National
Qualifications
2015

X713/76/02

Chemistry
Section 1 — Questions

THURSDAY, 28 MAY
1:00 PM – 3:30 PM

Instructions for the completion of Section 1 are given on *Page two* of your question and answer booklet X713/76/01.

Record your answers on the answer grid on *Page three* of your question and answer booklet.

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

Before leaving the examination room you must give your question and answer booklet to the Invigilator; if you do not you may lose all the marks for this paper.

SECTION 1 — 20 marks

Attempt ALL questions

1. The elements nitrogen, oxygen, fluorine and neon

A can form negative ions

B are made up of diatomic molecules

C have single bonds between the atoms

D are gases at room temperature.

2. Which of the following equations represents the first ionisation energy of fluorine?

A $F^-(g) \rightarrow F(g) + e^-$

B $F^-(g) \rightarrow \frac{1}{2}F_2(g) + e^-$

C $F(g) \rightarrow F^+(g) + e^-$

D $\frac{1}{2}F_2(g) \rightarrow F^+(g) + e^-$

3. Which of the following atoms has least attraction for bonding electrons?

A Carbon

B Nitrogen

C Phosphorus

D Silicon

4. Which of the following is **not** an example of a van der Waals' force?

A Covalent bond

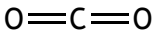
B Hydrogen bond

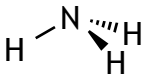
C London dispersion force

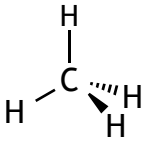
D Permanent dipole – permanent dipole attraction

5. Which of the following has more than one type of van der Waals' force operating between its molecules in the liquid state?

A 

B 

C 

D 

6. Oil molecules are more likely to react with oxygen in the air than fat molecules.

During the reaction the oil molecules

A are reduced

B become rancid

C are hydrolysed

D become unsaturated.

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

A Propanol and sodium ethanoate

B Ethanoic acid and sodium propanoate

C Sodium hydroxide and propyl ethanoate

D Sodium hydroxide and ethyl propanoate

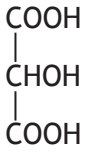
8. Oils contain carbon to carbon double bonds which can undergo addition reactions with iodine.

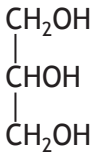
The iodine number of an oil is the mass of iodine in grams that will react with 100 g of oil.

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

	Oil	*Iodine number*
A	Corn	123
B	Linseed	179
C	Olive	81
D	Soya	130

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

A 

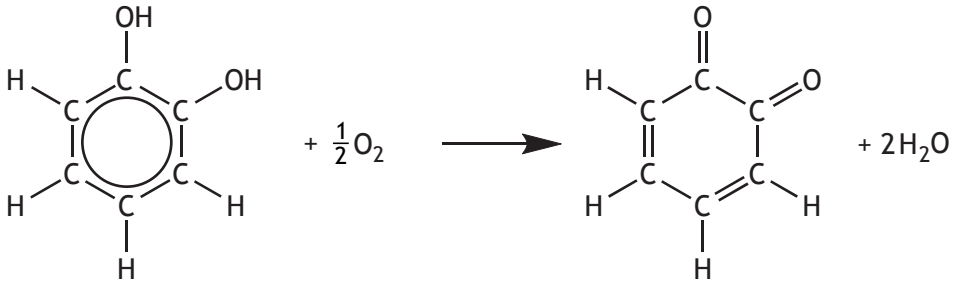
B 

C $C_{17}H_{35}COOH$

D $C_{17}H_{33}COOH$

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

One reaction taking place is:



Which of the following correctly describes the above reaction?

A Oxidation

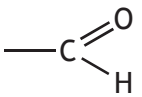
B Reduction

C Hydrolysis

D Condensation

11. Which of the following statements is correct for ketones?

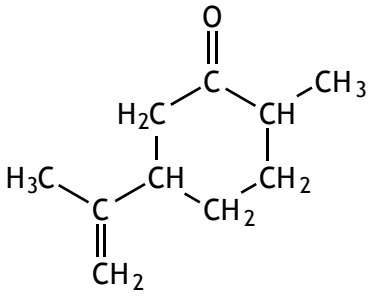
A They are formed by oxidation of tertiary alcohols.

B They contain the group  .

C They contain a carboxyl group.

D They will not react with Fehling's solution.

12. Carvone is a natural product that can be extracted from orange peel.

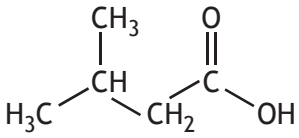


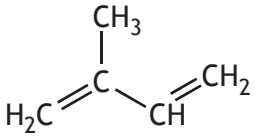
Carvone

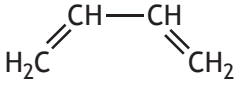
Which line in the table correctly describes the reaction of carvone with bromine solution and with acidified potassium dichromate solution?

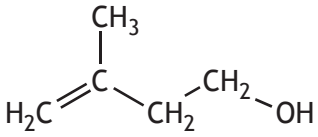
	Reaction with bromine solution	*Reaction with acidified potassium dichromate solution*
A	no reaction	no reaction
B	no reaction	orange to green
C	decolourises	orange to green
D	decolourises	no reaction

13. The structure of isoprene is

A 

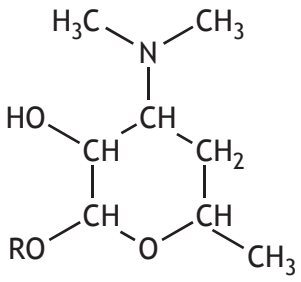
B 

C 

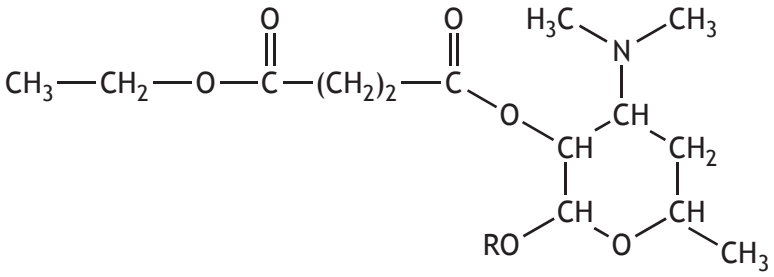
D 

[Turn over

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



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



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

A Alcohol

B Aldehyde

C Carboxylic acid

D Ketone

15. Which of the following is an isomer of 2,2-dimethylpentan-1-ol?

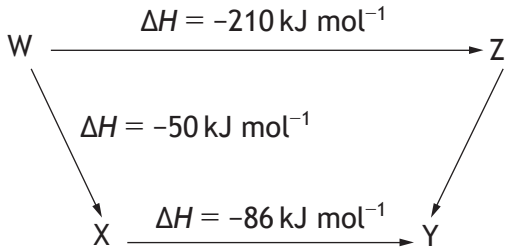
A $CH_3CH_2CH_2CH(CH_3)CH_2OH$

B $(CH_3)_3CCH(CH_3)CH_2OH$

C $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2OH$

D $(CH_3)_2CHC(CH_3)_2CH_2CH_2OH$

16. 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.

[Turn over

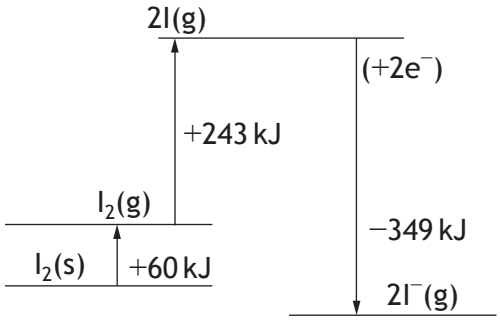
17. $I_2(s) \rightarrow I_2(g)$ $\Delta H = +60\ kJ\ mol^{-1}$

$I_2(g) \rightarrow 2I(g)$ $\Delta H = +243\ kJ\ mol^{-1}$

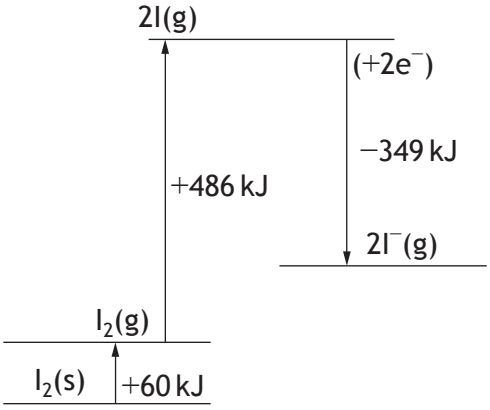
$I(g) + e^- \rightarrow I^-(g)$ $\Delta H = -349\ kJ\ mol^{-1}$

Which of the following would show the energy diagram for $I_2(s) + 2e^- \rightarrow 2I^-(g)$?

