Higher Chemistry Past Papers

September 2020

1 About this study aid...

This document has been designed to make revision and self-marking easy for students studying Higher chemistry in Scotland.
For those interested in how it was made, it has been compiled using LaTex.
The information in this publication has been reproduced to support SQA qualifications only on a noncommercial basis and can only be shared on that condition.

2 How to use...

The following two pages contain tables which cross-reference the course topics with SQA question numbers for the years 2015-19.
The first table is for multiple choice questions; the second accesses Section 2 questions. Each question number is hyperlinked to the SQA question and clicking it will take you there. The question pages have further hyperlinks taking you either back to the topic grid or to the SQA marking instructions.
Of course, you can always just treat it as a succession of question papers with marking instructions. This will be useful for end-of-course timed revision.

CfE Higher Past Papers - Multiple Choice Qs						
	Topic	2015	2016	2017	2018	2019
Unit 1	Periodicity	2, 3			4	
	Structure and Bonding	1, 4, 5	1, 2, 3	1, 3, 4, 5	5	1, 2, 16
	Oxidising and Reducing Agents	20	17, 18, 19	13	18, 19	3, 4
Unit 2	Systematic carbon chemistry	15	12	7, 10	7, 8	7, 9
	Alcohols, Carb. acids, Esters, Fats and Oils	7, 8, 9, 14	7	8, 19		5
	Soaps, Detergents and Emulsions		9, 10			
	Proteins		8		10	6
	Oxidation of Food	6, 10, 11 12	6, 11	2	6, 9	8, 11
	Fragrances	13	5	11		10
	Skincare			9		
Unit 3	Controlling the rate	19	4		1, 2, 3	20, 22, 24
	Getting the most from reactants		13	6, 14	12, 13, 14	13, 14, 15, 17, 18
	Equilibria	18	15	17, 20	15, 20	23
	Chemical Energy	16, 17	14, 16	12, 18	16, 17	21
	Chemical Analysis		20	15		
	Problem Solving			16	11	12, 19, 25

Table 1: Topic Grid Multiple Choice

CfE Higher Past Papers - Section 2 Questions						
	Topic	2015	2016	2017	2018	2019
Unit 1	Periodicity	1(b)(ii)	2a-b	1b	1a 2a	2a-b
	Structure and Bonding	1a&b(i&iii) 12ci	3a 5cii 12ai	1a 1c 5cii 6c	1b 2b-c 9b	2c 4di 6a 12b
	Oxidising and Reducing Agents	12aii	11bii	9bi	11b	12d
Unit 2	Systematic carbon chemistry	4d(ii)	5bii		4eii	7biii
	Alcohols, Carb. acids, Esters, Fats and Oils	11a-c	5 7biii-iv 7c	4a	3ci 6a 9c	4c 4dii 7b
	Soaps, Detergents and Emulsions			9a		12a
	Proteins	6	6	9c	6c	8a
	Oxidation of Food	13a	11bi&iii	6a	4 7cii 9diii	4e
	Fragrances	4d(i)			7a	4diii
	Skincare	12cii-iii	7		6b	7a
Unit 3	Controlling the rate	2	1a 1c	2aii 2aiv		9a
	Getting the most from reactants	3b 7a 12aiii	3b 7ciii 8bii	5aii 9bii	2cii 3cii-iii 7b 11c 12b	1ai 6aiii 6bii 8b-c 10b-c
	Equilibria	8b	8a	2aiii		12c
	Chemical Energy	7b-c	8c 9b	2ai 4b 5b	8	5 9c
	Chemical Analysis	3a 10 12ai	1bi 5ci 6d 11a 11biv	2b 5ai 5ci 7	2d 3a-b 9d 11a	4bii 9b 10
	Open ended	5 9	4 10	3 8	5 10	3 11
	Problem Solving	4(a-c) 4e 8a 11d 12b 13b	1bii 2c 3c 6eii 8bi 9a 12	6b 7d 9d 10	4eii 7ci 9a 12a 12bii	2d 4a 4bi 6a 6bi

Table 2: Section 2 Questions

H

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.

Go to Topic Grid

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

Go to Answers

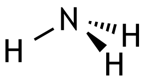
Go to Topic Grid

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

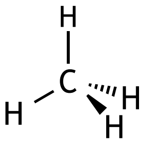
A $Br—Br$

B $O=C=O$

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.

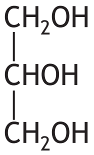
Which line in the table shows the oil that is likely to have the lowest melting point?

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

Go to Answers

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

A 
$$\begin{array}{l} COOH \\ | \\ CHOH \\ | \\ COOH \end{array}$$

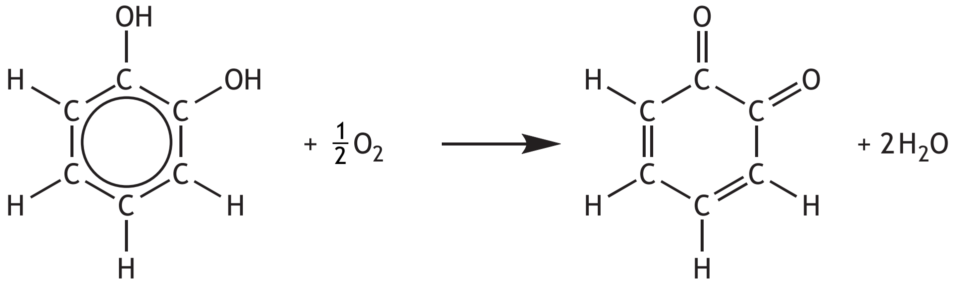
B 
$$\begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}$$

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

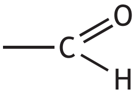
B Reduction

C Hydrolysis

D Condensation

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

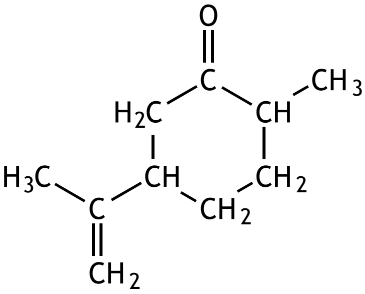
A They are formed by oxidation of tertiary alcohols.

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.



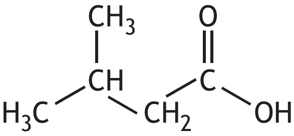
Carvone

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

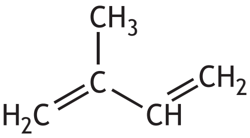
	Reaction with bromine solution	*Reaction with acidified potassium dichromate solution*
A	no reaction	no reaction
B	no reaction	orange to green
C	decolourises	orange to green
D	decolourises	no reaction

13. The structure of isoprene is

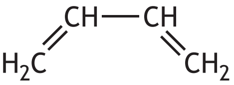
A



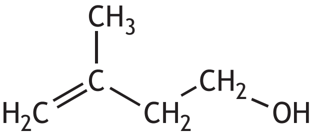
B



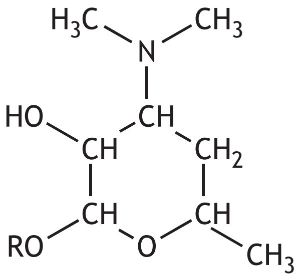
C



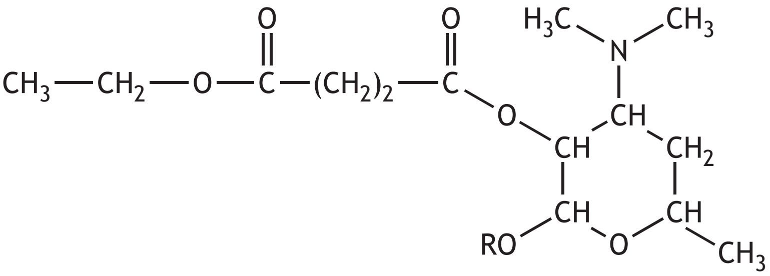
D



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 $CH_3CH_2CH_2CH(CH_3)CH_2OH$

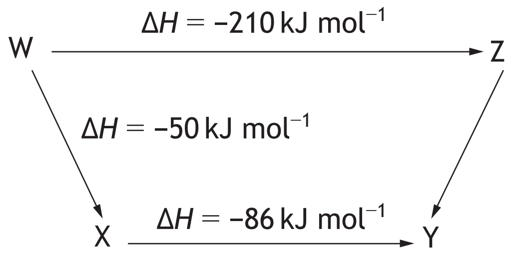
B $(CH_3)_3CCH(CH_3)CH_2OH$

C $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2OH$

D $(CH_3)_2CHC(CH_3)_2CH_2CH_2OH$

Go to Answers

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

Go to Answers

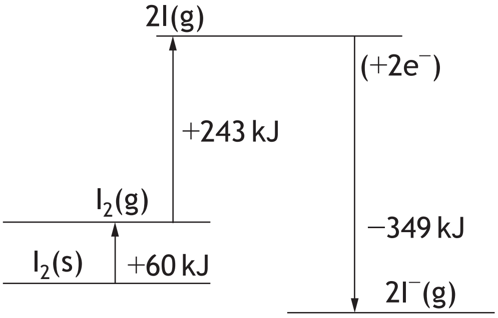
17. $I_2(s) \rightarrow I_2(g)$ $\Delta H = +60\ \text{kJ mol}^{-1}$

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

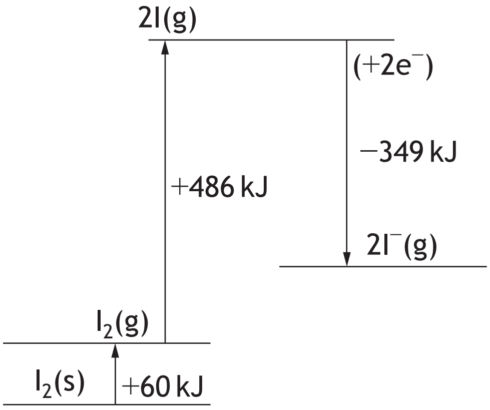
$I(g) + e^- \rightarrow I^-(g)$ $\Delta H = -349\ \text{kJ mol}^{-1}$

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

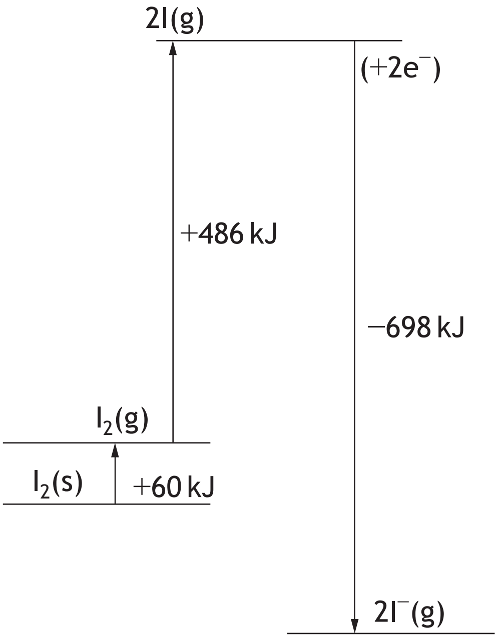
A



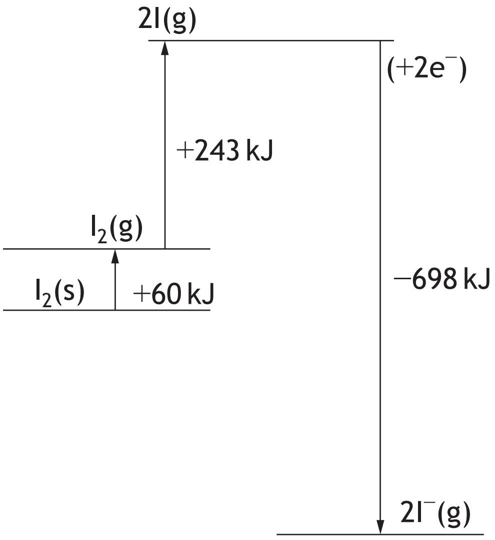
B



C



D



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

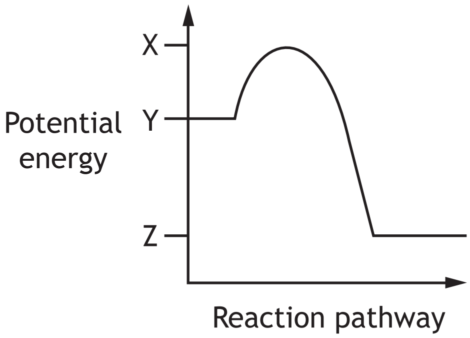
A The rates of the forward and reverse reactions are equal.

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.]

Go to Answers

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**

Go to Answers

1. (b) (continued)

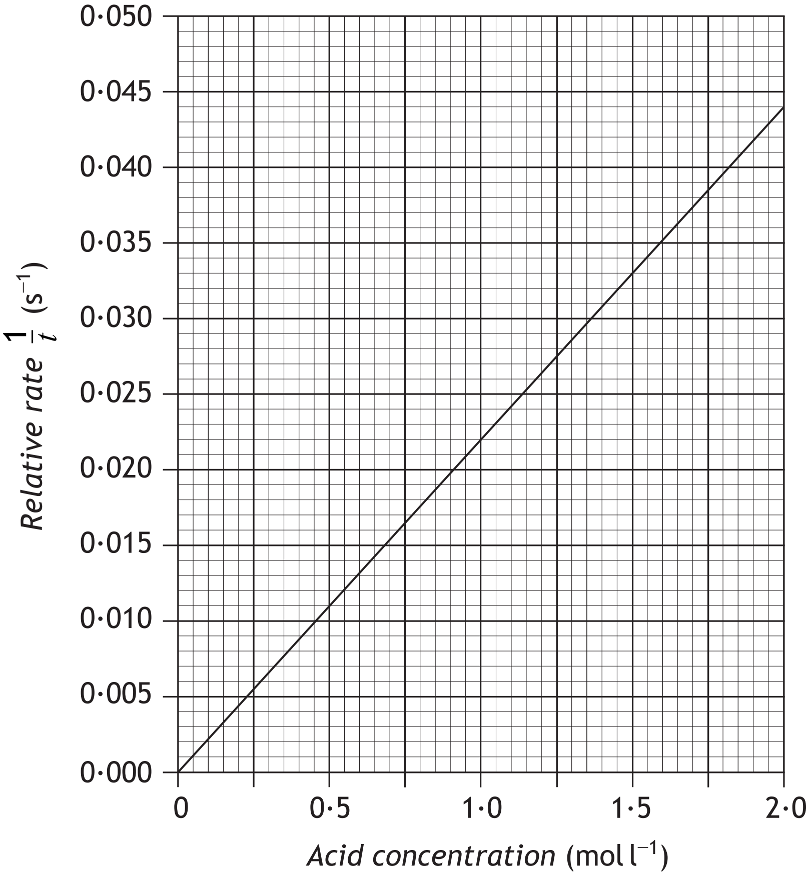
(iii) The melting point of sulfur is much higher than that of phosphorus.

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.

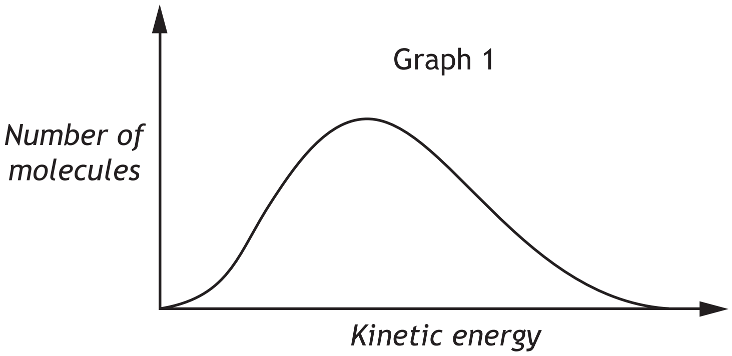


Use information from the graph to calculate the reaction time, in seconds, when the concentration of the acid was 1·0 mol l^{-1}. **1**

2. (continued)

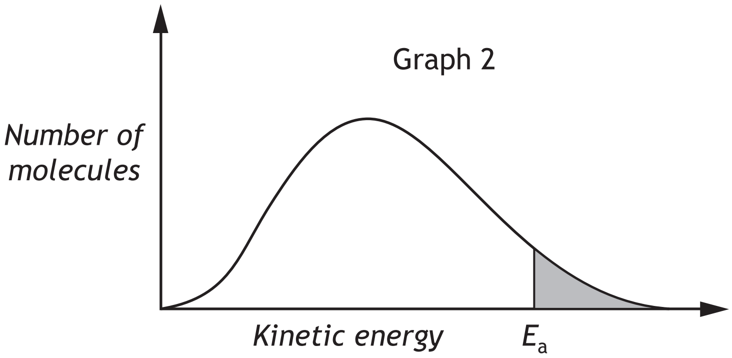
(b) The rate of reaction can also be altered by changing the temperature or using a catalyst.

(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**

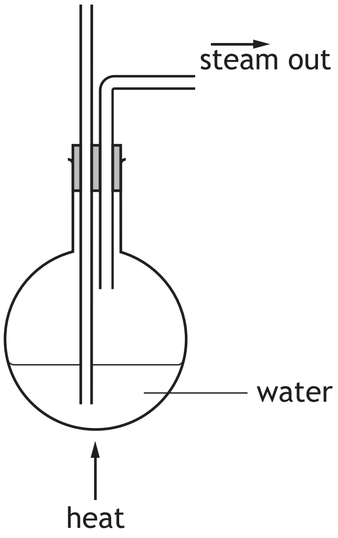
[Turn over

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

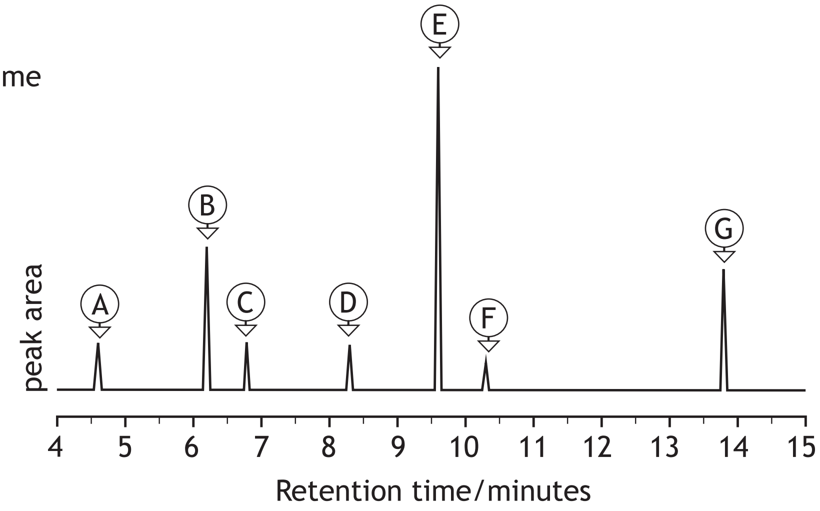
Go to Topic Grid

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

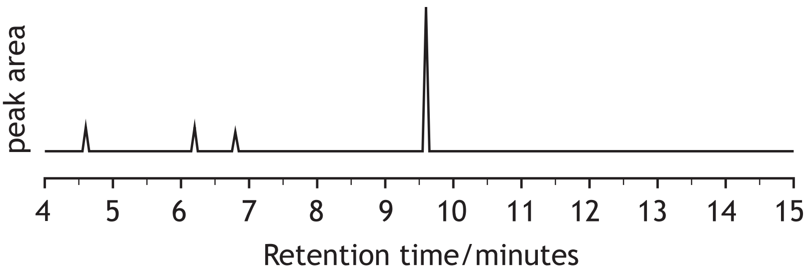
One way to identify if a perfume is counterfeit is to use gas chromatography. Shown below are gas chromatograms from a brand name perfume and two different counterfeit perfumes. Some of the peaks in the brand name perfume have been identified as belonging to particular compounds.

Brand name perfume

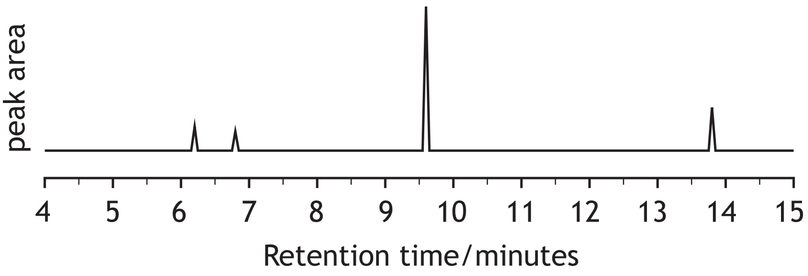
Ⓐ linalool
Ⓑ citronellol
Ⓒ geraniol
Ⓓ eugenol
Ⓔ anisyl alcohol
Ⓕ coumarin
Ⓖ benzyl salicylate



Counterfeit A



Counterfeit B



Go to Answers

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**

Go to Answers

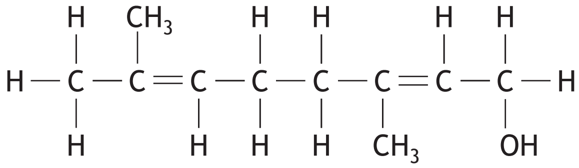
[Turn over

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**

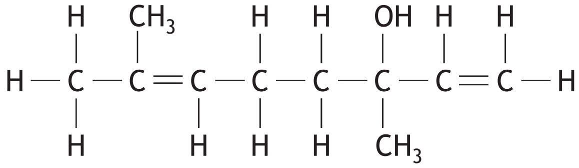
(ii) Geraniol is one of the compounds found in perfume. It has the following structural formula and systematic name.



$$\begin{array}{cccccccccc} & \mathrm{H} & \mathrm{CH_3} & & \mathrm{H} & \mathrm{H} & & \mathrm{H} & \mathrm{H} & \\ & | & | & & | & | & & | & | & \\ \mathrm{H}- & \mathrm{C}- & \mathrm{C}= & \mathrm{C}- & \mathrm{C}- & \mathrm{C}- & \mathrm{C}= & \mathrm{C}- & \mathrm{C}- & \mathrm{H} \\ & | & & | & | & | & | & & | & \\ & \mathrm{H} & & \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{CH_3} & & \mathrm{OH} & \end{array}$$

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

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



$$\begin{array}{cccccccccc} & \mathrm{H} & \mathrm{CH_3} & & \mathrm{H} & \mathrm{H} & \mathrm{OH} & \mathrm{H} & \mathrm{H} & \\ & | & | & & | & | & | & | & | & \\ \mathrm{H}- & \mathrm{C}- & \mathrm{C}= & \mathrm{C}- & \mathrm{C}- & \mathrm{C}- & \mathrm{C}- & \mathrm{C}= & \mathrm{C}- & \mathrm{H} \\ & | & & | & | & | & | & & & \\ & \mathrm{H} & & \mathrm{H} & \mathrm{H} & \mathrm{H} & \mathrm{CH_3} & & & \end{array}$$

(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

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**

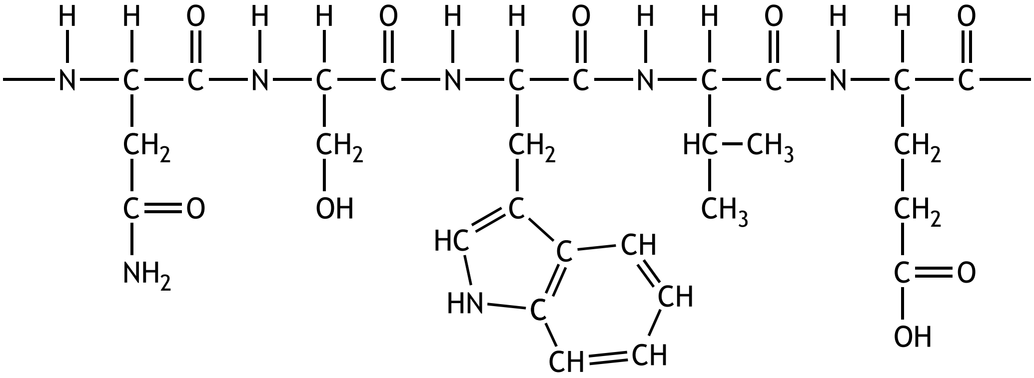
Go to Answers

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**

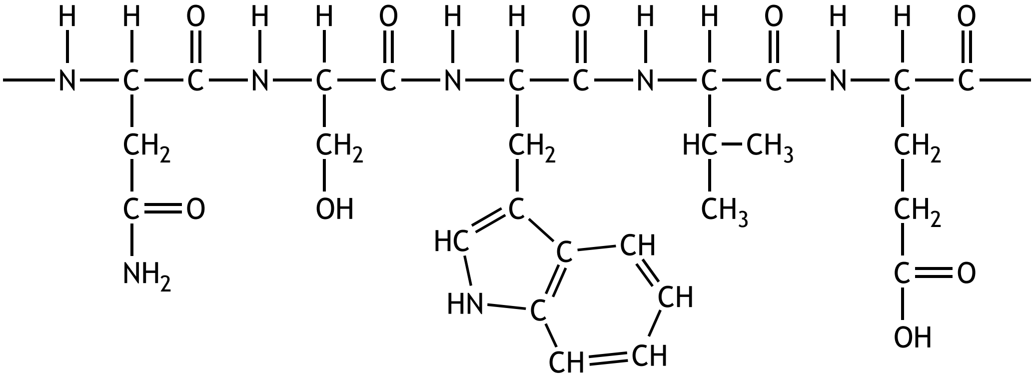
[Turn over

6. (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

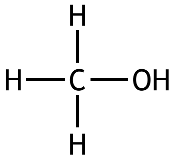
(ii)



(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.



$$H-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-OH$$

(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.

