European Food Safety Authority gives a tolerable daily intake of coumarin at 0.10 mg per kilogram of body weight.

1.0 kg of cinnamon powder from a particular source contains 4.4 g of coumarin. Calculate the mass of cinnamon powder, in g, which would need to be consumed by an adult weighing 75 kg to reach the tolerable daily intake.

2

(8)

*Marks*

5. Desirable characteristics for a supermarket ready meal are that it:

- has good flavour;
- retains its appearance and texture;
- has a long shelf life.

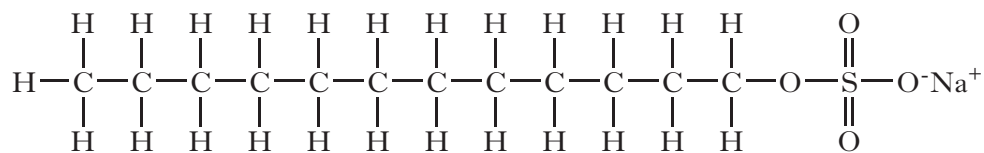
**Using your knowledge of chemistry**, comment on how manufacturers can achieve these characteristics.

(3)

**[Turn over**

Marks

6. Sodium lauryl sulfate,  $\text{CH}_3(\text{CH}_2)_{11}\text{OSO}_3\text{Na}$ , is a compound found in handwash. It has a similar cleaning action to soap.



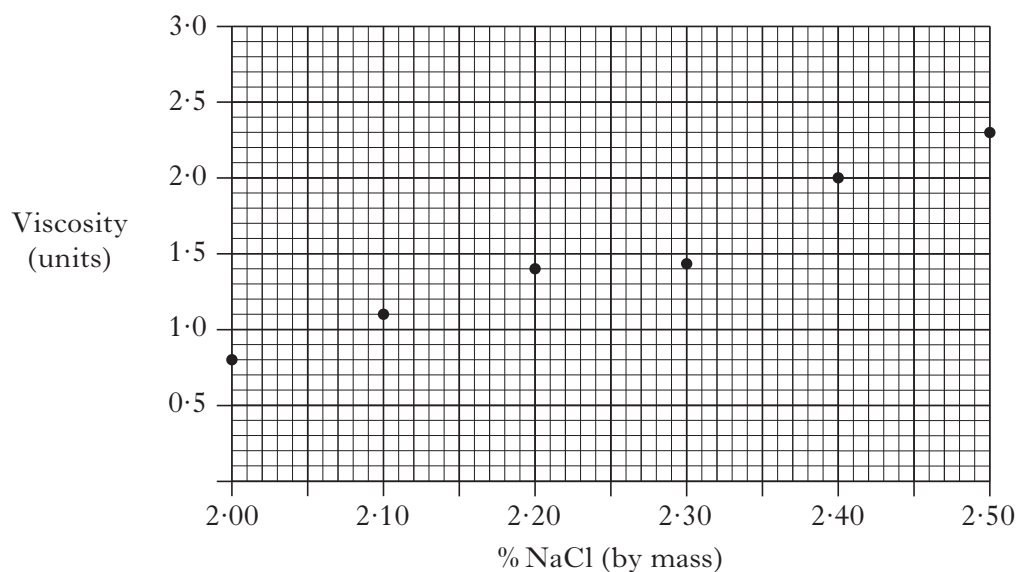
sodium lauryl sulfate

- (a) **Explain fully** the cleaning action of sodium lauryl sulfate. (You may wish to use diagrams to illustrate your answer.)

3

- (b) Sodium chloride is added during manufacture to increase the viscosity of handwashes.

In an investigation to measure the effect of sodium chloride on the viscosity of handwash, the following results were obtained.



