FOR OFFICIAL USE

Total
Section B

X273/12/02

NATIONAL QUALIFICATIONS 2014

MONDAY, 12 MAY
1.00 PM – 3.30 PM

CHEMISTRY
HIGHER (REVISED)

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Date of birth
Day Month Year

Scottish candidate number

Number of seat

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

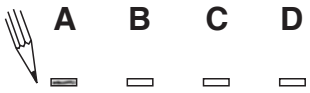
A chromatography

B fractional distillation

C fractional crystallisation

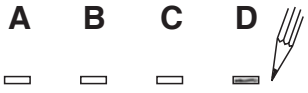
D filtration.

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

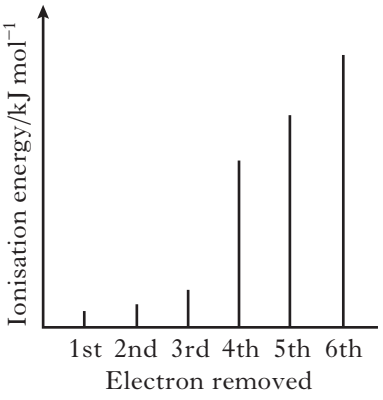


Changing an answer

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 spike graph shows the variation in successive ionisation energies of an element, **Z**.



In which group of the Periodic Table is element **Z**?

A 1

B 3

C 4

D 6

2. For elements in Group 7 of the Periodic Table, which of the following statements is true as the group is descended?

A The boiling point decreases.

B The covalent radius decreases.

C The electronegativity decreases.

D The strength of London dispersion forces decreases.

3. Which of the following chlorides is likely to have **least** ionic character?

A $BeCl_2$

B $CaCl_2$

C LiCl

D CsCl

4. Which of the following elements would have the strongest London dispersion forces?

A Argon

B Chlorine

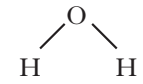
C Nitrogen

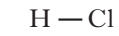
D Oxygen

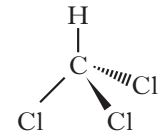
5. The shapes of some common molecules are shown below and each contains at least one polar bond.

Which molecule is non-polar?

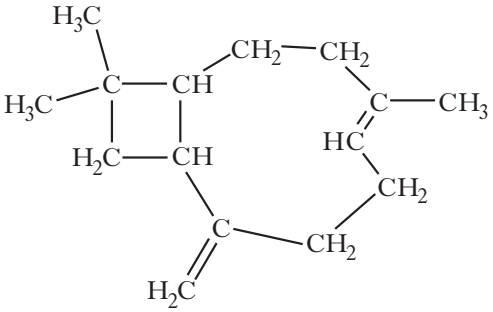
A 

B 

C 

D 

6. Caryophyllene is a natural product which can be extracted from clove oil using a solvent.



caryophyllene

Which of the following would be the best solvent for extracting caryophyllene?

A Hexane

B Hexanal

C Hexan-2-ol

D Hexan-3-one

7. Which of the following is the strongest oxidising agent?

A $Li^+(aq)$

B Li(s)

C $F^-(aq)$

D $F_2(g)$

8. Silver jewellery discoloured by tarnish (Ag_2S) can be cleaned by placing the item in an aluminium pot containing salt solution. The reaction occurring is shown below.

$3Ag_2S + 2Al \rightarrow 6Ag + Al_2S_3$

Which of the following statements is true?

A Aluminium metal is a reducing agent.

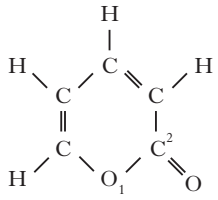
B Silver metal is an oxidising agent.

C Silver ions are acting as electron donors.

D Sulfide ions are acting as electron acceptors.

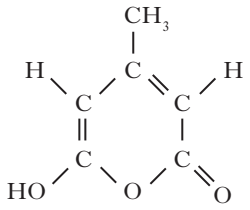
9. 4-Hydroxy-6-methyl-2-pyrone is a cyclic ester responsible for the smell of chocolate.

The number 2 identifies the position of the carbonyl group in the pyrone ring counting from the oxygen atom within the ring.



What is the structure of 4-hydroxy-6-methyl-2-pyrone?

A



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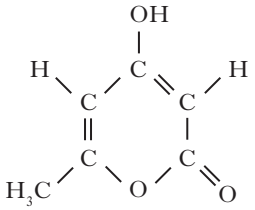

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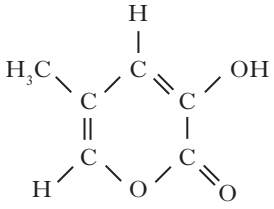
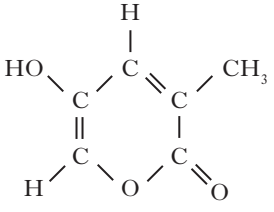


D



10. Which of the following consumer products is **least** likely to contain esters?

A Solvents

B Perfumes

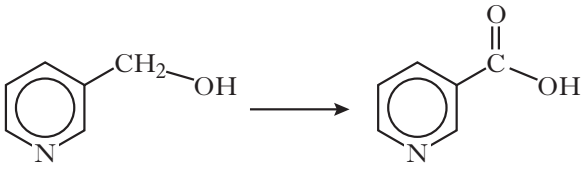
C Toothpastes

D Flavourings

11. Which line in the table shows correct functional groups for aldehydes and ketones and fats and oils?

	Aldehydes and ketones	**Fats and oils**
A	carbonyl	hydroxyl
B	carboxyl	hydroxyl
C	carboxyl	ester link
D	carbonyl	ester link

12. A step in the synthesis of nicotinic acid (vitamin B_3) is shown.



nicotinyl alcohol nicotinic acid

The type of reaction taking place in this step is

A hydration

B oxidation

C reduction

D condensation.

13. Which type of bond is broken when a protein is denatured?

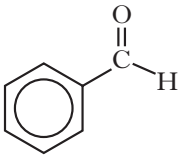
A Ionic

B Polar covalent

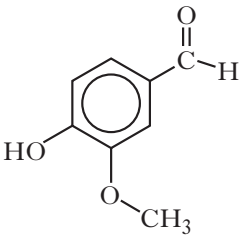
C Hydrogen

D Non-polar covalent

14. Benzaldehyde and vanillin are examples of flavour molecules.



benzaldehyde



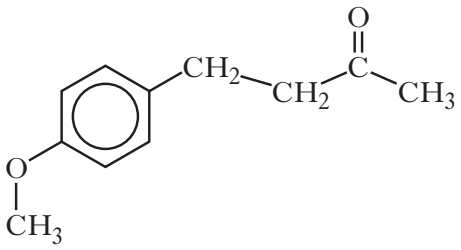
vanillin

Vanillin is soluble in water and is fairly volatile.

