

FOR OFFICIAL USE

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Total
Section B

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X012/12/02

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

CHEMISTRY
HIGHER

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 1–40 (40 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 (60 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

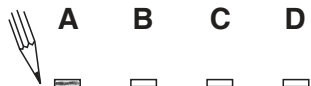
- 1 Check that the answer sheet provided is for **Chemistry Higher (Section A)**.
- 2 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.
- 3 Check that the answer sheet you have been given has **your name, date of birth, SCN** (Scottish Candidate Number)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

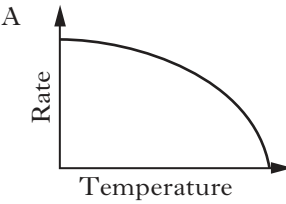
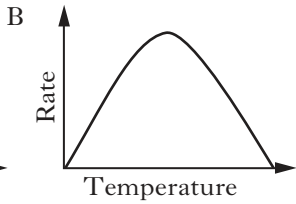
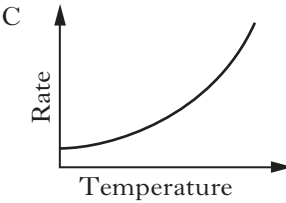
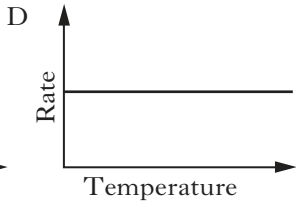


Changing an answer

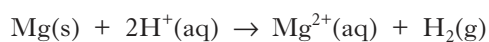
If you decide to change your answer, carefully erase your first answer and using your pencil, fill in the answer you want. The answer below has been changed to **D**.



- Which of the following statements is correct for isotopes of an element?
 - Their electron arrangements are different.
 - The masses of their nuclei are the same.
 - Their numbers of protons are the same.
 - Their nuclear charges are different.
- Which of the following solids has a low melting point and a high electrical conductivity?
 - Iodine
 - Potassium
 - Silicon oxide
 - Potassium fluoride

- Which of the following graphs of rate of reaction against temperature would apply to the reaction of dilute hydrochloric acid with zinc?
 - 
 - 
 - 
 - 

- Hydrochloric acid reacts with magnesium according to the following equation.



What is the least volume of 4 mol l^{-1} hydrochloric acid that would be required to completely react with 0.1 mol of magnesium?

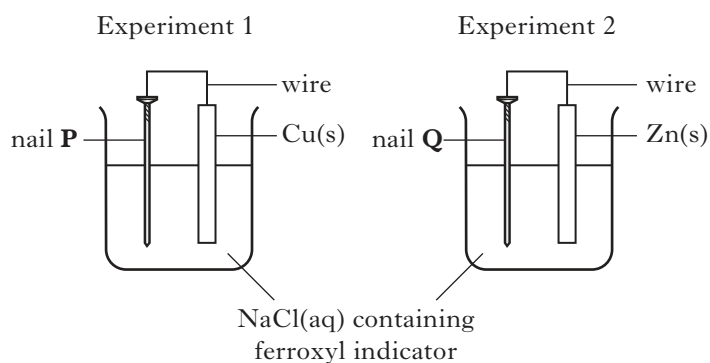
- 25 cm^3
- 50 cm^3
- 100 cm^3
- 200 cm^3

- Solutions of barium chloride and silver nitrate are mixed together.

The reaction that takes place is an example of

- displacement
- neutralisation
- oxidation
- precipitation.

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

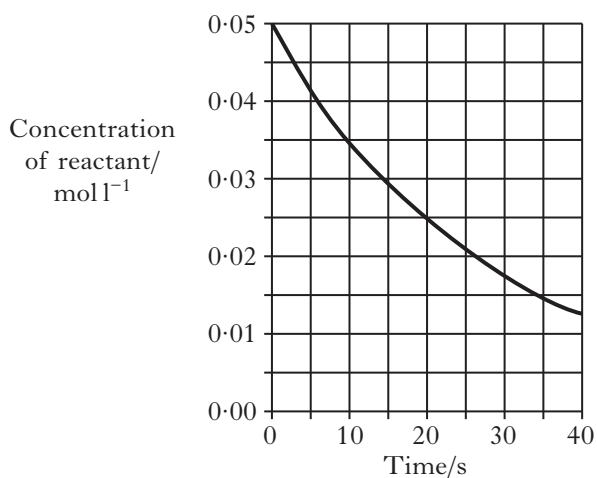


After a short time, a blue colour will have appeared at

- both **P** and **Q**
- neither **P** nor **Q**
- P** but not at **Q**
- Q** but not at **P**.

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7. The graph below shows the change in the concentration of a reactant with time for a given chemical reaction.



What is the average rate of this reaction, in $\text{mol l}^{-1}\text{s}^{-1}$, between 10 and 20 s?

- A 1.0×10^{-2}
 B 1.0×10^{-3}
 C 1.5×10^{-2}
 D 1.5×10^{-3}
8. 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.
9. Which of the following equations represents the first ionisation energy of fluorine?

- A $\text{F}^{-}(\text{g}) \rightarrow \text{F}(\text{g}) + \text{e}^{-}$
 B $\text{F}^{-}(\text{g}) \rightarrow \frac{1}{2}\text{F}_2(\text{g}) + \text{e}^{-}$
 C $\text{F}(\text{g}) \rightarrow \text{F}^{+}(\text{g}) + \text{e}^{-}$
 D $\frac{1}{2}\text{F}_2(\text{g}) \rightarrow \text{F}^{+}(\text{g}) + \text{e}^{-}$

10. Which line in the table shows the successive ionisation energies of a group 3 element?

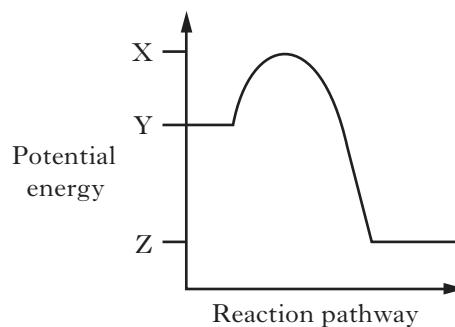
	Ionisation energy/ kJ mol^{-1}			
	1st	2nd	3rd	4th
A	900	1800	15 000	20 000
B	600	1800	2800	12 000
C	600	1200	5000	6500
D	500	1000	4000	5000

11. The electron affinity of an element is the energy change when one mole of gaseous atoms combines with one mole of electrons to form one mole of gaseous ions.

Which of the following equations represents the electron affinity of chlorine?