Marks

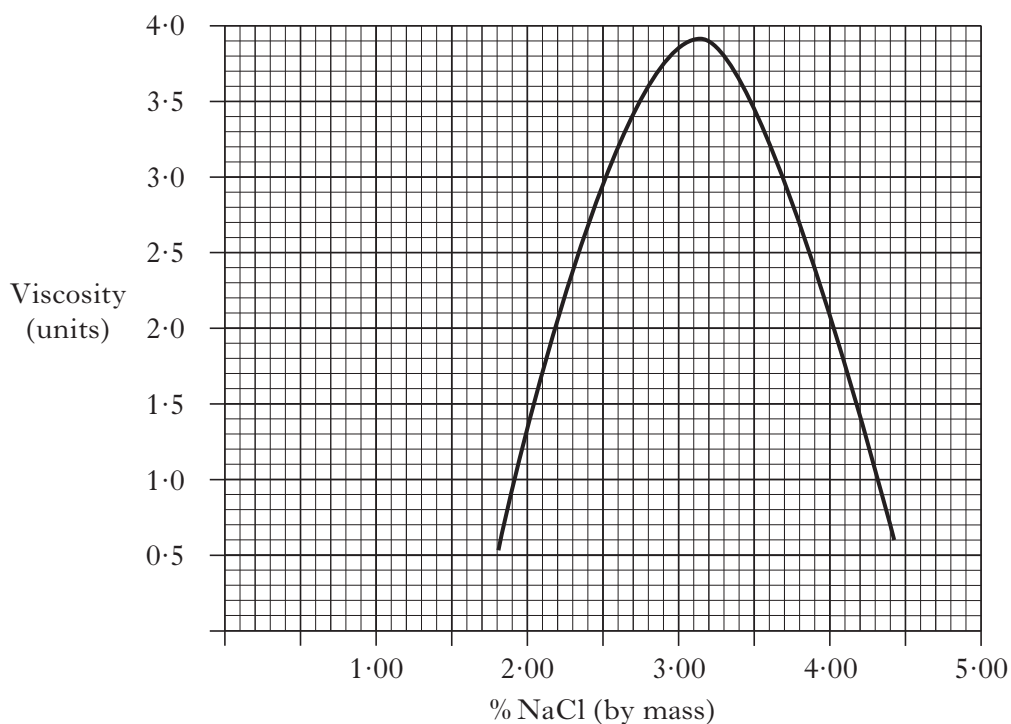
**6. (b) (continued)**

- (i) Use the graph to calculate the mass of sodium chloride, in grams, that should be added to 1 litre of handwash to give a viscosity of 1.5 viscosity units.

(Take the mass of  $1\text{ cm}^3$  of handwash to be  $1.1\text{ g}$ )

2

- (ii) The graph below shows how the mass of sodium chloride added, affects the viscosity of a particular handwash.



Manufacturers want to produce handwashes with high viscosity.

During the manufacturing process the mass of sodium chloride added is monitored. Suggest why this needs to be done.

1

**[Turn over**

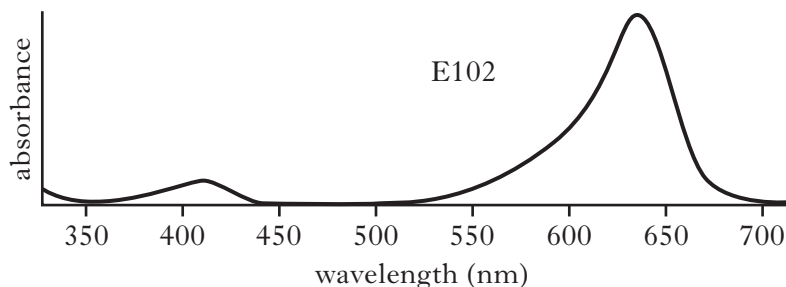
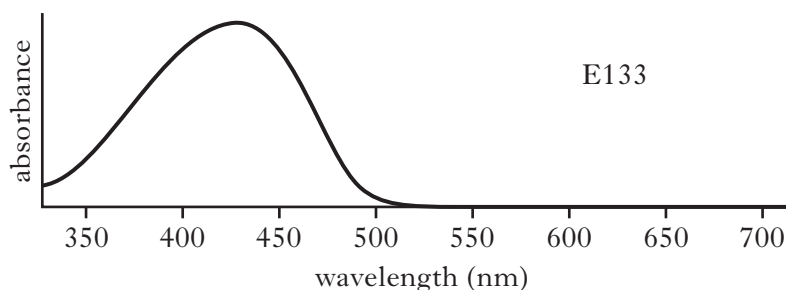
**6. (continued)**

- (c) The colour of a handwash is due to the wavelengths of light that pass through the handwash, ie, are not absorbed.