Which line in the table correctly compares benzaldehyde to vanillin?

	Solubility in water	**Relative volatility**
A	greater than vanillin	greater than vanillin
B	greater than vanillin	less than vanillin
C	less than vanillin	less than vanillin
D	less than vanillin	greater than vanillin

15. A compound with the following structure is used in perfumes to help provide a sweet, fruity fragrance.



This compound could be classified as

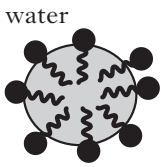
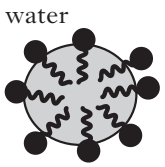
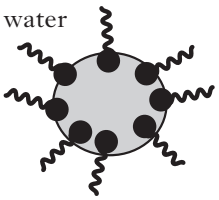
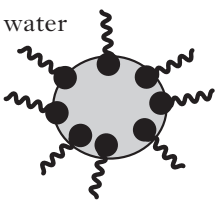
A an aldehyde

B a carboxylic acid

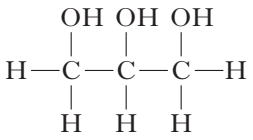
C an ester

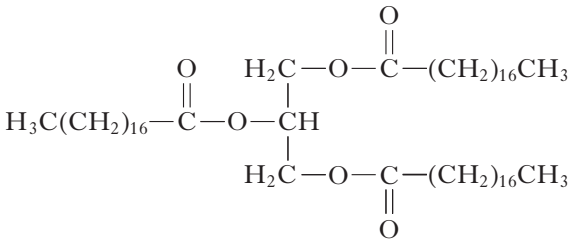
D a ketone.

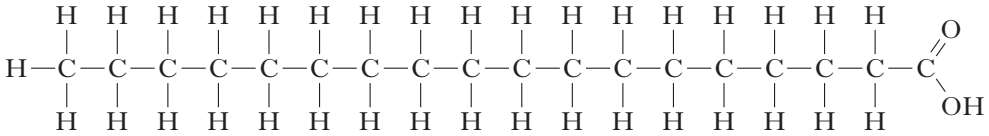
16. Which of the following diagrams and explanations best describes a step in the cleansing action of soap?

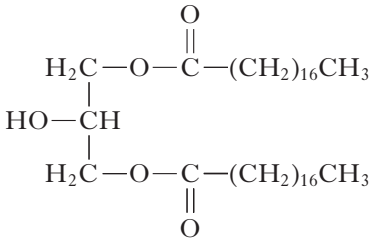
	Diagram	**Explanation**
A		Hydrophobic head dissolves in water. Hydrophilic tail dissolves in oil droplet.
B		Hydrophilic head dissolves in water. Hydrophobic tail dissolves in oil droplet.
C		Hydrophobic head dissolves in oil droplet. Hydrophilic tail dissolves in water.
D		Hydrophilic head dissolves in oil droplet. Hydrophobic tail dissolves in water.

17. Which of the following could act as an emulsifier?

A 

B 

C 

D 

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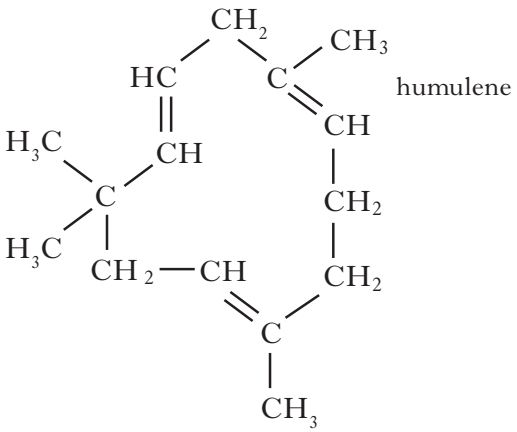
18. Humulene is a terpene which contributes to the aroma of beer.



humulene

How many isoprene units were used to form a humulene molecule?

A 2

B 3

C 4

D 5

19. Which of the following gases has the same volume as 128·2 g of sulfur dioxide?

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

A 2·0 g hydrogen

B 8·0 g helium

C 32·0 g oxygen

D 80·8 g of neon.

20. Which line in the table describes dynamic equilibrium?

	Concentration of reactants and products	**Forward and reverse reaction rates**
A	constant	equal
B	constant	not equal
C	not constant	equal
D	not constant	not equal

21. The following reaction takes place in a blast furnace:

$CO_2(g) + C(s) \rightleftharpoons 2CO(g) \quad \Delta H = +174\,kJ\ mol^{-1}$

Which conditions of pressure and temperature would favour the production of carbon monoxide?

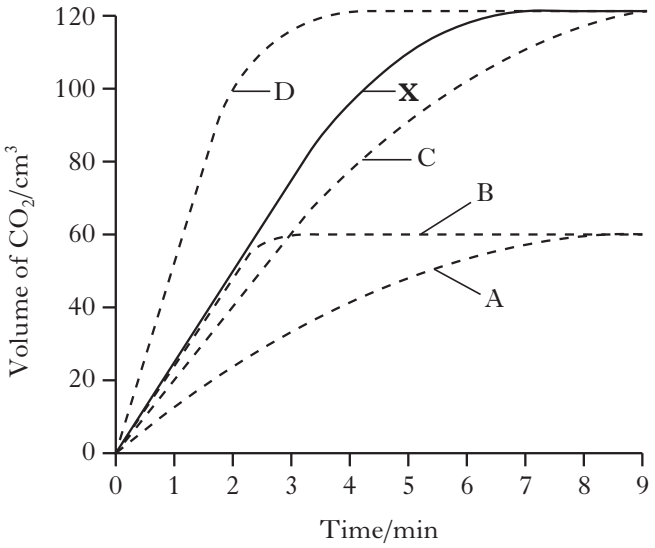
A Low pressure and low temperature

B High pressure and low temperature

C Low pressure and high temperature

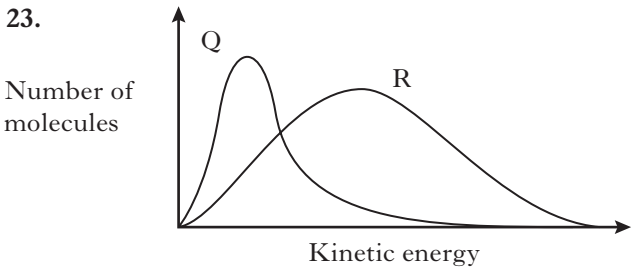
D High pressure and high temperature

22. Graph **X** was obtained when 1 g of calcium carbonate powder reacted with excess dilute hydrochloric acid at 20 °C.



Which curve would best represent the reaction of 0·5 g lump calcium carbonate with excess of the same dilute hydrochloric acid?