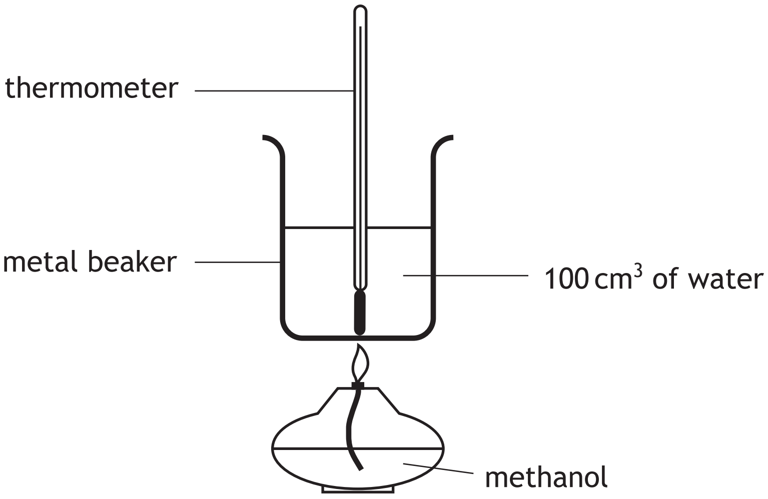
$$2CH_3OH(\ell) \quad + \quad 3O_2(g) \quad \rightarrow \quad 2CO_2(g) \quad + \quad 4H_2O(\ell)$$

(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.

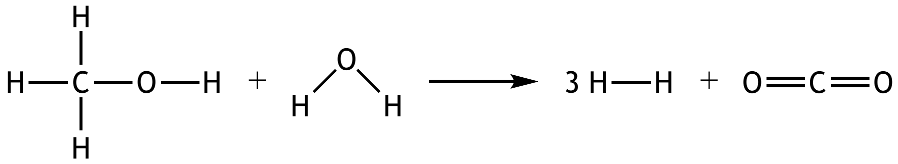
The student's results are shown below.

	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.

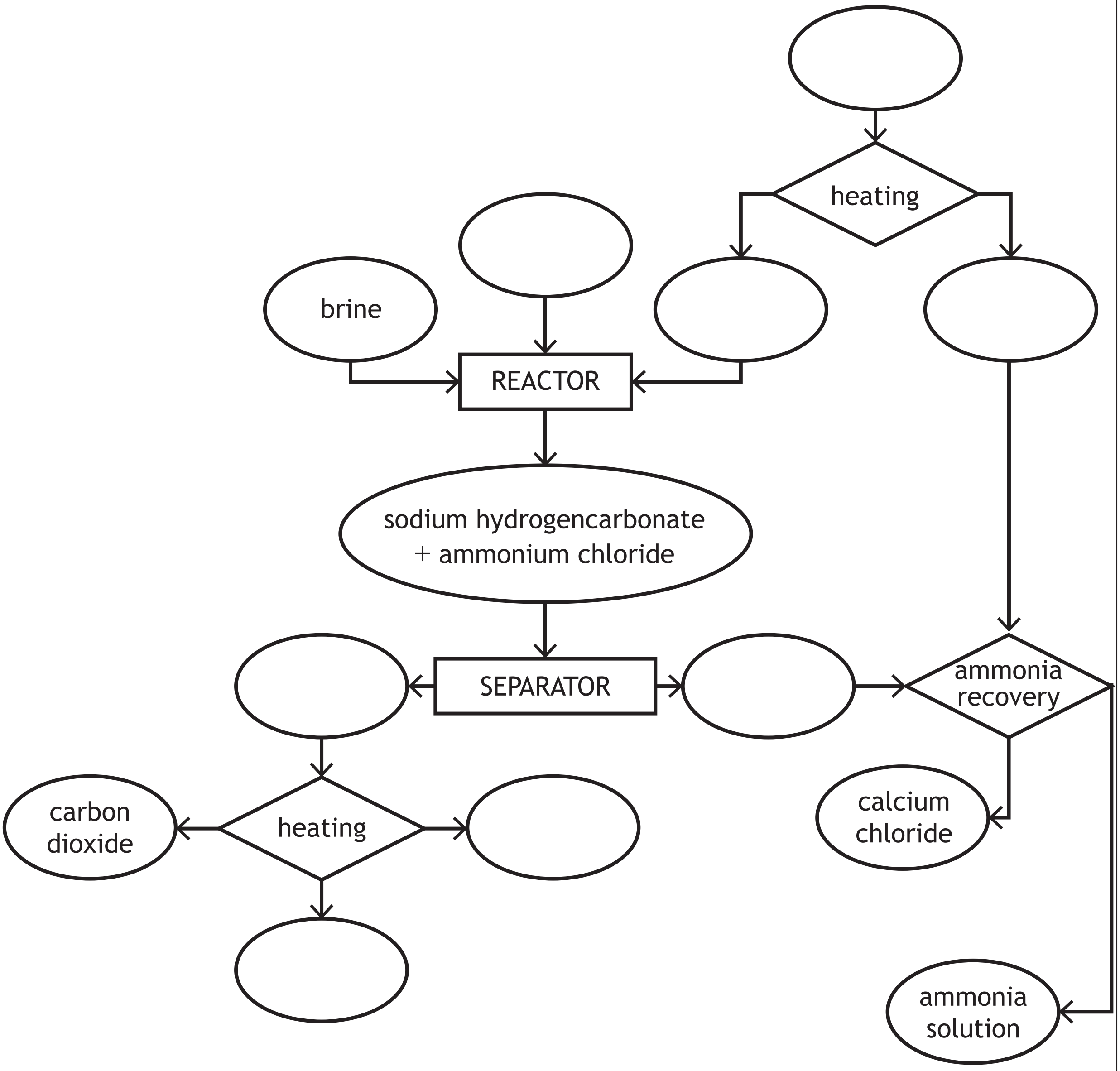
One industrial process used to make sodium carbonate is the Solvay process.

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

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**

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.

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

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**

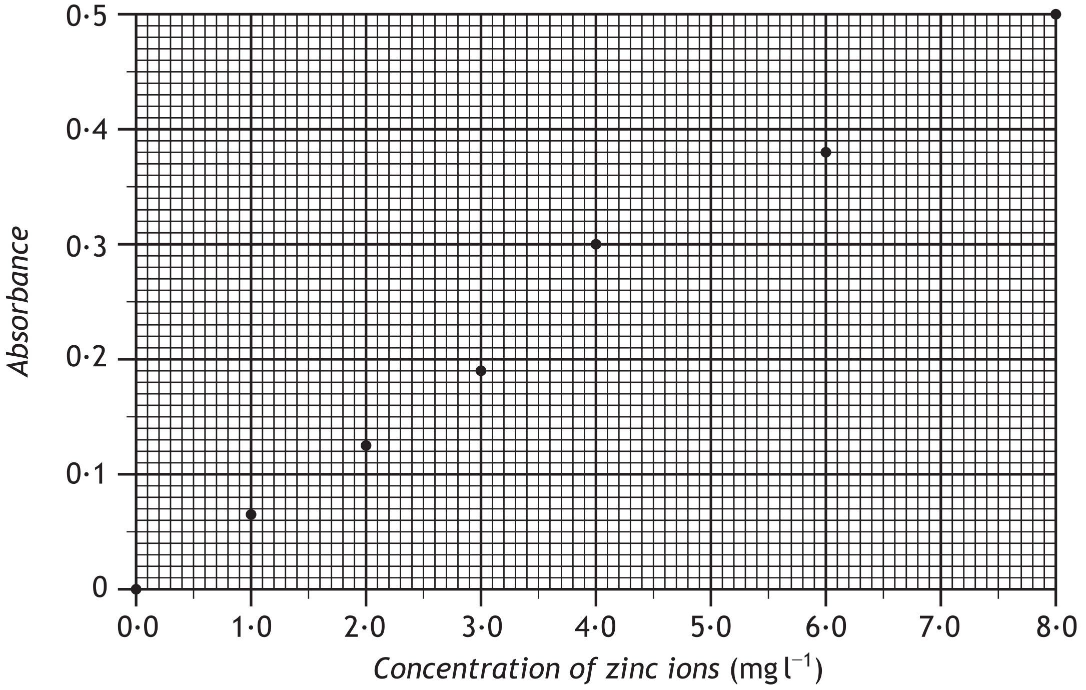
(b) Solutions of known zinc ion concentration were prepared by transferring accurate volumes of the stock solution to standard flasks and diluting with water.

(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**

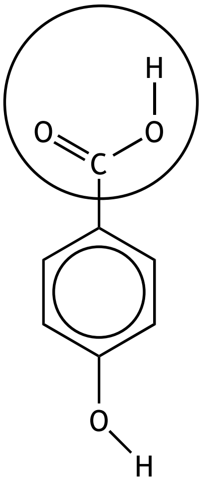
(c) The light absorbance of different solutions was measured and the results plotted.



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**

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

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.

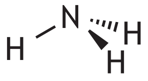
$OCl^{-}(aq) + NH_3(aq) \rightarrow NH_2Cl(aq) + OH^{-}(aq)$
monochloramine

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

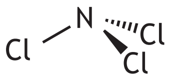
$OCl^{-}(aq) + NHCl_2(aq) \rightarrow NCl_3(aq) + OH^{-}(aq)$
trichloramine

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. **2**



ammonia



trichloramine

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.

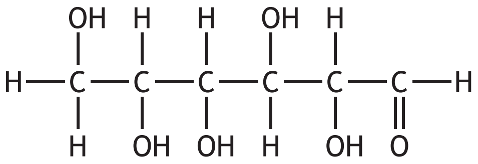
$$NH_2Cl + \bullet Cl \longrightarrow \bullet NHCl + HCl$$

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

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

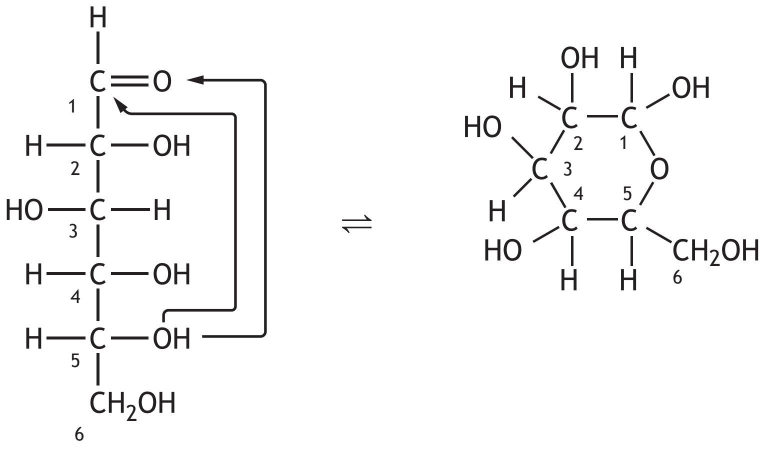
13. (a) One test for glucose involves Fehling's solution.

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



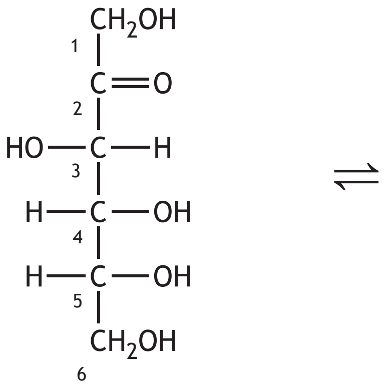
(b) In solution, sugar molecules exist in an equilibrium in straight-chain and ring forms.

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]

H

National
Qualifications
2015

2015 Chemistry

New Higher

Finalised Marking Instructions

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Go to Topic Grid

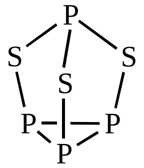
Detailed Marking Instructions for each question

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**

Go to Topic Grid

Section 2

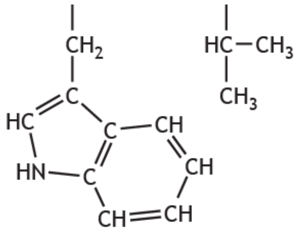
Question			Answer	Max Mark	Additional Guidance
1.	**(a)**		Sulfur – London dispersion forces / van der Waals / intermolecular forces **(1)** Silicon dioxide – (polar)covalent (network) bonds **(1)**	**2**	Accept LDF for London dispersion forces If candidate answers pure covalent, ignore pure.
	(b)	**(i)**	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**	

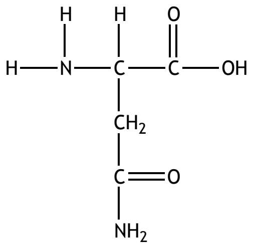
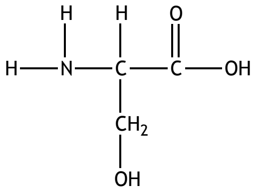
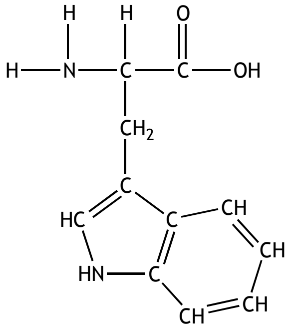
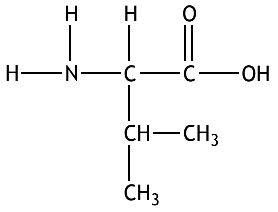
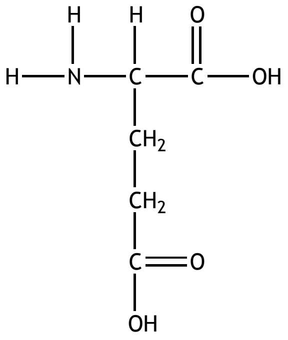
Question			Answer	Max Mark	Additional Guidance
3.	(a)	(i)	Workable apparatus for passing steam **through** strawberry gum leaves **(1)** Workable apparatus for condensing the steam and essential oil **(1)**	2	Treat both marks separately "Through" not "over" A closed system would not allow candidates 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.

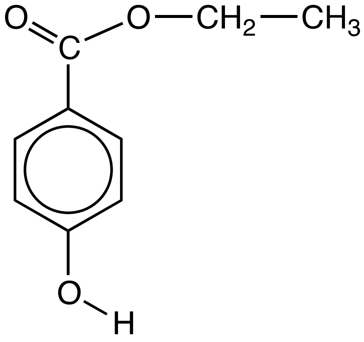
Question			Answer	Max Mark	Additional Guidance
6.	**(a)**		Heat breaks hydrogen bonds	**1**	
	(b)	**(i)**	Either of structures shown circled 	**1**	
		(ii)	50·5 ± 1 °C	**1**	
	(c)	**(i)**	Hydrolysis	**1**	
		(ii) (A)	5	**1**	

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

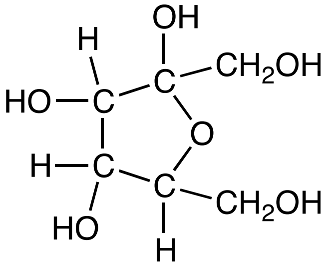
Question			Answer	Max Mark	Additional Guidance
		(ii)	0·799 (0·8)	**1**	Units not required
	(c)	**(i)**	If reactions are exothermic heat will need to be removed / If reactions are endothermic heat will need to be supplied **or** Chemists can create conditions to maximise yield	1	This is not a mark about 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]

H

National
Qualifications
2016

X713/76/02

Chemistry
Section 1 — Questions

WEDNESDAY, 18 MAY
9:00 AM – 11:30 AM

Instructions for the completion of Section 1 are given on *Page 02* of your question and answer booklet X713/76/01.

Record your answers on the answer grid on *Page 03* 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.

Go to Topic Grid

SECTION 1 — 20 marks

Attempt ALL questions

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

Which of the following compounds contains ions which are isoelectronic?

A Na_2S
B $MgCl_2$
C KBr
D $CaCl_2$

2. Which line in the table is correct for the polar covalent bond in hydrogen chloride?

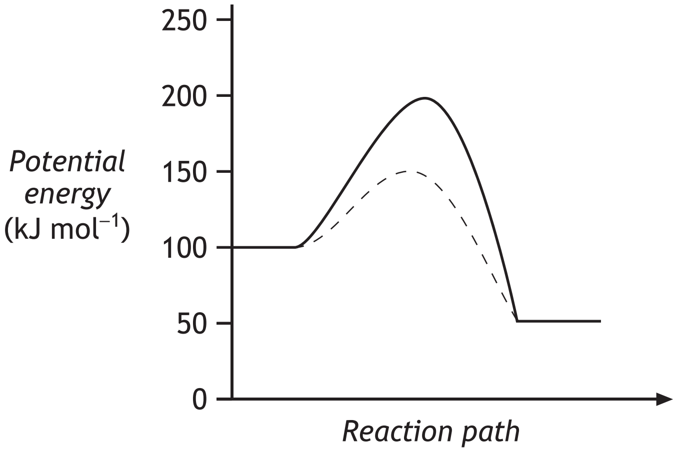
	Relative position of bonding electrons	*Dipole notation*
A	H —: Cl	$\overset{\delta+}{\mathrm{H}} — \overset{\delta-}{\mathrm{Cl}}$
B	H :— Cl	$\overset{\delta+}{\mathrm{H}} — \overset{\delta-}{\mathrm{Cl}}$
C	H —: Cl	$\overset{\delta-}{\mathrm{H}} — \overset{\delta+}{\mathrm{Cl}}$
D	H :— Cl	$\overset{\delta-}{\mathrm{H}} — \overset{\delta+}{\mathrm{Cl}}$

3. Which of the following compounds has the greatest ionic character?

A Caesium fluoride
B Caesium iodide
C Sodium fluoride
D Sodium iodide

Go to Answers

4. The diagram below shows the energy profiles for a reaction carried out with and without a catalyst.



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

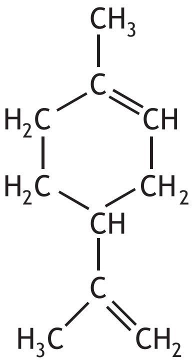
A –100

B –50

C +50

D +100

5. Limonene is a terpene molecule present in lemons.



limonene

How many isoprene units are joined together in a limonene molecule?

A 1

B 2

C 3

D 4

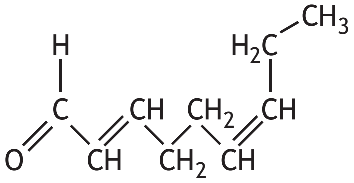
[Turn over

Go to Topic Grid

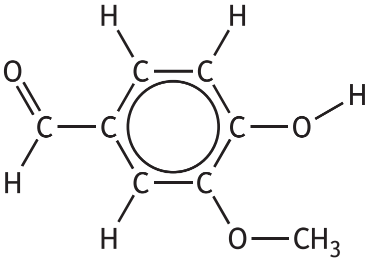
6. The following molecules give flavour to food.

Which of the following flavour molecules would be most likely to be retained in the food when the food is cooked in water?

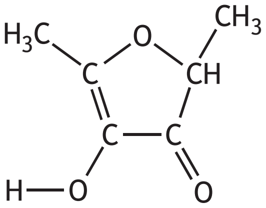
A



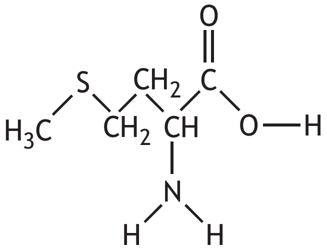
B



C



D



7. vegetable oil ⟶ vegetable fat

Which of the following reactions brings about the above change?

A Hydrolysis

B Condensation

C Hydrogenation

D Dehydrogenation

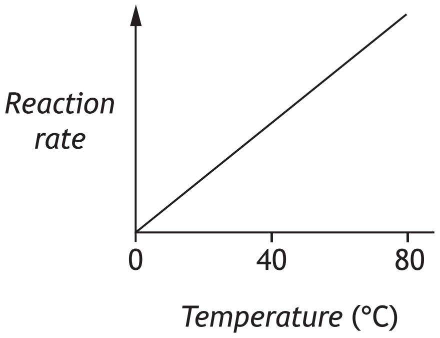
Go to Answers

Go to Topic Grid

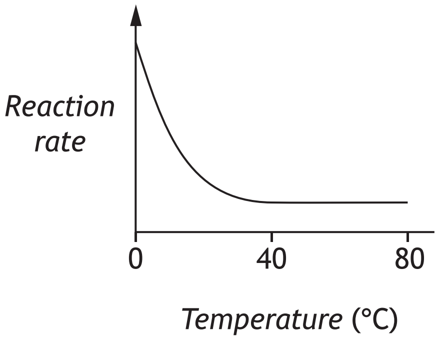
8. The rate of hydrolysis of protein, using an enzyme, was studied at different temperatures.

Which of the following graphs would be obtained?

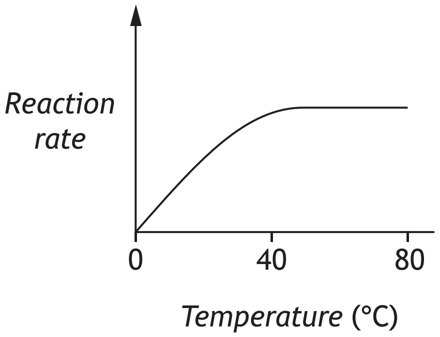
A



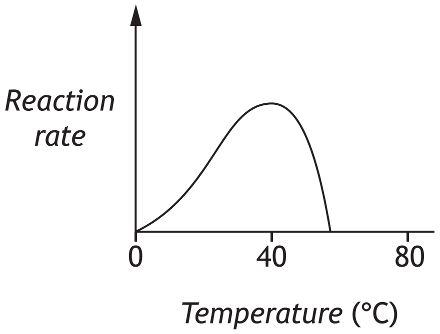
B



C



D



[Turn over

Go to Answers

9. Which of the following is the salt of a long-chain fatty acid?

A Fat
B Oil
C Soap
D Glycerol

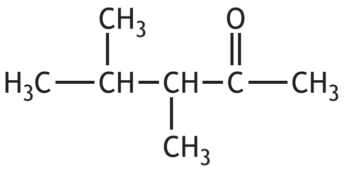
10. Emulsifiers for use in food are commonly made by reacting edible oils with

A esters
B glycerol
C fatty acids
D amino acids.