A handwash contains two dyes, E133 and E102, which absorb light of particular wavelengths. The typical wavelengths associated with some colours are shown in the table.

Colour	Wavelength (nm)
Red	650
Orange	590
Yellow	570
Green	510
Blue	475
Indigo	450
Violet	400

The peaks in the following spectra show the wavelengths of light absorbed by each of the two dyes.



State the colour of the handwash.

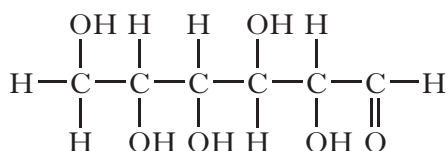
Marks

7. Bread is made from a variety of ingredients, the main one being flour.

- (a) Baking bread causes some of the starch in the flour to hydrolyse, producing sugars such as glucose and maltose.

One test for glucose involves Fehling's solution.

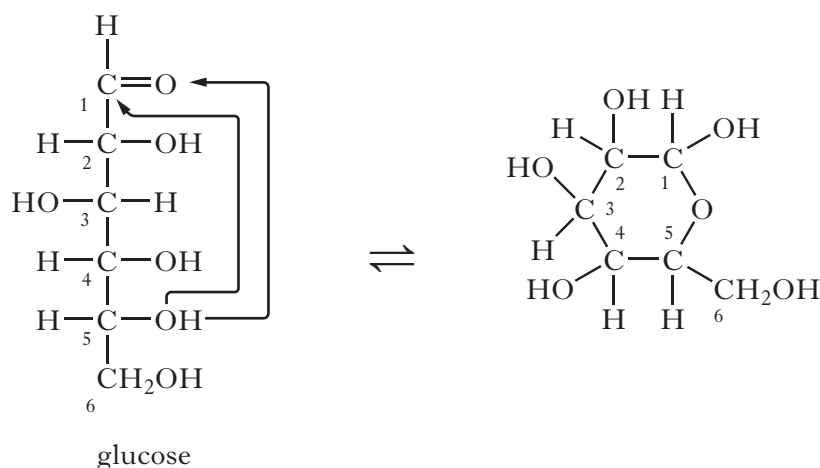
Circle the part of the glucose molecule that reacts with Fehling's solution.



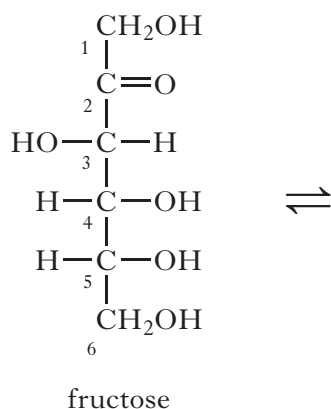
glucose

1

- (b) In solution, sugar molecules exist in an equilibrium of straight-chain and ring forms. To change from the straight-chain form to the ring form, the oxygen of the hydroxyl on carbon number 5 joins to the carbonyl carbon. This is shown below for glucose.



Draw the structure of a ring form for fructose.