- A $\text{Cl}(\text{g}) + \text{e}^{-} \rightarrow \text{Cl}^{-}(\text{g})$
 B $\frac{1}{2}\text{Cl}_2(\text{g}) + \text{e}^{-} \rightarrow 2\text{Cl}^{-}(\text{g})$
 C $\frac{1}{2}\text{Cl}_2(\text{g}) \rightarrow \text{Cl}^{+}(\text{g}) + \text{e}^{-}$
 D $\text{Cl}(\text{g}) \rightarrow \text{Cl}^{+}(\text{g}) + \text{e}^{-}$

12. A reaction has the following potential energy diagram.



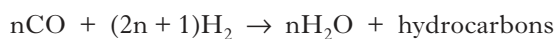
The activation energy for the forward reaction is

- A $X - Y$
 B $Y - X$
 C $Y - Z$
 D $Z - Y$

13. The enthalpy of neutralisation in an acid/alkali reaction is **always** the energy released when
- one mole of salt is formed
 - one mole of water is formed
 - one mole of acid is neutralised
 - one mole of alkali is neutralised.
14. The Avogadro Constant is the same as the number of
- ions in 1 mol of NaCl
 - atoms in 1 mol of hydrogen gas
 - electrons in 1 mol of helium gas
 - molecules in 1 mol of oxygen gas.
15. In which of the following pairs do the gases contain the same number of oxygen atoms?
- 1 mol of oxygen and 1 mol of carbon monoxide
 - 1 mol of oxygen and 0.5 mol of carbon dioxide
 - 0.5 mol of oxygen and 1 mol of carbon dioxide
 - 1 mol of oxygen and 1 mol of carbon dioxide
16. Under the same conditions of temperature and pressure, equal volumes of different gases always contain
- 6.02×10^{23} molecules
 - the same number of moles of electrons
 - the same number of atoms
 - the same number of moles of gas.
17. In which of the following reactions would the products have a lower volume than the reactants?
- $2\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow 2\text{CO}(\text{g})$
 - $\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$
 - $\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\ell)$
 - $\text{Ca}(\text{OH})_2(\text{aq}) + 2\text{CO}_2(\text{g}) \rightarrow \text{Ca}(\text{HCO}_3)_2(\text{aq})$
18. 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.)
- 0.10 mol of oxygen will be left unreacted.
 - 0.10 mol of sodium will be left unreacted.
 - 0.15 mol of oxygen will be left unreacted.
 - 0.20 mol of sodium oxide will be formed.
19. Which of the following shows the correct sequence of processes for the production of a petrol?
- Reforming, blending, fractionating
 - Reforming, fractionating, blending
 - Fractionating, reforming, blending
 - Fractionating, blending, reforming
20. Which of the following is an isomer of 2,2-dimethylpentan-1-ol?
- $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$
 - $(\text{CH}_3)_3\text{CCH}(\text{CH}_3)\text{CH}_2\text{OH}$
 - $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
 - $(\text{CH}_3)_2\text{CHC}(\text{CH}_3)_2\text{CH}_2\text{CH}_2\text{OH}$
21. Which of the following fuels can be produced by the fermentation of biological material under anaerobic conditions?
- Hydrogen
 - Methane
 - Methanol
 - Petrol

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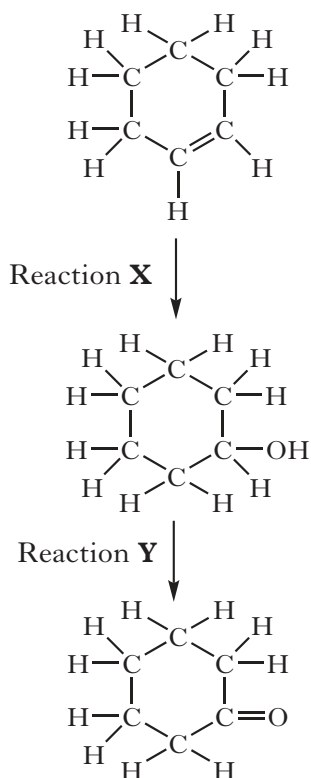
22. A mixture of carbon monoxide and hydrogen can be converted into water and a mixture of hydrocarbons.



What is the general formula for the hydrocarbons produced?

- A $\text{C}_n\text{H}_{2n-2}$
 B C_nH_{2n}
 C $\text{C}_n\text{H}_{2n+1}$
 D $\text{C}_n\text{H}_{2n+2}$

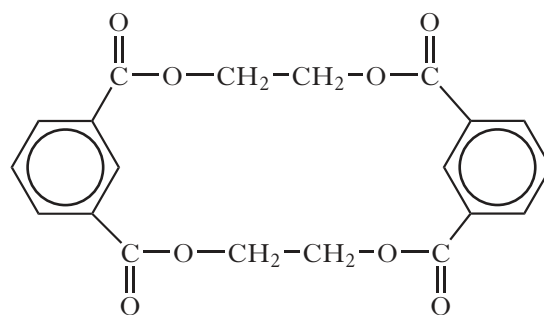
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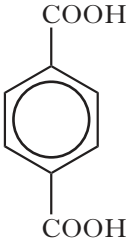
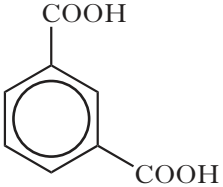
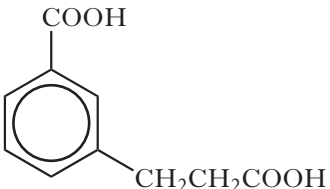
Which line in the table correctly describes reactions **X** and **Y**?

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

24. A by-product produced in the manufacture of a polyester has the structure shown.



What is the structure of the diacid monomer used in the polymerisation?

- A 
- B 
- C $\text{HOOC}-\text{CH}_2-\text{CH}_2-\text{COOH}$
- D 

25. A protective layer of ozone, O₃, exists in the atmosphere.

This protection arises from ozone's ability to

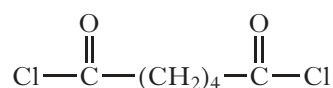
- A absorb ultraviolet radiation
- B reflect ultraviolet radiation
- C break down chlorofluorocarbons
- D release chlorofluorocarbons.

26. Polyesters are manufactured for use as fibres and resins.

Which line in the table is correct?

	Use	Property	Structure
A	resin	rigid	linear
B	resin	flexible	cross-linked
C	fibre	rigid	cross-linked
D	fibre	flexible	linear

27. The following monomers can be used to prepare nylon-6,6.



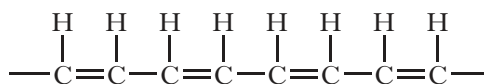
and



What molecule is released during the polymerisation reaction between these monomers?