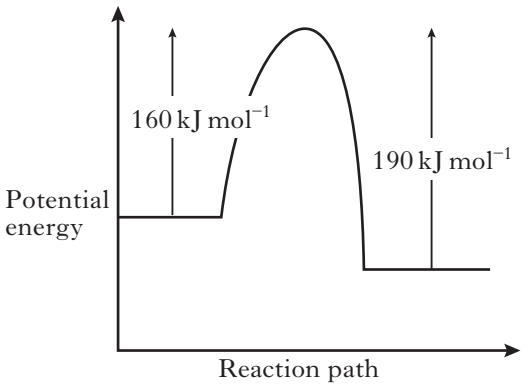
23.



Which line in the table is correct for curves **Q** and **R** in the above graph?

	Curve Q	**Curve R**
A	1 mol of O_2 at 50 °C	2 mol of O_2 at 100 °C
B	1 mol of O_2 at 100 °C	2 mol of O_2 at 100 °C
C	2 mol of O_2 at 50 °C	1 mol of O_2 at 100 °C
D	2 mol of O_2 at 100 °C	1 mol of O_2 at 100 °C

24.



When a catalyst is used, the activation energy of the forward reaction is reduced to 35 kJ mol^{-1}.

What is the activation energy of the catalysed reverse reaction?

A 30 kJ mol^{-1}

B 35 kJ mol^{-1}

C 65 kJ mol^{-1}

D 190 kJ mol^{-1}

[Turn over

25. Excess iron was added to 100 cm^3 of 1·0 $mol\,l^{-1}$ copper(II) sulfate solution releasing 3·1 kJ of energy.

$Fe(s) + CuSO_4(aq) \rightarrow Cu(s) + FeSO_4(aq)$

What is the enthalpy change, in $kJ\,mol^{-1}$ for the above reaction?

A −0·31

B −3·1

C −31

D −310

26. The enthalpy of combustion of an alcohol is always the enthalpy change for

A the alcohol burning in 1 mole of oxygen

B the alcohol burning to produce 1 mole of water

C 1 mole of the alcohol burning completely in oxygen

D 1 mole of the alcohol burning to produce 1 mole of carbon dioxide.

27. $C(graphite) + O_2(g) \rightarrow CO_2(g) \quad \Delta H = -394\,kJ\,mol^{-1}$

$C(diamond) + O_2(g) \rightarrow CO_2(g) \quad \Delta H = -395\,kJ\,mol^{-1}$

What is the enthalpy change, in $kJ\,mol^{-1}$, for the conversion of one mole of graphite into one mole of diamond?

A +789

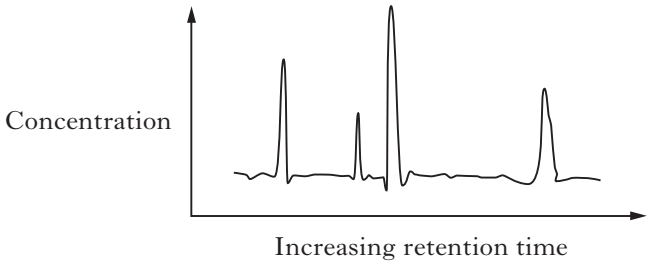
B +1

C −1

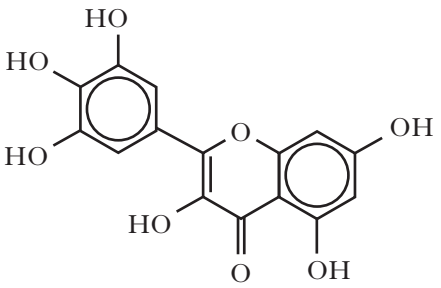
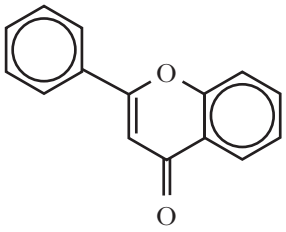
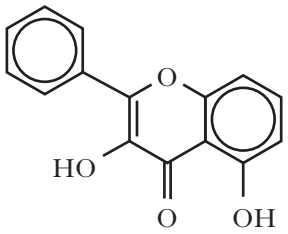
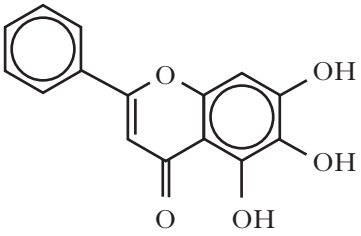
D −789

28. A chemist analysed a mixture of four dyes A, B, C and D using gas-liquid chromatography.

When a polar column was used the following chromatogram was obtained.



Which of the following compounds was present in greatest concentration?

Dye	Structure
A	
B	
C	
D	

29. The correct method of filling a 20 cm^3 pipette is to draw the liquid into the pipette

A doing it slowly at the end, until the top of the meniscus touches the mark

B doing it slowly at the end, until the bottom of the meniscus touches the mark

C to above the mark and then release liquid from the pipette until the top of the meniscus touches the mark

D to above the mark and then release liquid from the pipette until the bottom of the meniscus touches the mark.

30. A 0·10 mol l^{-1} solution could be prepared most accurately from a 1·0 mol l^{-1} solution using

A a 1 cm^3 dropping pipette and a 10 cm^3 measuring cylinder

B a 10 cm^3 measuring cylinder and a 100 cm^3 volumetric flask

C a 25 cm^3 pipette and a 250 cm^3 volumetric flask

D a 50 cm^3 burette and a 500 cm^3 measuring cylinder.

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

[Turn over

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DO NOT WRITE IN THIS MARGIN

Marks

SECTION B

All answers must be written clearly and legibly in ink.

1. Information about four elements from the third period of the Periodic Table is shown in the table.

Element	aluminium	silicon	phosphorus	sulfur
Bonding		covalent		covalent
Structure	lattice		molecular	

(*a*) Complete the table to show the bonding and structure for each element. **2**

(*b*) Why is there a decrease in the size of atoms across the period from aluminium to sulfur? **1**

(*c*) Argon is also in the third period. Argon is a very useful gas and each year 750 000 tonnes of argon are extracted from liquid air.

(i) Suggest how argon could be extracted from liquid air. **1**

(ii) Air contains 1·3% argon by mass. Calculate the mass of liquid air needed to obtain 750 000 tonnes of argon. **1**

(iii) Argon is used in the manufacture of magnesium powder. A jet of liquid argon is blown at a stream of molten magnesium producing fine droplets of metal. These cool to form the powder.