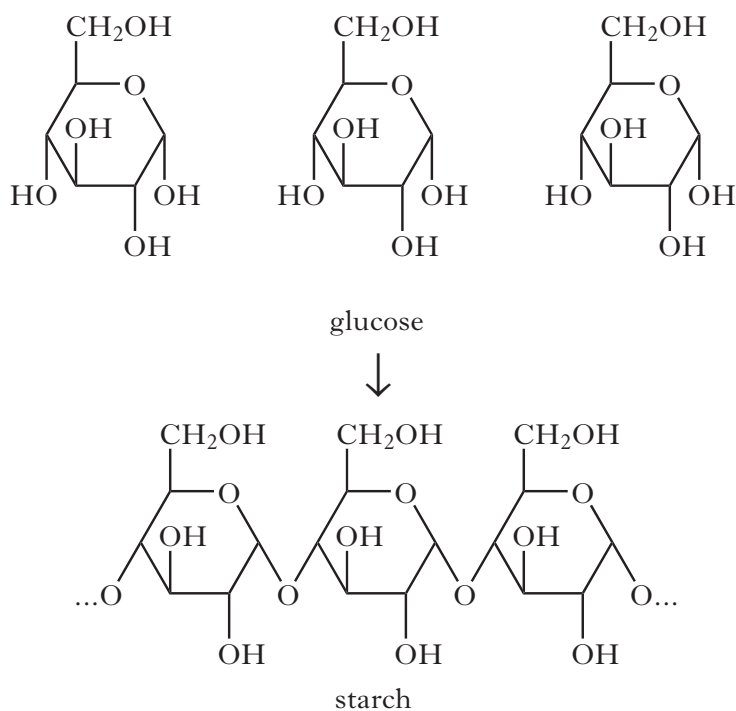


1

## 7. (continued)

Marks

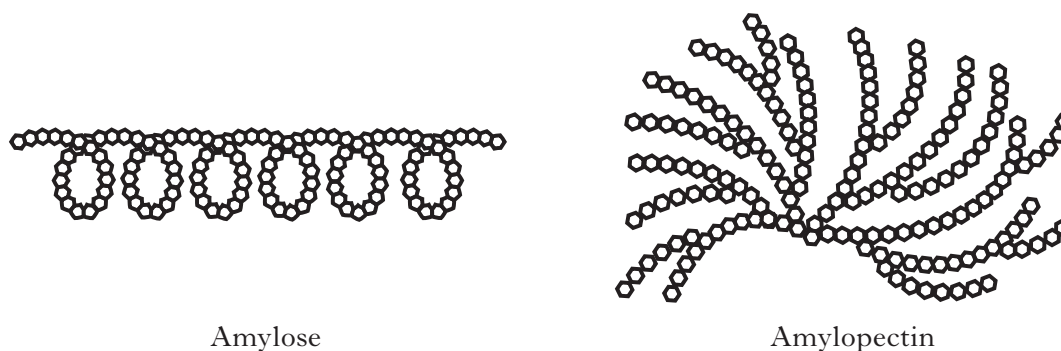
- (c) Starch is a polymer of glucose.



Name the type of reaction taking place when the starch polymer forms.

1

- (d) Starch can exist in two forms; a linear form, amylose and a branched form, amylopectin. Part of the structure of each is shown.



Each hexagon in the structures represents a glucose unit.

To make soft and moist bread, starch must separate and disperse into water. Amylopectin separates and disperses into water much more easily than amylose.

Suggest why this is the case.

1  
(4)



Marks

8.

**Patterns in the Periodic Table**

The periodic table is an arrangement of all the known elements in order of increasing atomic number. The reason why the elements are arranged as they are in the periodic table is to fit them all, with their widely diverse physical and chemical properties, into a logical pattern.

Periodicity is the name given to regularly-occurring similarities in physical and chemical properties of the elements.

Some Groups exhibit striking similarity between their elements, such as Group 1, and in other Groups the elements are less similar to each other, such as Group 4, but each Group has a common set of characteristics.

Adapted from Royal Society of Chemistry, *Visual Elements* (rsc.org)

**Using your knowledge of chemistry**, comment on similarities and differences in the patterns of physical and chemical properties of elements in both Group 1 and Group 4.