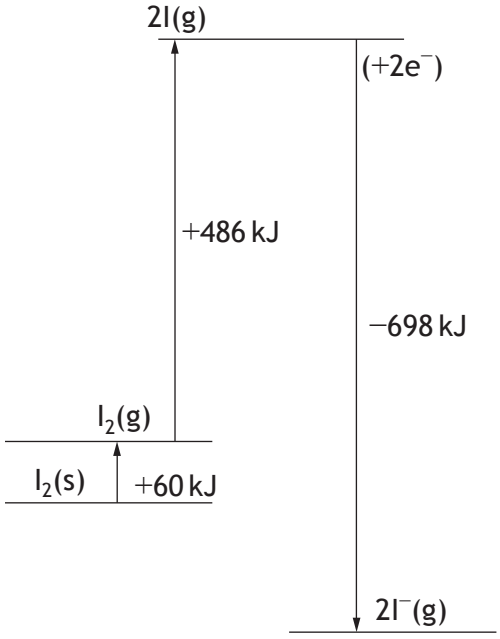
A



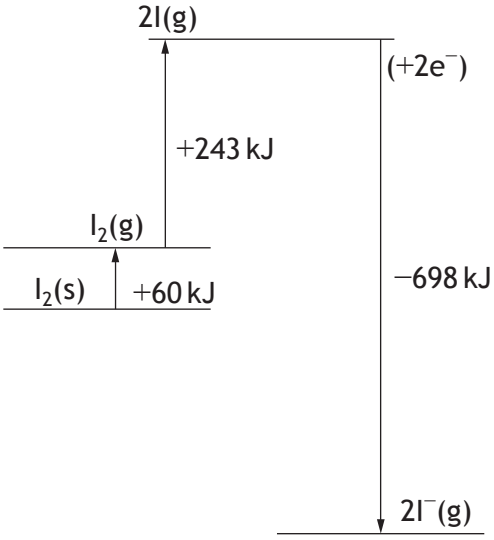
B



C



D



18. Which of the following statements regarding a chemical reaction at equilibrium is always correct?

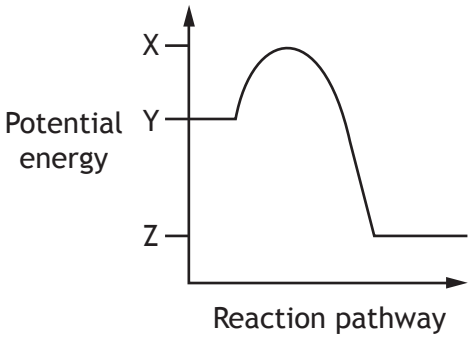
A The rates of the forward and reverse reactions are equal.

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 the equilibrium.

19. 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.

20. Which of the following will react with Br_2 but **not** with I_2?

A OH^-

B SO_3^{2-}

C Fe^{2+}

D Mn^{2+}

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET.]

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FOR OFFICIAL USE

National Qualifications 2015

Mark

X713/76/01

Chemistry
Section 1 — Answer Grid and Section 2

THURSDAY, 28 MAY

1:00 PM – 3:30 PM

X7137601

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day | Month | Year

Scottish candidate number

Total marks — 100

SECTION 1 — 20 marks

Attempt ALL questions.

Instructions for completion of Section 1 are given on *Page two*.

SECTION 2 — 80 marks

Attempt ALL questions

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

Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. You should score through your rough work when you have written your final copy.

Use **blue** or **black** ink.

Before leaving the examination room you must give this booklet to the Invigilator; if you do not you may lose all the marks for this paper.

SQA ©

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SECTION 1— 20 marks

The questions for Section 1 are contained in the question paper X713/76/02.
Read these and record your answers on the answer grid on *Page three* opposite.
Use **blue** or **black** ink. Do NOT use gel pens or pencil.

1. The answer to each question is **either** A, B, C or D. Decide what your answer is, then fill in the appropriate bubble (see sample question below).

2. There is **only one correct** answer to each question.

3. Any rough working should be done on the additional space for answers and rough work at the end of this booklet.

Sample Question

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

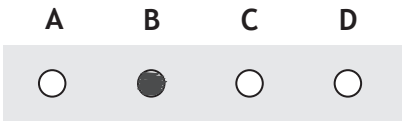
A fractional distillation

B chromatography

C fractional crystallisation

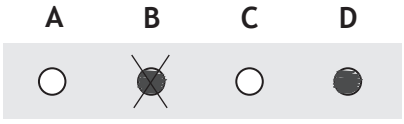
D filtration.

The correct answer is **B**—chromatography. The answer **B** bubble has been clearly filled in (see below).

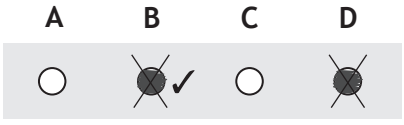


Changing an answer

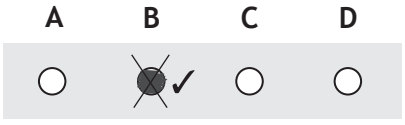
If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.



If you then decide to change back to an answer you have already scored out, put a tick (✓) to the **right** of the answer you want, as shown below:



or



SECTION 1 — Answer Grid

OBJ20AD1

	A	B	C	D
1	○	○	○	○
2	○	○	○	○
3	○	○	○	○
4	○	○	○	○
5	○	○	○	○
6	○	○	○	○
7	○	○	○	○
8	○	○	○	○
9	○	○	○	○
10	○	○	○	○
11	○	○	○	○
12	○	○	○	○
13	○	○	○	○
14	○	○	○	○
15	○	○	○	○
16	○	○	○	○
17	○	○	○	○
18	○	○	○	○
19	○	○	○	○
20	○	○	○	○

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[Turn over for Question 1 on *Page six*

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MARKS DO NOT WRITE IN THIS MARGIN

SECTION 2 — 80 marks

Attempt ALL questions

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

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

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

2

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

(i) Draw a possible structure for P_4S_3. **1**

(ii) Explain why the covalent radius of sulfur is smaller than that of phosphorus. **1**

MARKS | DO NOT WRITE IN THIS MARGIN

1. (b) (continued)

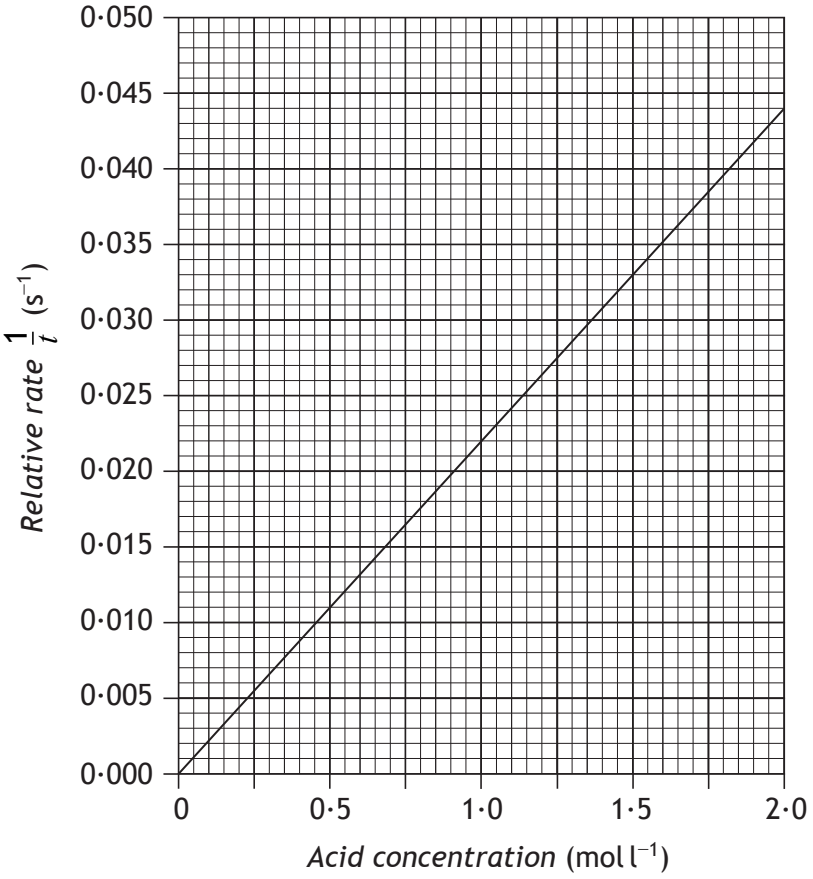
(iii) The melting point of sulfur is much higher than that of phosphorus.

Explain fully, in terms of the structures of sulfur and phosphorus molecules and the intermolecular forces between molecules of each element, why the melting point of sulfur is much higher than that of phosphorus. **3**

[Turn over

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.

