FOR OFFICIAL USE

Total
Section B

X012/12/02

NATIONAL QUALIFICATIONS 2014

MONDAY, 12 MAY
1.00 PM – 3.30 PM

CHEMISTRY
HIGHER

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 1–40 (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

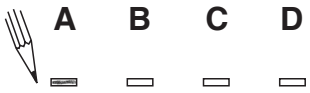
A chromatography

B fractional distillation

C fractional crystallisation

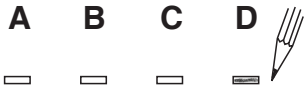
D filtration.

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**.



1. Particles with the same electron arrangement are said to be isoelectronic.

Which of the following compounds contains ions which are isoelectronic?

A $CaCl_2$

B KBr

C $MgCl_2$

D Na_2S

2. A mixture of sodium chloride and sodium sulphate is known to contain 0·6 mol of chloride ions and 0·2 mol of sulphate ions.

How many moles of sodium ions are present?

A 0·4

B 0·5

C 0·8

D 1·0

3. When an atom **X** of an element in Group 1 reacts to become $\mathbf{X}^+$

A the mass number of **X** increases

B the charge of the nucleus increases

C the atomic number of **X** decreases

D the number of occupied energy levels decreases.

4. The reaction of copper(II) oxide with dilute sulphuric acid is an example of

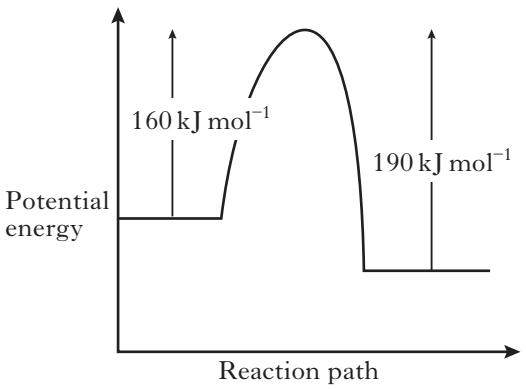
A displacement

B neutralisation

C oxidation

D reduction.

5.



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}

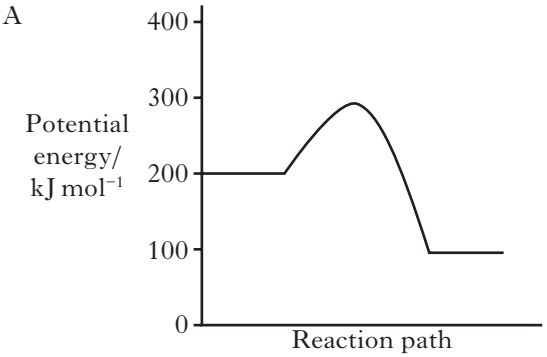
C 65 kJ mol^{-1}

D 190 kJ mol^{-1}

[Turn over

6. Which of the following potential energy diagrams represents the most exothermic reaction?

A



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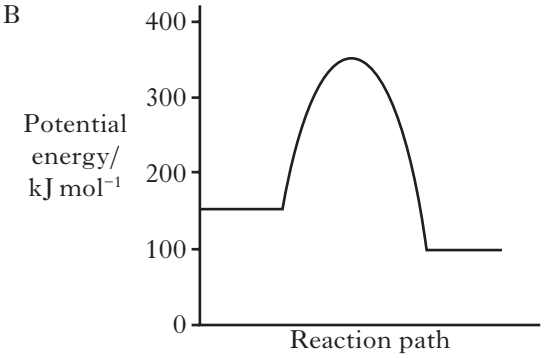

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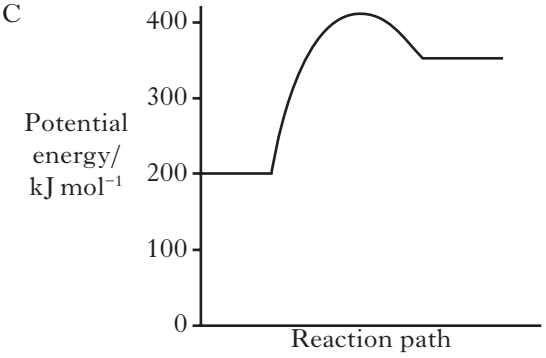
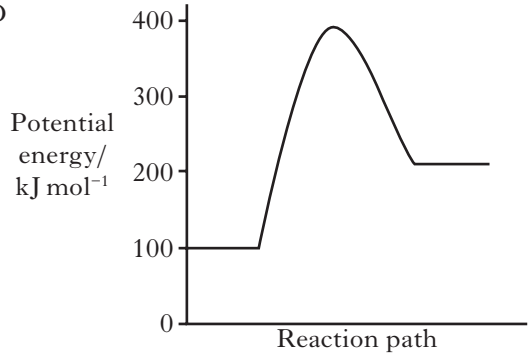
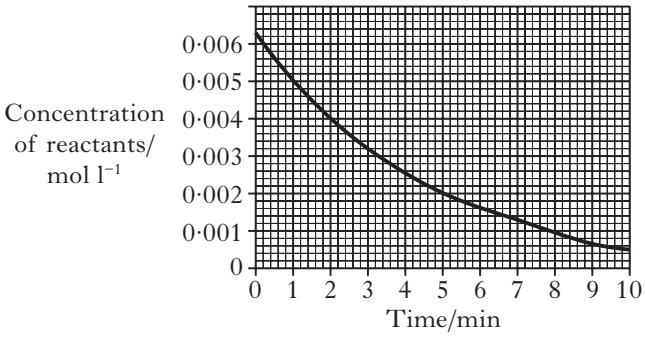


D



7. The following graph represents a reaction between sodium hydroxide and ethyl ethanoate.



What is the average rate of the reaction over the first 5 minutes, in mol l^{-1} min^{-1}?