11. The equation for the reduction reaction taking place when ethanal reacts with Tollens' reagent is

A $Cu^{2+}(aq) + e^{-} \rightarrow Cu^{+}(aq)$
B $Ag^{+}(aq) + e^{-} \rightarrow Ag(s)$
C $Cr_2O_7^{2-}(aq) + 14H^{+}(aq) + 6e^{-} \rightarrow 2Cr^{3+}(aq) + 7H_2O(\ell)$
D $MnO_4^{-}(aq) + 8H^{+}(aq) + 5e^{-} \rightarrow Mn^{2+}(aq) + 4H_2O(\ell)$

12. The name of the compound with structure:



$H_3C-CH(CH_3)-CH(CH_3)-C(=O)-CH_3$

is

A 2,3-dimethylpentan-4-one
B 2,3-dimethylpentan-2-al
C 3,4-dimethylpentan-2-one
D 3,4-dimethylpentan-2-al.

13. $CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(\ell)$

Mass of 1 mol = 100 g (under $CaCO_3$); Mass of 1 mol = 164 g (under $Ca(NO_3)_2$)

2·00 g of calcium carbonate ($CaCO_3$) was reacted with 200 cm^3 of 0·1 mol l^{-1} nitric acid (HNO_3).

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

In the reaction

A $CaCO_3$ is the limiting reactant

B an excess of 0·1 mol of nitric acid remains at the end of the reaction

C 1·64 g of calcium nitrate is produced by the reaction

D 480 cm^3 of carbon dioxide is produced by the reaction.

14. The mean bond enthalpy of a C – F bond is 484 kJ mol^{-1}.

In which of the processes is ΔH approximately equal to +1936 kJ mol^{-1}?

A $CF_4(g) \rightarrow C(s) + 2F_2(g)$

B $CF_4(g) \rightarrow C(g) + 4F(g)$

C $CF_4(g) \rightarrow C(g) + 2F_2(g)$

D $CF_4(g) \rightarrow C(s) + 4F(g)$

15. In a reversible reaction, equilibrium is reached when

A molecules of reactants cease to change into molecules of products

B the concentrations of reactants and products are equal

C the concentrations of reactants and products are constant

D the activation energy of the forward reaction is equal to that of the reverse reaction.

16. Which of the following equations represents the enthalpy of combustion of propane?

A $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell)$

B $C_3H_8(g) + \frac{7}{2}O_2(g) \rightarrow 3CO(g) + 4H_2O(\ell)$

C $C_3H_8(g) + 3O_2(g) \rightarrow 3CO_2(g) + 4H_2(g)$

D $C_3H_8(g) + \frac{3}{2}O_2(g) \rightarrow 3CO(g) + 4H_2(g)$

17. An oxidising agent

A gains electrons and is oxidised

B loses electrons and is oxidised

C gains electrons and is reduced

D loses electrons and is reduced.

18. During a redox process in acid solution, chlorate ions, $ClO_3^-(aq)$, are converted into chlorine, $Cl_2(g)$.

$$ClO_3^-(aq) \rightarrow Cl_2(g)$$

The numbers of $H^+(aq)$ and $H_2O(\ell)$ required to balance the ion-electron equation for the formation of 1 mol of $Cl_2(g)$ are, respectively

A 3 and 6

B 6 and 3

C 6 and 12

D 12 and 6.

19. Which of the following ions could be used to oxidise iodide ions to iodine?

$$2I^-(aq) \rightarrow I_2(s) + 2e^-$$

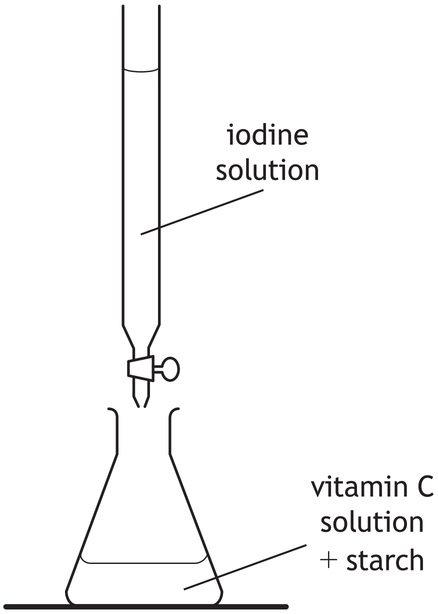
A $SO_4^{2-}(aq)$

B $SO_3^{2-}(aq)$

C $Cr^{3+}(aq)$

D $Cr_2O_7^{2-}(aq)$

20.



A student was carrying out a titration to establish the concentration of vitamin C using iodine solution.

Which of the following would help the student achieve a precise end-point?

A Placing a white tile underneath the conical flask

B Using the bottom of the meniscus when reading the burette

C Repeating titrations

D Carrying out a rough titration first

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

SECTION 2 — 80 marks

Attempt ALL questions

1. Hydrogen peroxide gradually decomposes into water and oxygen, according to the following equation.

$$2H_2O_2(aq) \rightarrow 2H_2O(\ell) + O_2(g)$$

(a) At room temperature, the reaction is very slow. It can be speeded up by heating the reaction mixture.

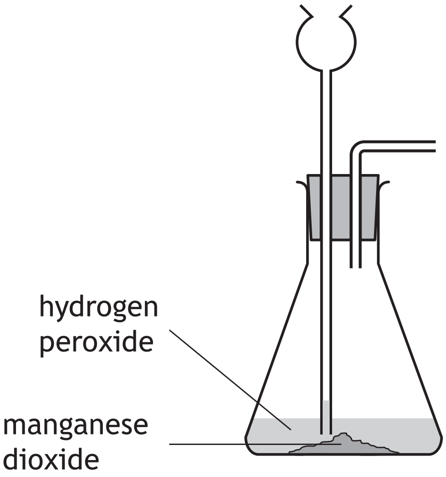
State why increasing the temperature causes an increase in reaction rate. **1**

(b) (i) The reaction can also be speeded up by adding a catalyst, such as manganese dioxide.

To determine the rate of the reaction, the volume of gas produced in a given time can be measured.

Complete the diagram below to show how the gas produced can be collected and measured. **1**

(An additional diagram, if required, can be found on *Page 38*).



1. (b) (continued)

(ii) The concentration of hydrogen peroxide is often described as a volume strength. This relates to the volume of oxygen that can be produced from a hydrogen peroxide solution.

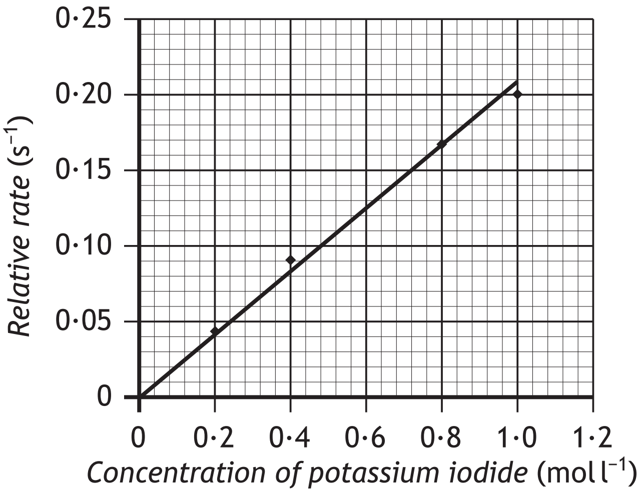
volume of oxygen produced	=	volume strength	×	volume of hydrogen peroxide solution

In an experiment, 74 cm^3 of oxygen was produced from 20 cm^3 of hydrogen peroxide solution.

Calculate the volume strength of the hydrogen peroxide. **1**

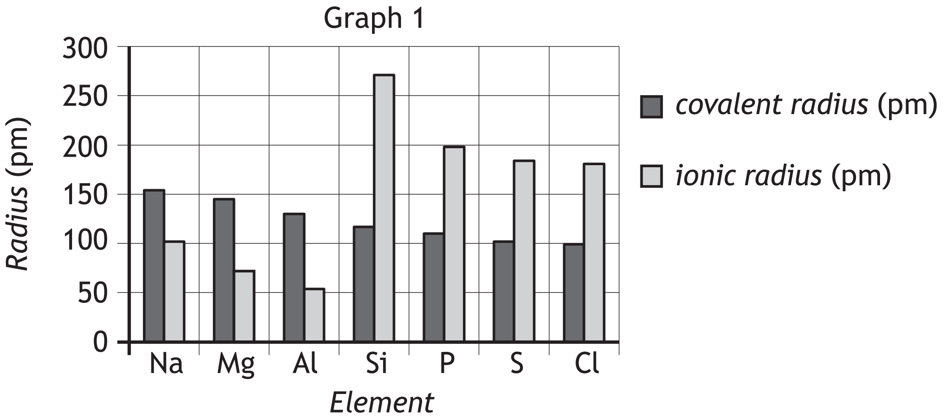
(c) Hydrogen peroxide can react with potassium iodide to produce water and iodine.

A student carried out an experiment to investigate the effect of changing the concentration of potassium iodide on reaction rate. The results are shown below.



Calculate the time taken, in s, for the reaction when the concentration of potassium iodide used was 0·6 mol l^{-1}. **1**

2. (a) Graph 1 shows the sizes of atoms and ions for elements in the third period of the Periodic Table.



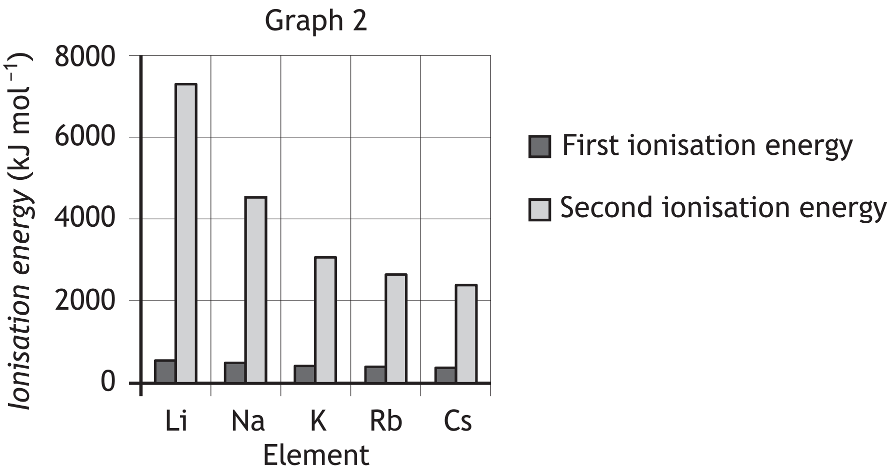
The covalent radius is a measure of the size of an atom.

(i) Explain why covalent radius decreases across the period from sodium to chlorine. **1**

(ii) Explain **fully** why the covalent radius of sodium is larger than the ionic radius of sodium. **2**

2. (continued)

(b) Graph 2 shows the first and second ionisation energies of elements in Group 1 of the Periodic Table.



(i) Explain why the first ionisation energy decreases going down Group 1. **1**

(ii) Explain **fully** why the second ionisation energy is much greater than the first ionisation energy for Group 1 elements. **2**

2. (continued)

(c) The lattice enthalpy is the energy needed to completely separate the ions in one mole of an ionic solid.

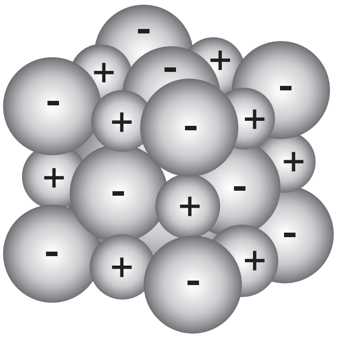


Table 1 shows the size of selected ions.

Table 1

Ion	Li^+	Na^+	K^+	Rb^+	F^-	Cl^-
Ionic radius (pm)	76	102	138	152	133	181

Table 2 shows the lattice enthalpies, in kJ mol^{-1}, for some Group 1 halides.

Table 2

Ions	F^-	Cl^-
Li^+	1030	834
Na^+	910	769
K^+	808	701
Rb^+		658

(i) Predict the lattice enthalpy, in kJ mol^{-1}, for rubidium fluoride. **1**

(ii) Write a general statement linking lattice enthalpy to ionic radii. **1**

3. Phosphine (PH_3) is used as an insecticide in the storage of grain.

Phosphine can be produced by the reaction of water with aluminium phosphide

$$AlP(s) + 3H_2O(\ell) \longrightarrow PH_3(g) + Al(OH)_3(aq)$$

(a) State the type of bonding and structure in phosphine. **1**

(b) 2·9 kg of aluminium phosphide were used in a phosphine generator.

Calculate the volume of phosphine gas, in litres, that would have been produced.

(Take the volume of 1 mole of phosphine to be 24 litres). **2**

(c) Carbon dioxide is fed into the phosphine generator to keep the phosphine concentration less than 2·6%. Above this level phosphine can ignite due to the presence of diphosphane, $P_2H_4(g)$, as an impurity.

Draw a structural formula for diphosphane. **1**

4. The viscosity of alcohols depends on a number of factors:

- the strength of intermolecular forces
- the size of the molecule
- temperature

These factors can be investigated using alcohols and apparatus from the lists below.

Alcohols	***Apparatus***
methanol	beakers
ethanol	funnels
propan-1-ol	burettes
ethane-1,2-diol	measuring cylinders
butan-1-ol	plastic syringes
propane-1,3-diol	glass tubing
pentan-1-ol	stoppers
propane-1,2,3-triol	timer
	metre stick
	ball bearing
	clamp stands
	kettle
	thermometer

Using your knowledge of chemistry, identify the alcohols and apparatus that you would select and describe how these could be used to investigate one, or more, of the factors affecting the viscosity of alcohols. **3**

5. When fats and oils are hydrolysed, mixtures of fatty acids are obtained.

(a) Name the other product obtained in this reaction. 1

(b) The table below shows the percentage composition of the fatty acid mixtures obtained by hydrolysis of coconut oil and olive oil.

Class of fatty acids produced on hydrolysis	*Name of oil*	
	Coconut oil	Olive oil
Saturated	91	14
Monounsaturated	6	72
Polyunsaturated	3	14

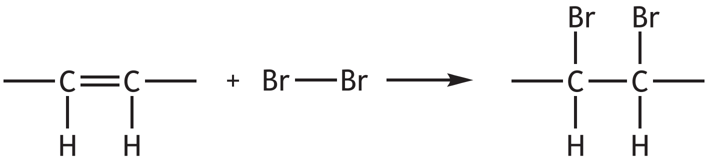
(i) One of the fatty acids produced by the hydrolysis of olive oil is linoleic acid, $C_{17}H_{31}COOH$.

State the class of fatty acid to which linoleic acid belongs. 1

(ii) Hydrolysed coconut oil contains the fatty acid, caprylic acid, with the formula $CH_3(CH_2)_6COOH$.

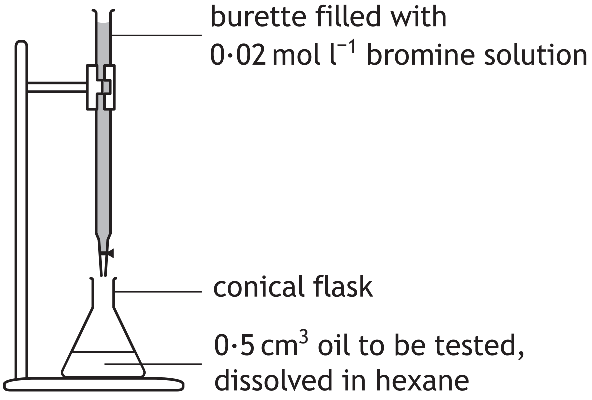
State the systematic name for caprylic acid. 1

(c) The degree of unsaturation of oil can be tested by adding drops of bromine solution to the oil. Bromine adds across carbon to carbon double bonds in the fatty acid chains.



5. (c) (continued)

The following apparatus can be used to compare the degree of unsaturation of different oils.



(i) Describe how this apparatus could be used to show that olive oil has a greater degree of unsaturation than coconut oil. **2**

(ii) Suggest why hexane is used as the solvent, rather than water. **1**

(iii) Coconut oil has a melting point of 25 °C. Olive oil has a melting point of −6 °C.

Give two reasons why coconut oil has a higher melting point than olive oil. **2**

6. Peptide molecules can be classified according to the number of amino acid units joined by peptide bonds in the molecule.

Type of peptide	*Example of amino acid sequence*
dipeptide	aspartic acid-phenylalanine
tripeptide	isoleucine-proline-proline
tetrapeptide	lysine-proline-proline-arginine
pentapeptide	serine-glycine-tyrosine-alanine-leucine
	alanine-glycine-valine-proline-tyrosine-serine
polypeptide	many amino acids

(a) Complete the table to identify the type of peptide with the following amino acid sequence

alanine-glycine-valine-proline-tyrosine-serine **1**

(b) Partial hydrolysis of another pentapeptide molecule gave a mixture of three smaller peptide molecules with the following amino acid sequences.

leucine-glycine-valine

isoleucine-leucine

glycine-valine-serine

Write the amino acid sequence for the original pentapeptide molecule. **1**

…………………… – …………………… – …………………… – …………………… – ……………………

(c) Some amino acids needed to form polypeptides cannot be produced in the human body.

State the term used to describe amino acids that the body cannot make. **1**

6. (continued)

(d) Paper chromatography is often used to analyse the mixtures of amino acids produced when peptides are broken down.

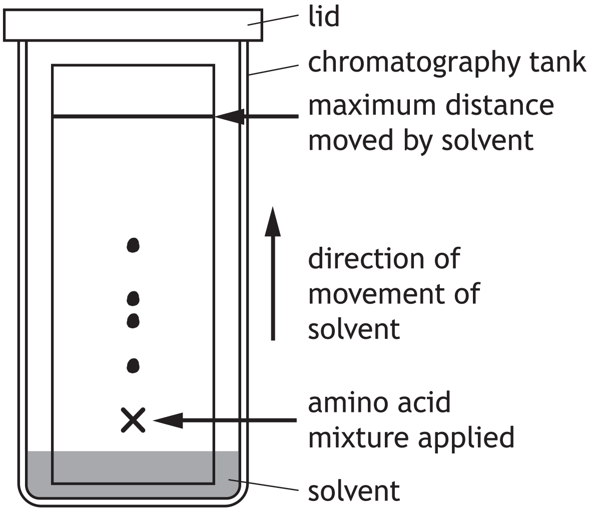
On a chromatogram, the retention factor R_f, for a substance can be a useful method of identifying the substance.

$$R_f = \frac{\text{distance moved by the substance}}{\text{maximum distance moved by the solvent}}$$

The structure of the pentapeptide methionine enkephalin was investigated.

A sample of the pentapeptide was completely hydrolysed into its constituent amino acids and this amino acid mixture was applied to a piece of chromatography paper and placed in a solvent.

The chromatogram obtained is shown below.



(i) Suggest why only four spots were obtained on the chromatogram of the hydrolysed pentapeptide. **1**

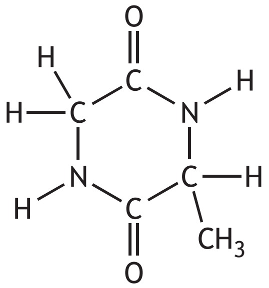
(ii) It is known that this amino acid mixture contains the amino acid methionine. The R_f value for methionine in this solvent is 0·40.

Draw a circle around the spot on the chromatogram that corresponds to methionine. **1**

6. (continued)

(e) Over the last decade several families of extremely stable peptide molecules have been discovered, where the peptide chain forms a ring.

(i) A simple cyclic dipeptide is shown.



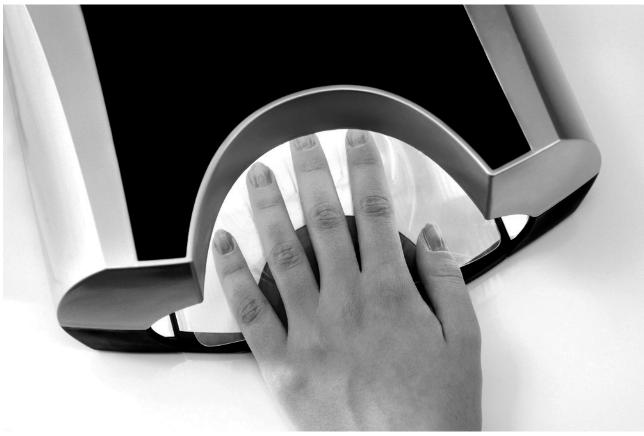
Draw a structural formula for one of the amino acids that would be formed on complete hydrolysis of the above cyclic dipeptide. **1**

(ii) Alpha-amanitin is a highly toxic cyclic peptide found in death cap mushrooms. The lethal dose for humans is 100 mg per kg of body mass.

1·0 g of death cap mushrooms contains 250 mg of alpha-amanitin.

Calculate the minimum mass of death cap mushrooms that would contain the lethal dose for a 75 kg adult. **2**

7. Modern shellac nail varnishes are more durable and so last longer than traditional nail polish.



The shellac nail varnish is applied in thin layers to the nails and then the fingers are placed under a UV lamp.

(a) The Skin Care Foundation has recommended that a sun-block is applied to the fingers and hand before using the lamp.

Suggest why the Skin Care Foundation makes this recommendation. **1**

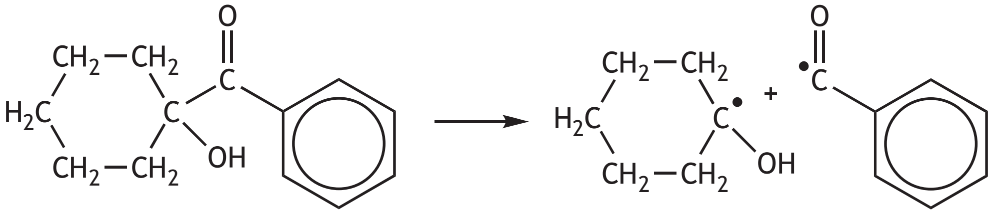
(b) A *free radical* chain reaction takes place and the varnish hardens.

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

7. **(b) (continued)**

(ii) The shellac nail varnish contains a mixture of ingredients that take part in the free radical chain reaction.

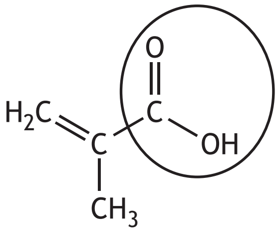
One of the steps in the free radical chain reaction is:



State the term used to describe this type of step in a free radical chain reaction. **1**

(iii) During the free radical chain reaction small molecules join to form large chain molecules.

One example of a small molecule used is



Name the functional group circled above. **1**

(iv) Alcohol wipes are used to finish the varnishing treatment. Alcohol wipes contain the alcohol propan-2-ol.

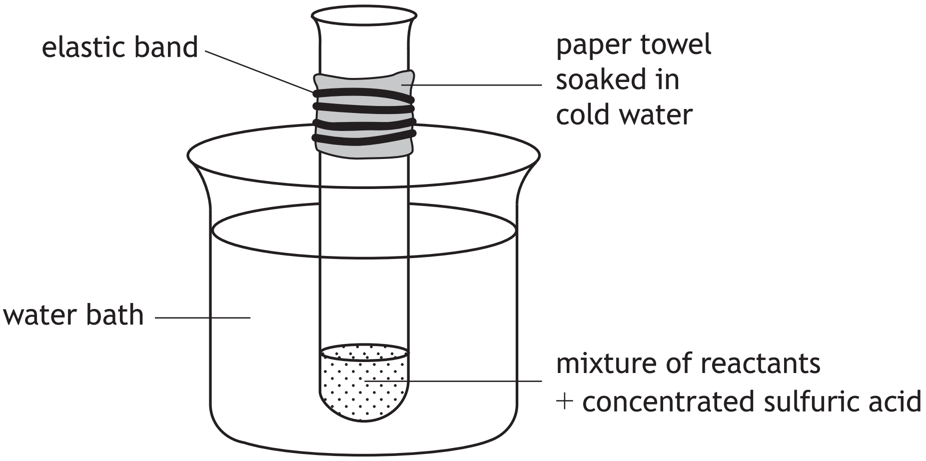
State why propan-2-ol can be described as a secondary alcohol. **1**

7. (continued)

(c) Traditional nail varnishes use ethyl ethanoate and butyl ethanoate as solvents.

(i) Draw a structural formula for butyl ethanoate. **1**

(ii) Ethyl ethanoate can be made in the laboratory using the following apparatus.