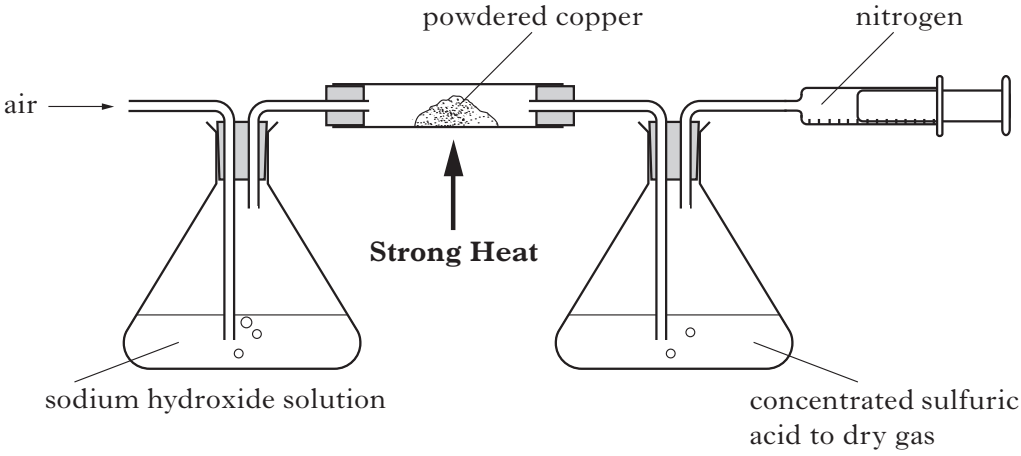
Why can liquid air not be used to make magnesium powder? **1**

1. (*c*) continued

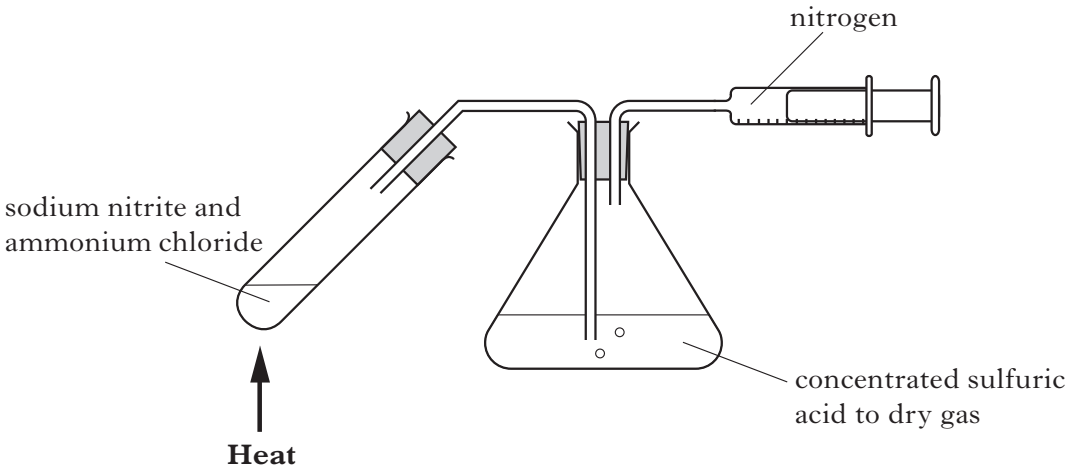
(iv) Argon was discovered in 1890's when samples of nitrogen prepared by different methods were compared. The element name was derived from the Greek *argos*, which means "lazy one".

Two samples of nitrogen can be prepared as shown.

Method 1 Removing carbon dioxide and oxygen from the air.



Method 2 Reaction of sodium nitrite with ammonium chloride.



$$NaNO_2(s) + NH_4Cl(s) \rightarrow NaCl(s) + N_2(g) + 2H_2O(\ell)$$

Heated magnesium metal can react with nitrogen gas to give magnesium nitride.

$$3Mg(s) + N_2(g) \rightarrow Mg_3N_2(s)$$

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1. (*c*) continued

Us**ing your knowledge of chemistry**, comment on the discovery and naming of argon.

3

(9)

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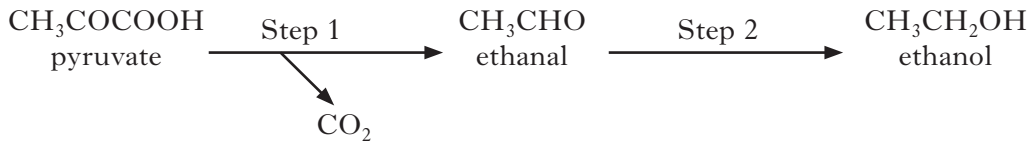
2. (*a*) In some countries, ethanol is used as a substitute for petrol. This ethanol is produced by fermentation of glucose, using yeast enzymes.

During the fermentation process, glucose is first converted into pyruvate. The pyruvate is then converted to ethanol in a two-step process.



(i) **Step 1** is catalysed by an enzyme. Enzymes are proteins that can act as catalysts because they have a specific shape.

Why, when the temperature is raised above a certain value, does the rate of reaction decrease?

1

(ii) Why can Step 2 be described as a reduction reaction?

1

(iii) The overall equation for the fermentation of glucose is

$C_6H_{12}O_6$	$\rightarrow$	$2C_2H_5OH$	+	$2CO_2$
mass of one mole = 180 g		mass of one mole = 46 g		

Calculate the percentage yield of ethanol if 445 g of ethanol is produced from 1·0 kg of glucose.

Show your working clearly

3

Marks

2. (continued)

(*b*) The energy density value of a fuel is the energy released when one kilogram of the fuel is burned.

The enthalpy of combustion of ethanol is $-1367\ kJ\ mol^{-1}$.

Calculate the energy density value, in $kJ\ kg^{-1}$, of ethanol.

1

(*c*) The quantity of alcohol present after a fermentation reaction is called the % alcohol by volume.

This can be calculated from measurements taken using an instrument called a hydrometer. The hydrometer is floated in the liquid sample, before and after fermentation, to measure its specific gravity.

% alcohol by volume = change in specific gravity of liquid x ***f***

where ***f*** is a conversion factor, which varies as shown in the table.

Change in specific gravity of liquid	***f***
Up to 6·9	0·125
7·0 – 10·4	0·126
10·5 – 17·2	0·127
17·3 – 26·1	0·128
26·2 – 36·0	0·129
36·1 – 46·5	0·130
46·6 – 57·1	0·131

The hydrometer readings taken for a sample are shown on *Page sixteen*.