3  
(3)**[Turn over**

Marks

9. Sodium carbonate is used in the manufacture of soaps, glass and paper as well as the treatment of water.

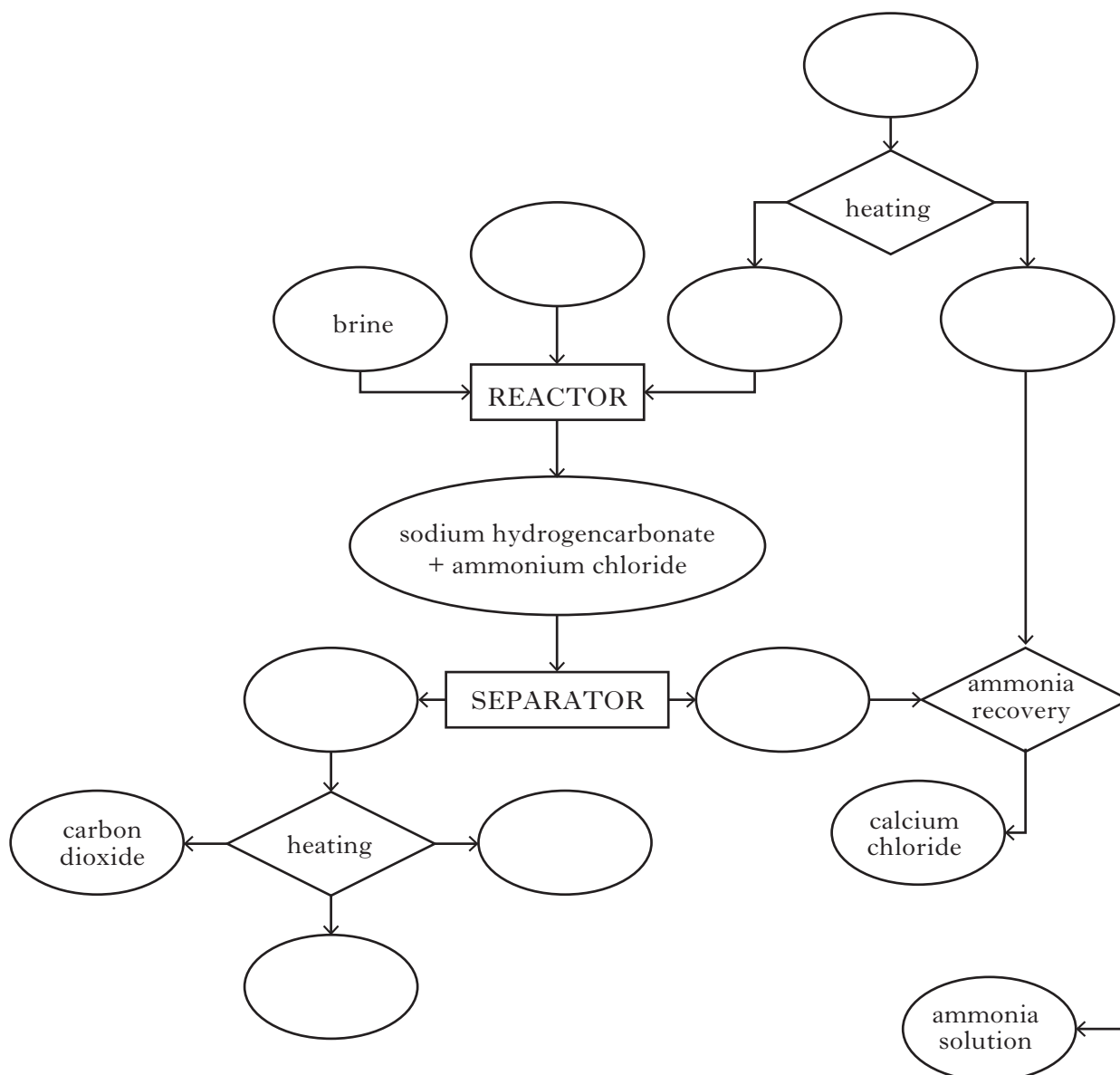
One industrial process used to make sodium carbonate is the Solvay process.