- A HCl
- B H₂O
- C NH₃
- D HOCl

28. Part of the structure of a polymer chain is shown below.

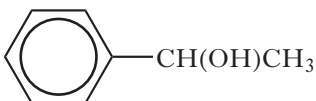


The monomer that reacts to give the polymer is

- A butene
- B buta-1,3-diene
- C ethene
- D ethyne.

29. The conversion of linoleic acid, C₁₈H₃₂O₂, into stearic acid, C₁₈H₃₆O₂, is likely to be achieved by

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

30. 

Which of the following statements about the above compound is correct?

- A It reacts readily with bromine solution.
- B It can be oxidised to an aldehyde.
- C It can be oxidised to a ketone.
- D It can be polymerised to form poly(phenylethene).

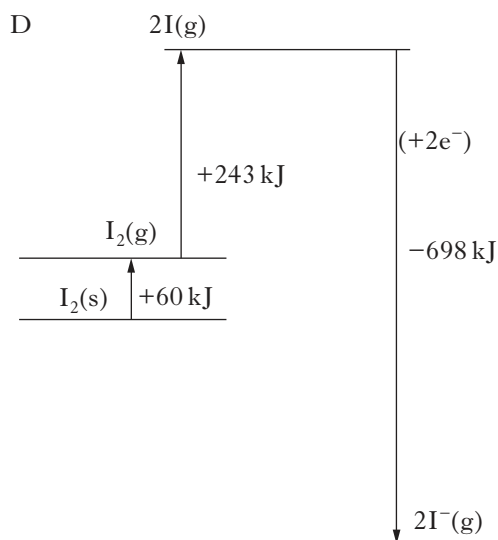
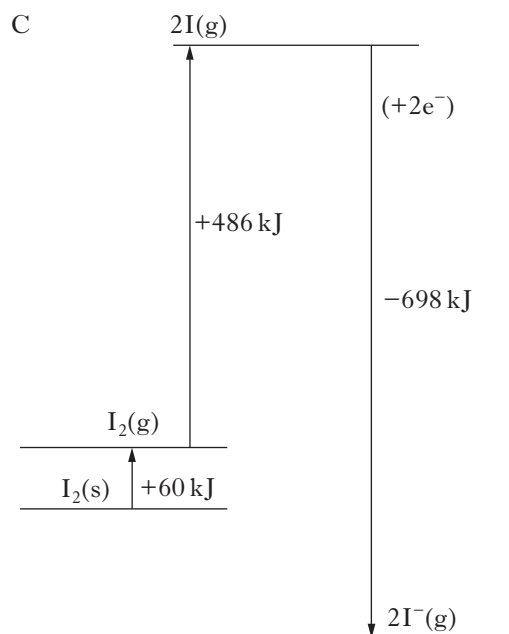
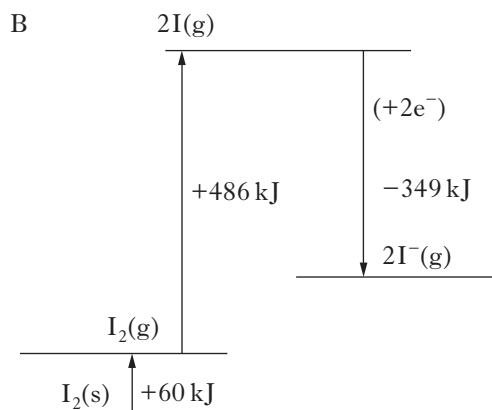
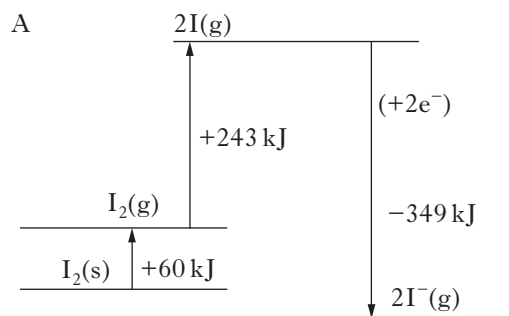
31. Which of the following is **not** a stage in the development of a new product?

- A Full scale production
- B Pilot study
- C Research
- D Scaling-up

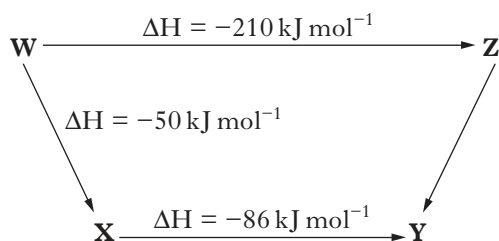
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32. $\text{I}_2(\text{s}) \rightarrow \text{I}_2(\text{g}) \quad \Delta H = +60 \text{ kJ mol}^{-1}$
 $\text{I}_2(\text{g}) \rightarrow 2\text{I}(\text{g}) \quad \Delta H = +243 \text{ kJ mol}^{-1}$
 $\text{I}(\text{g}) + \text{e}^- \rightarrow \text{I}^-(\text{g}) \quad \Delta H = -349 \text{ kJ mol}^{-1}$

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



33. Consider the reaction pathway shown below.



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

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

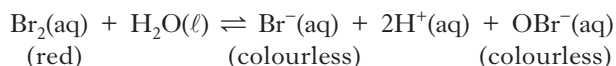
34. Which of the following statements regarding a chemical reaction at equilibrium is always true?

- 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.

35. 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 $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$

36. 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_3
- D NaOBr.

37. A solution of sodium hydroxide is diluted with water.

Which line in the table shows the changes that occur?

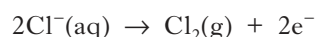
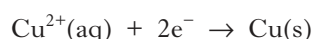
	$[\text{H}^+]$	$[\text{OH}^-]$	Conductivity
A	decreases	increases	increases
B	decreases	increases	decreases
C	increases	decreases	increases
D	increases	decreases	decreases

38. A lemon juice is found to have a pH of 3 and an apple juice a pH of 5.

From this information, the concentrations of $\text{H}^+(\text{aq})$ ions in the lemon juice and apple juice are in the proportion (ratio)

- A 100 : 1
- B 1 : 100
- C 20 : 1
- D 3 : 5.

39. When copper(II) chloride is electrolysed, the following reactions take place:



After electrolysis, it was found that 0.127 g of copper metal was deposited on the negative electrode.

What volume of chlorine gas, in litres, would be collected at the positive electrode?

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

- A 0.024
- B 0.048
- C 0.096
- D 0.142

40. Radioactive calcium would differ from non-radioactive calcium in its

- A atomic mass
- B chemical properties
- C atomic number
- D electron arrangement.

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

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Marks

SECTION B

All answers must be written clearly and legibly in ink.

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

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

Substance	Strongest type of attraction broken when substance melts
sulphur	
silicon dioxide	

1

- (b) Volcanic sulphur can be put to a variety of uses. One such use involves reacting sulphur 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 atomic size of sulphur is smaller than that of phosphorus.