A $3{\cdot}6 \times 10^{-4}$

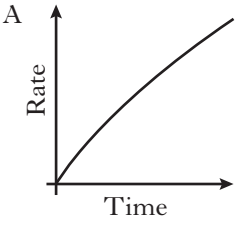
B $8{\cdot}4 \times 10^{-3}$

C $8{\cdot}4 \times 10^{-4}$

D $1{\cdot}2 \times 10^{-3}$

8. Which of the following graphs could represent the change in the rate of reaction when magnesium ribbon reacts with dilute hydrochloric acid?

A



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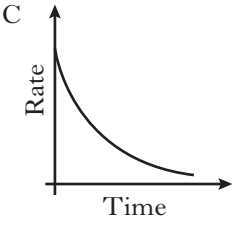

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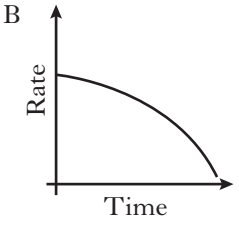
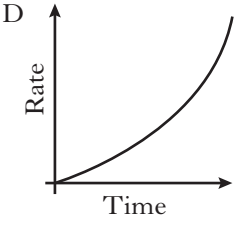
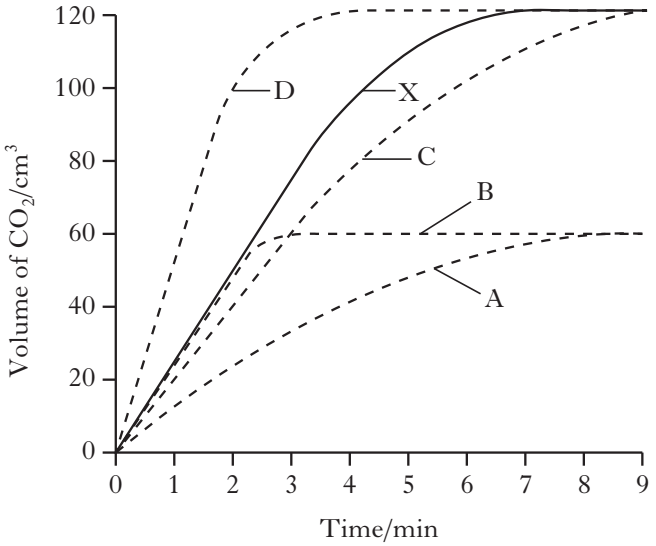


D

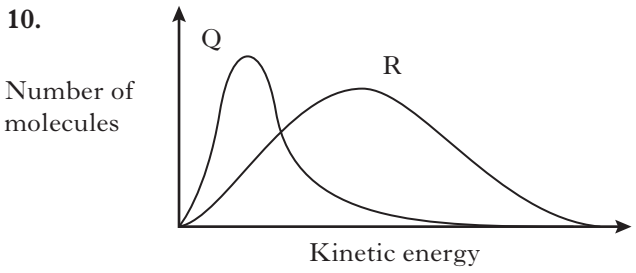


9. Graph **X** was obtained when 1 g of calcium carbonate powder reacted with excess dilute hydrochloric acid at 20 °C.



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

10.



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

11. Excess iron was added to 100 cm^3 of 1·0 mol l^{-1} copper(II) sulphate 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

12. 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 first ionisation energy increases.

D The strength of the van der Waals' forces increases.

13. Which line in the table is likely to be correct for the element francium?

	State at 30 °C	1st Ionisation Energy/kJ mol^{-1}
A	solid	less than 382
B	liquid	less than 382
C	solid	greater than 382
D	liquid	greater than 382

[Turn over

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

A $BeCl_2$

B $CaCl_2$

C LiCl

D CsCl

15. Which of the following compounds has polar molecules?

A CO_2

B NH_3

C CCl_4

D CH_4

16. Which of the following are **only** found in compounds?

A Metallic bonds

B Covalent bonds

C Hydrogen bonds

D Van der Waals' forces

17. The Avogadro constant is the same as the number of

A atoms in 24 g of carbon

B molecules in 16 g of oxygen

C electrons in 1 g of hydrogen

D ions in 1 litre of sodium chloride solution, concentration 1 mol l^{-1}.

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

A 2·0 g hydrogen

B 8·0 g helium

C 32·0 g oxygen

D 80·8 g of neon.

19. Which of the following statements is **not** true?

A Ethene and propene can be produced by cracking naphtha.

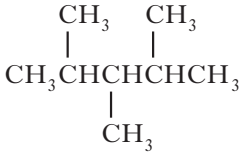
B Petrol can be produced by cracking naphtha.

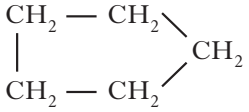
C Aromatic compounds can be produced by reforming naphtha.

D Cycloalkanes can be produced by reforming naphtha.

20. Which of the following hydrocarbons would have the greatest tendency to auto-ignite?

A $CH_3CH_2CH_2CH_2CH_2CH_2CH_3$

B 

C 

D 

21. MTBE and ethanol are oxygenates added to gasoline to increase the octane rating.

	Octane rating	Relative cost
MTBE	118	1·6
Ethanol	114	5·8
Gasoline	70	1·0

95 octane petrol typically contains 2·2% MTBE.

Which of the following would be true if ethanol was used instead of MTBE?

A More ethanol would be required and the petrol would cost less.

B More ethanol would be required and the petrol would cost more.