Suggest why a wet paper towel is wrapped around the test tube. **1**

7. (c) (continued)

(iii) A student used 2·5 g of ethanol and a slight excess of ethanoic acid to produce 2·9 g of ethyl ethanoate.

$$\underset{\substack{\text{mass of}\\\text{one mole}\\=46{\cdot}0\,\text{g}}}{\text{ethanol}} + \text{ethanoic acid} \rightleftharpoons \underset{\substack{\text{mass of}\\\text{one mole}\\=88{\cdot}0\,\text{g}}}{\text{ethyl ethanoate}} + \text{water}$$

(One mole of ethanol reacts with one mole of ethanoic acid to produce one mole of ethyl ethanoate.)

Calculate the percentage yield of ethyl ethanoate. **2**

(iv) Name the type of reaction that takes place during the formation of ethyl ethanoate. **1**

[Turn over

8. Methanol (CH_3OH) is an important chemical in industry.

(a) Methanol is produced from methane in a two-step process.

In step 1, methane is reacted with steam as shown.

Step 1: $CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g) \quad \Delta H = +210\,kJ\,mol^{-1}$

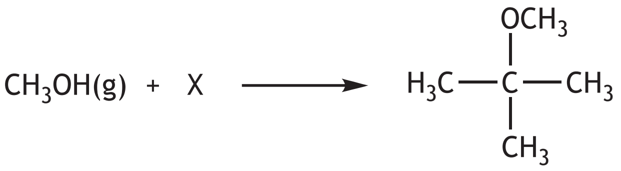
In step 2, hydrogen reacts with carbon monoxide.

Step 2: $2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -91\,kJ\,mol^{-1}$

Complete the table to show the most favourable conditions to maximise the yield for each step. **2**

	Temperature (High/Low)	*Pressure* (High/Low)
Step 1		
Step 2		

(b) Methanol reacts with compound X, in an addition reaction, to form methyl tertiary-butyl ether, an additive for petrol.



$$CH_3OH(g) + X \longrightarrow H_3C-\overset{\displaystyle OCH_3}{\underset{\displaystyle CH_3}{C}}-CH_3$$

methyl tertiary-butyl ether

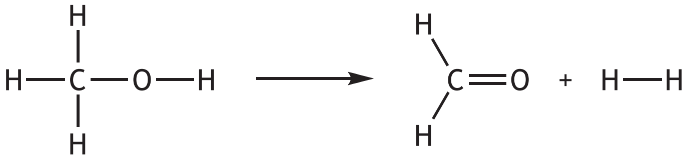
(i) Suggest a structure for compound X. **1**

(ii) The atom economy of this reaction is 100%.

Explain what this means. **1**

8. (continued)

(c) Methanol can be converted to methanal as shown.

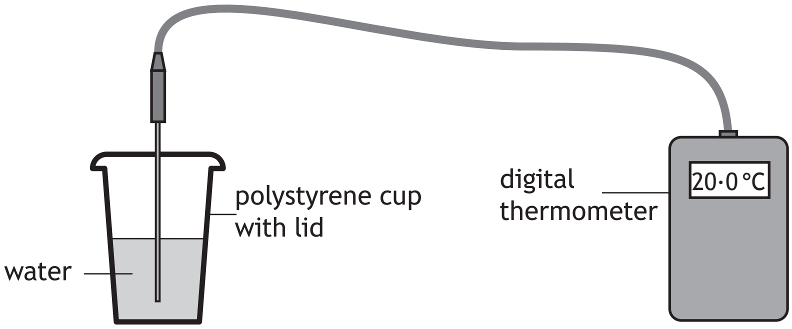


Using bond enthalpy and mean bond enthalpy values from the data booklet, calculate the enthalpy change, in kJ mol^{-1}, for the reaction. **2**

[Turn over

9. A group of students carried out an investigation into the energy changes that take place when metal hydroxides dissolve in water.

The following apparatus was used as a simple calorimeter to determine the change in temperature.



The experiment was carried out as follows.

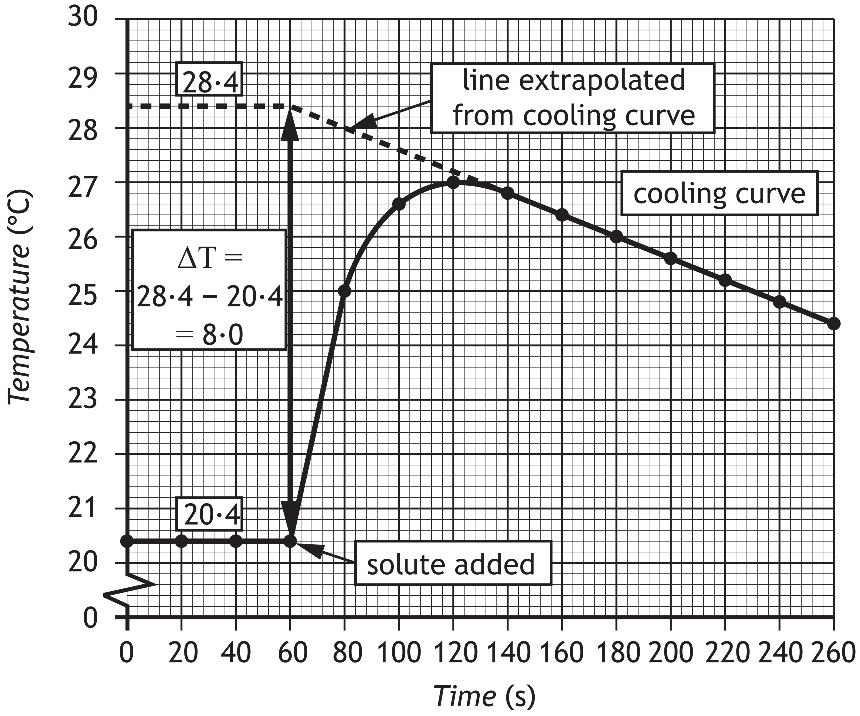
Step 1: 100 cm^3 of deionised water was added to the cup.

Step 2: The stop-clock was started, the water stirred continuously and the temperature recorded every 20 seconds.

Step 3: After 60 seconds, an accurately weighed mass of the metal hydroxide was added to the water and the temperature recorded every 20 seconds.

Graph 1 shows the group's results for lithium hydroxide.

Graph 1 – Lithium hydroxide



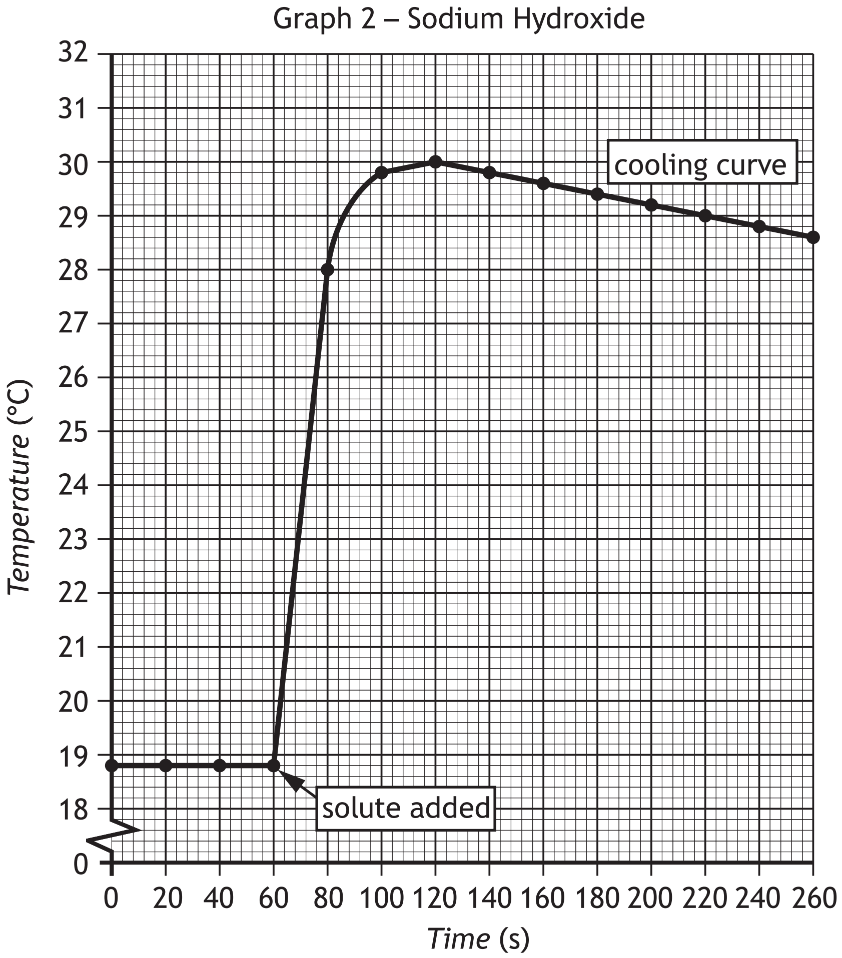
The heat energy transferred to the water can be calculated as shown.

$$E_h = cm\Delta T$$
$$= 4{\cdot}18 \times 0{\cdot}10 \times 8{\cdot}0$$
$$= 3{\cdot}3\ \text{kJ}$$

9. (continued)

(a) The experiment was repeated using sodium hydroxide.

Graph 2 shows the results of this experiment.



(i) Using Graph 2 calculate the heat energy transferred to the water, in kJ, when the sodium hydroxide dissolved. **2**

(ii) Suggest why the experiment was carried out in a polystyrene cup with a lid. **1**

9. (a) (continued)

(iii) **In another experiment** the students found that 5·61 g of potassium hydroxide (KOH) released 5·25 kJ of heat energy on dissolving.

Use this information to calculate the energy released, in kJ mol^{-1}, when one mole of potassium hydroxide dissolves in water. **1**

(b) Calcium hydroxide solution can be formed by adding calcium metal to excess water.

Solid calcium hydroxide would form if the exact molar ratio of calcium to water is used. The equation for the reaction is

$$Ca(s) + 2H_2O(\ell) \rightarrow Ca(OH)_2(s) + H_2(g)$$

Calculate the enthalpy change, in kJ mol^{-1}, for the reaction above by using the data shown below.

$H_2(g) + ½O_2(g) \rightarrow H_2O(\ell)$ $\Delta H = -286\ kJ\ mol^{-1}$

$Ca(s) + O_2(g) + H_2(g) \rightarrow Ca(OH)_2(s)$ $\Delta H = -986\ kJ\ mol^{-1}$ **2**

10. The chemical industry creates an immense variety of products which impact on virtually every aspect of our lives. Industrial scientists, including chemical engineers, production chemists and environmental chemists, carry out different roles to maximise the efficiency of industrial processes.

Using your knowledge of chemistry, comment on what industrial scientists can do to maximise profit from industrial processes and minimise impact on the environment. **3**

11. Soft drinks contain a variety of sugars. A student investigated the sugar content of a soft drink.

(a) The density of the soft drink can be used to estimate its total sugar concentration. Solutions of different sugars, with the same concentration, have similar densities.

The first experiment was to determine the total sugar concentration of the soft drink by comparing the density of the drink with the density of standard sucrose solutions.

(i) This firstly involved producing standard sucrose solutions of different concentrations.

The standard sucrose solutions were made up in volumetric flasks.

Draw a diagram of a volumetric flask. **1**

(ii) The density of each standard sucrose solution was then determined. In order to determine the density of each solution, the student accurately measured the mass of 10·0 cm^3 of each sucrose solution.

Describe **fully** a method that the student could have used to accurately measure the mass of 10·0 cm^3 of each sucrose solution. **2**

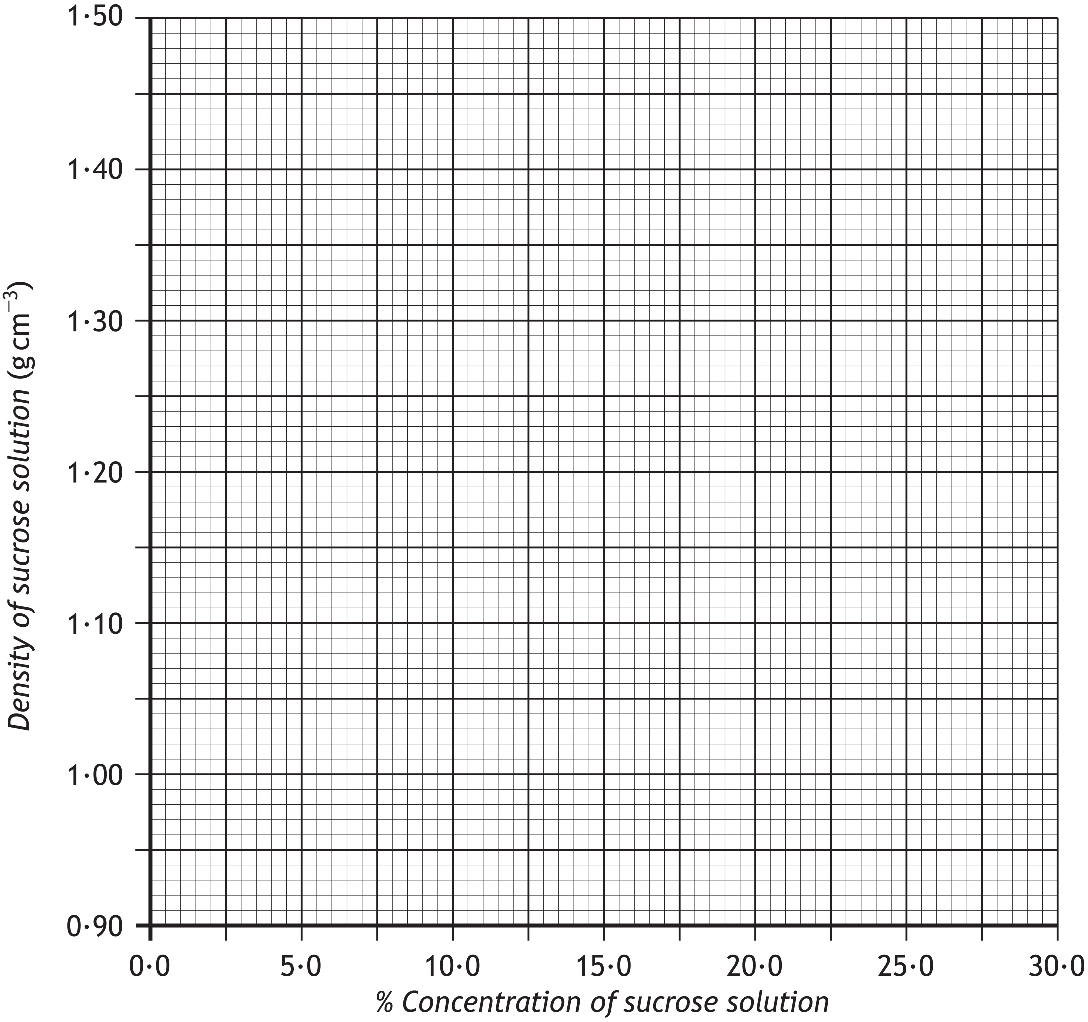
11. (a) (continued)

(iii) The results that the student obtained for the density of the standard solutions of sucrose are shown in the table.

% Concentration of sucrose solution	*Density of sucrose solution* ($g\,cm^{-3}$)
0·0	1·00
5·0	1·10
10·0	1·19
15·0	1·31
20·0	1·41

Draw a line graph using the student's results. **2**

(Additional graph paper, if required, can be found on *Page 38*.)



11. (a) (continued)

(iv) The student used the line graph to obtain the relationship between the concentration of sugars in solution and the density of the solution.

This equation shows the relationship.

density of sugar in g cm^{-3} = (0·0204 × % concentration of sugars in solution) + 1·00

The student then determined the density of a soft drink. In order to ensure that the drink was flat, all the gas had been allowed to escape.

(A) Suggest a reason why the soft drink needed to be flat before its density was determined. **1**

(B) The soft drink tested had a density of 1·07 g cm^{-3}.

Using the equation, calculate the % concentration of sugars present in the soft drink. **1**

(v) A different soft drink is found to contain 10·6 grams of sugar in 100 cm^3.

Calculate the total mass of sugar present, in grams, in a 330 cm^3 can of this soft drink. **1**

(b) The second experiment in the investigation was to determine the concentration of specific types of sugar called reducing sugars. This was carried out by titration with Fehling's solution.

(i) Reducing sugars contain an aldehyde functional group.

Draw this functional group. **1**

11. (b) (continued)

(ii) The overall reaction that occurs with Fehling's solution and a reducing sugar is shown.

$$C_6H_{12}O_6 + 2Cu^{2+} + H_2O \rightarrow C_6H_{12}O_7 + 2Cu^{+} + 2H^{+}$$

reducing sugar — Fehling's solution

Write the ion-electron equation for the oxidation reaction. **1**

(iii) State the colour change that would be observed when reducing sugars are reacted with Fehling's solution. **1**

(iv) For the titrations, the student diluted the soft drink to improve the accuracy of results.

25·0 cm^3 samples of the diluted soft drink were titrated with Fehling's solution which had a Cu^{2+} concentration of 0·0250 mol l^{-1}.

The average volume of Fehling's solution used in the titrations was 19·8 cm^3.

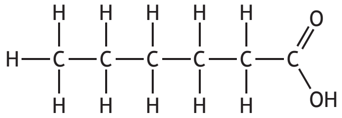
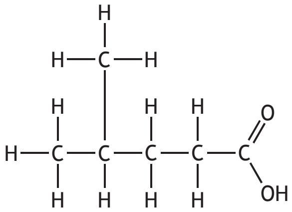
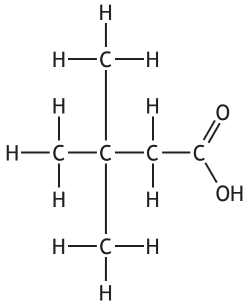
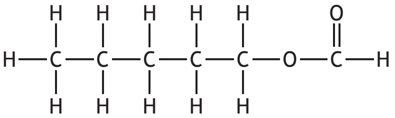
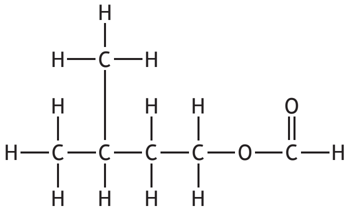
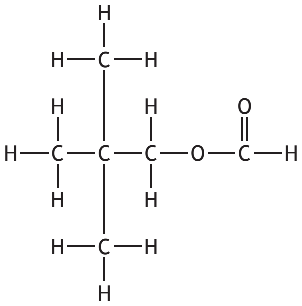
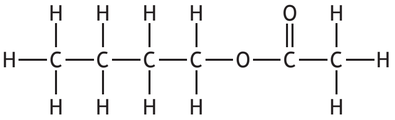
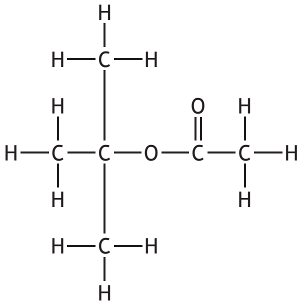
$$C_6H_{12}O_6 + 2Cu^{2+} + H_2O \rightarrow C_6H_{12}O_7 + 2Cu^{+} + 2H^{+}$$

reducing sugar — Fehling's solution

Calculate the concentration, in mol l^{-1}, of reducing sugars present in the diluted sample of the soft drink. **3**

Go to Topic Grid

12. (a) The table shows the boiling points and structures of some isomers with molecular formula $C_6H_{12}O_2$.

Isomer	*Structure*	*Boiling point* (°C)
1		205
2		201
3		187
4		132
5		125
6		119
7		126
8		98

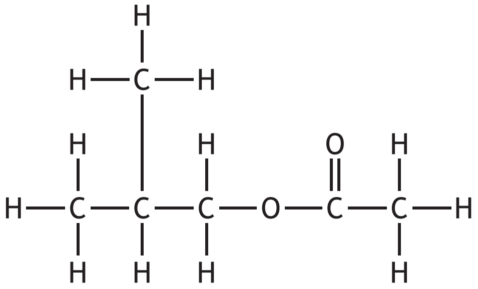
Go to Answers

12. (a) (continued)

(i) Name the intermolecular force which accounts for the higher boiling points of isomers 1, 2 and 3. **1**

(ii) Using the information in the table, describe **two** ways in which differences in structure affect the boiling points of isomeric esters 4–8. **2**

(iii) Predict the boiling point, in °C, for the isomer shown below. **1**



[Turn over

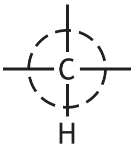
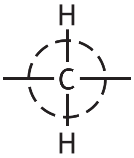
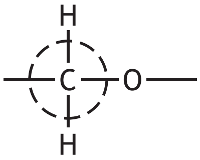
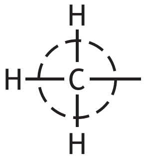
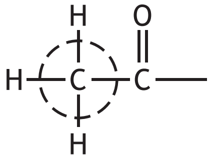
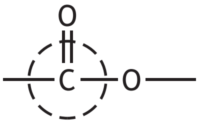
12. (continued)

(b) Carbon-13 NMR spectroscopy is a technique that can be used in chemistry to determine the structure of organic molecules such as esters.

In a carbon-13 NMR spectrum, a carbon atom in a molecule is identified by its **chemical shift**. This value depends on the other atoms bonded to the carbon atom, which is known as the "chemical environment" of the carbon-13 atom.

Carbon-13 chemical shift values are shown in the table below.

The carbon-13 atom in each chemical environment has been circled.

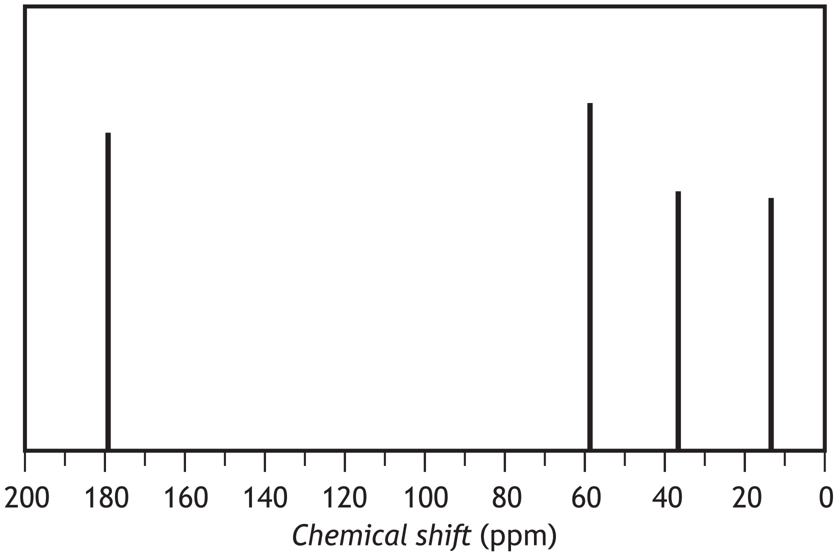
Chemical environment	*Chemical shift* (ppm)
	25–35
	16–25
	50–90
	10–15
	20–50
	170–185

The **number** of peaks in a carbon-13 NMR spectrum corresponds to the number of carbon atoms in different chemical environments within the molecule.

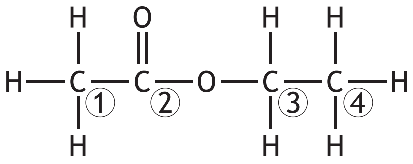
The **position** of a peak (the chemical shift) indicates the type of carbon atom.

12. (b) (continued)

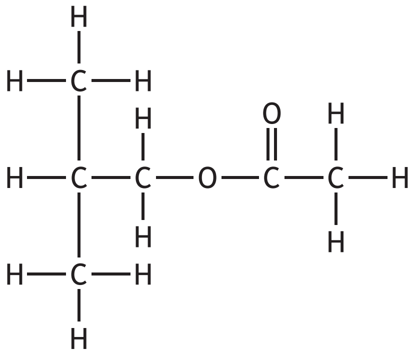
The spectrum for ethyl ethanoate is shown below.