- (a) The Solvay process involves several different chemical reactions.

It starts with heating calcium carbonate to produce carbon dioxide, which is transferred to a reactor where it reacts with ammonia and brine. The products of the reactor are solid sodium hydrogencarbonate and ammonium chloride which are passed into a separator.

The sodium hydrogencarbonate is heated to decompose it into the product sodium carbonate along with carbon dioxide and water. To recover ammonia the ammonium chloride from the reactor is reacted with calcium oxide produced by heating the calcium carbonate. Calcium chloride is a by-product of the ammonia recovery process.

- (i) Using the information above, complete the flow chart by adding the names of the chemicals involved.



2

Marks

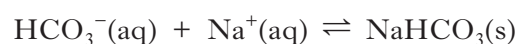
## 9. (a) (continued)

- (ii) One way in which the Solvay process is made cost efficient is by recycling ammonia and carbon dioxide.

State another way by which cost efficiency can be achieved in the Solvay process.

1

- (b) The reaction that produces the solid sodium hydrogencarbonate involves the following equilibrium:



Brine is a concentrated sodium chloride solution.

State why using a concentrated sodium chloride solution encourages production of sodium hydrogencarbonate as a solid.

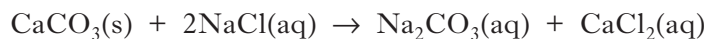
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**[Turn over**

Marks

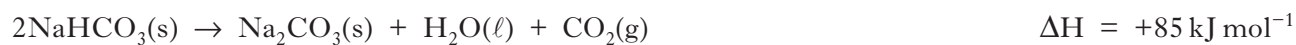
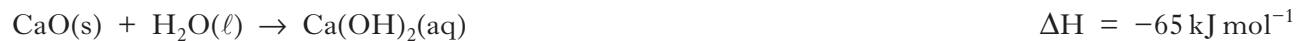
**9. (continued)**

(c) The overall equation for the Solvay process is



This reaction has to occur in a series of steps because calcium carbonate and sodium chloride do not react directly together.

The equations involved in the Solvay process are shown.



Calculate the enthalpy change, in  $\text{kJ mol}^{-1}$ , for the overall reaction in the Solvay process.

2  
(6)

**[Turn over for Question 10 on *Page thirty***

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10. Sodium hypochlorite, NaOCl, is a strong oxidising agent added to water in swimming pools.

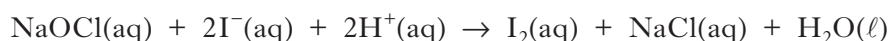
(a) State the purpose of adding sodium hypochlorite to water in swimming pools.

1

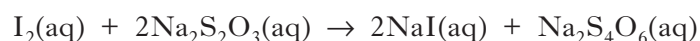
(b) The concentration of sodium hypochlorite in swimming pool water can be determined by redox titration.

**Step 1**

A 100.0 cm<sup>3</sup> sample from the swimming pool is first reacted with an excess of acidified potassium iodide solution forming iodine.

**Step 2**

The iodine formed in step 1 is titrated using a standard solution of sodium thiosulfate, concentration 0.00100 mol l<sup>-1</sup>. A small volume of starch solution is added towards the endpoint.



(i) Describe in detail how the burette should be prepared and set up, ready to begin the titration.

3

(ii) Write the ion-electron equation for the oxidation reaction occurring in step 1.

1

10. (b) (continued)

DO NOT  
WRITE  
IN THIS  
MARGIN

- (iii) Calculate the concentration, in  $\text{mol l}^{-1}$ , of sodium hypochlorite in the swimming pool water if an average volume of  $12.4 \text{ cm}^3$  of sodium thiosulfate was required.