C Less ethanol would be required and the petrol would cost more.

D Less ethanol would be required and the petrol would cost less.

22. The table shows the octane numbers of four hydrocarbons.

Hydrocarbon	Octane Number
2-methylhexane	43
heptane	0
2,4-dimethylhexane	66
octane	−19

The octane number for 2,2,4-trimethylpentane is most likely to be

A 21

B 38

C 54

D 100.

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

A Solvents

B Perfumes

C Toothpastes

D Flavourings

24. Cured polyester resins

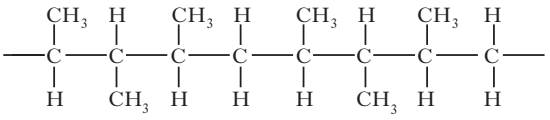
A are used as textile fibres

B are long chain molecules

C are formed by addition polymerisation

D have a three-dimensional structure with cross linking.

25. The structure of part of an addition polymer is shown.



Which pair of alkenes could be used as monomers to make this polymer?

A But-2-ene and ethene

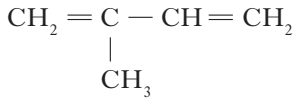
B But-2-ene and propene

C But-1-ene and ethene

D But-1-ene and propene

[Turn over

26. Natural rubber is a polymer of isoprene



The rubber formed will be

A a condensation polymer with hydrogen bonding between the molecules

B an addition polymer with hydrogen bonding between the molecules

C a condensation polymer with van der Waals' forces between the molecules

D an addition polymer with van der Waals' forces between the molecules.

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

A causes cross-linking between chains

B causes hydrolysis to occur

C increases the carbon chain length

D reduces the number of carbon-carbon double bonds.

28. The chemical indicator in a breath test kit turns from orange to green when a motorist is over the legal alcohol limit.

Which of the following indicators could have been used in a breath test kit?

A Acidified potassium dichromate

B Benedict's solution

C Fehling's solution

D Tollens' reagent

29. Which of the following compounds is **not** a raw material in the chemical industry?

A Benzene

B Iron ore

C Sodium chloride

D Water

30. Which of the following is produced by a batch process?

A Iron from iron ore

B Aspirin from salicylic acid

C Ammonia from nitrogen and hydrogen

D Sulphuric acid from sulphur and oxygen.

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

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

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

32. $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(\ell) \quad \Delta H_1$

$CH_3CHO(\ell) + 2½O_2(g) \rightarrow 2CO_2(g) + 2H_2O(\ell) \quad \Delta H_2$

$2O_3(g) \rightarrow 3O_2(g) \quad \Delta H_3$

The enthalpy change equal to $\Delta H_1 - \Delta H_2 + ½\Delta H_3$ is associated with the reaction

A $C_2H_4(g) + ½O_2(g) \rightarrow CH_3CHO(\ell)$

B $C_2H_4(g) + O_3(g) \rightarrow CH_3CHO(\ell) + O_2(g)$

C $C_2H_4(g) + 2O_3(g) \rightarrow CH_3CHO(\ell) + 2½O_2(g)$

D $C_2H_4(g) + 2½O_2(g) + CH_3CHO(\ell) + O_3(g) \rightarrow 4CO_2(g) + 4H_2O(\ell)$

33. 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

34. 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

35. Which of the following is the same for equal volumes of $0{\cdot}1\,mol\,l^{-1}$ solutions of sodium hydroxide and ammonia?

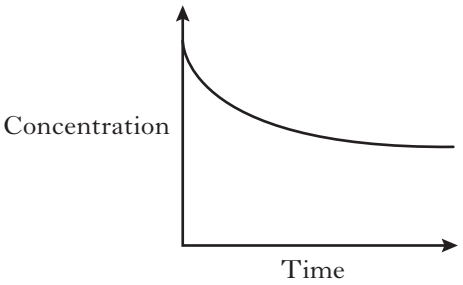
A The pH of solution

B The mass of solute present

C The conductivity of solution

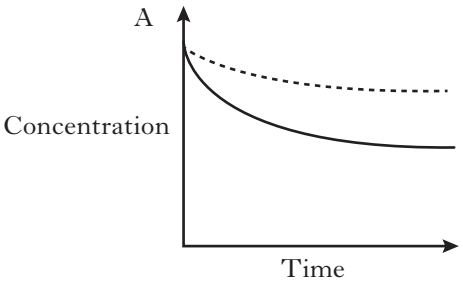
D The number of moles of hydrochloric acid needed for neutralisation

36. The graph represents the change in concentration of a reactant against time during a reversible chemical reaction.



In which diagram below does the dotted line show the result of repeating the reaction using a catalyst?

A



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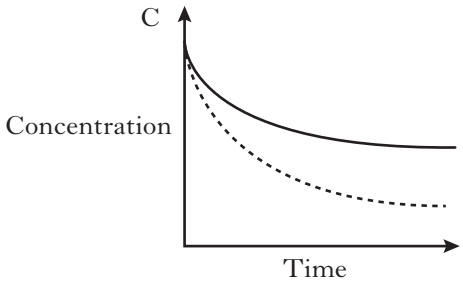

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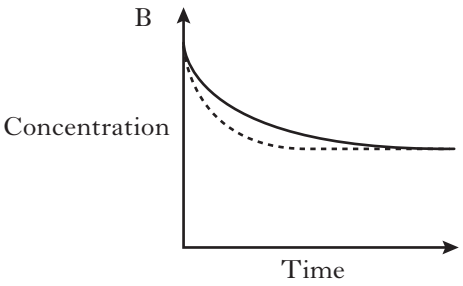

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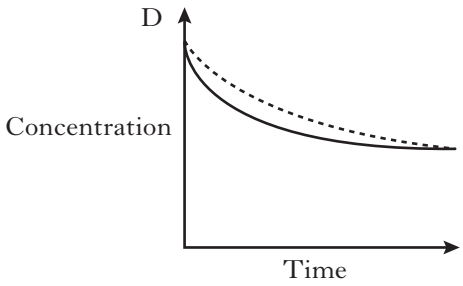


[Turn over

37. 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 Sulphide ions are acting as electron acceptors.