(i) Label each peak in the ethyl ethanoate spectrum with a number to match the carbon atom in ethyl ethanoate, shown below. **1**



(ii) Determine the number of peaks that would be seen in the carbon-13 NMR spectrum for the ester shown below. **1**



Number of peaks in carbon-13 NMR spectrum

= ________________

[END OF QUESTION PAPER]

H

National
Qualifications
2016

2016 Chemistry

Higher

Finalised Marking Instructions

Go to Topic Grid

Marking Instructions for each question

Section 1

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

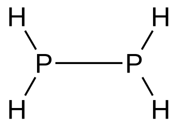
Go to Topic Grid

Section 2

Question			Answer	Max Mark	Additional Guidance
1.	(a)		The number of **successful** collisions will increase/There will be a greater chance of successful collisions **(1 mark)** **OR** More reactant particles will have energy equal to or greater than the activation energy. **(1 mark)**	**1**	Also acceptable More particles have sufficient/enough energy to react.
	(b)	(i)	1 mark for drawing suitable experiment that will work **and** for indicating how **volume** will be measured eg collecting in a gas syringe or downward displacement of water from a measuring cylinder or similar.	**1**	Accept a recognisable/labelled gas syringe, as long as graduations are shown. Graduations must be shown if a measuring cylinder is used. Mark not awarded if delivery tube passes through the side of a measuring cylinder.
		(ii)	3·7 (volume strength).	**1**	Ignore any units. 3·7 must clearly be final answer.
	(c)		8 (s).	**1**	Accept 7·7 (1/0·13) to 8·3 (1/0·12) or correct answer to 2 decimal places. No units required but no mark is awarded if wrong unit is given. (wrong units would only be penalised once in any paper).

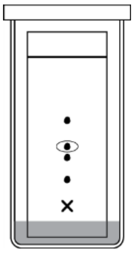
Question			Answer	Max Mark	Additional Guidance
2.	(a)	(i)	(The electron shells are pulled closer because) nuclear charge increases/the number of protons in the nucleus increases.	**1**	Mention must be made of nuclear charge or number of protons in candidate's answer giving the idea of pull by the nucleus. Increased nuclear pull is not accepted.
		(ii)	Two points are required Understanding that the atom loses an electron (when the ion is formed), **(1 mark)** **AND** the Sodium ion will only have two electron shells whereas the sodium atom has three electron shells **OR** the sodium ion will have fewer electron shells (than the sodium atom). **(1 mark)**	**2**	A diagram of the atom and ion or stating the electron arrangement of both would be sufficient to gain 1 mark but the second mark can only be awarded if this diagram or electron arrangement is accompanied with an explanatory statement.
	(b)	(i)	As you go down the group the outer electron is more shielded from the nuclear pull **OR** less strongly attracted by the nucleus.	**1**	
		(ii)	2nd ionisation energy involves removal from an electron shell which is inner/full (whole)/(more) stable/closer to the nucleus **OR** second electron is removed from an electron shell which is inner/full (whole)/(more) stable/closer to the nucleus. **(1 mark)** The electron is less shielded from, or, more strongly attracted to the nucleus. **(1 mark)**	**2**	Stating that more energy is required to remove the second electron would be seen as restating the information from the stem.

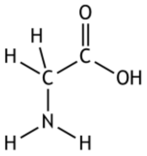
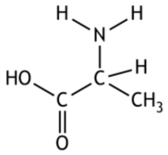
Question			Answer	Max Mark	Additional Guidance
2.	(c)	(i)	Any value in range 720–770 (kJ mol^{-1}).	**1**	Data value 760 kJ mol^{-1} No units required but no mark is awarded if wrong unit is given. (wrong units would only be penalised once in any paper).
		(ii)	As the ionic radii (of the positive and/or the negative ion) increase, the lattice enthalpy decreases.	**1**	A general statement stating the greater the difference in ionic radii the greater the lattice enthalpy must be related to either chlorides or fluorides. The mark cannot be awarded for a statement such as, "As the lattice enthalpy decreases the ionic radii increases" which implies that ionic radius is a dependent variable.

Question			Answer	Max Mark	Additional Guidance
3.	(a)		Covalent molecular.	**1**	
	(b)		n =m/gfm =2900/58 =50 **(1 mark)** V = n × Vm = 50 × 24 = 1200 (litres) **(1 mark)** Or by Proportion 58 g ⟶ 24 l **(1 mark)** 2·9 kg ⟶ 24 × 2900/58ℓ = 1200 (ℓ) **(1 mark)**	**2**	Follow through applies in this question. No units required but only one mark can be awarded if wrong unit is given. (wrong units would only be penalised once in any paper) Accept L for ℓ.
	(c)			**1**	

Question			Answer	Max Mark	Additional Guidance
4.			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
5.	(a)		Glycerol or glycerine or propan(e)-1,2,3-triol.	**1**	
	(b)	(i)	Polyunsaturated.	**1**	
		(ii)	Octanoic acid.	**1**	
	(c)	(i)	Bromine solution is added to both until the bromine is no longer decolourised. (or reddish-brown colour remains) **(1 mark)** More bromine would be required for the more unsaturated/olive oil **OR** Less bromine would be required for the more saturated/coconut oil. **(1 mark)**	**2**	
		(ii)	Hexane is a non-polar (solvent)/ water is a polar (solvent).	**1**	Answers in terms of "Like dissolves like" are only acceptable if explanation in terms of polarity is given. Oil and water don't mix would not be awarded a mark.
		(iii)	Coconut oil molecules can pack more closely together **OR** Coconut oil has linear fatty acid chains/olive oil chains have bends/kinks (due to the double bonds) **(1 mark)** There are stronger/more **intermolecular** forces between the molecules in coconut oil **OR** The London dispersion forces (van der Waals' forces) between the molecules in coconut oil are stronger than in olive oils. **(1 mark)**	**2**	

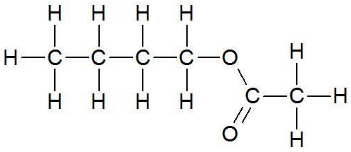
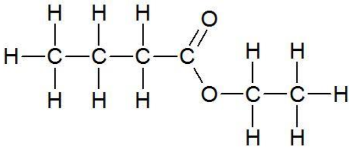
Question			Answer	Max Mark	Additional Guidance
6.	(a)		Hexapeptide.	**1**	
	(b)		isoleucine-leucine-glycine-valine-serine **OR** serine-valine-glycine-leucine-isoleucine.	**1**	
	(c)		Essential.	**1**	
	(d)	(i)	The peptide molecule: must have contained an amino acid that is repeated in the sequence **OR** contained only four different amino acids (accept four different peptides). **OR** The peptide contains two amino acids: with the same R_f value **OR** that moved the same distance.	**1**	
		(ii)		**1**	

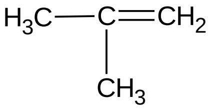
<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Max Mark</th><th>Additional Guidance</th></tr>
<tr><td>6.</td><td>(e)</td><td>(i)</td><td> OR </td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>30 g - units required (2 marks)
Partial marks:
Correctly calculated mass of mushrooms without units,
(1 mark)
Appropriate units (1 mark)
<table><tr><th>Mass (1)</th><th>Units (1)</th></tr><tr><td>0·03</td><td>kg</td></tr><tr><td>30</td><td>g</td></tr><tr><td>30000</td><td>mg</td></tr></table></td><td>2</td><td>If an incorrect mass is calculated but the units used are appropriate to the calculation then 1 mark would be awarded.

If the candidate has ended the calculation at the lethal dosage then the mark for units can be awarded if the unit is appropriate to the value calculated.

If the candidate’s working is unclear in terms of what is being worked out then the mark for units cannot be awarded.</td></tr>
</table>

Question			Answer	Max Mark	Additional Guidance
7.	(a)		Any reason from list UV light is damaging/harmful to skin. UV light causes sunburn. UV light can break bonds/molecules in skin. UV light damages collagen. UV light can cause skin cancer. UV light ages skin. UV light causes photo ageing. UV light creates free radicals/initiates free-radical chain reactions. Sunblocks contain free-radical scavengers.	**1**	
	(b)	(i)	Species (Atoms/molecules etc) with unpaired electrons.	**1**	
		(ii)	Initiation.	**1**	
		(iii)	Carboxylic acid **OR** carboxyl group.	**1**	
		(iv)	The hydroxyl/functional group is attached to a carbon that is attached to two other carbons **OR** The hydroxyl/functional group is attached to a carbon which has only one hydrogen attached.	**1**	The answer required is an answer based on structure not an answer based on a chemical property. ie, an answer stating it can be oxidised to give a ketone would not be awarded the mark.

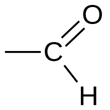
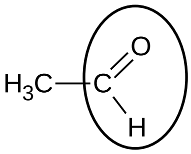
Question			Answer	Max Mark	Additional Guidance
7.	(c)	(i)	A correct structural formula for butyl ethanoate.	**1**	 ✓  X
		(ii)	To condense any vapours or reactants/products which evaporate **OR** To act as a condenser.	**1**	Must be indication that gases are being turned to liquid.
		(iii)	60·7/61 % **(2 marks)** **1 mark** Calculates theoretical mass = 4·78g **OR** correctly calculates no of moles reactant (0·054) and product (0·033) **1 mark** Calculating % yield using the actual and theoretical masses, or using the actual number of moles of products and actual number of moles of reactant.	**2**	Follow through applies.
7.		(iv)	Condensation **OR** Esterification.	**1**	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Max Mark</th><th>Additional Guidance</th></tr>
<tr><td>8.</td><td>(a)</td><td>(i)</td><td><table><tr><th></th><th>Temperature (High/Low)</th><th>Pressure (High/Low)</th></tr><tr><td>Step 1</td><td>High</td><td>Low</td></tr><tr><td>Step 2</td><td>Low</td><td>High</td></tr></table></td><td>2</td><td>Temperature and pressure are dealt with separately as two single marks.</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>Correct structure for 2-methylpropene.</td><td>1</td><td>
$H_3C-C(CH_3)=CH_2$
The name 2-methylpropene would be accepted on it’s own. (on the basis that the candidate would have to process through the structure to obtain the name).</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>The proportion of the total mass of all starting materials successfully converted into the desired product is 100%
OR
All the atoms in the reactants are converted into the product you want./Mass of product is equal to mass of reactants
OR
No by-products/no waste products/ only one product is formed.</td><td>1</td><td></td></tr>
</table>

Question			Answer	Max Mark	Additional Guidance
8	(c)		56 or + 56 **(2)** Bond breaking 412 + 412 + 412 + 360 + 463 = 2059 Bond forming 743 + 412 + 412 + 436 = 2003 2059 − 2003 = 56 (kJ mol^{-1}) A single mark is available if either of the following operations is correctly executed **Either** The five relevant values for the bond enthalpies of the C-H, H-H, C-O, O-H and C=O bonds (or multiples thereof) are retrieved from the data book 412,360,463,743,436 (ignore signs) **OR** If only four values are retrieved, the candidate recognises that bond breaking is endothermic and bond formation is exothermic and correctly manipulates the bond enthalpy values they have used to give their answer.	**2**	−56 would qualify for 1 mark. No units required but only one mark can be awarded for correct answer if wrong unit is given. (wrong units would only be penalised once in any paper). kJ is acceptable in place of kJ mol^{-1}. If less than four bond enthalpy values are retrieved then no mark can be awarded.

Question			Answer	Max Mark	Additional Guidance
9.	(a)	(i)	4·93 (kJ) (no units required) **1 mark** for extrapolating the graph and finding the corrected temperature difference ΔT = 11·8 (°C) **1 mark** for use of the relationship $E_h = cm\Delta T$ to calculate the E_h = 4·93 (kJ) Maximum of **1 mark** for using ΔT = 11·2 which gives E_h = 4·68 (kJ)	**2**	□T 11·6 - 12·0 acceptable 11·6 → 4·85 11·7 → 4·89 11·8 → 4·93 11·9 → 4·97 12·0 → 5·02 □T follow through applies No units required but only one mark can be awarded for correct answer if wrong unit is given. (wrong units would only be penalised once in any paper).
		(ii)	To prevent (minimise) heat loss to the surroundings **OR** polystyrene cup is a poor conductor of heat/insulator.	**1**	
		(iii)	52·5 (kJ or kJmol^{-1})	**1**	accept −52·5 (kJ or kJ mol^{-1}). No units required. No mark can be awarded if wrong unit is given. (wrong units would only be penalised once in any paper).
	(b)		−414 kJ mol^{-1} (no units required) Partial marks Treat as two concepts either would be acceptable for **1 mark** Evidence of understanding of reversal of first equation in order to achieve the target equation. Reversal of both equations would be taken as cancelling **OR** evidence of understanding of multiplying first equation by 2 in order to achieve the target equation.	**2**	No units required but only one mark can be awarded for correct answer if wrong unit is given. (wrong units would only be penalised once in any paper).

Question			Answer	Max Mark	Additional Guidance
10.			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
11.	(a)	(i)	A drawing that shows a flask with a long narrow neck and a single gradation mark which goes completely across, or is labelled, on the narrow neck.	**1**	
		(ii)	Accurate method for volume measurement eg uses pipette **(1 mark)** Describes weighing by difference or using a tared balance. **(1 mark)**	**2**	Burette would be accepted. Syringe not accepted for measuring volume accurately.
		(iii)	All points plotted correctly within tolerance of ½ a box **(1 mark)** Best fit line **(1 mark)**	**2**	
		(iv)	(A) The dissolved gas/bubbles will affect the density/mass/ volume of solution.	**1**	"The gas would affect the results" would not be enough to be awarded the mark.
			(B) 3·43%.	**1**	If a rounded answer is given there must be evidence of the equation being used.
		(v)	34·98 (g)/35·0 (g).	**1**	No units required. No mark can be awarded if wrong unit is given. (wrong units would only be penalised once in any paper).
	(b)	(i)	Correctly drawn aldehyde group 	**1**	Functional group must show open bond. Aldehyde structures only acceptable if functional group is highlighted. 
		(ii)	$C_6H_{12}O_6 + H_2O \rightarrow C_6H_{12}O_7 + 2H + 2e$	**1**	
		(iii)	Blue to orange/(brick)red/brown/ yellow/green.	**1**	Blue-green is not acceptable as the original colour.

Question			Answer	Max Mark	Additional Guidance
11.	(b)	(iv)	0·0099 (mol l^{-1}) **(3 marks)** 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 any one of the following steps: • Calculation of number of moles of Cu^{2+} eg 0·025 × 0·0198 = 0·000495 • Calculation of conc of reducing sugars eg 0·0002475 ÷ 0·025 • Insertion of correct pairings of values of conc and volume in titration formula eg $\frac{0\cdot025\times19\cdot8}{n_1}=\frac{C_{RS}\times25\cdot0}{n_2}$ **1 mark** for knowledge of relationship between Cu^{2+} and reducing sugars. This could be shown by any one of the following steps: • Calculation of moles of reducing sugars from moles Cu^{2+} eg 0·000495 ÷ 2 = 0·0002475 • Insertion of correct stoichiometric values in titration formula e.g. $\frac{0\cdot025\times19\cdot8}{2}=\frac{C_{RS}\times25\cdot0}{1}$ **1 mark** is awarded for correct arithmetic throughout the calculation. This mark can only be awarded if both concept marks have been awarded.	**3**	No units required but only two marks can be awarded for correct answer if wrong unit is given. (wrong units would only be penalised once in any paper). 2 concept marks 1 mark for stoichiometric relationship being applied. 1 mark for correctly using n = c × v Candidates require to correctly apply relationship if used twice in their working. In terms of the mark for the stoichiometric relationship, the 1 should be associated with the unknown concentration of the sugar and the 2 with the with concentration of the Fehling's.

Question			Answer	Max Mark	Additional Guidance
12.	(a)	(i)	hydrogen bonding.	**1**	
		(ii)	(More) branching lowers the boiling point **(1 mark)** The shorter the alcohol, the lower the boiling point/The longer the carboxylic acid the lower the b.p. **OR** The nearer the ester link is to the right hand end (of the molecule) the higher the boiling point. **(1 mark)**	**2**	An answer relating to chain length must be specific to either the alcohol or carboxylic acid portion of the ester. Accept this positional trend if the candidate correctly identifies it by reference to the oxygen atom in the chain or the C=O but not if candidate refers to a carbonyl group.
		(iii)	Any temperature between 99 and 124 (°C) (data value 116°C)	**1**	No units required. No mark can be awarded if wrong unit is given. (wrong units would only be penalised once in any paper).
	(b)	(i)	Peaks labelled in order $\underrightarrow{2,3,1,4}$	**1**	
		(ii)	5.	**1**	

[END OF MARKING INSTRUCTIONS]

H

National
Qualifications
2017

X713/76/02

Chemistry
Section 1 — Questions

MONDAY, 8 MAY

9:00 AM – 11:30 AM

Instructions for the completion of Section 1 are given on *Page 02* of your question and answer booklet X713/76/01.

Record your answers on the answer grid on *Page 03* of your question and answer booklet.

You may refer to the Chemistry Data Booklet for Higher and Advanced Higher.

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.

Go to Topic Grid

SECTION 1 — 20 marks

Attempt ALL questions

1. Which of the following bonds is the **least** polar?

A C — I

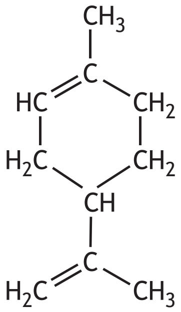
B C — F

C C — Cl

D C — Br

2. Which of the following compounds would be the **most water** soluble?

A



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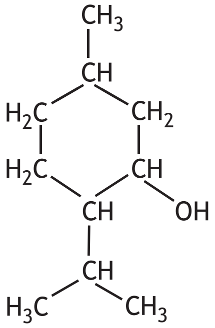
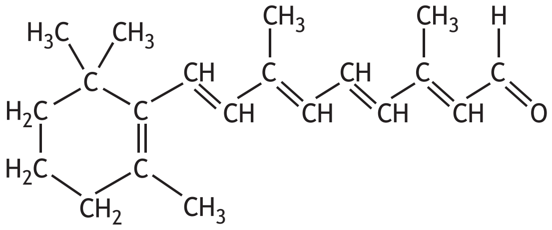


C



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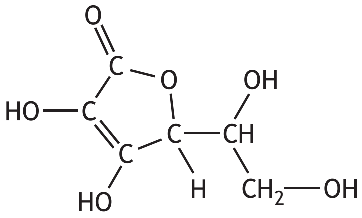


Go to Answers

Go to Topic Grid

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

A Sulfur

B Silicon

C Nitrogen

D Hydrogen

4. Which type of structure is found in phosphorus?

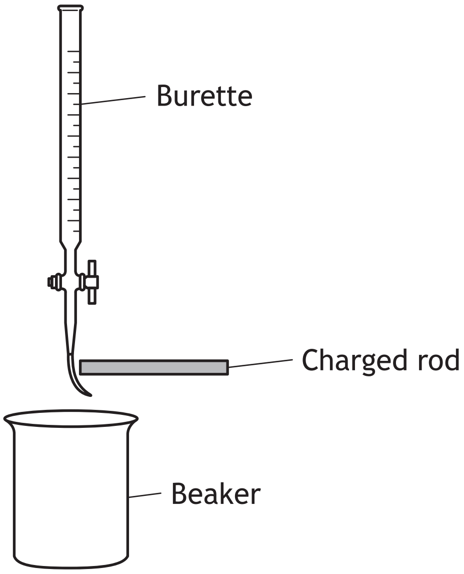
A Covalent network

B Covalent molecular

C Monatomic

D Metallic lattice

5. The polarity of molecules can be investigated using a charged rod. The charged rod will attract a stream of polar liquid flowing from a burette.



Which of the following liquids would **not** be attracted?

A Water

B Propanone

C Propanol

D Hexane

[Turn over

Go to Answers

Go to Topic Grid

6. $x\text{P}_2\text{H}_4 + y\text{O}_2 \rightarrow \text{P}_4\text{O}_{10} + z\text{H}_2\text{O}$

The equation is balanced when

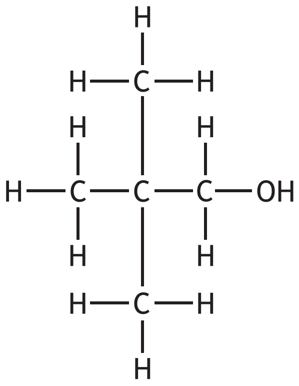
A $x = 1$, $y = 5$, $z = 4$

B $x = 4$, $y = 6$, $z = 2$

C $x = 2$, $y = 7$, $z = 4$

D $x = 2$, $y = 5$, $z = 2$

7. What is the systematic name for the compound below?



A 2,2,2-trimethylethanol

B 2,2-dimethylpropan-1-ol

C 2,2-dimethylpropan-3-ol

D 2,2-dimethylpentan-1-ol

8. Which of the following fatty acids is the most unsaturated?

A $\text{C}_{15}\text{H}_{29}\text{COOH}$

B $\text{C}_{15}\text{H}_{31}\text{COOH}$

C $\text{C}_{17}\text{H}_{31}\text{COOH}$

D $\text{C}_{17}\text{H}_{35}\text{COOH}$

Go to Answers

Go to Topic Grid

9. Which of the following is **not** a step in a free radical chain reaction?

A Activation
B Initiation
C Propagation
D Termination

10. Which of the following is an isomer of ethyl propanoate ($CH_3CH_2COOCH_2CH_3$)?

A Methyl propanoate
B Pentan-2-one
C Pentanoic acid
D Pentane-1,2-diol

11. Essential oils are

A non-water soluble, non-volatile compounds
B non-water soluble, volatile compounds
C water soluble, non-volatile compounds
D water soluble, volatile compounds.

12. The enthalpy of combustion of a hydrocarbon is the enthalpy change when

A one mole of a hydrocarbon burns to give one mole of water
B one mole of a hydrocarbon burns to give one mole of carbon dioxide
C one mole of a hydrocarbon burns completely in oxygen
D one mole of a hydrocarbon burns in one mole of oxygen.

13. Which of the following is the strongest reducing agent?

A Fluorine
B Lithium
C Calcium
D Iodine

[Turn over

Go to Answers

14.

$TiCl_4$	$+$	$2Mg$	$\rightarrow$	$2MgCl_2$	$+$	Ti
mass of one mole = 189·9 g		mass of one mole = 24·3 g		mass of one mole = 95·3 g		mass of one mole = 47·9 g

The atom economy for the production of titanium in the above equation is equal to

A $\frac{47{\cdot}9}{189{\cdot}9 + 24{\cdot}3} \times 100$

B $\frac{47{\cdot}9}{189{\cdot}9 + (2 \times 24{\cdot}3)} \times 100$

C $\frac{95{\cdot}3 + 47{\cdot}9}{189{\cdot}9 + 24{\cdot}3} \times 100$

D $\frac{(2 \times 47{\cdot}9)}{189{\cdot}9 + 24{\cdot}3} \times 100$

15. The vitamin C content of a carton of orange juice was determined by four students. Each student carried out the experiment three times.

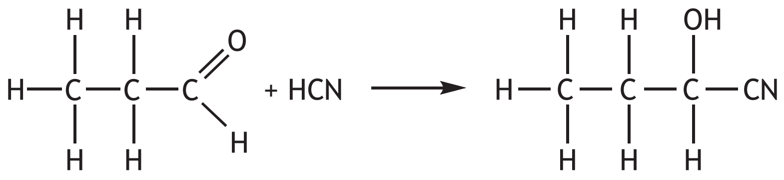
	Experiment 1 (mg/100 cm^3)	*Experiment 2* (mg/100 cm^3)	*Experiment 3* (mg/100 cm^3)
Student A	30·0	29·0	28·0
Student B	26·4	26·6	26·8
Student C	26·9	27·0	26·9
Student D	26·9	26·5	26·9

The most reproducible results were obtained by

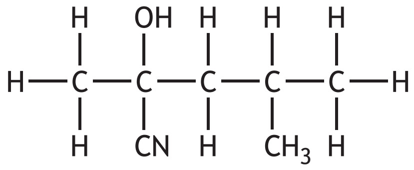
A Student A
B Student B
C Student C
D Student D.