1

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

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

2

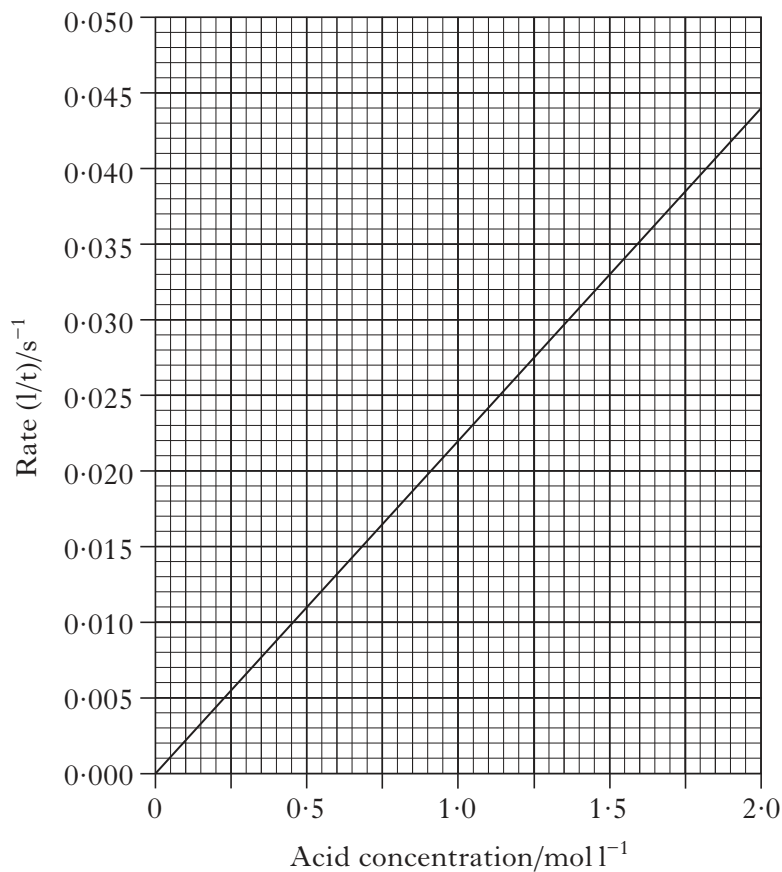
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2. (a) A student investigated the effect of changing acid concentration on reaction rate. Identical strips of magnesium ribbon were dropped into different concentrations of excess hydrochloric acid and the time taken for the magnesium to completely react, recorded.

A graph of the student's results is shown below.



Use information from the graph to calculate the reaction time, in seconds, when the concentration of the acid was 1.0 mol l⁻¹.

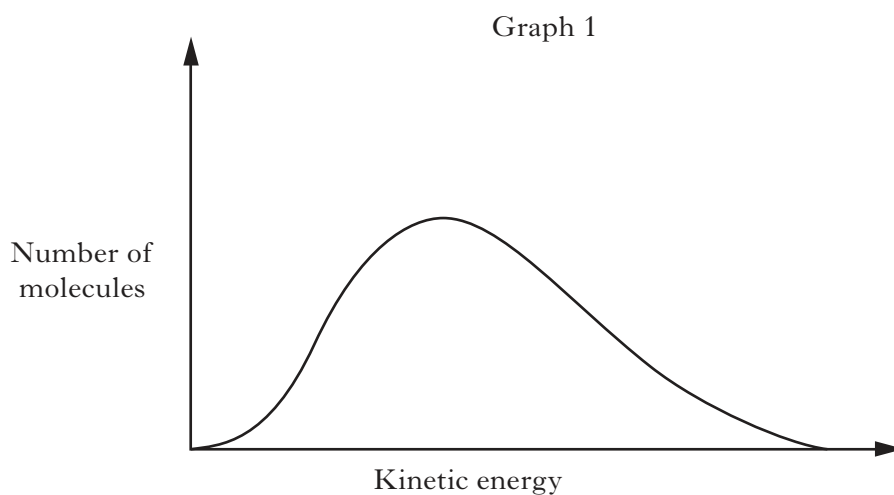
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2. (continued)

(b) The rate of a reaction can also be altered by changing the temperature or using a catalyst.

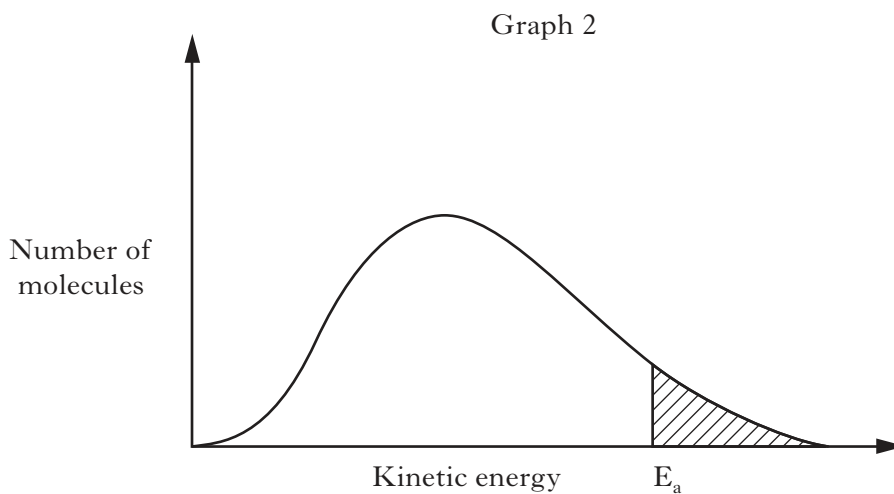
(i) Graph 1 shows the distribution of kinetic energies of molecules in a gas at 100 °C.



Add a second curve to Graph 1 to show the distribution of kinetic energies at 50 °C.

1

(ii) In Graph 2, the shaded area represents the number of molecules with the required activation energy, E_a .



Draw a line to show how a catalyst affects the activation energy.

1
(3)

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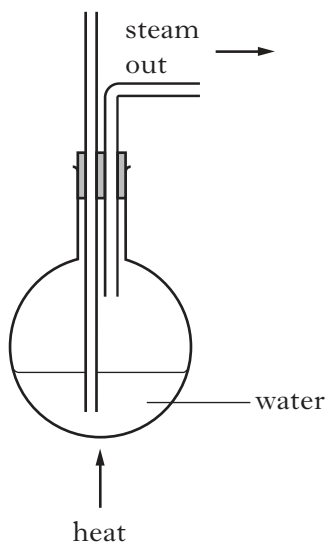
Marks

3. 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.