38. The conductivity of pure water is low because

A water molecules are polar

B only a few water molecules are ionised

C water molecules are linked by hydrogen bonds

D there are equal numbers of hydrogen and hydroxide ions in water.

39. Limestone was added to a loch to combat the effects of acid rain. The pH of the water rose from 4 to 6.

The concentration of the $H^+(aq)$

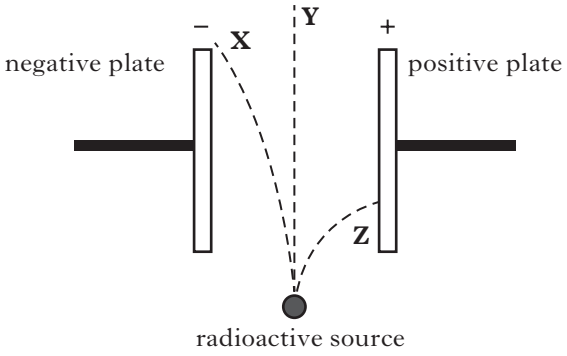
A increased by a factor of 2

B increased by a factor of 100

C decreased by a factor of 2

D decreased by a factor of 100.

40. The diagram shows the paths of alpha, beta and gamma radiations as they pass through an electric field.



Which line in the table correctly identifies the types of radiation which follow paths **X**, **Y** and **Z**?

	Path X	**Path Y**	**Path Z**
A	alpha	beta	gamma
B	beta	gamma	alpha
C	beta	alpha	gamma
D	alpha	gamma	beta

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

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**	**sulphur**
Bonding		covalent		covalent
Structure	lattice		molecular	

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

(*b*) What feature of the bonding in aluminium allows it to conduct electricity?

1

(*c*) Why is there a decrease in the size of atoms across the period from aluminium to sulphur?

1

(4)

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks

2. Petrol contains branched-chain hydrocarbons, which increase the efficiency of burning.

(*a*) Name the fraction from crude oil that is used to produce petrol.

1

(*b*) (i) 2,3,3-Trimethylpentane is a branched-chain hydrocarbon that is added to petrol to improve the burning efficiency.

Draw a full structural formula for this compound.

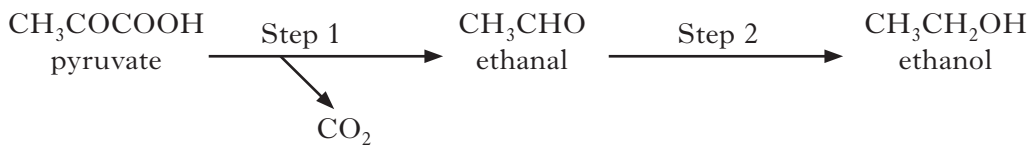
1

(ii) Name one other **type** of hydrocarbon that is also added to petrol to improve the efficiency of burning.

1

(*c*) 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 the enzyme, pyruvate decarboxylase.

State **two** factors that need to be considered when choosing the best temperature at which to carry out this reaction.

1

Marks

2. (*c*) continued

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

1

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

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

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

Show your working clearly

2

(7)

[Turn over

DO NOT WRITE IN THIS MARGIN

Marks

3. (*a*) A student was asked to plan a procedure for a Prescribed Practical Activity (**PPA**).

The student's plan is shown.

Aim

To find the effect of changing the concentration of iodide ions on the rate of reaction between hydrogen peroxide and an acidified solution of potassium iodide.

Procedure

1. *Using 100 cm^3 measuring cylinders, measure out 10 cm^3 of sulphuric acid, 10 cm^3 of sodium thiosulphate solution, 1 cm^3 of starch solution and 25 cm^3 of potassium iodide solution. Pour these into a dry 100 cm^3 glass beaker and place the beaker on the bench.*
2. *Measure out 5 cm^3 of hydrogen peroxide solution and start the timer.*
3. *Add the hydrogen peroxide solution to the beaker. When the blue/black colour just appears, stop the timer and record the time (in seconds).*
4. *Repeat this procedure four times but each time use a different concentration of potassium iodide solution.*

(i) In step 4 of the procedure, what should be done to obtain potassium iodide solutions of different concentration?

1

(ii) State **two** improvements that could be made to the student's planned procedure.

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 a condition necessary for the collisions to result in the formation of products.

1

(3)

DO NOT WRITE IN THIS MARGIN

Marks

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

The boiling point of hydrogen fluoride, HF, is much higher than the boiling point of fluorine, 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.

2

(*b*) Hydrogen fluoride dissolves in water to form the weak acid, hydrofluoric acid.

Dilute hydrofluoric acid reacts with sodium hydroxide solution to produce a solution of the salt sodium fluoride.

Suggest a pH for a solution of sodium fluoride.

1

(3)

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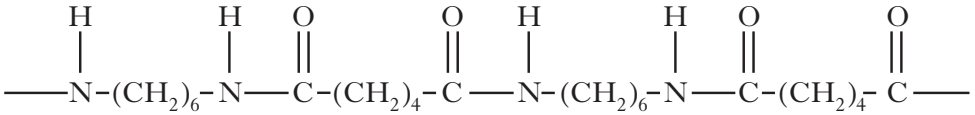
5. (*a*) The polymer nylon was first synthesised by Wallace Carothers in 1935.