Go to Answers

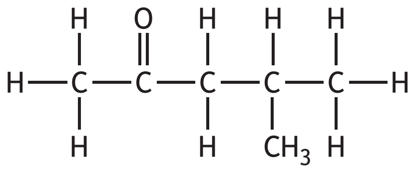
16. Cyanohydrin compounds can be made from carbonyl compounds by reacting the carbonyl compound with hydrogen cyanide (HCN).



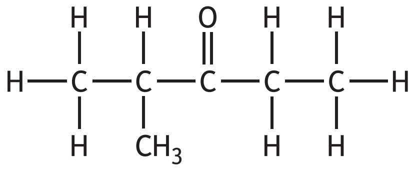
Which carbonyl compound would react with hydrogen cyanide (HCN) to form the following compound?



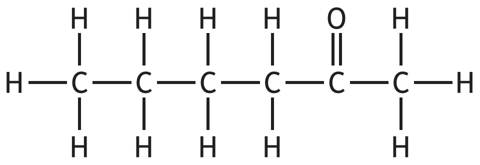
A



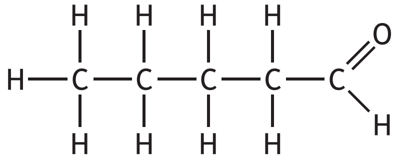
B



C



D



Go to Topic Grid

17. Chemical reactions are in a state of dynamic equilibrium only when

A the reaction involves no enthalpy change

B the concentrations of reactants and products are equal

C the activation energies of the forward and backward reactions are equal

D the rate of the forward reaction equals that of the backward reaction.

18. Bromine and hydrogen react together to form hydrogen bromide.

$$H_2(g) + Br_2(g) \rightarrow 2HBr(g)$$

Bonds broken	Bonds made
H—H	2 × H—Br
Br—Br	

Bond	Bond enthalpy (kJ mol^{-1})
H—H	436
Br—Br	194
H—Br	366

The enthalpy change for this reaction, in kJ mol^{-1}, is

A −102

B +102

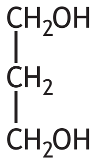
C −264

D +264.

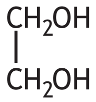
Go to Answers

Go to Topic Grid

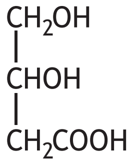
19. Which of the following is a structural formula for glycerol?

A


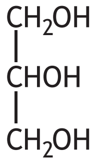
$$\begin{array}{l} CH_2OH \\ | \\ CH_2 \\ | \\ CH_2OH \end{array}$$

B


$$\begin{array}{l} CH_2OH \\ | \\ CH_2OH \end{array}$$

C


$$\begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2COOH \end{array}$$

D


$$\begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}$$

20. Which line in the table best describes the effect of adding a catalyst to the following reaction?

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -ve$$

	Position of equilibrium	*Rate of forward reaction*
A	unchanged	unchanged
B	unchanged	increased
C	moves to right	unchanged
D	moves to right	increased

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

Go to Answers

SECTION 2 — 80 marks

Attempt ALL questions

1. The elements sodium to argon make up the third period of the Periodic Table.

Na	Mg	Al	Si	P	S	Cl	Ar

(a) Name the element from the third period that exists as a covalent network. **1**

(b) Ionisation energy changes across the period.

(i) Explain why the first ionisation energy increases across the period. **1**

(ii) Write an equation, including state symbols, for the **second** ionisation energy of magnesium. **1**

(iii) The table shows the values for the first four ionisation energies of aluminium.

Ionisation energies (kJ mol^{-1})			
First	Second	Third	Fourth
578	1817	2745	11 577

Explain why there is a large difference between the third and fourth ionisation energies. **1**

1. (continued)

(c) The boiling point of chlorine is much higher than that of argon.

Explain **fully**, in terms of structure and the type of van der Waals forces present, why the boiling point of chlorine is higher than that of argon. **3**

2. Reactions involving iodine are commonly used to investigate rates of reaction.

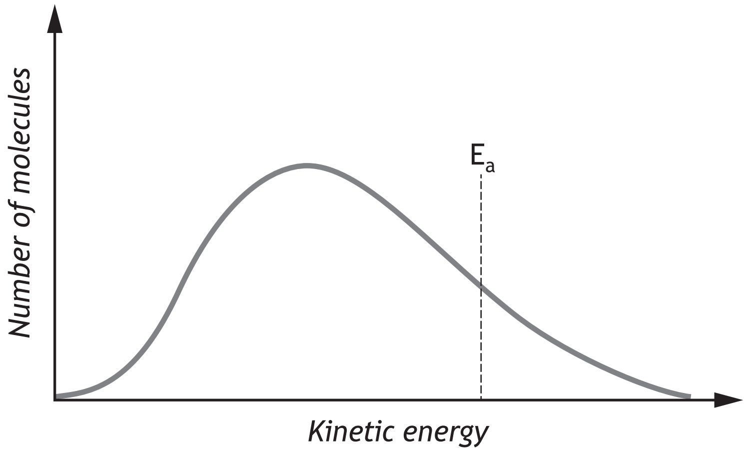
(a) One reaction involves hydrogen and iodine reacting together to form hydrogen iodide.

$$H_2(g) \quad + \quad I_2(g) \quad \rightleftharpoons \quad 2HI(g)$$

(i) This reaction is thought to occur by initially breaking bonds in one of the reactants.

Explain, using bond enthalpies, which bond is more likely to break first during this reaction. **1**

(ii) The graph shows the distribution of kinetic energies of reactant molecules in the gas mixture at 300 °C.



Add a second curve to the graph to show the distribution of kinetic energies at 400 °C. **1**

(An additional graph, if required, can be found on *Page 35*)

2. (a) (continued)

(iii) The reaction to produce hydrogen iodide is exothermic.

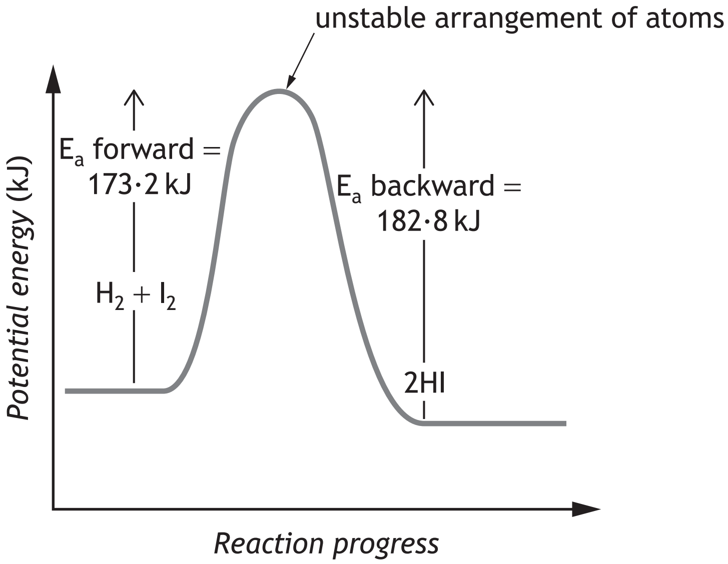
$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(A) State the effect of increasing temperature on the position of equilibrium. **1**

(B) State why changing the pressure has no effect on this equilibrium reaction. **1**

2. (a) (continued)

(iv) The potential energy diagram for the reaction between hydrogen and iodine is shown.



(A) State the term for the unstable arrangement of atoms. **1**

(B) Calculate the enthalpy change, in kJ, for the forward reaction. **1**

(C) Platinum can be used as a catalyst for this reaction.

State the effect that platinum would have on the activation energy for the reaction. **1**

2. (continued)

(b) The reaction between iodide ions, I^-(aq), and persulfate ions, $S_2O_8^{2-}$(aq), is used to investigate the effect of changing concentration on rate of reaction. The relative rate of the reaction is determined by mixing the reactants in a beaker and recording the time taken for the mixture to change colour.

The results of the investigation are shown in the table.

Experiment	*Concentration of I^-(aq)* (mol l^{-1})	*Concentration of $S_2O_8^{2-}$(aq)* (mol l^{-1})	*Time* (s)	*Relative rate* (s^{-1})
1	0·04	0·05	241	0·00415
2	0·06	0·05	180	0·00556
3	0·08	0·05		0·00819
4	0·1	0·05	103	0·00971

(i) The instructions state that a dry beaker must be used for each experiment.

Suggest a reason why the beaker should be dry. **1**

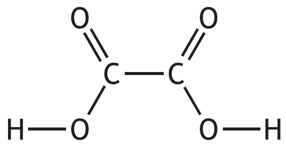
(ii) Calculate the time, in seconds, for the reaction in experiment 3. **1**

(iii) Explain why decreasing the concentration of iodide ions lowers the reaction rate. **1**

Go to Answers

3. The leaves of the rhubarb plant are considered poisonous because they contain high levels of oxalic acid.

Oxalic acid is a white, water-soluble solid. It is a dicarboxylic acid that has the structural formula shown.



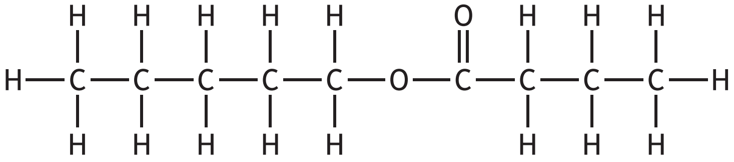
Oxalic acid reacts with bases to form salts.

It can also be oxidised by strong oxidising agents to form carbon dioxide gas. The oxidation equation for oxalic acid is shown.

$$H_2C_2O_4 \rightarrow 2CO_2 + 2e^- + 2H^+$$

Using your knowledge of chemistry, comment on how the mass of oxalic acid in a rhubarb leaf could be determined. **3**

4. Pentyl butanoate is responsible for some of the flavour in apricots and strawberries.



(a) Hydrolysis of pentyl butanoate using sodium hydroxide produces an alcohol and the salt of the carboxylic acid.

(i) Name the alcohol that would be formed when pentyl butanoate is hydrolysed. **1**

(ii) Draw a structural formula for the sodium salt of the carboxylic acid that would be formed. **1**

(b) Fats and oils belong to the same class of compounds as pentyl butanoate.

(i) Name this class of compounds. **1**

(ii) When a fat is hydrolysed using sodium hydroxide, sodium salts of fatty acids are produced.

State a use for sodium salts of fatty acids. **1**

Go to Answers

[Turn over

Go to Topic Grid

4. (b) (continued)

(iii) Hydrolysis of fats using hydrochloric acid produces fatty acids. Stearic acid is a fatty acid that can be made from hydrolysis of beef fat. It is a fuel sometimes found in fireworks.

During combustion, stearic acid ($C_{17}H_{35}COOH$) produces 623 kJ of energy **per mole of CO_2 produced.**

$$C_{17}H_{35}COOH \quad + \quad 26O_2 \quad \rightarrow \quad 18CO_2 \quad + \quad 18H_2O$$

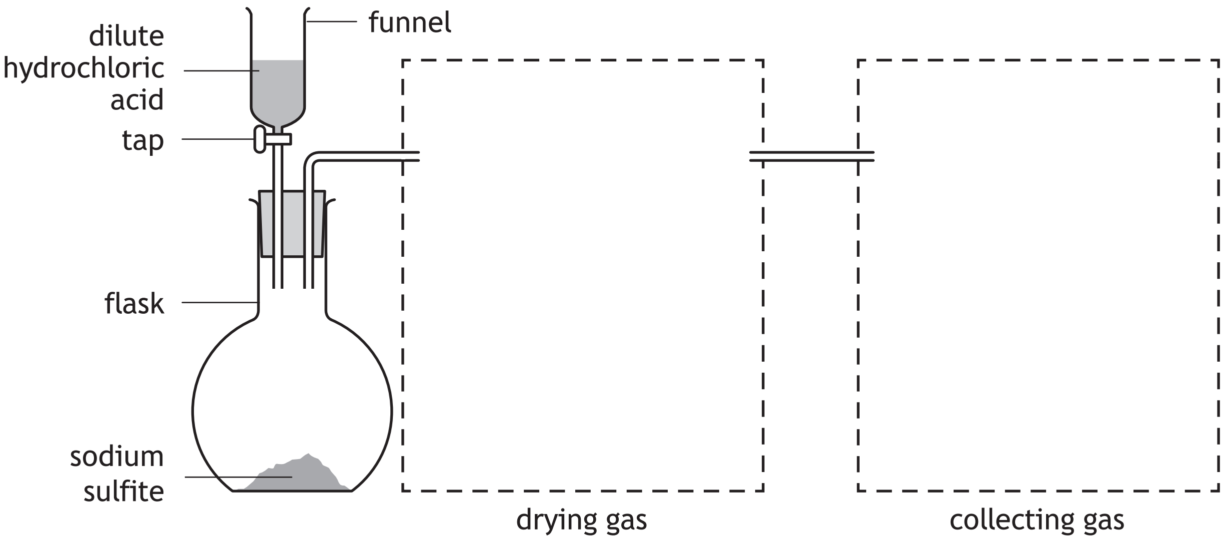
mass of
one mole
= 284 g

Calculate the energy released, in kJ, by combustion of 10 grams of stearic acid. **2**

Go to Answers

5. Sulfur dioxide is a colourless, toxic gas that is soluble in water and more dense than air.

(a) One laboratory method for preparation of sulfur dioxide gas involves adding dilute hydrochloric acid to solid sodium sulfite. The sulfur dioxide gas produced is dried by bubbling the gas through concentrated sulfuric acid. The sulfur dioxide gas can then be collected.



MARKS DO NOT WRITE IN THIS MARGIN

(i) Complete the diagram by drawing:

in the first box, apparatus suitable for drying the sulfur dioxide gas;

in the second box, apparatus suitable for collecting the gas. **2**

(An additional diagram, if required, can be found on *Page 35*)

5. (a) (continued)

(ii) 0·40 g of sodium sulfite, Na_2SO_3, is reacted with 50 cm^3 of dilute hydrochloric acid, concentration 1·0 mol l^{-1}.

$$Na_2SO_3(s) + 2HCl(aq) \rightarrow H_2O(\ell) + 2NaCl(aq) + SO_2(g)$$

mass of
one mole
= 126·1 g

Show, by calculation, that sodium sulfite is the limiting reactant. **2**

(b) Another reaction that produces sulfur dioxide gas involves combustion of carbon disulfide in the reaction shown.

$$CS_2(\ell) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$$

Calculate the enthalpy change, in kJ mol^{-1}, for this reaction using the following information. **2**

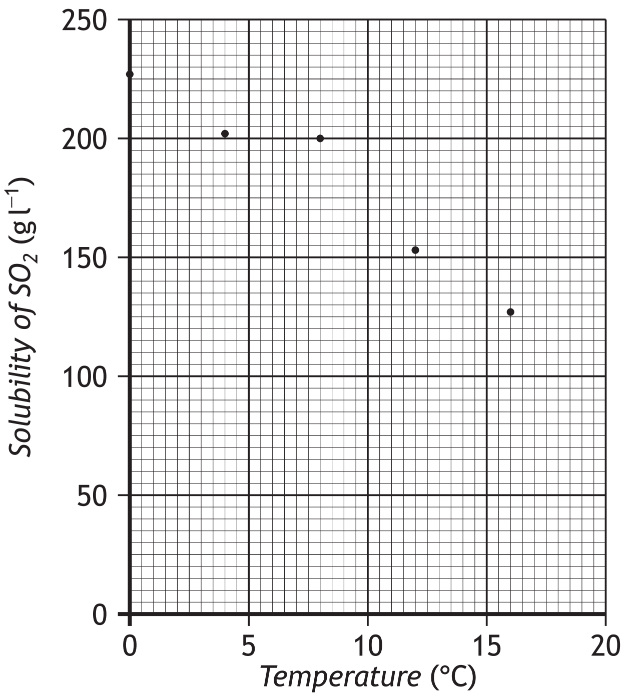
$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -393{\cdot}5 \text{ kJ mol}^{-1}$$

$$S(s) + O_2(g) \rightarrow SO_2(g) \qquad \Delta H = -296{\cdot}8 \text{ kJ mol}^{-1}$$

$$C(s) + 2S(s) \rightarrow CS_2(\ell) \qquad \Delta H = +87{\cdot}9 \text{ kJ mol}^{-1}$$

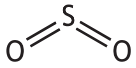
5. (continued)

(c) The graph shows results for an experiment to determine the solubility of sulfur dioxide in water.



(i) Determine the solubility of sulfur dioxide, in g l^{-1}, in water at 10 °C. **1**

(ii) Information about sulfur dioxide and carbon dioxide is shown in the table.

	Shape of molecule	*Electronegativity difference between elements*	*Solubility in water at 25 °C (g l^{-1})*
carbon dioxide	linear $O=C=O$	1·0	1·45
sulfur dioxide	bent 	1·0	94

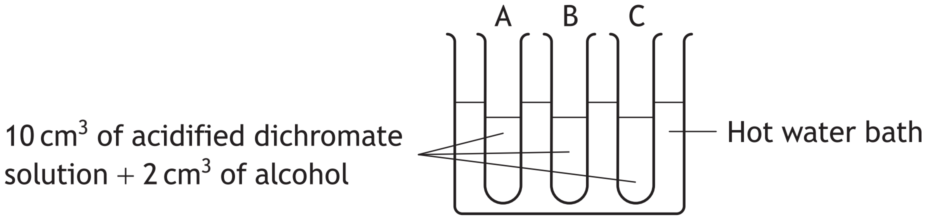
Explain **fully** why carbon dioxide is much less soluble in water than sulfur dioxide is in water. **2**

6. A student was carrying out an investigation into alcohols, aldehydes and ketones.

(a) The student was given three alcohols labelled as **A**, **B** and **C**. These alcohols were all isomers with the formula C_4H_9OH.

(i) Draw a structural formula for the secondary alcohol with the formula C_4H_9OH. **1**

(ii) The student set up the following experiment.



Alcohol	*Observation*
A	Colour change
B	No change
C	Colour change

(A) Suggest why a water bath is an appropriate method of heating the reaction mixture. **1**

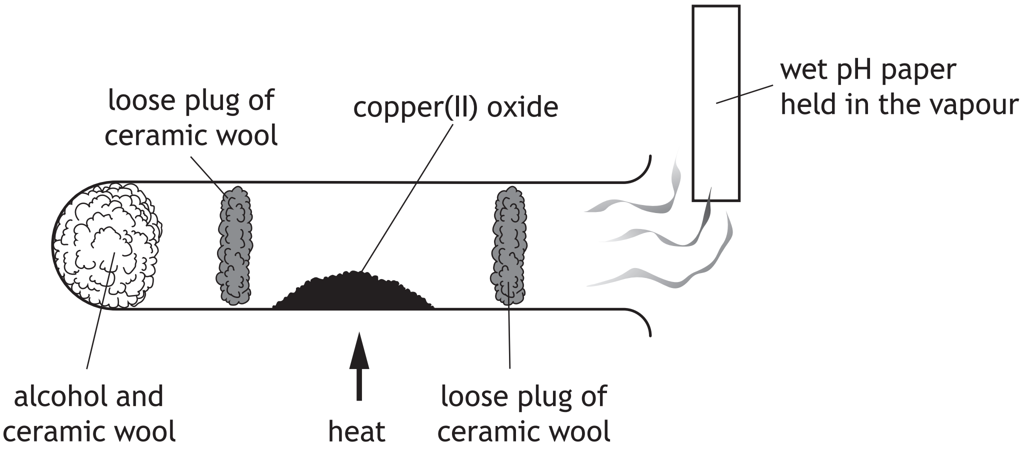
(B) Describe the colour change that would have been observed with alcohols **A** and **C**. **1**

(C) Alcohol **B** is not oxidised.

State the **type** of alcohol which cannot be oxidised by acidified dichromate solution. **1**

6. (a) (continued)

(iii) The student set up a second experiment with alcohol **A**.



Hot copper(II) oxide is an oxidising agent.

(A) When alcohol **A** (C_4H_9OH) is oxidised the product turns the pH paper red.

Suggest a name for the product. **1**

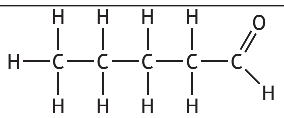
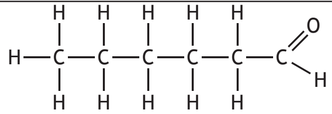
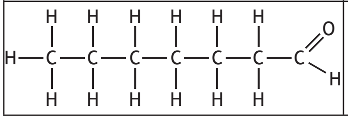
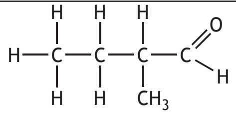
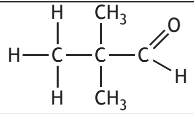
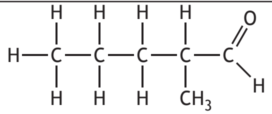
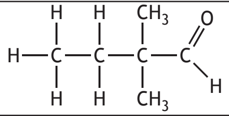
(B) Complete the ion-electron equation for the oxidation reaction. **1**

$C_4H_9OH \quad \rightarrow \quad C_4H_8O_2$

Go to Topic Grid

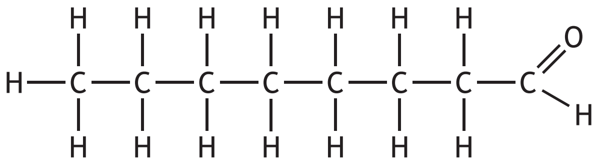
6. (continued)

(b) The student found the following information about the boiling points of some aldehydes.

Aldehyde	*Molecular formula*	*Boiling point* (°C)
	$C_5H_{10}O$	102
	$C_6H_{12}O$	130
	$C_7H_{14}O$	153
	$C_5H_{10}O$	95
	$C_5H_{10}O$	75
	$C_6H_{12}O$	119
	$C_6H_{12}O$	111

(i) Name the aldehyde that has a boiling point of 119 °C. **1**

(ii) Predict the boiling point, in °C, of the following molecule. **1**



Go to Answers

6. (b) (continued)

(iii) Using information from the table, describe one way in which differences in structure affect the boiling point of **isomeric** aldehydes. 1

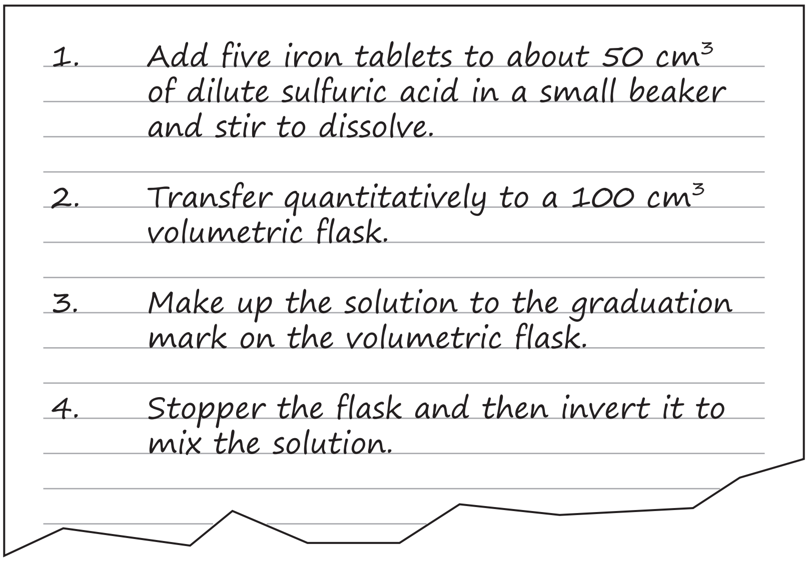
(iv) State what would be observed when an aldehyde is gently heated with Tollens' reagent. 1

(c) Ketones contain a carbonyl group.

Name the type of intermolecular interaction between ketone molecules. 1

7. Some people take iron tablets as a dietary supplement. Iron tablets may contain iron(II) sulfate.

(a) A student was investigating the iron(II) content of iron tablets. A work card gave the following instructions for preparing an iron tablet solution.



1. Add five iron tablets to about 50 cm^3 of dilute sulfuric acid in a small beaker and stir to dissolve.
2. Transfer quantitatively to a 100 cm^3 volumetric flask.
3. Make up the solution to the graduation mark on the volumetric flask.
4. Stopper the flask and then invert it to mix the solution.

To 'transfer quantitatively' means that **all** of the iron tablet solution must be transferred into the volumetric flask.