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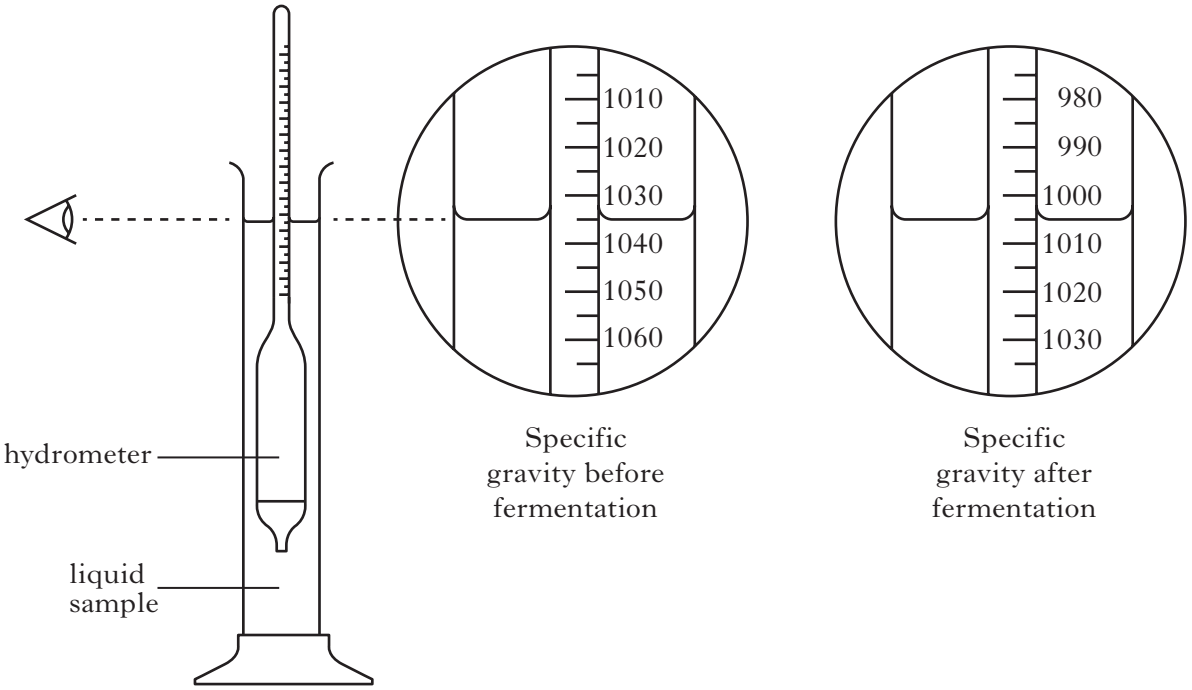
2. (*c*) continued



Calculate the % alcohol by volume for this sample.

2

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3. (*a*) Hydrogen and fluorine can react explosively to form hydrogen fluoride gas.

The equation for the reaction is shown.

$$H_2(g) + F_2(g) \rightarrow 2HF(g)$$

Using bond enthalpy values from the data booklet, calculate the enthalpy change for this reaction.

2

(*b*) The boiling point of hydrogen fluoride, HF, is much higher than the boiling point of F_2.

H — F	F — F
boiling point: 19·5 °C	boiling point: −188 °C

Explain fully why the boiling point of hydrogen fluoride is much higher than the boiling point of fluorine.

In your answer you should mention the intermolecular forces involved and how they arise.

3

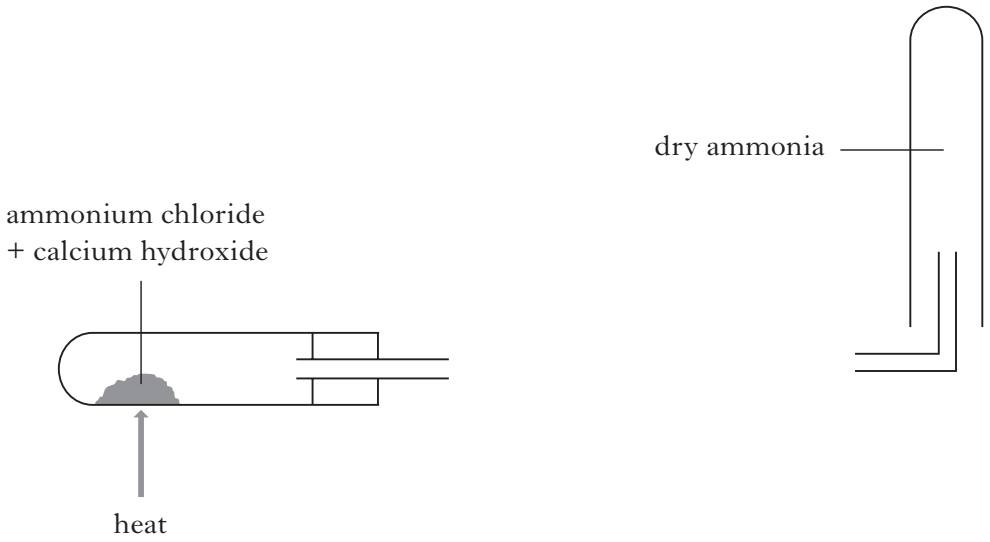
(5)

Marks

4. (*a*) A small sample of ammonia can be prepared in the laboratory by heating a mixture of ammonium chloride and calcium hydroxide. The ammonia is dried by passing it through small lumps of calcium oxide and collected by the downward displacement of air.

Complete the diagram to show how ammonia gas can be dried before collection.

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



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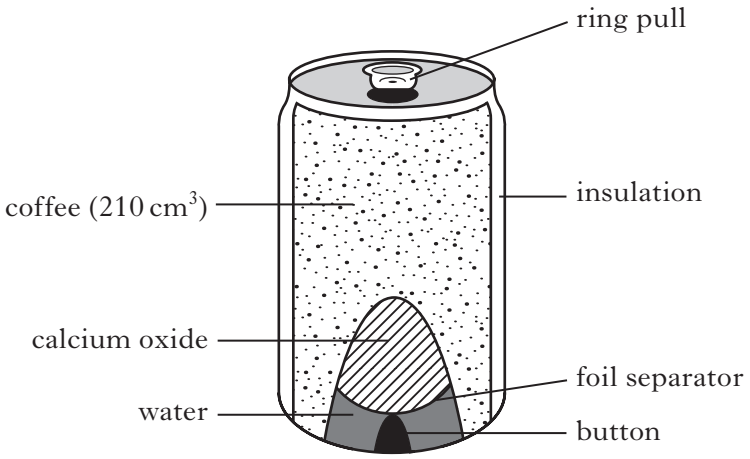
(*b*) Self-heating cans may be used to warm drinks such as coffee.

When the button on the can is pushed, a seal is broken, allowing water and calcium oxide to mix and react.

The reaction produces solid calcium hydroxide and releases heat.



The equation for this reaction is:

$$CaO(s) + H_2O(\ell) \rightarrow Ca(OH)_2(s) \qquad \Delta H = -65\,kJ\ mol^{-1}$$

Marks

4. (*b*) continued

(i) Calculate the mass, in grams, of calcium oxide required to raise the temperature of 210 cm^3 of coffee from 20 °C to 70 °C.