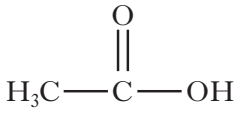
Part of the structure of nylon is shown.



(i) What **type** of polymerisation produces nylon?

1

(ii) During the manufacture of nylon, ethanoic acid can be added to the process to ensure that the polymer chains do not become too long.



ethanoic acid

Why does adding ethanoic acid limit the polymer chain length?

1

(*b*) Wallace Carothers' earlier research work involved the polymerisation of alkynes. This included making poly(ethyne).

Poly(ethyne) can be treated to make a polymer with an unusual property.

What is this unusual property?

1

(3)

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Marks

6. Methyl orange indicator, $C_{14}H_{15}N_3SO_3$, is a weak acid.

The equilibrium in solution is shown.

$$\underset{\text{red}}{C_{14}H_{15}N_3SO_3(aq)} \rightleftharpoons \underset{\text{yellow}}{C_{14}H_{14}N_3SO_3^-(aq)} + H^+(aq)$$

Explain fully the colour that would be observed when the indicator is added to dilute sodium hydroxide solution.

2

[Turn over

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Marks

7. Carbon-14 is a radioactive isotope of carbon.

It is produced in the upper atmosphere when nitrogen-14 atoms are bombarded by neutrons from space. If a neutron is captured by a nitrogen-14 nucleus, a carbon-14 isotope is produced along with one other particle.

(*a*) Complete the nuclear equation for the formation of carbon-14.

$$^{14}_{7}\mathrm{N} \quad + \quad ^{1}_{0}\mathrm{n} \quad \rightarrow \quad ^{14}_{6}\mathrm{C} \quad +$$

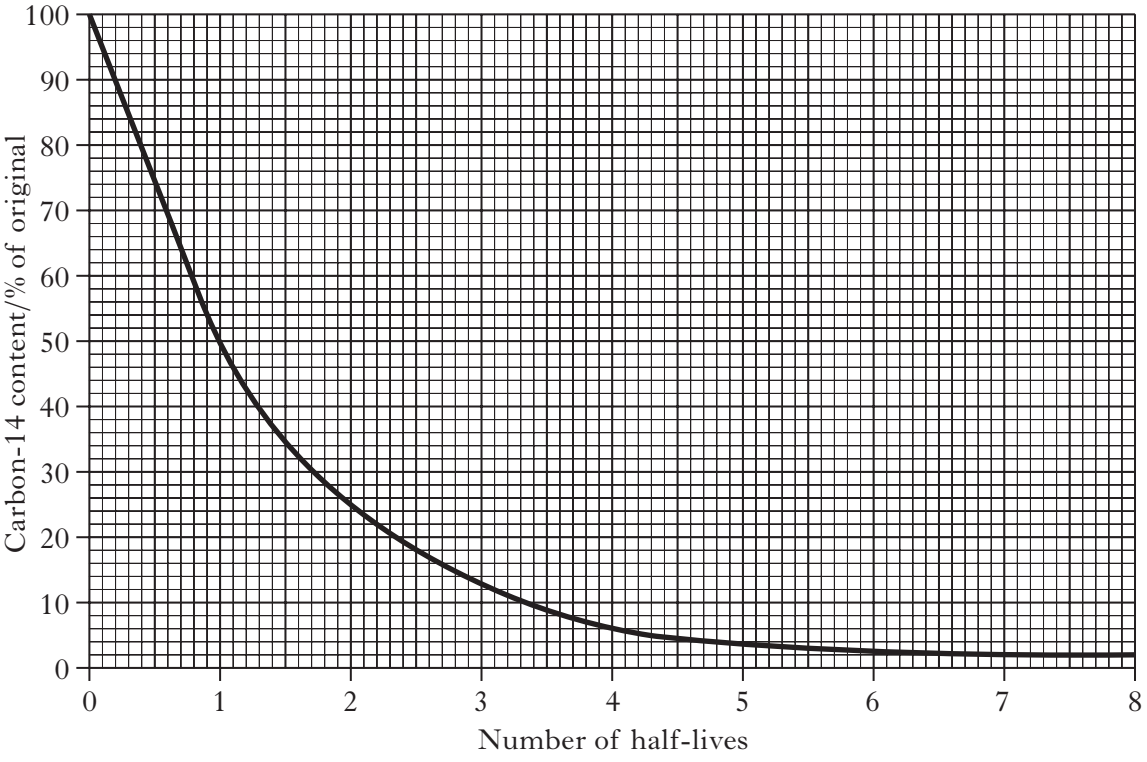
1

(*b*) Carbon-14 decays by beta emission. Why does the atomic number increase by one unit when a carbon-14 nucleus decays?

1

(*c*) Carbon dating can be used to estimate the age of wood found in archaeological sites.

The decay curve shows the decrease in the percentage of carbon-14 against the number of half-lives.



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Marks

7. (*c*) continued

(i) A piece of wood was found to contain 5% of the original carbon-14 content. The half-life of carbon-14 is 5700 years. Calculate the age of the wood, in years.

1

(ii) Suggest a reason why carbon-14 is unsuitable for dating samples that are more than 50 000 years old.