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

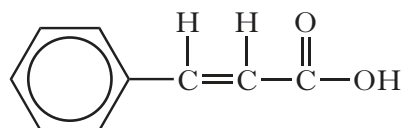
(An additional diagram, if required, can be found on *Page thirty-three*.)



2

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

A structural formula for cinnamic acid is shown.



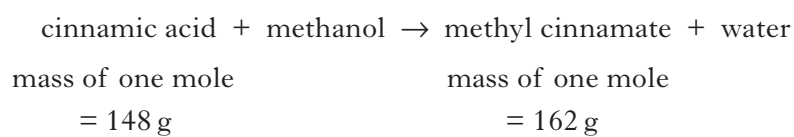
Draw a structural formula for the ester, methyl cinnamate.

1

Marks

3. (continued)

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



6.5 g of cinnamic acid was reacted with excess methanol.

The student obtained 3.7 g of methyl cinnamate.

Calculate the percentage yield.

(One mole of cinnamic acid reacts with one mole of methanol.)

2
(5)

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4. (a) Give a reason why oils are part of a balanced diet.

1

(b) Oils are mixtures of triglycerides. To which family of organic compounds do triglycerides belong?

1

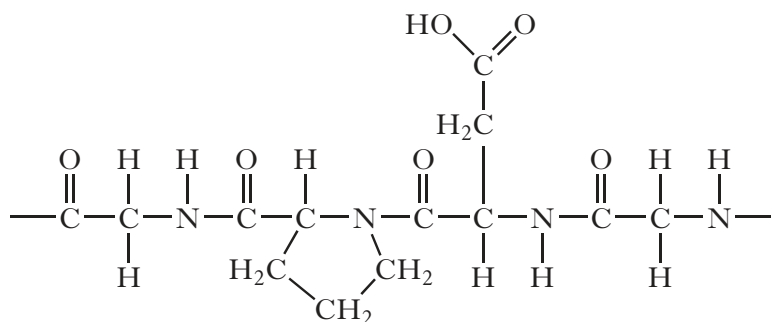
(c) Oils are broken down to release fatty acids. What term describes the breakdown of these oils?

1

(3)

Marks

5. Collagen is a protein that is found in muscle and the skin of animals.
Part of the structure of collagen is shown.



- (a) How many amino acid molecules formed this section of collagen?

1

- (b) Draw a structural formula for an amino acid that would be obtained when this section of chain is broken down.

1

(2)

[Turn over

Marks

6. Petrol is made by reforming the naphtha fraction from crude oil.

(a) (i) What happens to molecules during reforming?

1

(ii) One of the compounds found in petrol is 1,4-dimethylbenzene.

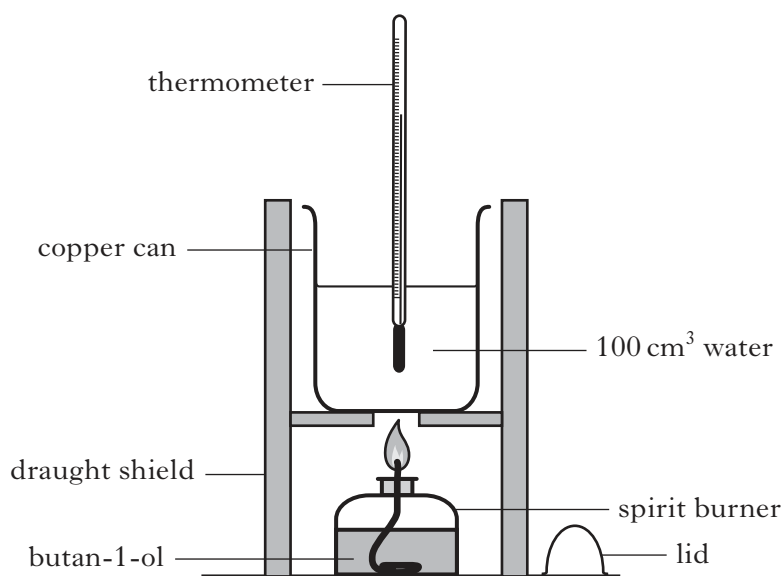


1,4-dimethylbenzene

Write the molecular formula for 1,4-dimethylbenzene.

1

(b) Butan-1-ol, C_4H_9OH , can be blended with petrol. The enthalpy of combustion of butan-1-ol can be measured experimentally. An apparatus that can be used to carry out the experiment is shown.



(i) Why is it important that the lid is kept on the spirit burner when it is being weighed?

1

Marks

6. (b) (continued)

- (ii) In the experiment, burning 0.64 g of butan-1-ol raised the temperature of the water in the can from 20 °C to 41 °C.

Use these results to calculate an experimental value for the enthalpy of combustion, in kJ mol^{-1} , of butan-1-ol.

2

- (c) The enthalpies of combustion of some alcohols are shown in the table.

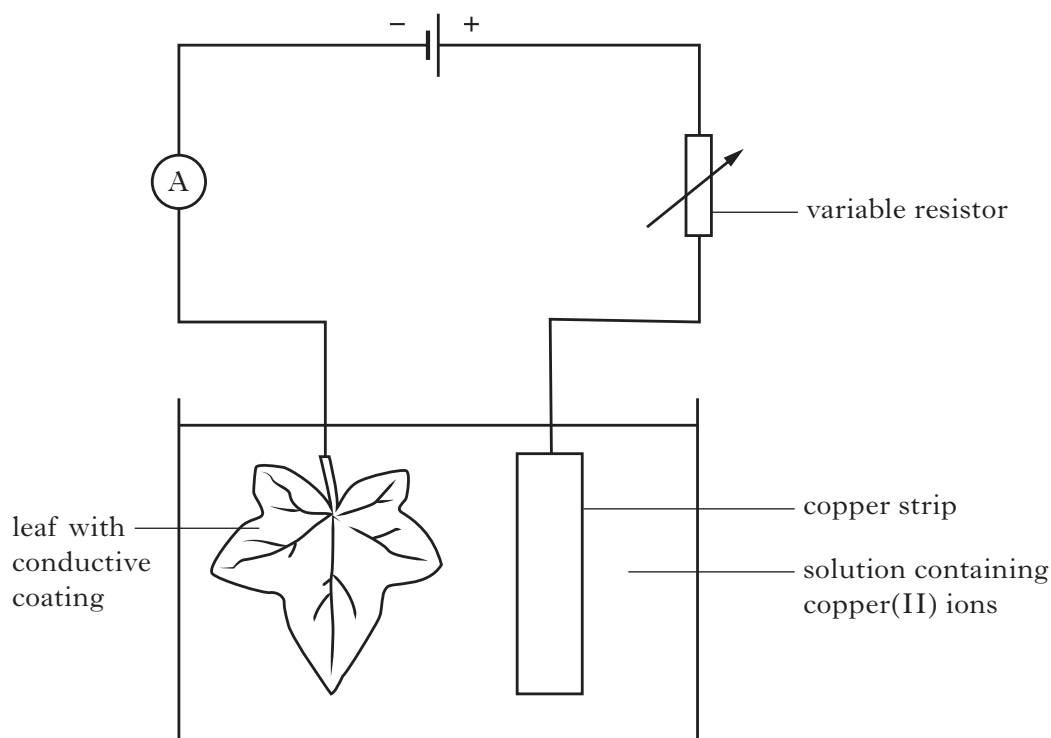
Alcohol	Enthalpy of combustion/kJ mol^{-1}
ethanol	-1367
propan-1-ol	-2020
butan-1-ol	-2676

Using this data, predict a value for the enthalpy of combustion, in kJ mol^{-1} , of pentan-1-ol.