Show your working clearly.

3

(ii) If more water is used the calcium hydroxide is produced as a solution instead of as a solid.

The equation for the reaction is:

$$CaO(s) + H_2O(\ell) \rightarrow Ca(OH)_2(aq)$$

Using the following data, calculate the enthalpy change, in kJ mol^{-1}, for this reaction.

$$Ca(s) + \tfrac{1}{2}O_2(g) \rightarrow CaO(s) \qquad \Delta H = -635\ kJ\ mol^{-1}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(\ell) \qquad \Delta H = -286\ kJ\ mol^{-1}$$

$$Ca(s) + O_2(g) + H_2(g) \rightarrow Ca(OH)_2(s) \qquad \Delta H = -986\ kJ\ mol^{-1}$$

$$Ca(OH)_2(s) \rightarrow Ca(OH)_2(aq) \qquad \Delta H = -82\ kJ\ mol^{-1}$$

Show your working clearly.

2

(6)

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Marks

5. Some fruit drinks claim to be high in antioxidants such as vitamin C.

(*a*) The vitamin C content in a fruit drink can be determined by titrating it with iodine.

The redox reaction which takes place is shown.

$$\underset{\text{vitamin C}}{C_6H_8O_6(aq)} + I_2(aq) \rightarrow C_6H_6O_6(aq) + 2H^+(aq) + 2I^-(aq)$$

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

1

(ii) Some students carried out an investigation of fruit drinks to determine their vitamin C content. The following steps were followed in each experiment.

Step 1 A 20·0 cm^3 sample of fruit drink was transferred to a conical flask by pipette.

Step 2 A burette was filled with a standard iodine solution.

Step 3 The fruit drink sample was titrated with the iodine.

Step 4 Titrations were repeated until concordant results were obtained.

The burette, pipette and conical flask were all rinsed before they were used.

Tick the appropriate boxes below to show which solution should be used to rinse each piece of glassware.

Glassware used	**Rinse with water**	**Rinse with iodine**	**Rinse with fruit drink**
pipette			
burette			
conical flask			

2

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5. (*a*) continued

(iii) Titrating a whole carton of fruit drink would require large volumes of iodine solution.

Apart from this disadvantage, give another reason for titrating several smaller samples of fruit drink.

1

(iv) An average of 25·4 cm^3 of 0·00125 $mol\,l^{-1}$ iodine solution was required for the complete titration of the vitamin C in a 20·0 cm^3 sample of fruit drink.

Calculate the mass, in grams, of vitamin C in the 1 litre carton of fruit drink.

(mass of 1 mole vitamin C = 176 g)

Show your working clearly.

3

(*b*) The recommended daily allowance (RDA) for vitamin C is 60 mg.

A one litre carton of an orange fruit drink contains 240 mg of vitamin C.

What percentage of the RDA is provided by 200 cm^3 of this drink?

2

(9)

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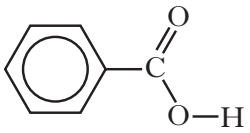
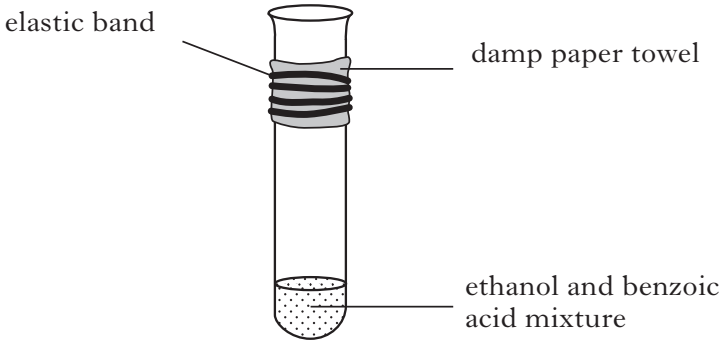
6. Benzoic acid, C_6H_5COOH, is an important feedstock in the manufacture of chemicals used in the food industry.



benzoic acid

(*a*) The ester ethyl benzoate is used as food flavouring.

Ethyl benzoate can be prepared in the laboratory by an esterification reaction. A mixture of ethanol and benzoic acid is heated, with a few drops of concentrated sulfuric acid added to catalyse the reaction.



(i) Suggest a suitable method for heating the reaction mixture.

1

(ii) During esterification the reactant molecules join by eliminating a small molecule. What name is given to this type of chemical reaction?

1

(iii) Draw a structural formula for ethyl benzoate.

1

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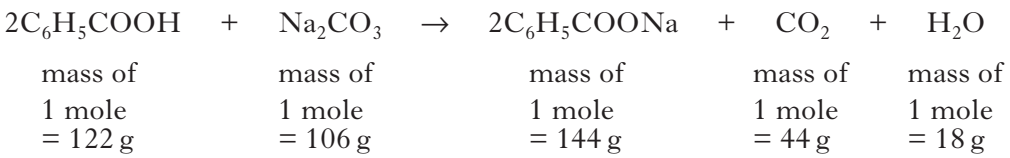
6. (continued)

(*b*) Sodium benzoate is used in the food industry as a preservative. It can be made by reacting benzoic acid with a concentrated solution of sodium carbonate.



Calculate the atom economy for the production of sodium benzoate.

2

(5)

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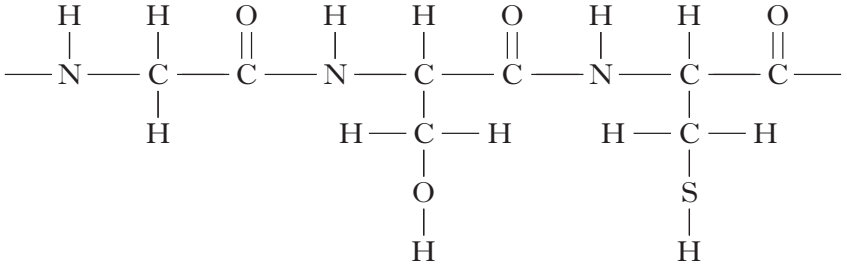
7. Proteins are made from monomers called amino acids.

Human hair is composed of long strands of a protein called keratin.

(*a*) Part of the structure of a keratin molecule is shown.

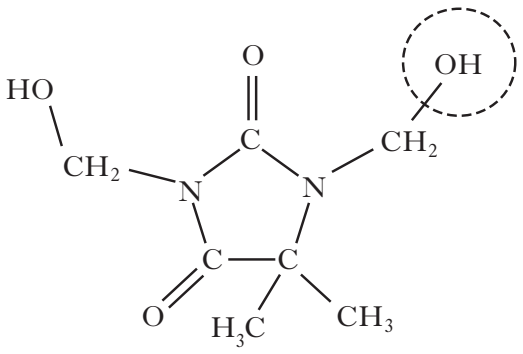


Circle a peptide link in the structure. **1**

(*b*) Hair products contain a large variety of different chemicals.