1

(4)

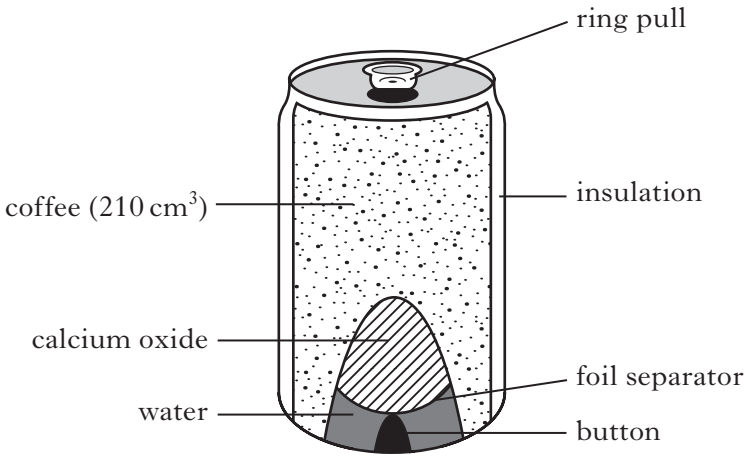
[Turn over

Marks

8. 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:

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

(*a*) 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.

2

DO NOT WRITE IN THIS MARGIN

Marks

8. continued

(*b*) 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

(4)

[Turn over

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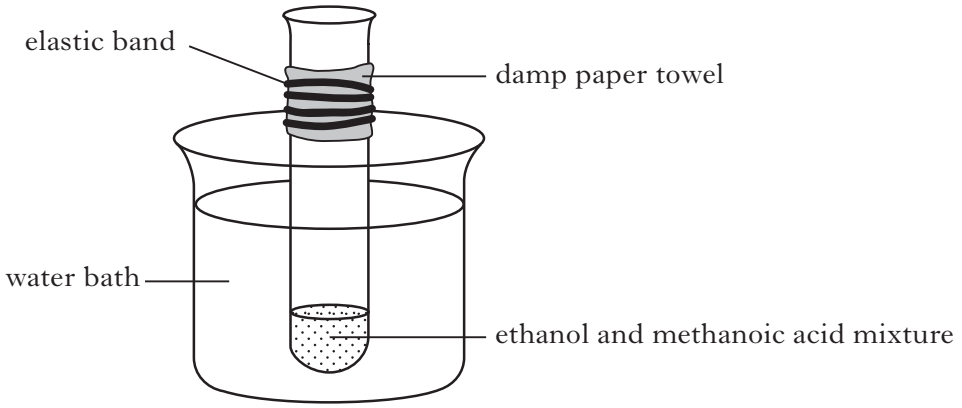
Marks

9. (*a*) An ester can be prepared from a mixture of ethanol and methanoic acid.



(i) Name another substance that should be added to the mixture.

1

(ii) Why should the reaction mixture be heated using a water bath and not a Bunsen burner?

1

(iii) Draw a structural formula for the ester that would be produced in this reaction.

1

(*b*) Sodium methanoate is a food additive (E237). It can be prepared by reacting chloroform, $CHCl_3$, with sodium hydroxide.

$$CHCl_3(\ell) + NaOH(aq) \rightarrow HCOONa(aq) + NaCl(aq) + H_2O(\ell)$$

Balance this equation.

1

(4)

DO NOT WRITE IN THIS MARGIN

10. Ammonia is produced by the Haber process from nitrogen and hydrogen in the presence of an iron catalyst.

Marks

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\ mol^{-1}$$

(*a*) Name the **type** of catalysis taking place in the Haber process.

1

(*b*) The source of hydrogen gas for the Haber process is methane. Methane is steam-reformed to produce carbon monoxide and hydrogen.

$$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$$

The carbon monoxide is further reacted with steam to produce carbon dioxide and hydrogen.

$$CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$$

Write the overall equation for the reforming process.

1

(*c*) An alternative source of hydrogen involves the electrolysis of water.

(i) Calculate the volume, in litres, of hydrogen produced when a current of 200 A is passed through acidified water for 30 minutes.

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

The ion-electron equation for the process is:

$$2H^+(aq) + 2e^- \rightarrow H_2(g)$$

2

(ii) **In terms of the products**, suggest an advantage of producing hydrogen by electrolysis of water rather than by steam reforming of methane.

1

(5)

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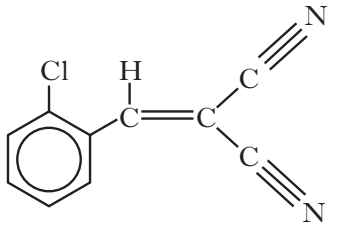
Marks

11. The active chemical in CS spray was developed by two chemists, Corson and Stoughton, after whom it is named.

(*a*) The active "CS" chemical has the structure shown.

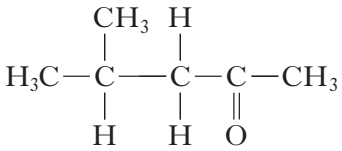


The molecular formula for this compound can be written as $C_wH_xN_yCl_z$.

Give the values for w, x, y and z.

w = x = y = z = **1**

(*b*) The solvent used in CS spray is commonly known as MiBK and has the structure shown.



Give the systematic name for this solvent.

1

(*c*) The propellant gas in a CS canister is nitrogen.

Previously, CFCs were widely used as the propellant gases for many sprays.

Why was the use of CFCs discontinued?