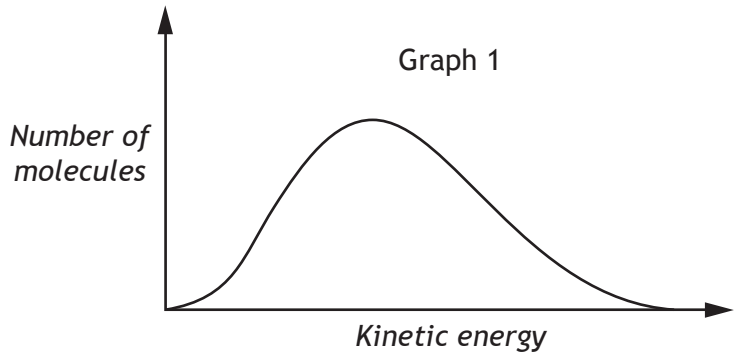


Use information from the graph to calculate the reaction time, in seconds, when the concentration of the acid was 1·0 mol l^{-1}. **1**

2. (continued)

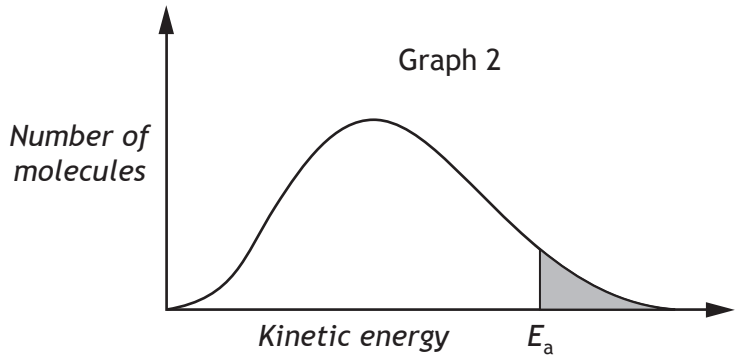
(b) The rate of reaction can also be altered by changing the temperature or using a catalyst.

(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**

[Turn over

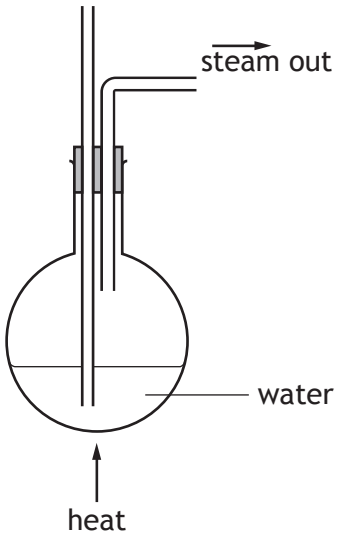
MARKS | DO NOT WRITE IN THIS MARGIN

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

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

(i) Complete the diagram to show an apparatus suitable for carrying out this extraction. **2**

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



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

Suggest a technique that could be used to separate the mixture into pure compounds. **1**

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

cinnamic acid	+	methanol	→	methyl cinnamate	+	water
mass of one mole = 148 g		mass of one mole = 32 g		mass of one mole = 162 g		

6·5 g of cinnamic acid was reacted with 2·0 g of methanol.

3. (b) (continued)

(i) Show, by calculation, that cinnamic acid is the limiting reactant. (One mole of cinnamic acid reacts with one mole of methanol.) **2**

(ii) (A) The student obtained 3·7 g of methyl cinnamate from 6·5 g of cinnamic acid.

Calculate the percentage yield. **2**

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

Cinnamic acid costs £35·00 per 250 g.

Calculate the cost of cinnamic acid needed to produce 100 g of methyl cinnamate. **2**

[Turn over

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

One way to identify if a perfume is counterfeit is to use gas chromatography. Shown below are gas chromatograms from a brand name perfume and two different counterfeit perfumes. Some of the peaks in the brand name perfume have been identified as belonging to particular compounds.

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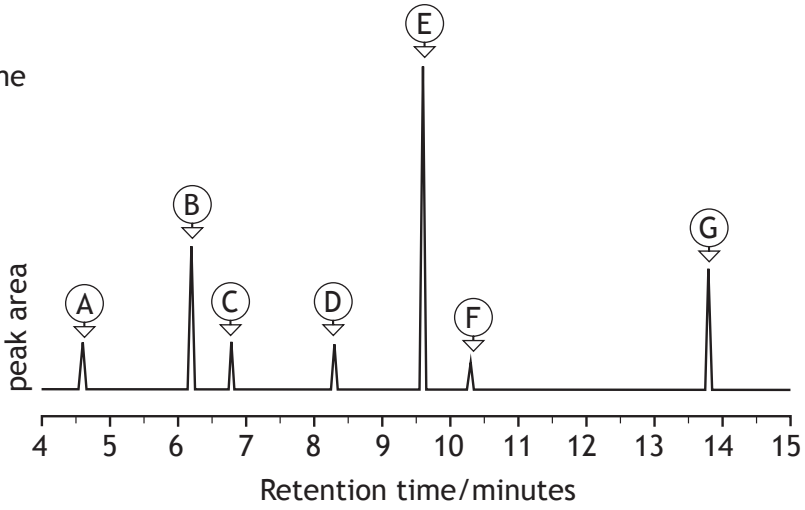
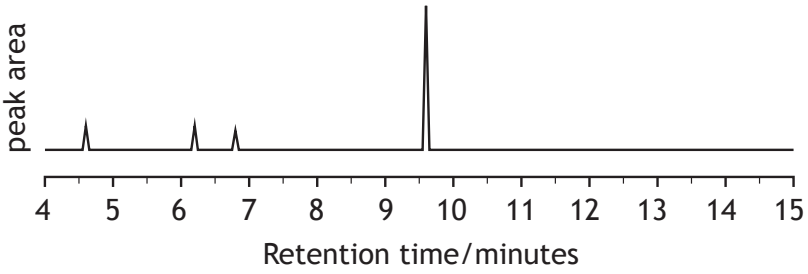
Brand name perfume

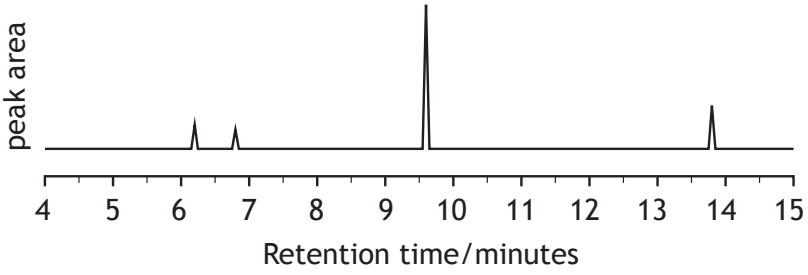


(A) linalool
(B) citronellol
(C) geraniol
(D) eugenol
(E) anisyl alcohol
(F) coumarin
(G) benzyl salicylate

Counterfeit A



Counterfeit B



4. (continued)

(a) Identify one compound present in the brand name perfume that appears in both counterfeit perfumes. **1**

(b) Some compounds in the brand name perfume are not found in the counterfeit perfumes. State another difference that the chromatograms show between the counterfeit perfumes and the brand name perfume. **1**

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

(i) Suggest why helium is used. **1**

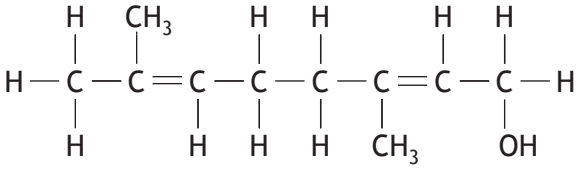
(ii) Apart from the polarity of the molecules, state another factor that would affect the retention time of molecules during gas chromatography. **1**

4. (continued)

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

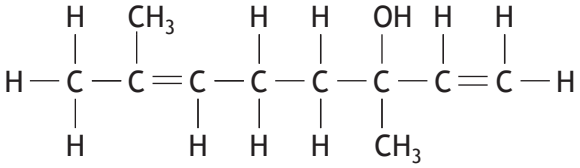
(i) State the name that is given to molecules consisting of joined isoprene units. **1**

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



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

Linalool can also be present. Its structural formula is shown.



(A) State the systematic name for linalool. **1**

(B) Explain why linalool can be classified as a tertiary alcohol. **1**

4. (continued)

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

The European Food Safety Authority gives a tolerable daily intake of coumarin at 0·10 mg per kilogram of body weight.

1·0 kg of cinnamon powder from a particular source contains 4·4 g of coumarin. Calculate the mass of cinnamon powder, in g, which would need to be consumed by an adult weighing 75 kg to reach the tolerable daily intake. **2**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

5. Patterns in the Periodic Table

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

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

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

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

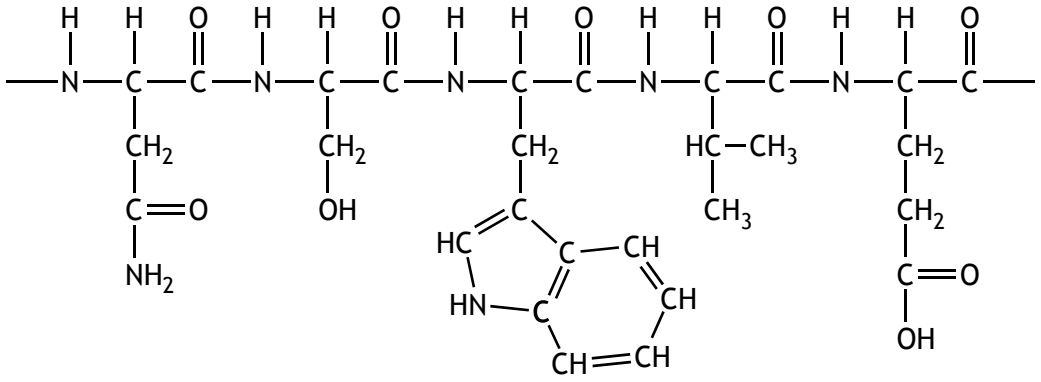
Using your knowledge of chemistry, comment on similarities and differences in the patterns of physical and chemical properties of elements in both Group 1 and Group 4. **3**

6. Uncooked egg white is mainly composed of dissolved proteins. During cooking processes, the proteins become denatured as the protein chains unwind, and the egg white solidifies.