Chemicals called hydantoins are used as preservatives in shampoos to kill any bacteria.

A typical hydantoin is shown.



Name the functional group circled.

1

(*c*) Some hair conditioners contain the fatty acid, behenic acid, $CH_3(CH_2)_{19}CH_2COOH$.

Behenic acid is produced by hydrolysing the edible oil, ben oil.

(i) Name the compound, other than fatty acids, which is produced by hydrolysing the edible oil, ben oil.

1

Marks

7. (*c*) (continued)

(ii) 5·0 g of behenic acid can be obtained from 50·0 cm^3 of ben oil.

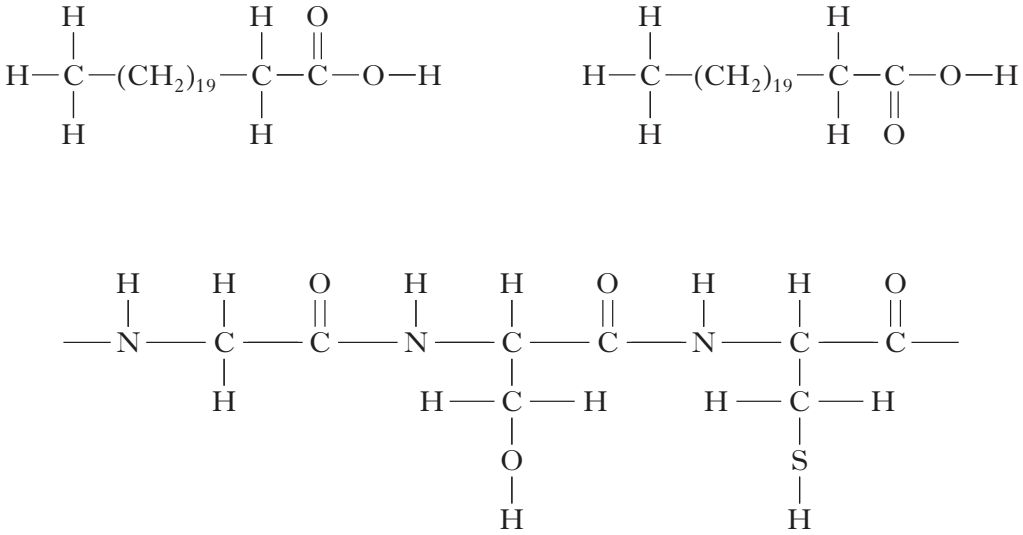
1 litre of ben oil costs £90.

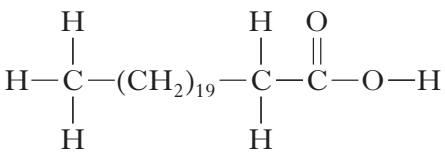
How much would it cost to buy sufficient ben oil to produce 20·0 g of behenic acid?

1

(iii) When conditioner containing behenic acid is applied to hair, the behenic acid molecules make strong intermolecular hydrogen bonds to the keratin protein molecules.

On the diagram below use a dotted line to show **one** hydrogen bond that could be made between a behenic acid molecule and the keratin.





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7. (continued)

(*d*) Blocked drains can be very unpleasant. Common causes of blocked drains in homes are fats, hair and food waste.

Using your knowledge of chemistry, comment on chemical methods that might be used to unblock drains.

3

(8)

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8. (*a*) Carbon monoxide gas is produced as a result of the incomplete combustion of fuels.

The amount of carbon monoxide in the atmosphere is controlled by a series of free radical reactions.

(i) What is meant by the term *free radical*?

1

(ii) Why do free radicals form in the atmosphere?

1

(iii) The equation shows one of the steps in the free radical chain reaction which controls the level of carbon monoxide.

$$CO + HO\bullet \rightarrow CO_2 + H\bullet$$

What term describes this type of step in the free radical chain reaction

1

(*b*) Carbon monoxide can be used to produce the gas tricarbon dioxide, C_3O_2, a substance used to bind dyes to natural fur.

Draw a structural formula for tricarbon dioxide.

1

(4)

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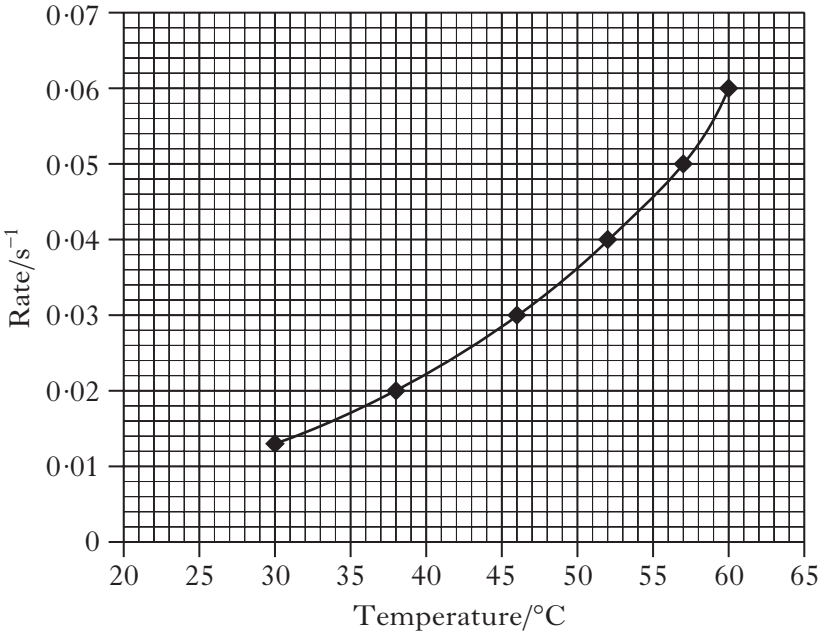
9. A student investigated the effect of changing temperature on the rate of chemical reaction.

The results from the investigation are shown in the graph below.



(*a*) Use the graph to determine the temperature rise required to double the rate of reaction.

1

(*b*) Collision theory can be used to explain reaction rates.

Collision theory states that for two molecules to react, they must first collide with one another.

State **two** conditions necessary for the collisions to result in the formation of products.

2

(3)

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10. The table shows the boiling points of some alcohols.