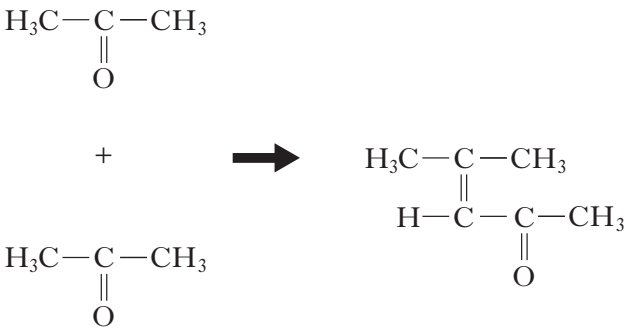
1

Marks

11. (continued)

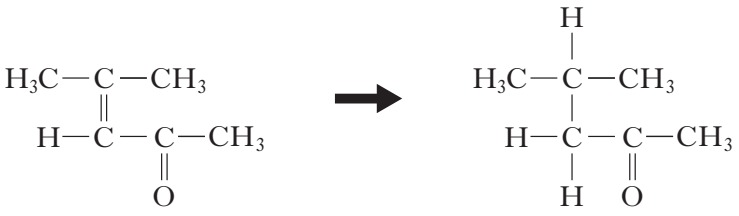
(*d*) The MiBK solvent is manufactured from propanone as shown in the following reaction sequence.

Step 1 Two molecules of propanone react



In this reaction the carbon to carbon double bond forms between the carbonyl group of one molecule and the α-carbon of the second molecule (the α-carbon is the carbon adjacent to the carbonyl group).

Step 2



MiBK

(i) What is the name for the type of addition reaction taking place in **Step 2**?

1

(ii) Draw the product formed at the end of **Step 1** when a molecule of propanone reacts with a molecule of methanal.

propanone methanal

1

(5)

DO NOT WRITE IN THIS MARGIN

Marks

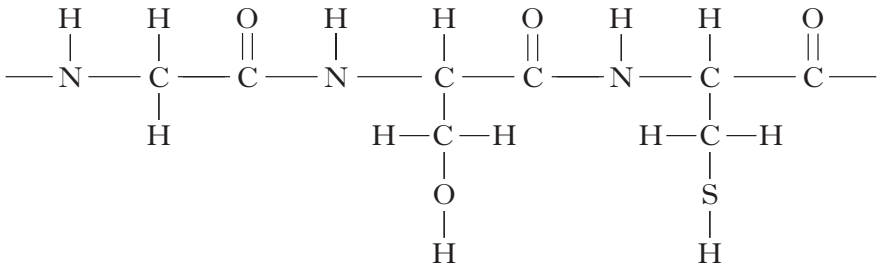
12. Proteins are made from monomers called amino acids.

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

(*a*) What **type** of protein is keratin?

1

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

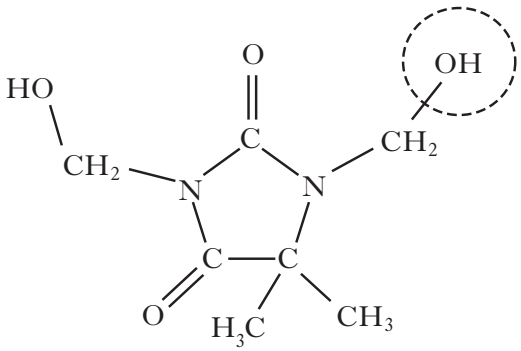


Circle a peptide link in the structure. **1**

(*c*) 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

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Marks

12. (continued)

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

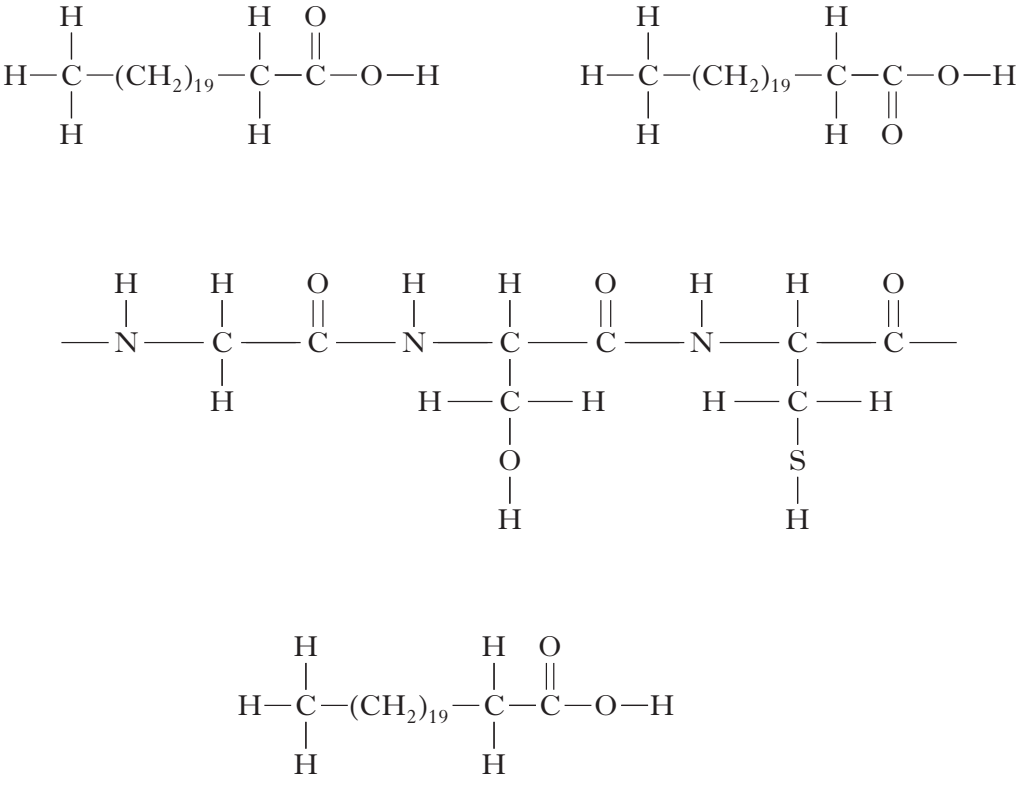
Behenic acid is produced by hydrolysing the edible oil, ben oil.