1
(6)

Marks

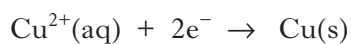
7. Electroforming is a process that can be used to create metal objects by depositing a thick layer of metal on the surface of natural items, such as leaves. Copper is often used. The natural items are first coated using a conductive spray. The electroforming process is carried out as shown below.



- (a) What is the purpose of the variable resistor in the circuit?

1

- (b) At the negative electrode copper atoms are deposited onto the leaf.



The current is set at 0.030 A per cm^2 of the leaf.

Calculate the time taken, in seconds, to deposit 4.5 g of copper on a leaf with an area of 24 cm^2 .

3

(4)

Marks

8. Cobalt-60 is a radioactive isotope that is used for sterilising medical equipment and food.

(a) Cobalt-60 decays by emission of a beta particle. Complete the nuclear equation for the decay of cobalt-60.



1

(b) Cobalt-60 releases gamma radiation which can be used to sterilise packaged food by killing bacteria. Suggest a property of gamma radiation that allows it to be used for sterilisation.

1

(c) Cobalt-60 is used in the form of pellets and has a half life of 5.27 years. When the activity of the pellets has fallen to 1/16th of their original value the pellets need to be replaced.

(i) After how many years would cobalt-60 pellets need to be replaced?

1

(ii) What would happen to this time period if the cobalt-60 pellets were stored at a lower temperature?

1

(4)

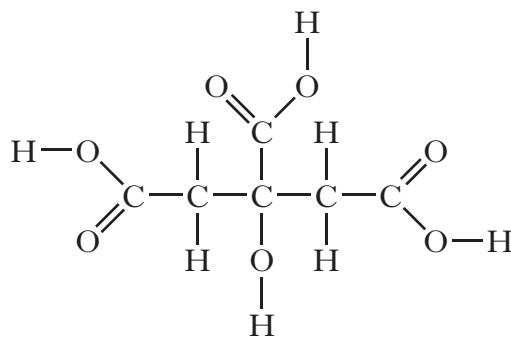
[Turn over

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

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(a) A sherbet contains citric acid.

Marks



citric acid

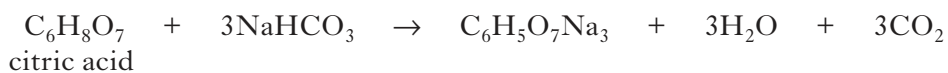
(i) Name the two types of functional group in the citric acid molecule.

1

(ii) 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.



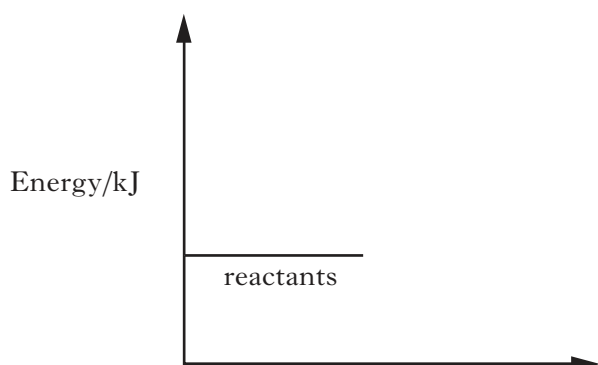
Explain why the reaction will only take place when water is present.

1

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

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*.)

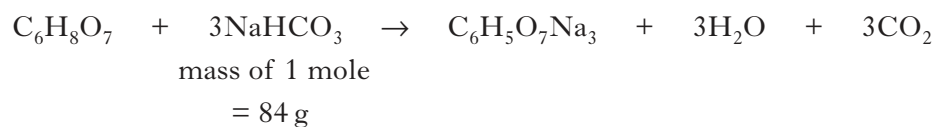


1

Marks

9. (continued)

- (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.

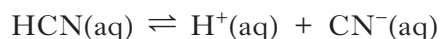
(Take the volume of 1 mole of carbon dioxide to be 24 litres)

2
(6)

[Turn over

Marks

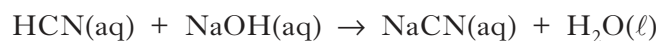
10. Hydrogen cyanide gas, HCN, dissolves in water to produce the weak acid, hydrocyanic acid.



- (a) What is meant by a weak acid?

1

- (b) Hydrocyanic acid reacts with sodium hydroxide to produce the salt, sodium cyanide, NaCN.



Suggest a pH value for a dilute solution of sodium cyanide.

1

- (c) One of the main uses for sodium cyanide is in the extraction of precious metals, such as gold, from ores.

In the presence of oxygen and water, trace amounts of gold in the ore react with sodium cyanide and dissolve out of the rock.



- (i) Balance the equation.

1

- (ii) If the pH is too low, toxic hydrogen cyanide gas is produced. To prevent this, the reaction mixture is maintained at pH 10 by addition of sodium hydroxide solution.

Calculate the concentration, in mol l^{-1} , of $\text{OH}^-(\text{aq})$ ions in a solution of pH 10.

1

(4)

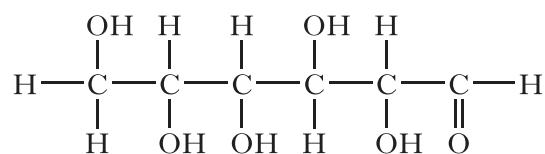
Marks

11. 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 or Benedict's solution.

- (i) Circle the part of the glucose molecule that reacts with Fehling's or Benedict's solution.



glucose

- (ii) Describe how a test using Fehling's or Benedict's solution should be carried out.

- (iii) State the colour change when a food containing glucose is tested with Fehling's or Benedict's solution.