Describe how this is carried out in practice. **1**

(b) The concentration of iron(II) ions (Fe^{2+}) in this iron tablet solution can be determined by a redox titration with permanganate (MnO_4^-) solution.

$$5Fe^{2+}(aq) + 8H^+(aq) + MnO_4^-(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(\ell)$$

(i) Suggest why it is **not** necessary to add an indicator to this titration. **1**

7. (b) (continued)

(ii) Suggest why the titration must be carried out under acidic conditions. **1**

(iii) Three 25·0 cm^3 samples of the iron tablet solution were titrated with a standard solution of 0·020 mol l^{-1} permanganate (MnO_4^-). The results are shown below.

Sample	*Volume of permanganate* (cm^3)
1	14·9
2	14·5
3	14·6

(A) State why the volume of permanganate used in the calculation was taken to be 14·55 cm^3, although this is not the average of the three titres in the table. **1**

(B) Calculate the concentration, in mol l^{-1}, of iron(II) ions in the iron tablet solution. **3**

$$5Fe^{2+}(aq) + 8H^+(aq) + MnO_4^-(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(\ell)$$

7. (b) (iii) (continued)

(C) State what is meant by the term **standard solution**. 1

(D) Name an appropriate piece of apparatus which could be used to measure 25·0 cm^3 samples of iron tablet solution. 1

(c) In a different experiment, five iron tablets were found to contain 0·00126 moles of iron(II) ions.

Calculate the average mass, in **mg**, of iron present in **one** tablet. 1

(d) It is recommended an adult female takes in 14·8 mg of iron per day.

100 g of a breakfast cereal contains 12·0 mg of iron.

Calculate the percentage of the recommended daily amount of iron provided for an adult female by a 30 g serving. 2

Go to Topic Grid

8. Skin care products contain a mixture of polar covalent, non-polar covalent and ionic compounds. The compounds need to stay mixed within the product.

Skin care products also need to spread easily and remain on the skin for a period of time, as well as provide physical and chemical protection from the sun. In order to do this, skin care products contain a range of chemicals including water, fats and oils, antioxidants, minerals and sun block.

Using your knowledge of chemistry, explain the role of different chemicals in skin care products. **3**

Go to Answers

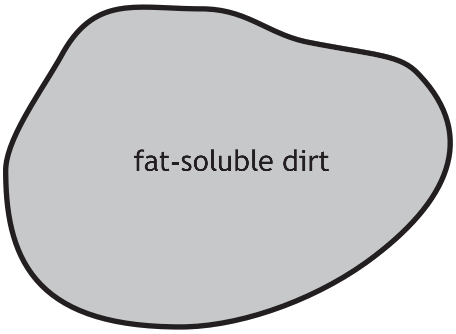
9. Dishwasher tablets contain chemicals which remove dirt from dishes.

(a) Dishwasher tablets include detergents. These molecules act like soaps to allow mixing of fat-soluble dirt and water.

(i) During the cleaning process, the detergent molecules combine with fat-soluble dirt.

A simplified diagram of a detergent molecule is shown.

Complete the diagram below to show how detergent molecules combine with fat-soluble dirt. **1**



(An additional diagram, if required, can be found on *Page 36*)

(ii) State the term used to describe the non-polar, hydrocarbon tail of a detergent molecule. **1**

9. (continued)

(b) Dishwasher tablets produce the bleach hydrogen peroxide, H_2O_2. One action of this oxidising agent is to oxidise food.

(i) Suggest another action of the bleach produced by the dishwasher tablets. **1**

(ii) Hydrogen peroxide decomposes to form water and oxygen.

$$2H_2O_2(\ell) \rightarrow 2H_2O(\ell) + O_2(g)$$

A dishwasher tablet produces 0·051 g of hydrogen peroxide (mass of one mole = 34 g).

Calculate the volume of oxygen that would be produced when 0·051 g of hydrogen peroxide decomposes. **3**

Take the volume of 1 mole of oxygen gas to be 24 litres.

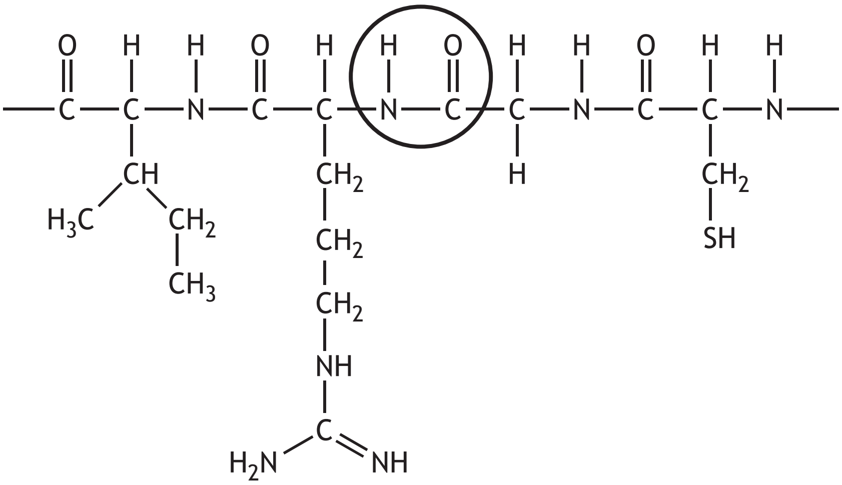
(c) Enzymes are commonly added to dishwasher tablets. These are used to break down proteins.

(i) The proteins are broken down into small, water-soluble molecules.

Name the small, water-soluble molecules made when proteins are broken down completely. **1**

9. (c) (continued)

(ii) The structure of a section of protein chain found in egg white is shown.



(A) Name the functional group circled. **1**

(B) Draw a structural formula for **one** of the molecules that would be made when this section of egg white protein chain is completely broken down. **1**

(iii) As part of the program in the dishwasher, the conditions in the dishwasher change so that the enzyme molecules no longer work because they change shape.

(A) State the term used to describe the change in shape of enzyme molecules. **1**

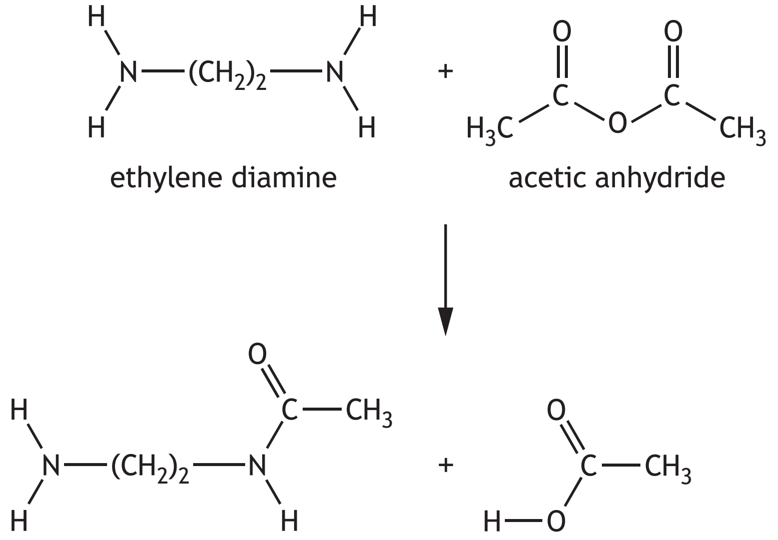
(B) Suggest a change in conditions which would cause the enzyme molecules to change shape. **1**

9. (continued)

(d) A bleach activator is frequently added to dishwasher tablets to speed up the bleaching reaction. One common bleach activator is TAED.

TAED could be produced in a process which involves a number of stages.

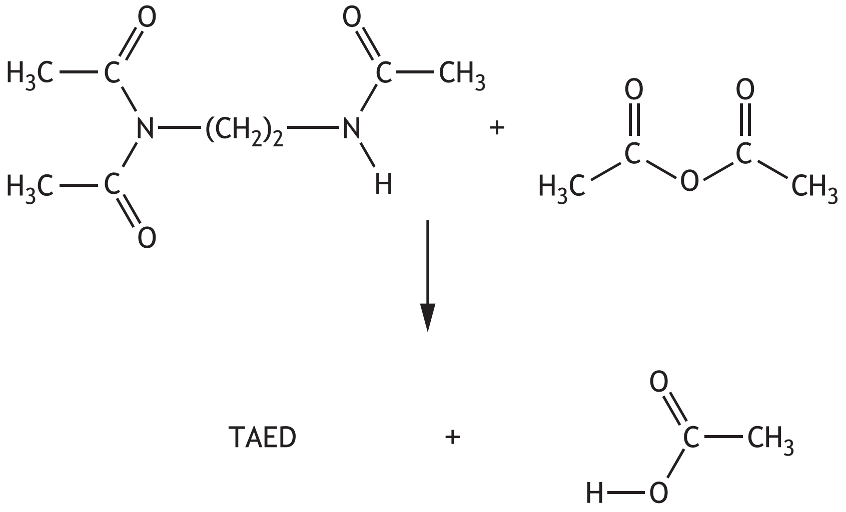
(i) The first stage in producing TAED is shown below.



Suggest a name for this type of reaction. **1**

9. (d) (continued)

(ii) The final stage in the process producing TAED is shown below.

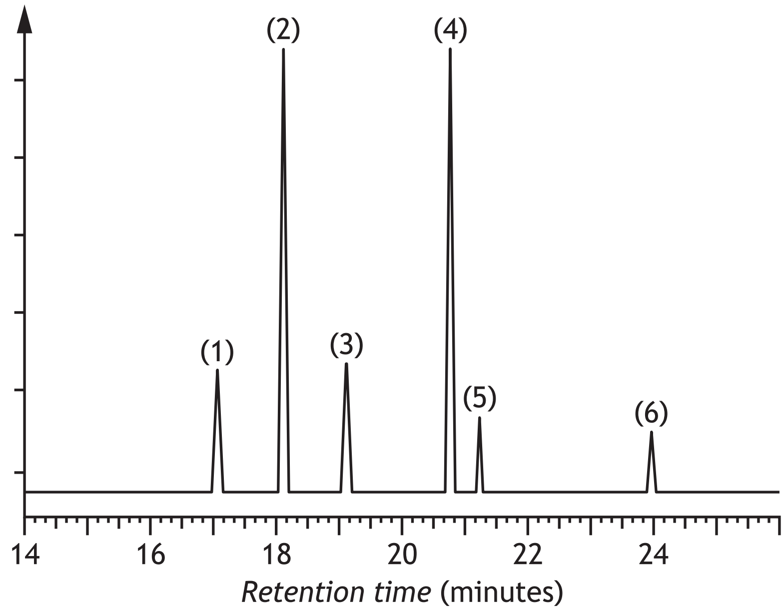


Draw a structural formula for TAED. **1**

10. Essential oils from the lavender plant are used in aromatherapy.

(a) Gas chromatography can be used to separate and identify the organic compounds in lavender oils.

Chromatogram 1 - Lavender oil **A**



Peak	*Component*	*Component peak area*
1	1,8-cineole	7432
2	linalool	31 909
3	camphor	7518
4	linalyl acetate	27 504
5	geranyl acetate	3585
6	farnesene	1362

Total peak area = 79 310

The relative concentration of each component can be calculated using the following formula.

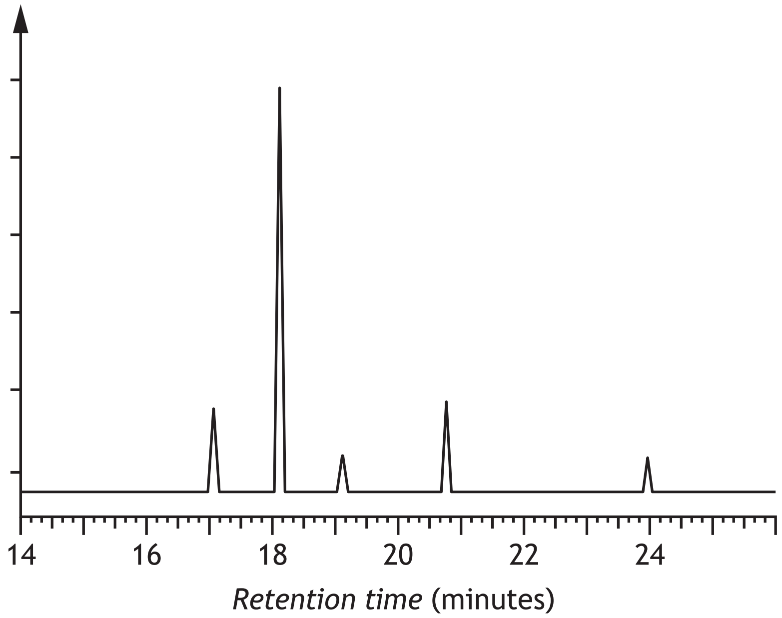
$$\text{Relative concentration} = \frac{\text{Component peak area}}{\text{Total peak area}} \times 100\ (\%)$$

(i) Calculate the relative concentration of linalool in lavender oil **A**. **1**

10. (a) (continued)

(ii) Different varieties of lavender oils have different compositions.

Chromatogram 2 – Lavender oil **B**



Identify the component found in lavender oil **A** that is missing from lavender oil **B**. **1**

(b) A brand of mouthwash contains the component 1,8-cineole at a concentration of 0·92 mg per cm^3. The cost of 1 kg of 1,8-cineole is £59·10.

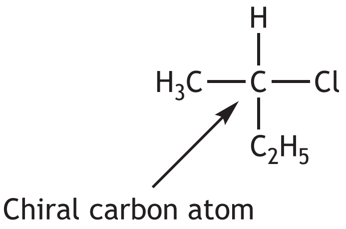
Calculate the cost, in pence, of 1,8-cineole that is present in a 500 cm^3 bottle of this brand of mouthwash. **2**

10. (continued)

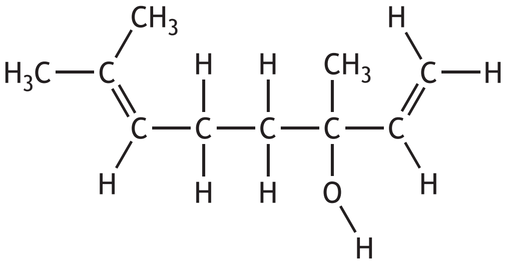
(c) The component molecules found in lavender oils are terpenes or terpenoids.

(i) A chiral carbon is a carbon atom attached to **four** different atoms or groups of atoms.

An example is shown below.



A molecule of the terpenoid linalool has a chiral carbon. Linalool has the following structure.



Circle the chiral carbon atom in the linalool structure. **1**

(An additional diagram, if required, can be found on *Page 36*)

(ii) Farnesene is a terpene consisting of **three** isoprene units (2-methylbuta-1,3-diene) joined together.

Write the molecular formula of farnesene. **1**

[END OF QUESTION PAPER]

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Finalised Marking Instructions

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Marking instructions for each question

Section 1

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

Section 2

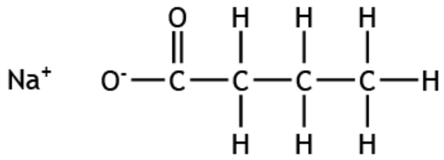
Question			Answer	Max mark	Additional guidance
1.	(a)		Silicon	**1**	Accept symbol
	(b)	(i)	Increasing/greater/stronger/higher nuclear charge (holds electron more tightly) **OR** Increasing number of protons	**1**	Increased nuclear pull is not accepted on its own. Mention must be made of nuclear charge **or** number of protons.
		(ii)	$Mg^{+}(g) \longrightarrow Mg^{2+}(g) + e^{-}$	**1**	State symbols required.
		(iii)	Fourth ionisation energy involves removal of an electron from an electron shell which is inner/full (whole)/(more) stable/closer to the nucleus **OR** fourth electron is removed from an electron shell which is inner/full (whole)/(more) stable/closer to the nucleus. **OR** removing third electron is taking from an outer/a part full shell **OR** taking an electron from a full shell requires more energy (than removing from a part full shell) **OR** taking an electron from a part full shell requires less energy (than removing from a full shell) **OR** fourth electron is less shielded than the third electron **OR** third electron is more shielded than the fourth electron	**1**	

Question			Answer	Max mark	Additional guidance
	(c)		1 mark - Correctly identify that there are stronger/more (Van der Waals) forces between chlorine (molecules) than between the argon (atoms) 1 mark - Correctly identifying that the van der Waals forces present in both these elements are London dispersion forces 1 mark Chlorine molecules (Cl_2) have more electrons than argon atoms (Ar).	**3**	This mark can only be awarded if no other forces are mentioned as being broken.

Question			Answer	Max mark	Additional guidance
2.	(a)	(i)	I-I bond is weaker/has a lower bond enthalpy value (so will break more easily) **OR** I_2 (151 kJ mol^{-1}) is less than H_2 (436 kJ mol^{-1}), (so will break more easily).	**1**	Iodine on its own is not acceptable.
		(ii)	Peak of curve should be further to the right and no higher than the original line.	**1**	
		(iii) (A)	Equilibrium will shift to the reactant side/left (hand side).	**1**	
		(iii) (B)	There are the same/equal volume/ number of moles/molecules (of gases) on each side (of the equation). **OR** Pressures of reactants and products are equal.	**1**	Ratios on their own, without an explanation, are not acceptable eg 1:1 or 2:2
		(iv) (A)	Activated complex	**1**	Accept activation complex or transition state.
		(iv) (B)	-9·6 (kJ) If candidate has calculated from graph values **OR** -9 (kJ) If candidate has calculated using bond enthalpies Answer must include the negative sign	**1**	No units required. No mark can be awarded for the correct answer if wrong unit is given. (wrong units would only be penalised once in any paper) kJ mol^{-1} is acceptable in place of kJ
		(iv) (C)	Decrease/lower it	**1**	

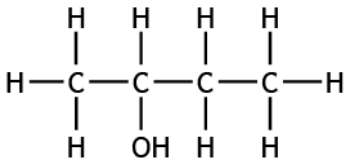
Question			Answer	Max mark	Additional guidance
	(b)	(i)	To keep the concentration (of the reactants) constant. **OR** Adding water will change/affect/dilute/decrease the concentration (of the reactants) **OR** To keep the total volume constant.	**1**	
		(ii)	122·1 (accept 122) (s)	**1**	No units required. No mark can be awarded for the correct answer if wrong unit is given. (wrong units would only be penalised once in any paper)
		(iii)	The number of (successful) collisions will decrease. **OR** Less chance of (successful) collisions **OR** The frequency of (successful) collisions will decrease.	**1**	Any mention of time of collisions is unacceptable.

Question			Answer	Max mark	Additional guidance
3.			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**
4.	(a)	(i)	Pentan-1-ol	**1**	Pentanol is not acceptable.
		(ii)		**1**	Candidates should be awarded zero marks if they draw a covalent bond between O and Na. Charges not required but if shown they must **both** be correct. Accept shortened structural formulae.
	(b)	(i)	ester	**1**	
		(ii)	soap	**1**	Accept emulsifier or detergent.
		(iii)	395 or -395 (kJ) Partial marking one mark can be awarded for **the correct application of number of moles of stearic acid** eg 10/284 x 623 or 0·0352 x 623 (=21.94) (=21.93) or 10/284 x 18 or 0·0352 x 18 (=0.634) (=0.634) **OR** **the correct application of the stoichiometry** eg the energy change for 1 mole of stearic acid as 623 x 18 = 11214 (kJ) or 284 g ←→ 623 x 18	**2**	No units required. Only 1 mark can be awarded for the correct answer if wrong unit is given. (wrong units would only be penalised once in any paper)

Question			Answer	Max mark	Additional guidance
5.	(a)	(i)	Diagram shows a workable method of bubbling through concentrated sulfuric acid. 1 mark Diagram for appropriate gas collection method i.e. using a gas syringe or upward displacement of air. 1 mark	**2**	
		(ii)	Calculating that 0·05 moles HCl would require 0·025 moles sodium sulfite and there are only 0.00317 moles of sodium sulfite **OR** Calculating that 0·00317 moles of sodium sulfite would require 0·00634 moles of HCl and there are 0.05 moles of HCl **OR** Calculating that 3·15 g sodium sulfite would be needed to react with 50 cm^3 hydrochloric acid and there are only 0.4 g of sodium sulfite **OR** Calculating that 6·3 cm^3 of (1 M) HCl would be needed to react with 0·4 g of sodium sulfite and there are 50 cm^3 (1M) HCl	**2**	General marking principle (j) applies. Partial marking 1 mark awarded for correct arithmetical calculation of moles of Na_2SO_3 (= 0·00317 mol) **AND** HCl = 0·05 mol) **OR** 1 mark awarded for correct arithmetical calculation of moles of acid (0.05) and correct application of stoichiometry to either reactant. **OR** 1 mark awarded for correct arithmetical calculation of moles of sodium sulfite (0.00317) and correct application of stoichiometry to either reactant.

Question			Answer	Max mark	Additional guidance
	(b)		-1075 (kJ mol^{-1}) Partial marks Treat as two concepts either would be acceptable for 1 mark Evidence of understanding of reversal for third equation only in order to achieve the target equation. Reversal of additional equations would be taken as cancelling **OR** evidence of understanding of multiplying for second equation by 2 in order to achieve the target equation. Multiplication of additional equations would be taken as cancelling.	**2**	If answer given is 1075 or +1075, maximum of 1 mark can be awarded. No units required. Only 1 mark can be awarded for the correct answer if wrong unit is given. (wrong units would only be penalised once in any paper) kJ is acceptable in place of kJ mol^{-1}
	(c)	(i)	163 -167 inclusive (g l^{-1})	**1**	No units required. No mark can be awarded for correct answer if wrong unit is given. (wrong units would only be penalised once in any paper)
		(ii)	1 mark for carbon dioxide is non-polar due to its shape/dipoles cancelling out **and** sulfur dioxide is polar due to its shape/dipoles not cancelling out 1 mark for an explanation which links polarity of CO_2 and SO_2 molecules to the polarity of water	**2**	

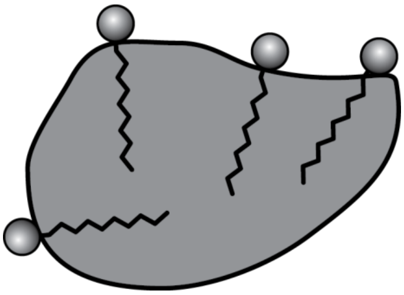
Question			Answer	Max mark	Additional guidance
6.	(a)	(i)	 $H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{OH}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-H$	**1**	Accept a correct shortened structural formula
		(ii) (A)	Reactants or products are flammable/could catch fire.	**1**	
		(ii) (B)	orange to green/ blue-green/blue	**1**	
		(ii) (C)	Tertiary	**1**	
		(iii) (A)	Butanoic acid **OR** (2-)methylpropanoic acid	**1**	
		(iii) (B)	$C_4H_9OH + H_2O \rightarrow C_4H_8O_2 + 4H^+ + 4e^-$	**1**	Negative sign on electron not required. Positive sign on H^+ required.
	(b)	(i)	2-methylpentanal	**1**	2-methylpentan-1-al is not acceptable.
		(ii)	Any temperature between 166 and 181 (°C)	**1**	No units required. No mark can be awarded if wrong unit is given. (wrong units would only be penalised once in any paper)
		(iii)	(More) branching lowers the boiling point (of isomeric aldehydes).	**1**	
		(iv)	Silver mirror/silver precipitate	**1**	Accept silver on its own
	(c)		(Permanent) dipole to (permanent) dipole	**1**	Accept London Dispersion Forces

Question			Answer	Max mark	Additional guidance
7.	(a)		Rinse beaker and transfer the rinsings/washings to the flask	**1**	
	(b)	(i)	The reaction is self-indicating. **OR** Potassium permanganate can act as its own indicator. **OR** Reaction changes colour.	**1**	
		(ii)	To provide H^+ ions for the reaction.	**1**	
		(iii) (A)	**1 mark** for any of the following • first titre is a rough (or approximate) result/practice • first titre is not accurate/not reliable/rogue • first titre is too far away from the others • you take average of concordant/close results	**1**	

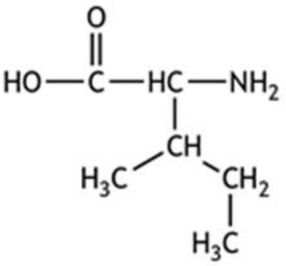
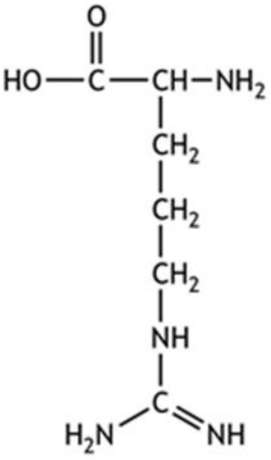
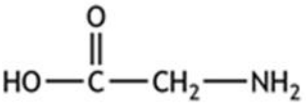
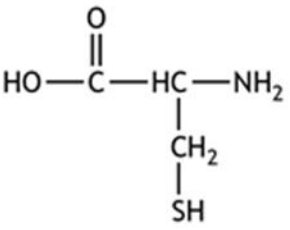
Question			Answer	Max mark	Additional guidance
		(iii) (B)	0·0582 (mol l^{-1}) **(3)** Partial marks can be awarded using a scheme of two "concept" marks. **1 mark** for knowledge of the relationship between moles, concentration and volume. This could be shown by any <u>one</u> of the following steps: • Calculation of moles MnO_4^- solution eg 0·02 × 0·01455 = 0·000291 • calculation of concentration of Fe^{2+} solution eg 0·001455/0·025 • Insertion of correct pairings of values for concentration and volume in a valid titration formula eg $\frac{0 \cdot 02 \times 14 \cdot 55}{n_1} = \frac{C_{Fe^{2+}} \times 25 \cdot 0}{n_2}$ **1 mark** for knowledge of relationship between moles of MnO_4^- and Fe^{2+}. This could be shown by one of the following steps: • Calculation of moles Fe^{2+} from moles MnO_4^- - eg 0·000291x5 = 0·001455 • Insertion of correct stoichiometric values in a valid titration formula eg $\frac{0 \cdot 02 \times 14 \cdot 55}{1} = \frac{C_{Fe^{2+}} \times 25 \cdot 0}{5}$	**3**	No units required but only two marks can be awarded for correct answer if wrong unit is given. (wrong units would only be penalised once in the paper) In terms of the mark for the stoichiometric relationship, the 5 should be associated with the unknown concentration of the Fe^{2+} and the 1 should be associated with the concentration of MnO_4^-
		(iii) (C)	A solution of accurately/exactly/ precisely known concentration	**1**	
		(iii) (D)	Pipette	**1**	Not: Burette Accept graduated pipette.