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

1

(ii) When conditioner containing behenic acid is applied to hair, the behenic acid molecules make 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.



1

(5)

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

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

To determine the vitamin C content in a 1·0 litre carton of orange juice, three separate 20 cm^3 samples of the juice were titrated with a 0·00125 mol l^{-1} iodine solution. Starch indicator was used to determine the endpoint.

(*a*) The iodine solution is dark brown in colour which makes reading the scale on the burette difficult.

How can this difficulty be overcome?

1

(*b*) What colour indicates the endpoint of the titration?

1

(*c*) The following results were obtained from titration of the three 20 cm^3 samples of orange juice.

Titration	Volume of 0·00125 mol l^{-1} iodine solution used/cm^3
1	26·3
2	25·5
3	25·3

Average volume of iodine solution used = 25·4 cm^3

Suggest why the volume of iodine solution added in the first titration was higher than that added in the other two titrations.

1

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Marks

13. (continued)

(*d*) $C_6H_8O_6(aq) + I_2(aq) \rightarrow C_6H_6O_6(aq) + 2H^+(aq) + 2I^-(aq)$

vitamin C

1 mol 1 mol

Calculate the mass, in grams, of vitamin C, in the 1·0 litre carton of orange juice.

(mass of 1 mole vitamin C = 176 g)

Show your working clearly.

2

(5)

[Turn over

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Marks

14. 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 explosion it decomposes as shown.

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

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

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

Show your working clearly

2

14. (continued) *Marks*

(*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**

(3)

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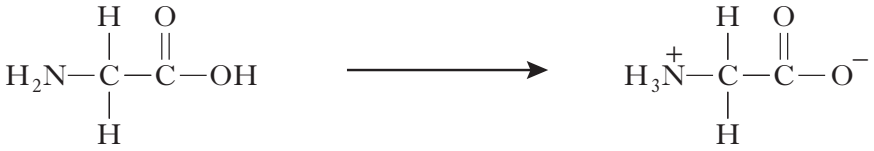
Marks

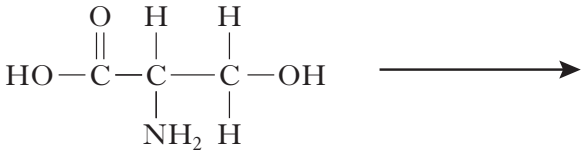
15. In solution, amino acid molecules can form zwitterions when a hydrogen ion moves from the carboxyl group onto the amino group.

For example,



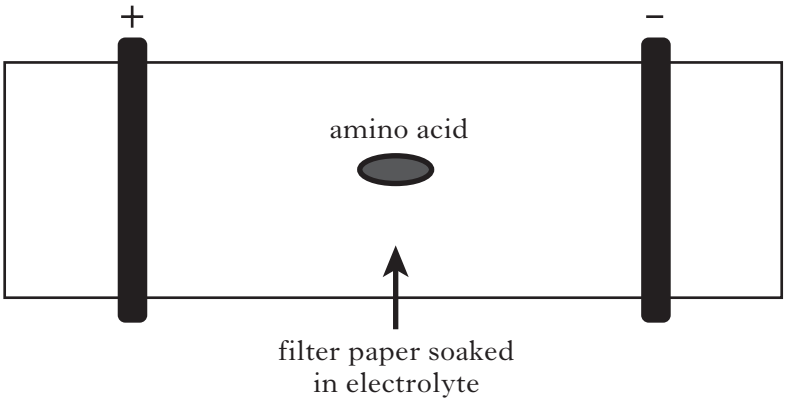
glycine — glycine zwitterion

(*a*) Draw the zwitterion produced by the amino acid serine.



serine — serine zwitterion **1**

(*b*) Having both positive and negative charges, an amino acid zwitterion is electrically neutral and will not move if placed between oppositely charged electrodes.



Zwitterions only exist at a specific pH, which varies for each amino acid. This specific pH is called the isoelectric point (IEP). At pH's higher than the IEP, amino acids in solution exist as negative ions and move towards the positive electrode. At pH's lower than the IEP, they exist as positive ions and move towards the negative electrode.

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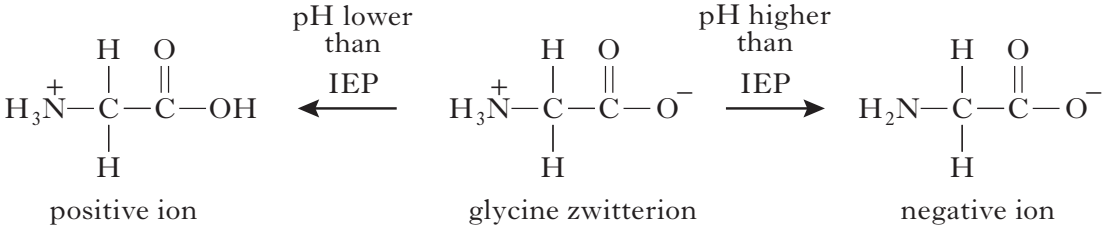
15. (*b*) continued

For example,



Lysine is an amino acid with an IEP of pH 9·7.

Explain clearly whether lysine would be attracted to the positive or negative electrode in a $1{\cdot}0 \times 10^{-5}$ mol l^{-1} sodium hydroxide solution.

2

(3)

[*END OF QUESTION PAPER*]

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ADDITIONAL SPACE FOR ANSWERS

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