(a) Explain why the protein chains unwind. **1**

(b) The temperature at which the protein becomes denatured is called the melting temperature. The melting temperature of a protein can be determined using fluorescence. In this technique, the protein is mixed with a dye that gives out visible light when it attaches to hydrophobic parts of the protein molecule. The hydrophobic parts of the structure are on the inside of the protein and the dye has no access to them unless the protein unwinds.

(i) Ovalbumin is a protein found in egg white. Part of the structure of unwound ovalbumin is shown below.

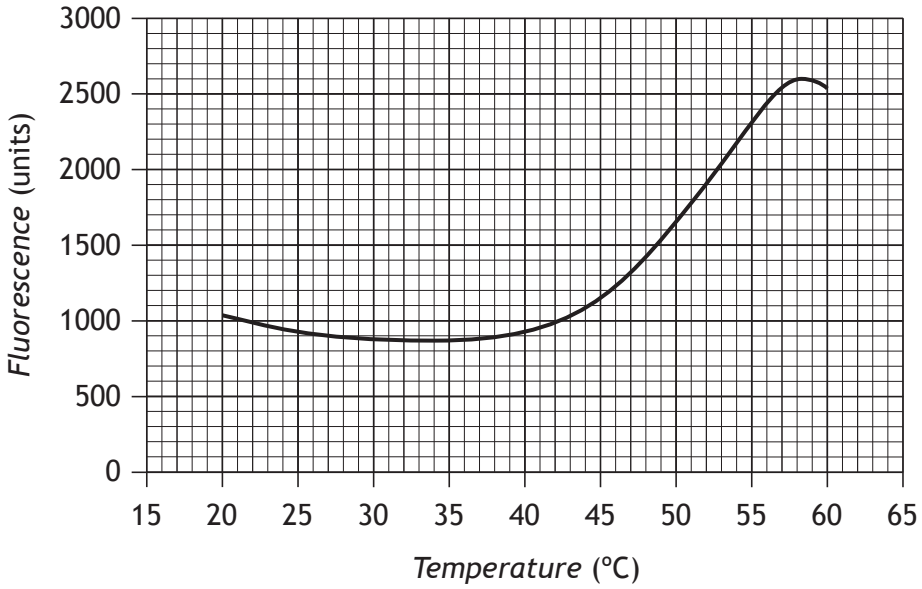


Circle the part of the structure to which the hydrophobic dye is most likely to attach. **1**

[Turn over

6. (b) (continued)

(ii) Another protein in egg white is conalbumin. The temperature of a conalbumin/dye mixture is gradually increased. The fluorescence is measured and a graph is produced.



The melting temperature is the temperature at which the fluorescence is halfway between the highest and lowest fluorescence values.

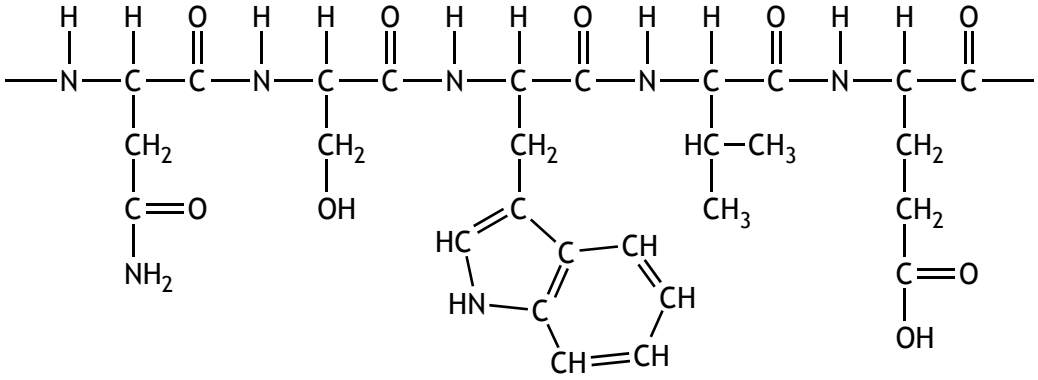
Determine the melting temperature, in °C, for this protein. **1**

6. (continued)

(c) Once cooked and eaten, the digestive system breaks the protein chains into amino acids with the help of enzymes.

(i) State the name of the digestion process where enzymes break down proteins into amino acids. **1**

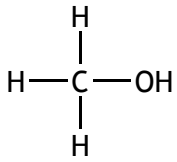
(ii)



(A) State how many amino acid molecules joined to form this section of protein. **1**

(B) Draw the structure of one amino acid that would be produced when this section of the protein chain is broken down. **1**

7. Methanol can be used as a fuel, in a variety of different ways.



(a) An increasingly common use for methanol is as an additive in petrol.

Methanol has been tested as an additive in petrol at 118 g per litre of fuel.

Calculate the volume of carbon dioxide, in litres, that would be released by combustion of 118 g of methanol.

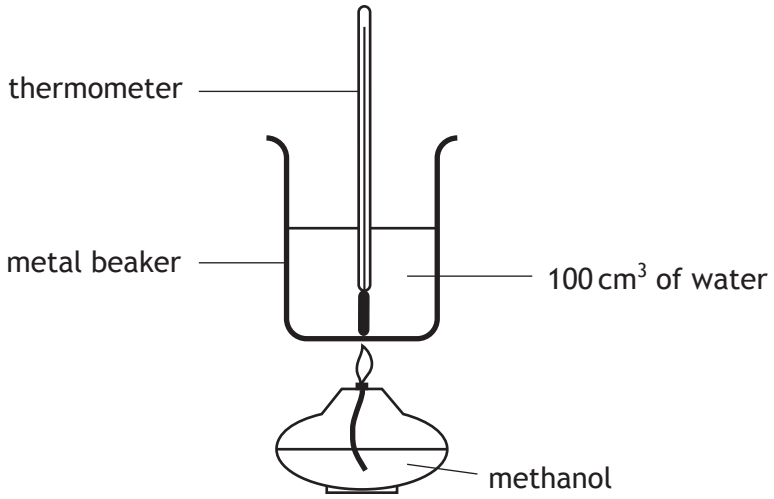
$$2CH_3OH(\ell) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(\ell)$$

(Take the molar volume of carbon dioxide to be 24 litres mol^{-1}). **2**

7. (continued)

(b) A student investigated the properties of methanol and ethanol.

(i) The student carried out experiments to determine the enthalpy of combustion of the alcohols.



(A) The student carried out the first experiment as shown, but was told to repeat the experiment as the thermometer had been placed in the wrong position.

Suggest why the student's placing of the thermometer was incorrect. **1**

(B) The student always used 100 cm^3 of water.

State another variable that the student should have kept constant. **1**

[Turn over

7. (b) (i) (continued)

(C) The student burned 1·07 g of methanol and recorded a temperature rise of 23 °C.

Calculate the enthalpy of combustion, in kJ mol^{-1}, for methanol using the student's results. **3**

(ii) The student determined the density of the alcohols by measuring the mass of a volume of each alcohol.

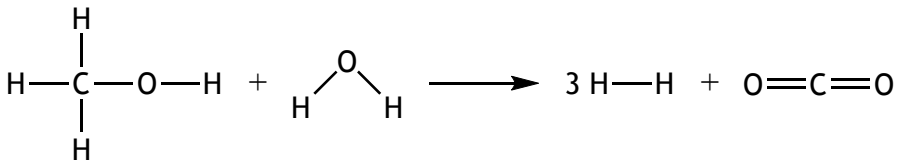
The student's results are shown below.

	Methanol	*Ethanol*
Volume of alcohol (cm^3)	25·0	25·0
Mass of alcohol (g)	19·98	20·05
Density of alcohol (g cm^{-3})		0·802

Calculate the density, in g cm^{-3}, of methanol. **1**

7. (continued)

(c) Methanol is used as a source of hydrogen for fuel cells. The industrial process involves the reaction of methanol with steam.