Alcohol	Boiling point/°C
$CH_3CH_2CH_2CH_2OH$	118
$CH_3CH_2CH(OH)CH_3$	98
$CH_3CH(CH_3)CH_2OH$	108
$CH_3CH_2CH_2CH_2CH_2OH$	137
$CH_3CH_2CH_2CH(OH)CH_3$	119
$CH_3CH_2CH(CH_3)CH_2OH$	128
$CH_3CH_2C(OH)(CH_3)CH_3$	101
$CH_3CH_2CH_2CH_2CH_2CH_2OH$	159
$CH_3CH_2CH_2CH(CH_3)CH_2OH$	149
$CH_3CH_2CH_2C(OH)(CH_3)CH_3$	121

Marks

(*a*) Using information from the table, describe **two** ways in which differences in the structures affect boiling point of **isomeric alcohols**.

2

(*b*) Predict a boiling point for hexan-2-ol.

1

(3)

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11. Some types of steel contain manganese.

The manganese content of a steel can be determined by converting the manganese into permanganate ions.

The steel is reacted with nitric acid giving manganese ions in solution. These are converted into permanganate ions by reaction with periodate ions.

$Mn(s) \rightarrow Mn^{2+}(aq) \rightarrow MnO_4^-(aq)$

During the reaction the periodate ions, $IO_4^-(aq)$, are reduced to iodate ions, $IO_3^-(aq)$.

(*a*) Complete the ion-electron equation for this reduction reaction -

$IO_4^-(aq) \rightarrow IO_3^-(aq)$ **1**

(*b*) When light is shone through a permanganate solution some of the light is absorbed.

The concentration of a permanganate solution can be found by measuring the amount of light absorbed and comparing this with the light absorbed by solutions of known concentration.

(i) To obtain solutions of known concentration a stock solution of accurately known concentration is first prepared.

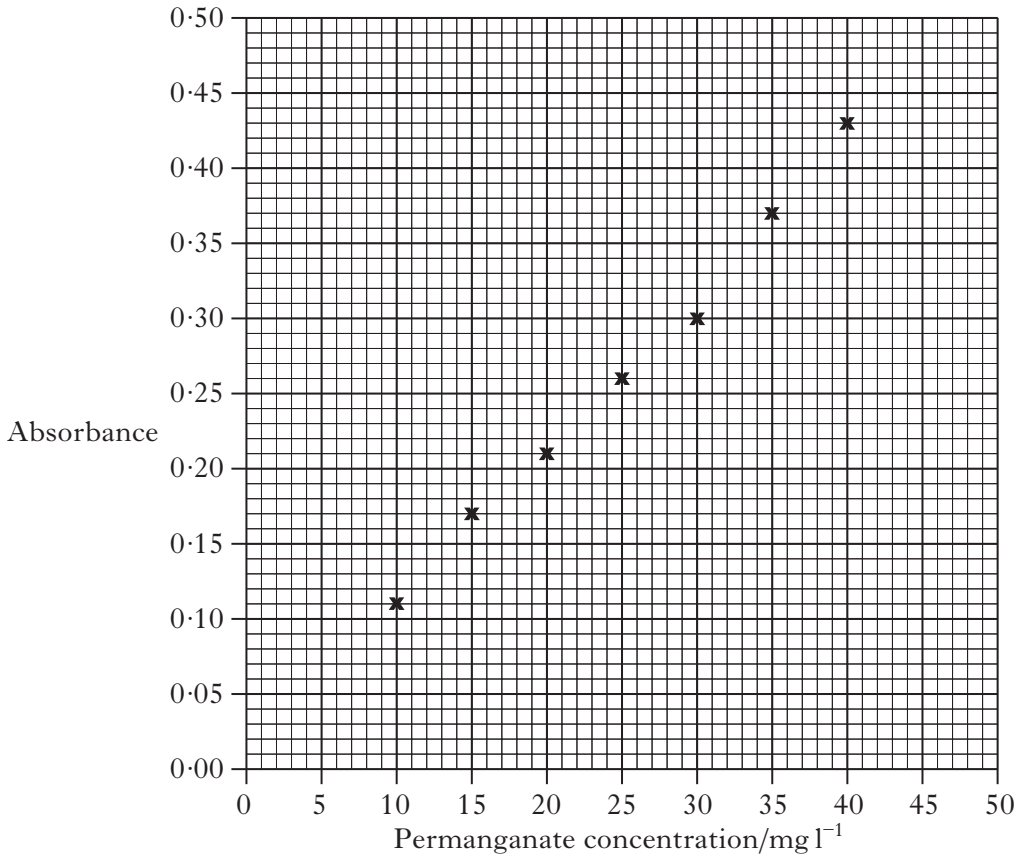
Describe how a stock solution of accurately known concentration could be prepared from a weighed sample of potassium permanganate crystals.

2

Marks

11. (b) (continued)

The graph was plotted using the absorbance of different permanganate solutions.



(ii) A sample of steel was reacted to give one litre of solution containing permanganate ions. The absorbance of the solution was 0·30.

Use your graph to determine the mass of manganese in the steel sample.

(1 mole of manganese gives 1 mole of permanganate ions.)

3

(6)

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Marks

12. A chemical explosion is the result of a very rapid reaction that generates a large quantity of heat energy and, usually, a large quantity of gas.

(*a*) The explosive RDX, $C_3H_6N_6O_6$, is used in the controlled demolition of disused buildings.

During the reaction it decomposes as shown.

$$C_3H_6O_6N_6(s) \rightarrow 3CO(g) + 3H_2O(g) + 3N_2(g)$$

Calculate the volume, in litres, of gas released when 1·0 g of RDX decomposes.

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

3

Marks

12. (continued)

(*b*) The products formed when an explosive substance decomposes can be predicted by applying the Kistiakowsky-Wilson rules. These rules use the number of oxygen atoms in the molecular formula to predict the products.

In the example below these rules are applied to the decomposition of the explosive RDX, $C_3H_6N_6O_6$

Rule Number	Rule	Atoms available in $C_3H_6N_6O_6$	Apply Rule to show products
1	Using oxygen atoms from the formula convert any carbon atoms in the formula to carbon monoxide.	3 × C	3CO formed
2	If any oxygen atoms remain convert H atoms in the formula to water.	3 × O remain	$3H_2O$ formed
3	If any oxygen atoms still remain then convert CO formed to CO_2.	No more oxygen left	No CO_2 formed
4	Convert any nitrogen atoms in the formula to N_2.	6 × N	$3N_2$ formed

Decomposition equation:

$C_3H_6N_6O_6(s) \rightarrow 3CO(g) + 3H_2O(g) + 3N_2(g)$

By applying the same set of rules, complete the equation for the decomposition of the explosive PETN, $C_5H_8N_4O_{12}$.

$C_5H_8N_4O_{12}(s) \rightarrow$ **1**

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ADDITIONAL DIAGRAM FOR QUESTION 4(*a*)