Marks

3

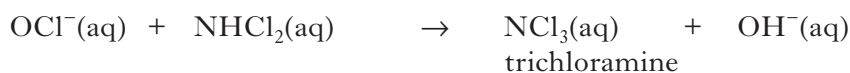
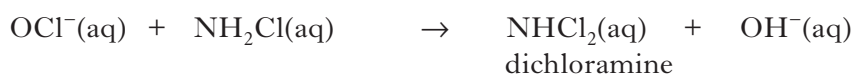
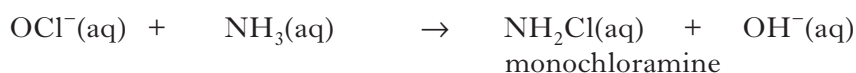
- (c) The level of hypochlorite in swimming pools needs to be maintained between 1 and 3 parts per million (1–3 ppm).

$400 \text{ cm}^3$  of a commercial hypochlorite solution will raise the hypochlorite level of 45 000 litres of water by 1 ppm.

Calculate the volume of hypochlorite solution that will need to be added to an Olympic sized swimming pool, capacity 2 500 000 litres, to raise the hypochlorite level from 1 ppm to 3 ppm.

1

- (d) The familiar chlorine smell of a swimming pool is not due to chlorine but compounds called chloramines. Chloramines are produced when the hypochlorite ion reacts with compounds such as ammonia, produced by the human body.



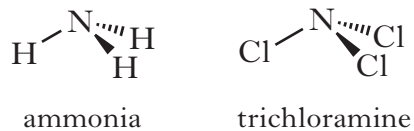
Chloramines are less soluble in water than ammonia due to the polarities of the molecules, and so readily escape into the atmosphere, causing irritation to the eyes.

[Turn over for Questions 10(d)(i), (ii) and (iii) on Page thirty-two

Marks

## 10. (d) (continued)

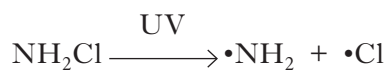
- (i) Explain the difference in polarities of ammonia and trichloramine molecules.



2

- (ii) Chloramines can be removed from water using ultra-violet light treatment.

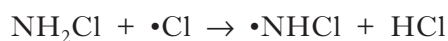
One step in the process is the formation of free radicals.



What are free radicals?

1

- (iii) Another step in the process is



State the name for this type of step in a free radical reaction.

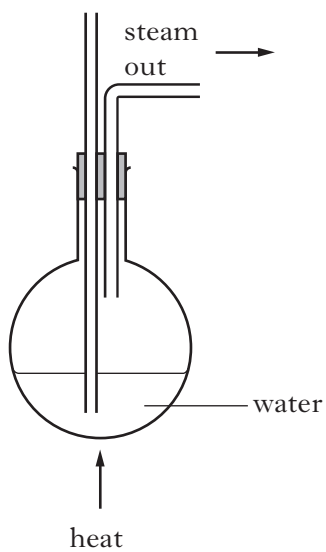
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(13)

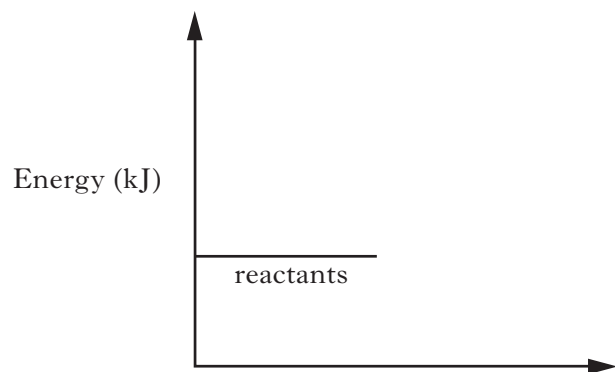
[END OF QUESTION PAPER]



**ADDITIONAL DIAGRAM FOR USE IN QUESTION 2(a)**



**ADDITIONAL DIAGRAM FOR USE IN QUESTION 3(c)(i)**



**ADDITIONAL SPACE FOR ANSWERS**

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**ADDITIONAL SPACE FOR ANSWERS**

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## ACKNOWLEDGEMENTS

Question 8 – Extract is adapted from “*Royal Society of Chemistry, Visual Elements.*”  
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