(i) State why it is important for chemists to predict whether reactions in an industrial process are exothermic or endothermic. **1**

(ii) Using bond enthalpies from the data booklet, calculate the enthalpy change, in $kJ\,mol^{-1}$, for the reaction of methanol with steam. **2**

[Turn over

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

MARKS | DO NOT WRITE IN THIS MARGIN

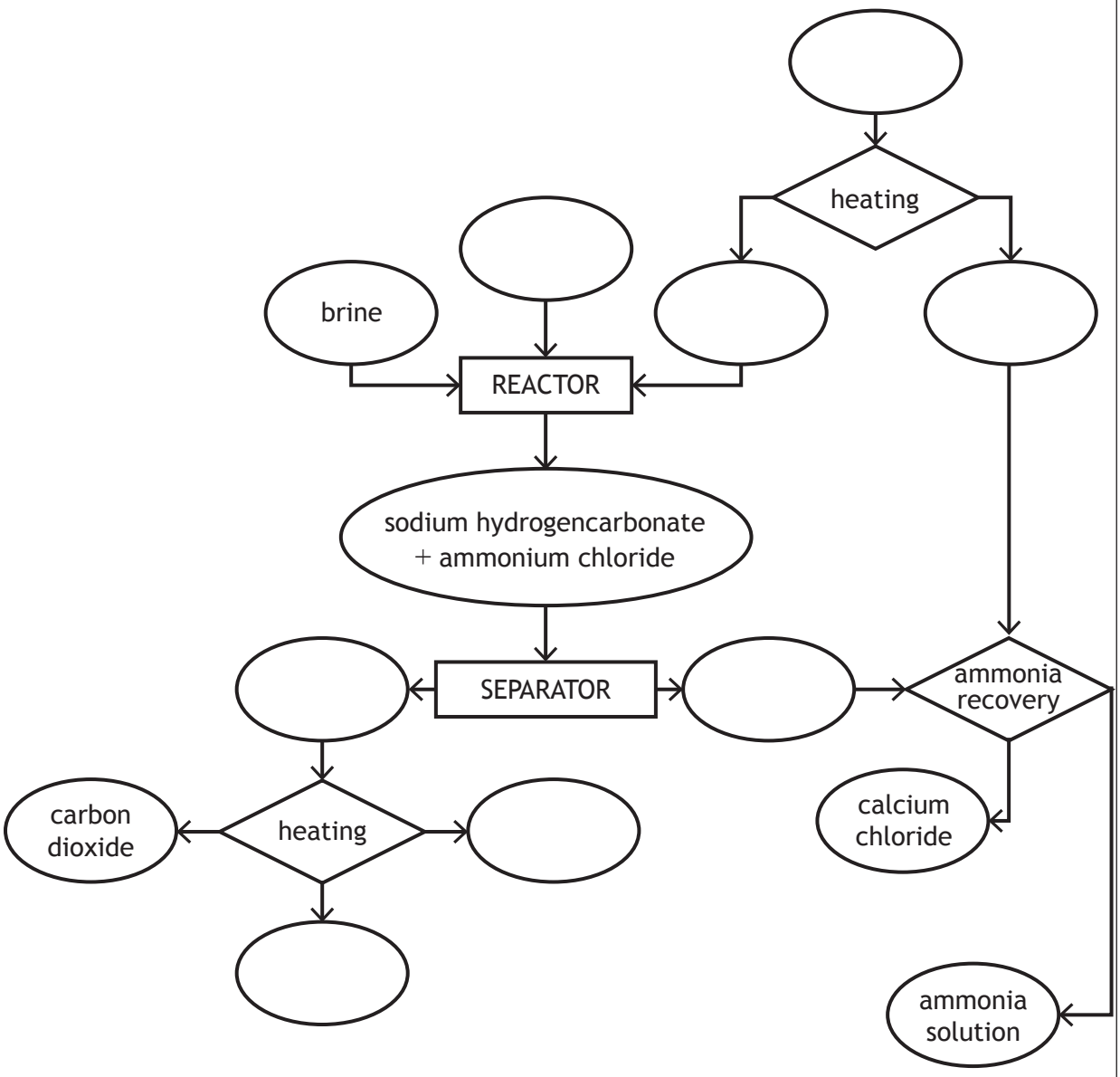
One industrial process used to make sodium carbonate is the Solvay process.

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.

(a) Using the information above, complete the flow chart by adding the names of the chemicals involved. **2**



8 (continued)

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

$$HCO_3^-(aq) + Na^+(aq) \rightleftharpoons NaHCO_3(s)$$

Brine is a concentrated sodium chloride solution.

Explain fully why using a concentrated sodium chloride solution encourages production of sodium hydrogencarbonate as a solid. **2**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

9. Occasionally, seabirds can become contaminated with hydrocarbons from oil spills. This causes problems for birds because their feathers lose their waterproofing, making the birds susceptible to temperature changes and affecting their buoyancy. If the birds attempt to clean themselves to remove the oil, they may swallow the hydrocarbons causing damage to their internal organs.

Contaminated seabirds can be cleaned by rubbing vegetable oil into their feathers and feet before the birds are rinsed with diluted washing-up liquid.

Using your knowledge of chemistry, comment on the problems created for seabirds by oil spills and the actions taken to treat affected birds. **3**

[Turn over for Question 10 on *Page twenty-eight*

DO NOT WRITE ON THIS PAGE

MARKS | DO NOT WRITE IN THIS MARGIN

10. Plants require trace metal nutrients, such as zinc, for healthy growth. Zinc ions are absorbed from soil through the plant roots.

The zinc ion concentration in a solution can be found by adding a compound which gives a blue colour to the solution with zinc ions. The concentration of zinc ions is determined by measuring the absorption of light by the blue solution. The higher the concentration of zinc ions in a solution, the more light is absorbed.

A student prepared a stock solution with a zinc ion concentration of $1\,g\,l^{-1}$. Samples from this were diluted to produce solutions of known zinc ion concentration.

(a) The stock solution was prepared by adding 1·00 g of zinc metal granules to $20\,cm^3$ of 2 mol l^{-1} sulfuric acid in a $1000\,cm^3$ standard flask.

$$Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$$

The flask was left for 24 hours, without a stopper. The solution was then diluted to 1000 cm^3 with water.

(i) **Explain fully** why the flask was left for 24 hours, without a stopper. **2**

(ii) Explain why the student should use deionised water or distilled water, rather than tap water, when preparing the stock solution. **1**

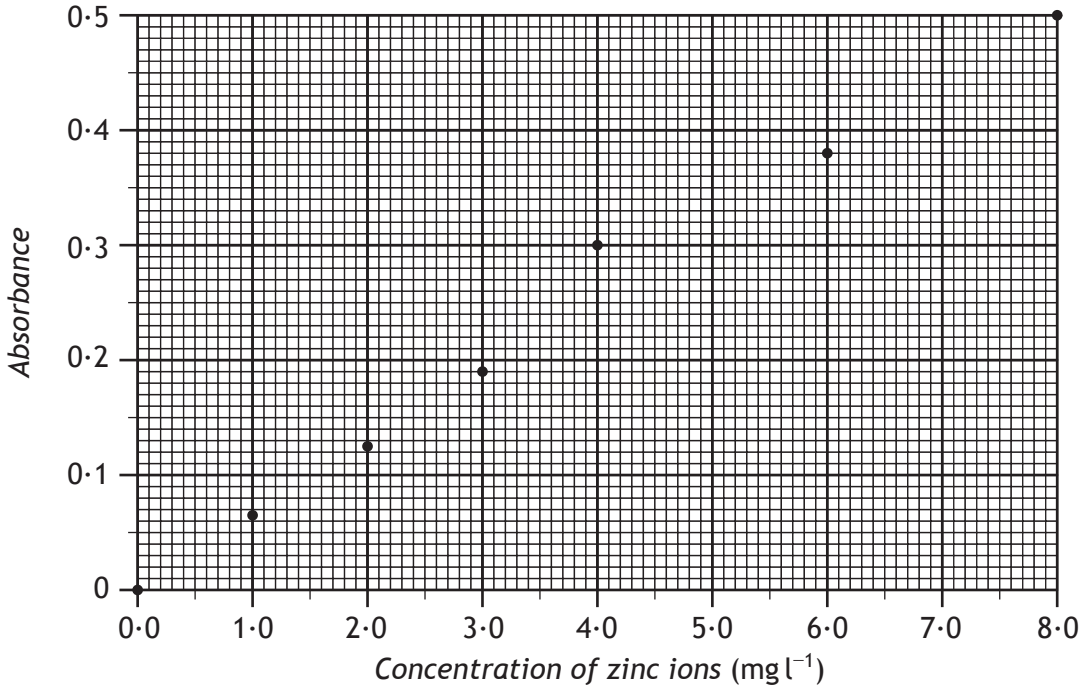
(b) Solutions of known zinc ion concentration were prepared by transferring accurate volumes of the stock solution to standard flasks and diluting with water.

(i) Name the piece of apparatus which should be used to transfer $10\,cm^3$ of stock solution to a standard flask. **1**

10. (b) (continued)

(ii) Calculate the concentration, in mg l^{-1}, of the solution prepared by transferring 10 cm^3 of the 1 g l^{-1} stock solution to a 1000 cm^3 standard flask and making up to the mark. **1**

(c) The light absorbance of different solutions was measured and the results plotted.



A solution prepared from a soil sample was tested to determine the concentration of zinc ions. The solution had an absorbance of 0·3.

Determine the concentration, in mg l^{-1}, of zinc ions in the solution. **1**

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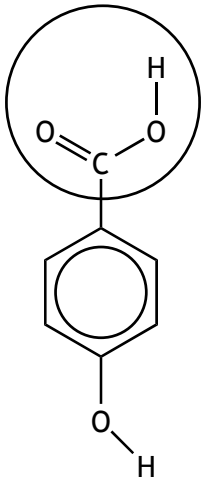
11.



4-hydroxybenzoic acid

4-hydroxybenzoic acid can react with alcohols to form compounds known as parabens.