1

1

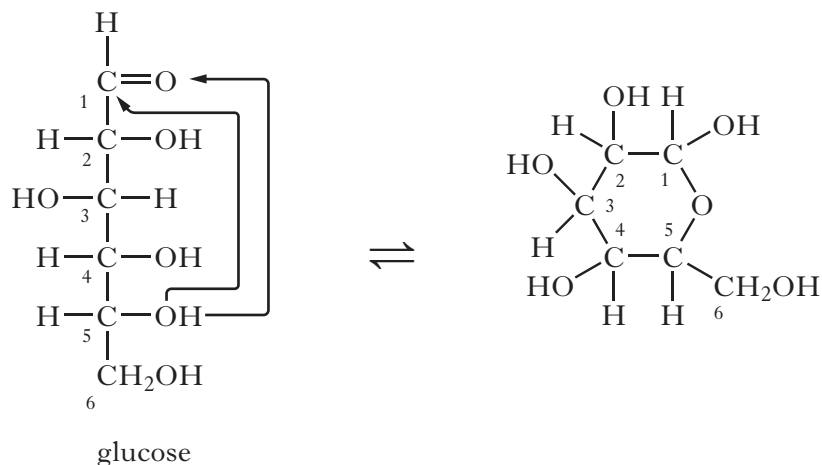
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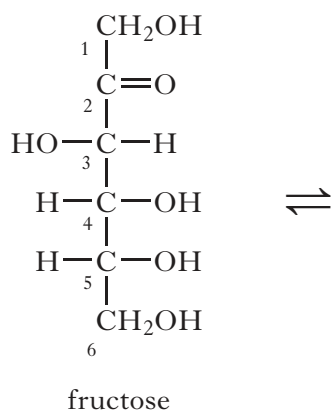
Marks

11. (continued)

- (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.

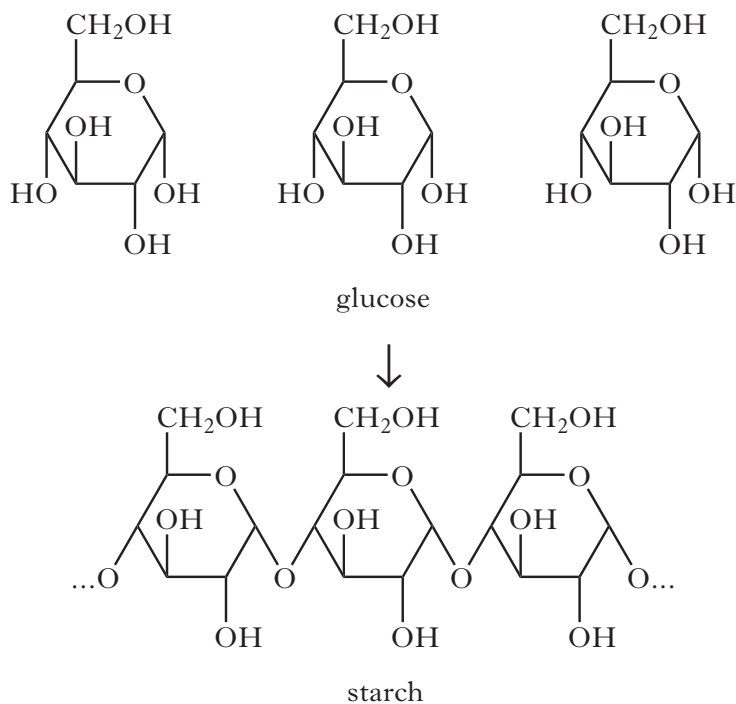


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11. (continued)

Marks

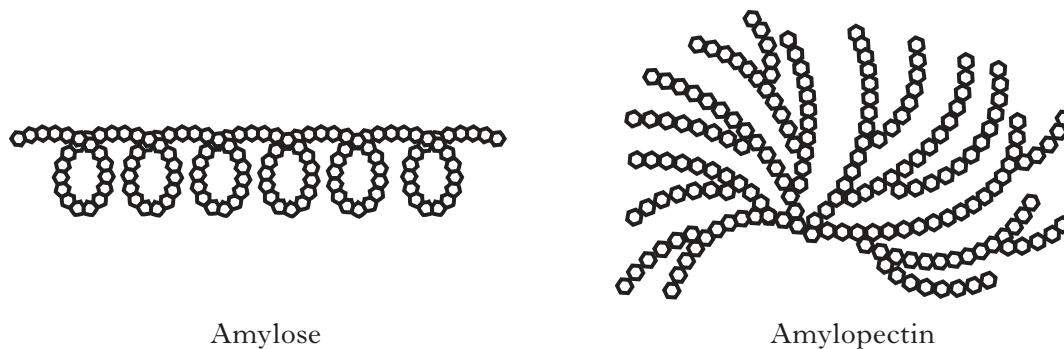
(c) Starch is a polymer of glucose.



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 repeating 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
(6)

Marks

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

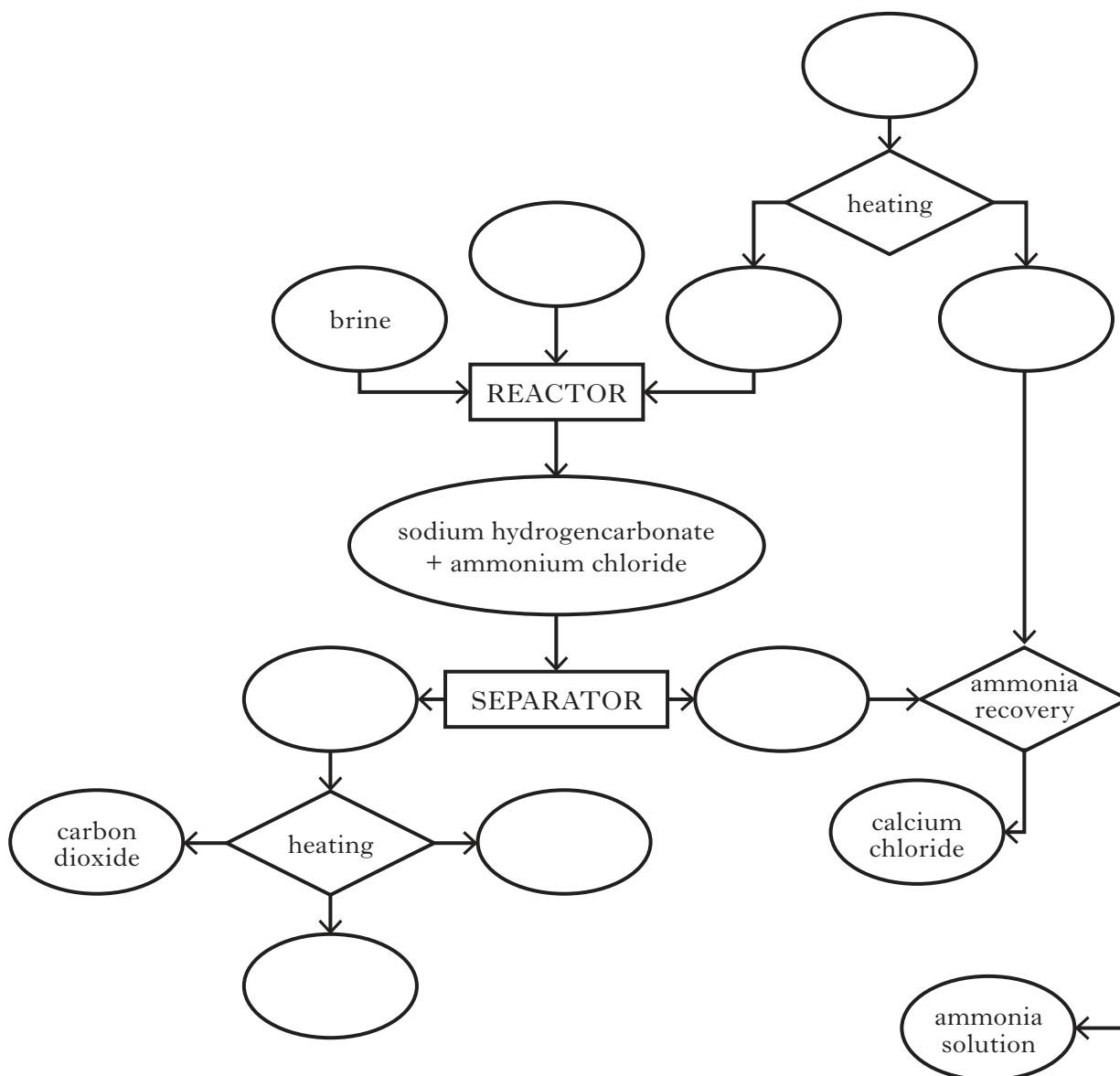
One industrial process used to make sodium carbonate is the Solvay process.