(a) Name the functional group circled in the structure of 4–hydroxybenzoic acid. **1**

(b) Name the type of reaction taking place when parabens are formed. **1**

(c) Draw the paraben formed when 4–hydroxybenzoic acid reacts with ethanol. **1**

11. (continued)

(d) Parabens can be used as preservatives in cosmetics and toiletries.

Parabens are absorbed into the body through the skin. The following table indicates the absorption of some parabens.

Paraben	*Absorption* ($\mu g\,cm^{-2}$)
Methyl	32·50
Ethyl	20·74
Propyl	11·40
Butyl	7·74
Hexyl	1·60

State a conclusion that can be drawn from the information in the table. **1**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

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

Step 1

A 100·0 cm^3 sample from the swimming pool is first reacted with an excess of acidified potassium iodide solution forming iodine.

$$NaOCl(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + NaCl(aq) + H_2O(\ell)$$

Step 2

The iodine formed in step 1 is titrated using a standard solution of sodium thiosulfate, concentration 0·00100 mol l^{-1}. A small volume of starch solution is added towards the endpoint.

$$I_2(aq) + 2Na_2S_2O_3(aq) \rightarrow 2NaI(aq) + Na_2S_4O_6(aq)$$

(i) Describe in detail how a burette should be prepared and set up, ready to begin the titration. **3**

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

12. (a) (continued)

(iii) Calculate the concentration, in mol l^{-1}, of sodium hypochlorite in the swimming pool water, if an average volume of 12·4 cm^3 of sodium thiosulfate was required. **3**

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

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

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

[Turn over

12. (continued)

(c) 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.

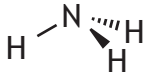
$OCl^-(aq) + NH_3(aq) \rightarrow NH_2Cl(aq) + OH^-(aq)$
monochloramine

$OCl^-(aq) + NH_2Cl(aq) \rightarrow NHCl_2(aq) + OH^-(aq)$
dichloramine

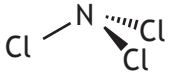
$OCl^-(aq) + NHCl_2(aq) \rightarrow NCl_3(aq) + OH^-(aq)$
trichloramine

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.

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



ammonia



trichloramine

2

12. (c) (continued)

(ii) Chloramines can be removed from water using ultraviolet light treatment.

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

$$NH_2Cl \xrightarrow{UV} \bullet NH_2 + \bullet Cl$$

State what is meant by the term free radical. **1**

(iii) Another step in the process is shown below.

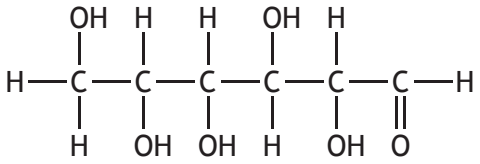
$$NH_2Cl + \bullet Cl \longrightarrow \bullet NHCl + HCl$$

State the name for this type of step in a free radical reaction. **1**

[Turn over for Question 13 on *Page thirty-six*

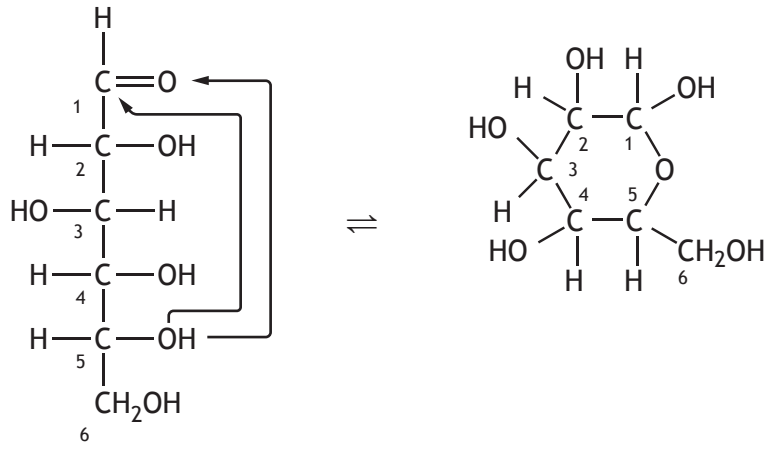
13. (a) One test for glucose involves Fehling's solution.

Circle the part of the glucose molecule that reacts with Fehling's solution. **1**



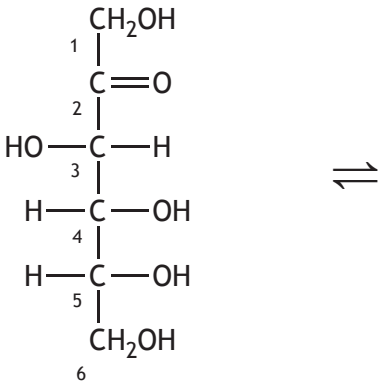
(b) In solution, sugar molecules exist in an equilibrium in straight-chain and ring forms.

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.



glucose

Draw the structure of a ring form for fructose. **1**



fructose

[END OF QUESTION PAPER]

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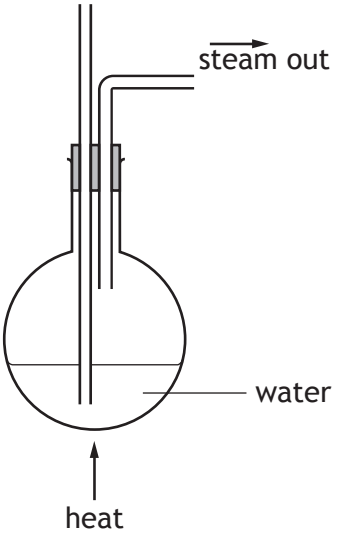
ADDITIONAL DIAGRAM FOR USE IN QUESTION 3 (a) (i)



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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

MARKS | DO NOT WRITE IN THIS MARGIN

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

ACKNOWLEDGEMENTS

Question 5 – Extract is adapted from "*Royal Society of Chemistry, Visual Elements*." Reproduced by kind permission of the Royal Society of Chemistry.

National
Qualifications
2015

2015 Chemistry

New Higher

Finalised Marking Instructions

General Marking Principles for Higher Chemistry

This information is provided to help you understand the general principles you must apply when marking candidate responses to questions in this paper. These principles must be read in conjunction with the detailed marking instructions, which identify the key features required in candidate responses.

(a) Marks for each candidate response must <u>always</u> be assigned in line with these General Marking Principles and the Detailed Marking Instructions for this assessment.

(b) Marking should always be positive. This means that, for each candidate response, marks are accumulated for the demonstration of relevant skills, knowledge and understanding: they are not deducted from a maximum on the basis of errors or omissions.

(c) If a specific candidate response does not seem to be covered by either the principles or detailed Marking Instructions, and you are uncertain how to assess it, you must seek guidance from your Team Leader.

(d) There are no half marks awarded.

(e) Where a candidate makes an error at an early stage in a multi stage calculation, credit should normally be given for correct follow on working in subsequent stages, unless the error significantly reduces the complexity of the remaining stages. The same principle should be applied in questions which require several stages of non-mathematical reasoning. The exception to this rule is where the marking instructions for a numerical question assign separate "concept marks" and an "arithmetic mark". In such situations, the marking instructions will give clear guidance on the assignment or partial marks.

(f) Unless a numerical question specifically requires evidence of working to be shown, full marks should be awarded for a correct final answer (including units) on its own.

(g) Larger mark allocations may be fully accessed whether responses are provided in continuous prose, linked statements or a series of developed bullet points.

(h) Marks should not be deducted for inaccurate or unconventional spelling or vocabulary as long as the meaning of the word(s) is conveyed. **For example**, responses that include 'distilling' for 'distillation', or 'it gets hotter' for 'the temperature rises', should be accepted.

(i) If a correct answer is followed by a wrong answer, it should be treated as a cancelling error and no marks should be given. **For example**, in response to the question, 'State the colour seen when blue Fehling's solution is warmed with an aldehyde', the answer 'red green' gains no marks.
However, if a correct answer is followed by additional information which does not conflict with that, the additional information should be ignored, whether correct or not. **For example**, in response to a question concerned with melting point, 'State why the tube should not be made of copper', the response 'Copper has a low melting point and is coloured grey' would **not** be treated as having a cancelling error. **I**f a candidate lists a number of possible answers it should not be for the marker to choose the correct answer from the list

(j) Full marks are usually awarded for the correct answer to a calculation without working and the partial marks shown in the detailed marking instructions are for use when working is given but the final answer is incorrect. An exception is when candidates are asked to 'Find, by calculation', when full marks cannot be awarded for the correct answer without working.

(k) Ignore the omission of one H atom from a full structural formula provided the bond is shown or of one bond if the hydrogen is shown.
When structures involving an –OH group or an $-NH_2$ are asked for, a mark should only be deducted when a bond is drawn to the wrong atom, if understanding of the functional group structure is required.

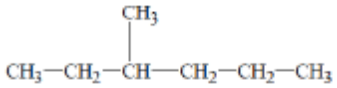
(l) A symbol or correct formula should be accepted in place of a name unless stated otherwise in the detailed marking instructions.

(m) When formulae of ionic compounds are given as answers it will only be necessary to show ion charges if these have been specifically asked for. However, if ion charges are shown, they must be correct. If incorrect charges are shown, no marks should be awarded.

(n) If an answer comes directly from the text of the question, no marks should be given. **For example**, in response to the question, ' A student found that 0·05 mol of propane, C_3H_8 burned to give 82·4 kJ of energy. $C_3H_8(g) + 5O_2(g) = 3CO_2(g) + 4H_2O(\ell)$. Name the kind of enthalpy change that the student measured', no marks should be given for "burning" since the word "burned" appears in the text.

(o) A guiding principle in marking is to give credit for correct elements of a response rather than to look for reasons not to give marks.

Example 1: The structure of a hydrocarbon found in petrol is shown below.



Name the hydrocarbon

- Although the punctuation is not correct '3, methyl-hexane' should gain the full mark.

Example 2: A student measured the pH of four carboxylic acids to find out how their strength is related to the number of chlorine atoms in the molecule. The results are shown.

Structural formula	*pH*
CH_3COOH	1·65
$CH_2ClCOOH$	1·27
$CHCl_2COOH$	0·90
CCl_3COOH	0·51

Describe the relationship between the number of chlorine atoms in the molecule and the strengths of the acids.

- Although not completely correct, an answer such as 'the more Cl_2, the stronger the acid' should gain the full mark.

(p) Unless the question is clearly about a non-chemistry issue, eg costs in an industrial chemical process, a non-chemical answer gains no marks.
For example, in response to the question, 'Why does the (catalytic) converter have a honeycomb structure?', 'to make it work' may be correct but it is not a chemical answer and the mark should not be given.

(q) Marks are awarded only for a valid response to the question asked. For example, in response to questions that ask candidates to:

- **identify, name, give** or **state**, they need only name or present in brief form;
- **describe**, they must provide a statement or structure of characteristics and/or features;
- **explain**, they must relate cause and effect and/or make relationships between

things clear;

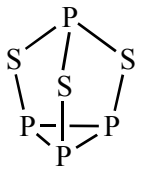
- **compare**, they must demonstrate knowledge and understanding of the similarities and/or differences between things;
- **complete**, they must finish a chemical equation or fill in a table with information
- **determine** or **calculate**, they must determine a number from given facts, figures or information;
- **draw**, they must draw a diagram or structural formula, eg "Draw a diagram to show the part of a poly(propene) molecule formed from two propene molecules"
- **estimate**, they must determine an approximate value for something;
- **predict**, they must suggest what may happen based on available information;
- **evaluate**, they must make a judgement based on criteria;
- **suggest**, they must apply their knowledge and understanding of [subject] to a new situation. A number of responses are acceptable; marks will be awarded for any suggestions that are supported by knowledge and understanding of [subject];
- **use your knowledge of [chemistry or aspect of chemistry] to comment on**, they must apply their skills, knowledge and understanding to respond appropriately to the problem/situation presented (for example by making a statement of principle(s) involved and/or a relationship or equation, and applying these to respond to the problem/situation). They will be rewarded for the breadth and/or depth of their conceptual understanding.
- **Write**, they must complete a chemical or word equation, eg "Write the word equation for the complete combustion of ethanol."

Detailed Marking Instructions for each question

Section 1

Question	Answer	Max Mark
1.	D	**1**
2.	C	**1**
3.	D	**1**
4.	A	**1**
5.	C	**1**
6.	B	**1**
7.	A	**1**
8.	B	**1**
9.	B	**1**
10.	A	**1**
11.	D	**1**
12.	D	**1**
13.	B	**1**
14.	C	**1**
15.	B	**1**
16.	A	**1**
17.	D	**1**
18.	A	**1**
19.	A	**1**
20.	C	**1**

Section 2

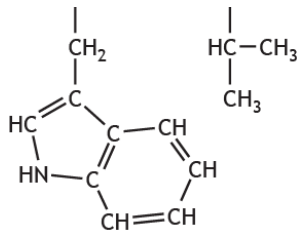
Question			Answer	Max Mark	Additional Guidance
1.	**(a)**		Sulfur – London dispersion forces / van der Waals / intermolecular forces **(1)** Silicon dioxide – (polar)covalent (network) bonds **(1)**	**2**	Accept LDF for London dispersion forces If candidate answers pure covalent, ignore pure.
	(b)	**(i)**	Any structure for P_4S_3 that obeys valency rules 	**1**	Only trivalent phosphorus structures accepted
		(ii)	Increased nuclear attraction for electrons / increased nuclear charge / sulfur has more protons in nucleus	**1**	0 marks awarded for increased attraction of electrons for nucleus
		(iii)	**1 mark** Correctly identify that the forces are stronger between sulfur (molecules) than between the phosphorus molecules **1 mark** Correctly identifying that there are London dispersion forces between the molecules of both these elements **1 mark** These forces are stronger due to sulfur structure being S_8 whereas phosphorus is P_4	**3**	 This mark should only be awarded if no other forces are mentioned Must mention S_8 and P_4 (A-mark)
2.	**(a)**		From graph, rate = 0·022 t = 1/rate = 45 s accept answers in range 45 − 46 s	**1**	Units not required
	(b)	**(i)**	Second line displaced to left of original. Peak of curve should be to the left of the original peak	**1**	
		(ii)	A vertical line drawn at a lower kinetic energy that the original E_a shown on graph	**1**	

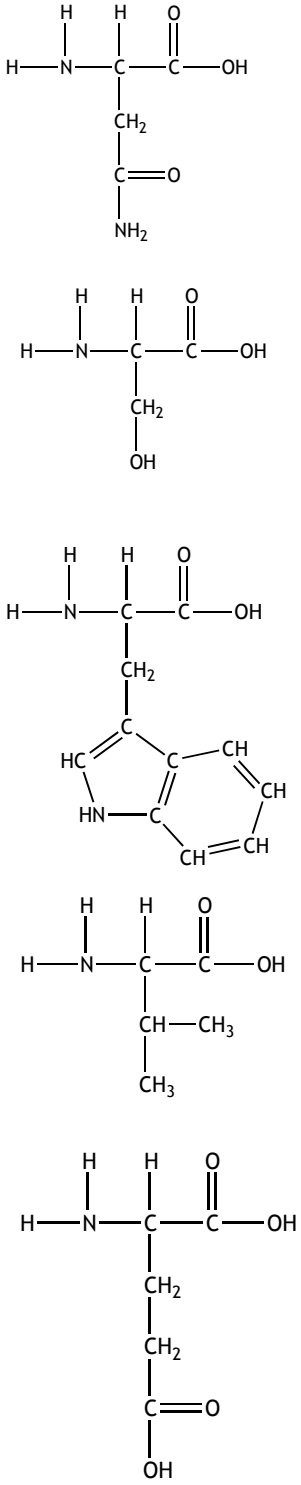
Question			Answer	Max Mark	Additional Guidance
3.	**(a)**	**(i)**	Workable apparatus for passing steam **through** strawberry gum leaves **(1)** Workable apparatus for condensing the steam and essential oil **(1)**	**2**	Treat both marks separately "Through" not "over" A closed system would not allow candidates to gain mark for condensation.
		(ii)	(Fractional) distillation or chromatography	**1**	
	(b)	**(i)**	**1 mark** awarded for correct arithmetical calculation of moles of acid = 0·044 **and** moles alcohol = 0·063 (no penalty for candidates who round to 0·04 and 0·06 etc) **or** working out that 9·25 g cinnamic acid would be needed to react with 2 g methanol or 6·5 g cinnamic acid would react with 1·41 g methanol **1 mark** awarded for statement demonstrating understanding of limiting reactant. eg there are less moles of cinnamic acid therefore it is the limiting reactant **or** 0·0625 moles methanol would require 0·625 moles cinnamic acid **or** methanol is in excess therefore cinnamic acid is the limiting reactant.	**2**	

Question			Answer	Max Mark	Additional Guidance
		(ii) (A)	52% **(2)** Partial Marking 1 mark is given for working out the theoretical yield ie 7·1 g or for working out **both** the moles of reactant used and product formed ie **both** 0·044 moles and 0·023 moles 1 mark is given for calculating the % yield, either using the actual and theoretical masses, or using the actual number of moles of products and actual number of moles of reactant	**2**	**0 marks awarded for** – 3·7/6·5 × 100 or 56·9%
		(ii) (B)	£24·59 **(2)** Partial marking for **1 mark** Award 1 mark for Evidence for costing to produce of 3·7 g (£0·91) **or** evidence of a calculated mass of cinnamic acid x 14p **or** evidence that 176 g of cinnamic acid required £12·80 would be using 100% yield	**2**	Assume units are £ unless otherwise stated Apply follow through from (b) (ii) (A)

Question			Answer	Max Mark	Additional Guidance
4.	**(a)**		Any one of the common compounds correctly identified ie citronellol / geraniol / anisyl alcohol	**1**	
	(b)		The concentration / volume of compounds (that are common to both/present in the counterfeit) is different are present in lower concentration in the counterfeit	**1**	Answer must relate to the perfume and not to the chromatogram.
	(c)	**(i)**	Inert / will not react with the molecules (being carried through the column)	**1**	
		(ii)	Size (mass) of molecules / temperature of column.	**1**	
	(d)	**(i)**	Terpenes	**1**	
		(ii) (A)	3,7-dimethylocta-1,6-dien-3-ol	**1**	
		(ii) (B)	Hydroxyl attached to C which is attached to 3 other C atoms **or** hydroxyl attached to a C that has no H atoms attached	**1**	
	(e)		1·7 g (units not required) **(2)** partial marking **for 1 mark** for evidence within candidate answer of calculating that 1 mg coumarin is obtained from 0·227 g cinnamon or tolerable daily intake =7·5mg for 75kg individual or evidence of multiplying DTI by 227 (multiplying by 1000 and dividing by 4·4)	**2**	