(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

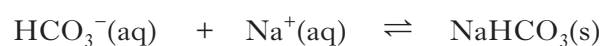
12. (a) (continued)

- (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.

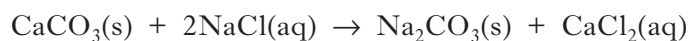
State why using a concentrated sodium chloride solution encourages production of sodium hydrogencarbonate as a solid.

1**[Turn over**

Marks

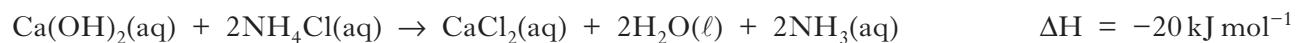
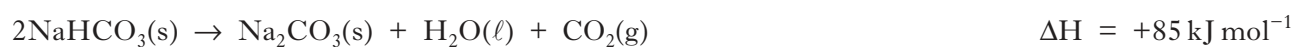
12. continued

(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.



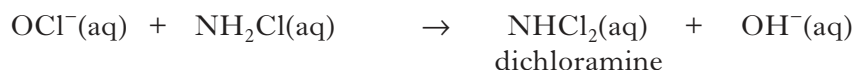
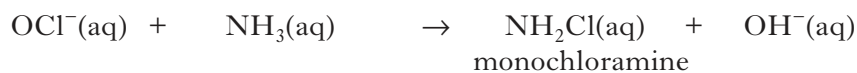
Calculate the enthalpy change, in kJ mol^{-1} , for the overall reaction in the Solvay process.

2
(6)

Marks

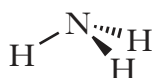
13. Sodium hypochlorite, NaOCl, is a strong oxidising agent used to disinfect water in swimming pools.

(a) 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.

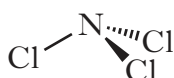


Chloramines are less soluble in water than ammonia due to the polarities of the molecules, and so readily escape into the atmosphere, causing irritation to the eyes.

Explain the difference in polarities of ammonia and trichloramine molecules.



ammonia



trichloramine

2

[Turn over for Question 13 (continued) on Page thirty-two

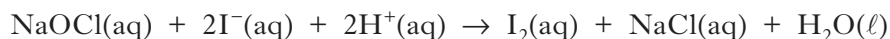
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13. (continued)

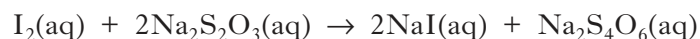
- (b) The concentration of sodium hypochlorite in swimming pool water can be determined by redox titration.

Step 1

A 100.0 cm³ sample from the swimming pool is first reacted with an excess of acidified potassium iodide (KI) solution, forming iodine (I₂).

**Step 2**

The iodine formed in step 1 is titrated using a standard solution of sodium thiosulphate, concentration 0.00100 mol l⁻¹. A small volume of starch solution is added towards the endpoint.



- (i) Write the ion-electron equation for the oxidation reaction occurring in step 1.
- (ii) Why is starch solution added to the reaction mixture?
- (iii) Calculate the concentration, in mol l⁻¹, of sodium hypochlorite in the swimming pool water if an average volume of 12.4 cm³ of sodium thiosulphate was required.

1

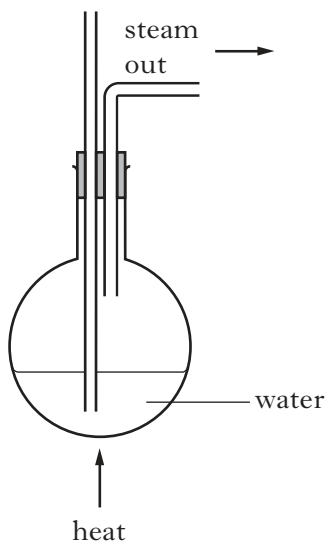
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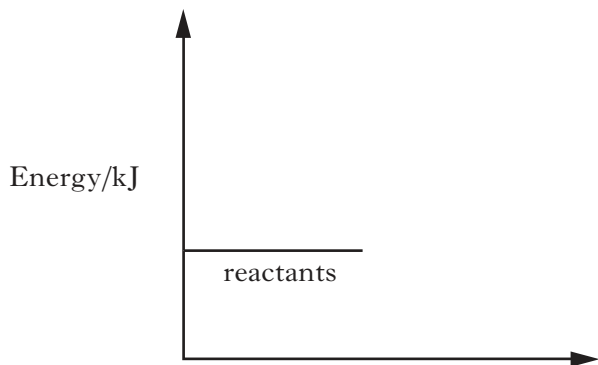
(6)

[END OF QUESTION PAPER]

ADDITIONAL DIAGRAM FOR USE IN QUESTION 3(a)



ADDITIONAL DIAGRAM FOR USE IN QUESTION 9(c)



ADDITIONAL SPACE FOR ANSWERS

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ADDITIONAL SPACE FOR ANSWERS

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