Question			Answer	Max Mark	Additional Guidance
5.			This is an open ended question **1 mark:** The student has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. The student has made some statement(s) which is/are relevant to the situation, showing that at least a little of the chemistry within the problem is understood. **2 marks:** The student has demonstrated a reasonable understanding, at an appropriate level, of the chemistry involved. The student makes some statement(s) which is/are relevant to the situation, showing that the problem is understood. **3 marks:** The maximum available mark would be awarded to a student who has demonstrated a good understanding, at an appropriate level, of the chemistry involved. The student shows a good comprehension of the chemistry of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. This does not mean the answer has to be what might be termed an "excellent" answer or a "complete" one.	**3**	Zero marks should be awarded if: The student has demonstrated no understanding of the chemistry involved. There is no evidence that the student has recognised the area of chemistry involved or has given any statement of a relevant chemistry principle. This mark would also be given when the student merely restates the chemistry given in the question.

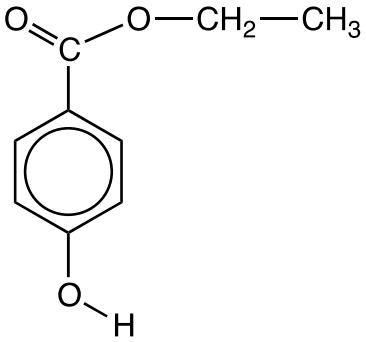
Question			Answer	Max Mark	Additional Guidance
6.	**(a)**		Heat breaks hydrogen bonds	**1**	
	(b)	**(i)**	Either of structures shown circled 	**1**	
		(ii)	50·5 ± 1 °C	**1**	
	(c)	**(i)**	Hydrolysis	**1**	
		(ii) (A)	5	**1**	

Question			Answer	Max Mark	Additional Guidance
		(ii) (B)	Correctly drawn amino acid structure 	**1**	Ignore bond positioning in side chains

Question			Answer		Max Mark	Additional Guidance
7.	**(a)**		118/32 or 3·69 mol CH_3OH **(1)** 3·69 × 24 = 88·5 litres **(1)**		**2**	Units not required but if given need to be appropriate to the calculation. eg 88 500 cm^3 Follow through applies. eg 1 mark can be awarded if use 64 for GFM giving an answer of 44·25 litres **or** for an arithmetically correct answer derived by multiplying a wrongly calculated number of moles (for which working shown) by 24
	(b)	**(i)**	(A)	Thermometer touching bottom or directly above flame or temperature rise recorded would be greater than expected.	**1**	
			(B)	Distance between flame and beaker **or** Height of wick in burner Same type of beaker (this needs to be qualified) Same draught proofing	**1**	
			(C)	2 concept marks + 1 arithmetic mark Concept marks Demonstration of the correct use of the relationship $E_h = cm\Delta T$ **(1)** eg 4·18 × 0·1 × 23 **or** 9·61 **and** Knowledge that enthalpy of combustion relates to 1 mol **(1)** evidenced by scaling up of energy released Correct arithmetic = −288 kJ mol^{-1} **(1)** Allow follow through of wrong GFM from part (a)	**3**	Maximum of 2 marks can be awarded if negative enthalpy sign is not shown in final answer. If candidate converts 1·07g to 0·033 mol, then candidate answer should be −291 kJ mol^{-1} Units not required

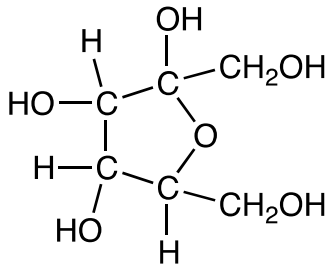
Question			Answer	Max Mark	Additional Guidance
		(ii)	0·799 (0·8)	**1**	Units not required
	(c)	**(i)**	If reactions are exothermic heat will need to be removed / If reactions are endothermic heat will need to be supplied **or** Chemists can create conditions to maximise yield	1	This is not a mark about safety
		(ii)	Answer = +191 kJ mol^{-1} **(2)** Partial mark 1 mark Evidence of the use of **all** the correct bond enthalpies. **(1)** (412, 360, 463, 436, 743) **or** Correct use of incorrect bond enthalpy values	**2**	Positive sign does not need to be given in answer
8.	**(a)**		Calcium carbonate / carbon dioxide / ammonia / calcium oxide **all** correctly identified in flow diagram **(1)** Ammonium chloride / sodium hydrogen carbonate / sodium carbonate / water – all correctly identified in flow diagram **(1)**	**2**	
	(b)		(Adding brine) increases sodium ion concentration hence equilibrium shifts to right **(1)** Rate of forward reaction is increased (by addition of brine) **(1)**	**2**	

Question			Answer	Max Mark	Additional Guidance
9.			This is an open ended question **1 mark:** The student has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. The candidate has made some statement(s) at which is/are relevant to the situation, showing that at least a little of the chemistry within the problem is understood. **2 marks:** The student has demonstrated, at an appropriate level, a reasonable understanding of the chemistry involved. The student makes some statement(s) which is/are relevant to the situation, showing that the problem is understood. **3 marks:** The maximum available mark would be awarded to a student who has demonstrated, at an appropriate level, a good understanding of the chemistry involved. The student shows a good comprehension of the chemistry of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. This does not mean the answer has to be what might be termed an 'excellent' answer or a 'complete' one.	**3**	Zero marks should be awarded if: The student has demonstrated, at an appropriate level, no understanding, of the chemistry involved. There is no evidence that the student has recognised the area of chemistry involved or has given any statement of a relevant chemistry principle. This mark would also be given when the student merely restates the chemistry given in the question.

Question			Answer	Max Mark	Additional Guidance
10.	**(a)**	**(i)**	24 hours allows time for all of the zinc to react **(1)** No stopper allows hydrogen gas to escape from the flask. **(1)**	**2**	
		(ii)	Zinc ions / impurities / metal ions / salts may be present in tap water	**1**	
	(b)	**(i)**	pipette	**1**	Do not accept measuring cylinder or syringe or burette
		(ii)	10 (Units not required, if given mg per litre, mg l^{-1})	**1**	Accept 0·01 g l^{-1}
	(c)		Answer in range 4·6 – 4·8 (mg per litre, mg l^{-1})	**1**	A-mark Use candidate best fit line, if provided, to check answer
11.	**(a)**		Carboxyl / carboxylic (acid) group	**1**	
	(b)		Esterification / condensation	**1**	
	(c)			**1**	
	(d)		As molecular size (no. of carbon atoms) increases, the absorption decreases.	**1**	

Question			Answer	Max Mark	Additional Guidance
12.	**(a)**	**(i)**	3 points **1 mark** for rinsing the burette – rinse the burette with the **thiosulfate / required solution** / with the solution to be put in it. **2 marks (1 mark each)** for any 2 of the following points fill burette above the scale with thiosulfate solution filter funnel used should be removed tap opened / some solution drained to ensure no air bubbles (thiosulfate) solution run into scale reading should be made from bottom of meniscus	**3**	
		(ii)	$2I^-(aq) \longrightarrow I_2(aq) + 2e^-$	**1**	Ignore state symbols

Question			Answer	Max Mark	Additional Guidance
		(iii)	0·000062 (mol l^{-1}) Partial marks can be awarded using a scheme of two "concept" marks, and one "arithmetic" mark **1 mark** for knowledge of the relationship between moles, concentration and volume. This could be shown by one of the following steps: Calculation of moles thiosulfate solution eg 0·001 × 0·0124 = 0·0000124 **or** calculation of concentration of iodine solution eg 0·0000062/0·1 **or** Insertion of correct pairings of values for concentration and volume in a valid titration formula **1 mark** for knowledge of relationship between moles of thiosulfate and hypochlorite. This could be shown by one of the following steps: Calculation of moles hypochlorite from moles thiosulfate – eg 0·0000124/2 = 0·0000062 **or** Insertion of correct stoichiometric values in a valid titration formula **1 mark** is awarded for correct arithmetic through the calculation. This mark can only be awarded if both concept marks have been awarded.	**3**	units not required

Question			Answer	Max Mark	Additional Guidance
	(b)		**1 mark** correct arithmetic either 44·4 (litres) or 44400 (cm^3) **1 mark** correct units	**2**	
	(c)	**(i)**	**1 mark** Ammonia is polar and trichloramine is non-polar. **1 mark** Explanation of this in terms of polarities of bonds or electronegativity differences of atoms in bonds	**2**	
		(ii)	Substances that have unpaired electrons	**1**	
		(iii)	Propagation	**1**	
13.	**(a)**		Aldehyde group correctly identified	**1**	
	(b)		Ring form correctly drawn 	**1**	

[END OF MARKING INSTRUCTIONS]