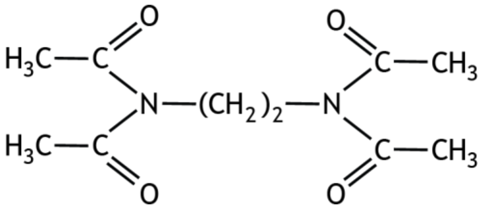
Question			Answer	Max mark	Additional guidance
	(c)		14mg, 14·06 mg, 0·01406 g	**1**	No units required. No mark can be awarded for correct answer if wrong unit is given. (wrong units would only be penalised once in the paper)
	(d)		24%, 24·3% Partial marks **1 mark** awarded for 30 g would contain 3·6 mg **1 mark** for $\frac{\text{any calculated mass}}{14 \cdot 8} \times 100$	**2**	

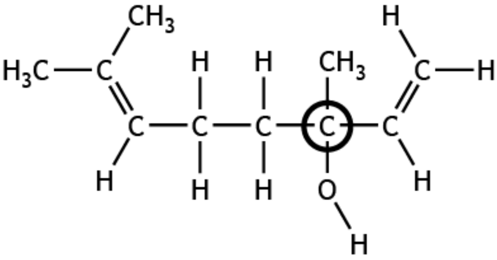
Question			Answer	Max mark	Additional guidance
8.			This is an open ended question **1 mark:** The student has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. The candidate has made some statement(s) at which is/are relevant to the situation, showing that at 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
9.	(a)	(i)	A drawing similar to  Diagram shows **at least one** detergent molecule. All tails shown should be **fully** inside the fat-soluble dirt.	**1**	
		(ii)	hydrophobic	**1**	
	(b)	(i)	To break down coloured compounds/ removes stains/kill bacteria/kill fungi/inactivate viruses/germs	**1**	Stating only that oxidation occurs would be seen as restating the information from the stem. Discolour is not accepted.

Question			Answer	Max mark	Additional guidance
		(ii)	18 cm^3/0·018 litres **with correct unit** **Partial marking** 1 mark can be awarded for two of the three steps shown below correctly calculated: 1. number of moles of H_2O_2 2. mole ratio applied 3. calculated number of moles of O_2 multiplied by 24 (24000) If processed by proportion 68 g ←→ 24 l (24000 cm^3) 1 mark OR 0.051 g ←→ 0.036 l (36 cm^3) 1 mark **1 mark** for correct units.	**3**	If an incorrect volume is calculated but the units of volume used are appropriate to the calculation then 1 mark would be awarded for correct units. Accept L for litres

Question			Answer	Max mark	Additional guidance
	(c)	(i)	amino acids	**1**	
		(ii) (A)	Amide/amide link/peptide link	**1**	Amine/amino not acceptable
		(ii) (B)	Any of the shown amino acids:    	**1**	

Question			Answer	Max mark	Additional guidance
		(iii) (A)	Denaturing	**1**	
		(iii) (B)	Temperature increase/pH	**1**	Temperature on its own is not acceptable. High/higher/above optimum temperature are also accepted.
	(d)	(i)	Condensation	**1**	
		(ii)		**1**	

Question			Answer	Max mark	Additional guidance
10.	(a)	(i)	40·23/40·2/40 (%)	**1**	
		(ii)	geranyl acetate/peak 5	**1**	
	(b)		2·7p/ 3p Partial marking 1 mark can be awarded for Evidence of scaling up to 500cm^3 eg 460mg of 1,8-cineole **OR** Evidence for determining a correct cost for a calculated mass of 1,8-cineole eg 0·92mg costs 0.00544 pence	**2**	
	(c)	(i)		**1**	
		(ii)	$C_{15}H_{24}$ OR $(C_5H_8)_3$	**1**	

[END OF MARKING INSTRUCTIONS]

H

National
Qualifications
2018

X713/76/02

Chemistry
Section 1 — Questions

MONDAY, 21 MAY

9:00 AM – 11:30 AM

Instructions for the completion of Section 1 are given on *page 02* of your question and answer booklet X713/76/01.

Record your answers on the answer grid on *page 03* of your question and answer booklet.

You may refer to the Chemistry Data Booklet for Higher and Advanced Higher.

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.

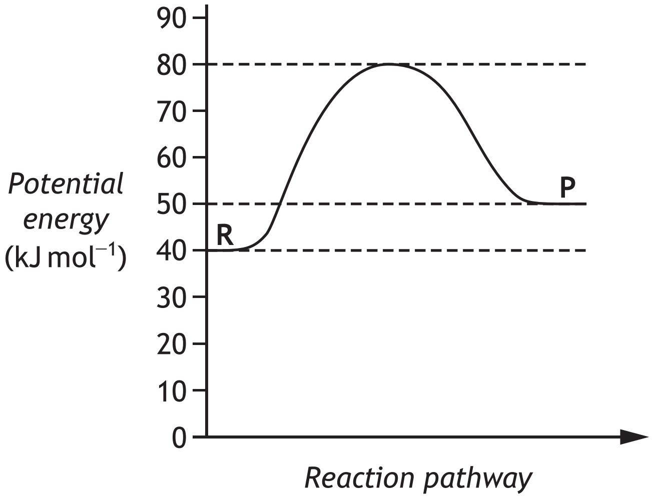
X7137602

Go to Topic Grid

SECTION 1 — 20 marks

Attempt ALL questions

1. The potential energy diagram below refers to the reversible reaction involving reactants **R** and products **P**.



What is the enthalpy change, in kJ mol^{-1}, for the **reverse** reaction?

A –40

B –10

C +10

D +30

2. The relative rate of a reaction which reached completion in 1 minute 40 seconds is

A 0·010 s^{-1}

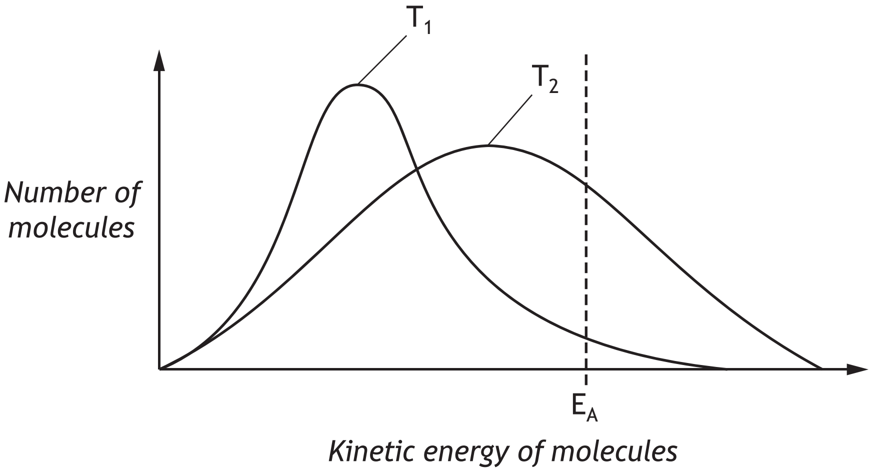
B 0·714 s^{-1}

C 0·010 min^{-1}

D 0·714 min^{-1}.

Go to Answers

3.



Which of the following is the correct interpretation of the above energy distribution diagram for a reaction as the temperature **decreases** from $\mathbf{T_2}$ to $\mathbf{T_1}$?

	Activation energy (E_A)	*Number of successful collisions*
A	remains the same	increases
B	decreases	decreases
C	decreases	increases
D	remains the same	decreases

4. The table shows the first three ionisation energies of aluminium.

Ionisation energy (kJ mol^{-1})		
First	*Second*	*Third*
578	1817	2745

Using this information, what is the enthalpy change, in kJ mol^{-1}, for the following reaction?

$$Al^{+}(g) \rightarrow Al^{3+}(g) + 2e^{-}$$

A 1817

B 2395

C 4562

D 5140

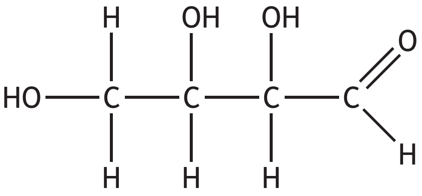
[Turn over

5. An element contains covalent bonding and London dispersion forces.

The element could be

- A boron
- B neon
- C sodium
- D sulfur.

6. Erythrose is a chemical that is known to kill cancer cells.

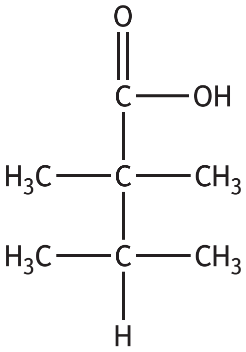


erythrose

The two functional groups present in erythrose are

- A carboxyl and ester
- B carbonyl and ester
- C carbonyl and hydroxyl
- D carboxyl and hydroxyl.

7.



The name of the above compound is

- A 2,2,3-trimethylbutanoic acid
- B 2,3,3-trimethylbutanoic acid
- C 1,1,2,2-tetramethylpropanoic acid
- D 2,2,3,3-tetramethylpropanoic acid.

Go to Answers

Go to Topic Grid

8. Which of the following is an isomer of pentan-3-ol?

A $CH_3CH_2CH(OH)CH_2CH_3$

B $CH_3CHCHCH_2CH_2OH$

C $CH_3CHCHCH(OH)CH_3$

D $CH_3CH(CH_3)CH_2CH_2OH$

9. Oxidation of 4-methylpentan-2-ol to the corresponding ketone results in the alcohol

A losing 2 g per mole

B gaining 2 g per mole

C losing 16 g per mole

D gaining 16 g per mole.

10. Essential amino acids are defined as the amino acids which

A are necessary for building proteins

B humans must acquire through their diet

C plants cannot synthesise for themselves

D are produced when any protein is hydrolysed.

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

$$\mathbf{n}\,CO + (\mathbf{2n} + \mathbf{1})\,H_2 \rightarrow \mathbf{n}\,H_2O + \text{hydrocarbons}$$

What is the general formula for the hydrocarbons produced?

A C_nH_{2n-2}

B C_nH_{2n}

C C_nH_{2n+1}

D C_nH_{2n+2}

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

How many moles of sodium ions are present?

A 0·4

B 0·5

C 0·8

D 1·0

Go to Answers

Go to Topic Grid

13. Under the same conditions of temperature and pressure, which of the following gases would occupy the largest volume?

A 0·20 g of hydrogen

B 0·44 g of carbon dioxide

C 0·60 g of neon

D 0·80 g of argon

14. $3CuO + 2NH_3 \rightarrow 3Cu + N_2 + 3H_2O$

What volume of gas, in cm^3, would be obtained by reaction between 100 cm^3 of ammonia gas and excess copper(II) oxide?

All volumes are measured at atmospheric pressure and 20 °C.

A 50

B 100

C 200

D 400

15. $Cl_2(g) + H_2O(\ell) \rightleftharpoons Cl^-(aq) + ClO^-(aq) + 2H^+(aq)$

The addition of which of the following substances would move the above equilibrium to the right?

A Hydrogen

B Hydrogen chloride

C Sodium chloride

D Sodium hydroxide

16. When 3·6 g of butanal (mass of one mole = 72 g) was burned, 124 kJ of energy was released.

What is the enthalpy of combustion of butanal, in kJ mol^{-1}?

A −6·2

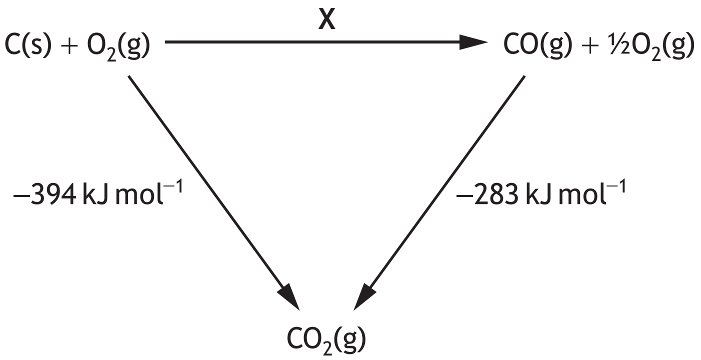
B +6·2

C −2480

D +2480

Go to Answers

17. Consider the reaction pathways shown below.



According to Hess's Law, the enthalpy change, in $kJ\ mol^{-1}$, for reaction **X** is

A +111

B −111

C −677

D +677.

18. $SO_3^{2-}(aq) + H_2O(\ell) \rightarrow SO_4^{2-}(aq) + 2H^+(aq) + 2e^-$

Which of the following ions could be used to oxidise sulfite ions to sulfate ions?

A $Cr^{3+}(aq)$

B $Al^{3+}(aq)$

C $Fe^{3+}(aq)$

D $Sn^{4+}(aq)$

19. During a redox reaction nitrate ions, NO_3^-, are converted to nitrogen monoxide, NO.

$$NO_3^- \rightarrow NO$$

Which line in the table correctly completes the ion-electron equation?

	Reactants	*Products*
A	$6H^+ + 5e^-$	$3H_2O$
B	$4H^+ + 3e^-$	$2H_2O$
C	$6H^+$	$3H_2O + 5e^-$
D	$4H^+$	$2H_2O + 3e^-$

Go to Answers

20. $ICl(\ell) \quad + \quad Cl_2(g) \quad \rightleftharpoons \quad ICl_3(s) \qquad \Delta H = -106\,\text{kJ mol}^{-1}$

Which line in the table identifies correctly the changes that will cause the greatest increase in the proportion of solid in the above equilibrium mixture?

	Temperature	*Pressure*
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

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

Go to Answers

SECTION 2 — 80 marks

Attempt ALL questions

1. The elements of group 7 in the periodic table are known as the halogens.

(a) Going down group 7 the electronegativity of the halogens decreases.

(i) State what is meant by the term *electronegativity*. **1**

(ii) Explain why electronegativity values decrease going down group 7. **1**

(b) Explain **fully** why the boiling points of the halogens increase going down group 7.

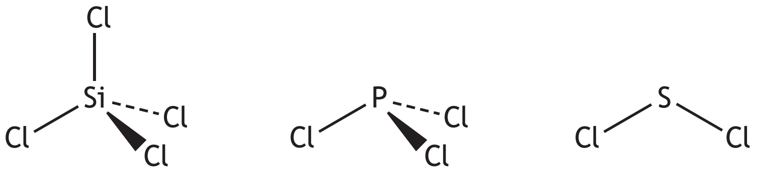
In your answer you should name the intermolecular forces involved. **3**

2. The elements sodium to argon form the third period of the periodic table.

(a) Explain the decrease in atom size going across the third period from sodium to argon. **1**

(b) Elements in the third period of the periodic table form chlorides.

The structures of three of these chlorides are shown.



(i) Circle the structure of the molecule above that contains **bonds** with the lowest polarity. **1**

(An additional diagram, if required, can be found on *page 37*).

(ii) Explain **fully** why, of these three chlorides, silicon tetrachloride is the most soluble in hexane. **2**

[Turn over

2. (continued)

(c) Silicon tetrachloride can be used to make silicon nitride (Si_3N_4), a compound found in many cutting tools.

(i) Silicon nitride has a melting point of 1900 °C and does not conduct electricity when molten.

Explain **fully**, in terms of structure and bonding, why silicon nitride has a high melting point. **2**

(ii) An equation for the formation of silicon nitride is shown.

$3SiCl_4$	$+$	$16NH_3$	$\rightarrow$	Si_3N_4	$+$	$12NH_4Cl$
mass of one mole = 170·1 g		mass of one mole = 17·0 g		mass of one mole = 140·3 g		mass of one mole = 53·5 g

Calculate the atom economy for the formation of silicon nitride. **2**

2. (continued)

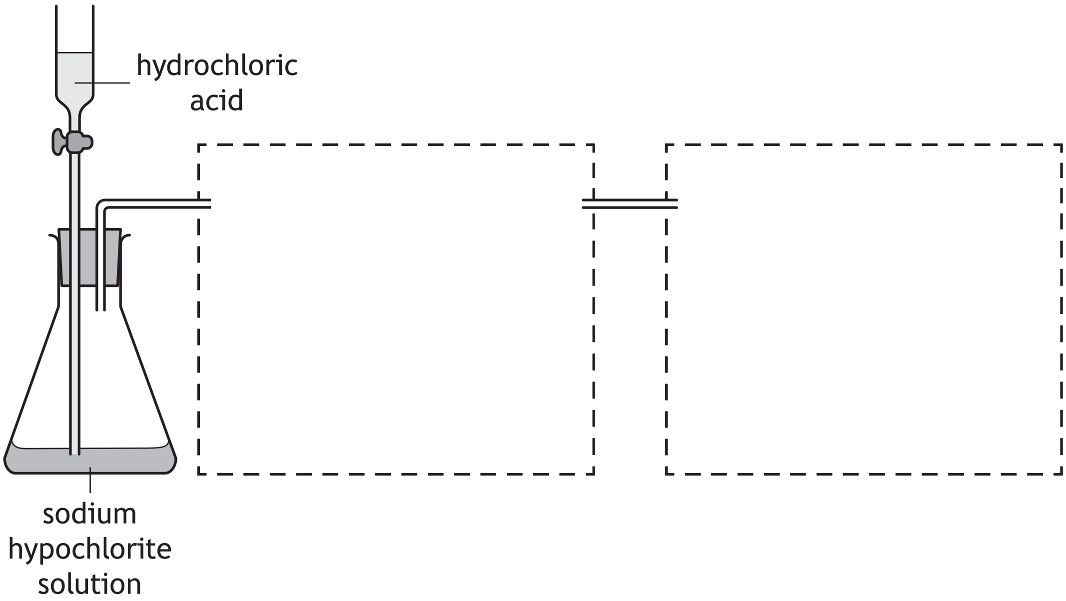
(d) Aluminium, another element in the third period, also forms a chloride. Aluminium chloride is prepared by reacting aluminium metal and chlorine gas.

Chlorine gas is produced by the reaction between hydrochloric acid and sodium hypochlorite. The chlorine is then passed over heated aluminium foil, forming aluminium chloride as a hot gas. The hot aluminium chloride gas and unreacted chlorine gas are passed into a flask where the aluminium chloride cools to a fine white powder.

For safety it is important that any unreacted chlorine gas can escape from the flask.

(i) Complete a labelled diagram to show an apparatus suitable for carrying out this preparation. **2**

(An additional diagram, if required, can be found on *page 37*).

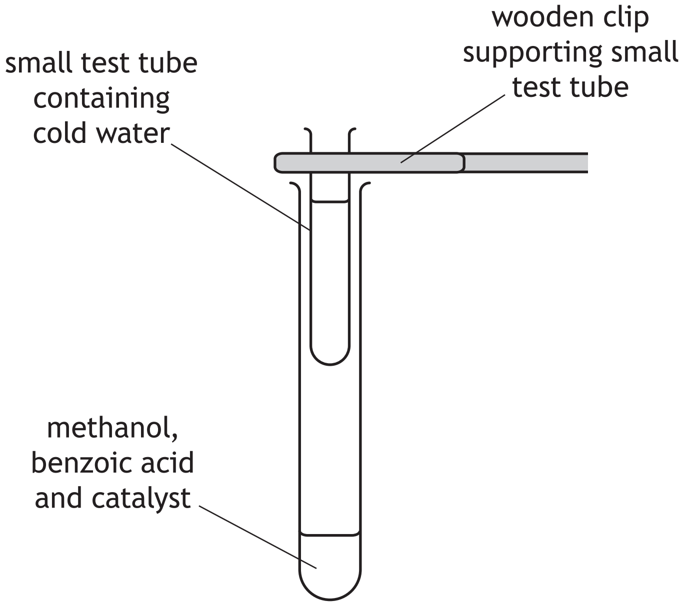


(ii) Explain why the aluminium foil needs to be heated at the start of the preparation, despite the reaction being highly exothermic. **1**

[Turn over

3. Methyl benzoate is commonly added to perfumes as it has a pleasant smell.

A student carries out a reaction to produce methyl benzoate using the following apparatus.



(a) The reaction mixture needs to be heated.

Describe a safe method of heating a flammable mixture. **1**

(b) Suggest a reason why there is a small test tube filled with cold water in the neck of the tube containing the reaction mixture. **1**

3. (continued)

(c) The chemical reaction involved in the experiment is shown.

$C_6H_5COOH(s)$ benzoic acid	+	$CH_3OH(\ell)$	→	$C_6H_5COOCH_3(\ell)$ methyl benzoate	+	**X**
mass of one mole = 122 g		mass of one mole = 32 g		mass of one mole = 136 g		

(i) Name product **X**. **1**

(ii) In a laboratory experiment, a student used 5·0 g of benzoic acid and 2·5 g of methanol to produce methyl benzoate.

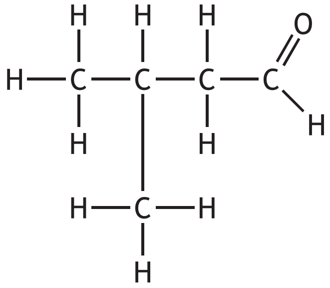
Explain why benzoic acid is the limiting reactant.

You must include calculations in your answer. **2**

(iii) The student produced 3·1 g of methyl benzoate from 5·0 g of benzoic acid. Benzoic acid costs £39·80 for 500 g.

Calculate the cost, in £, of the benzoic acid needed to make 100 g of methyl benzoate using the student's method. **2**

4. 3-Methylbutanal is a compound that is found in low concentrations in many types of food. The structure of 3-methylbutanal is shown.



(a) Draw a structural formula for a ketone that is an isomer of 3-methylbutanal. **1**

(b) Name a reagent which could be used to distinguish between 3-methylbutanal and a ketone. **1**

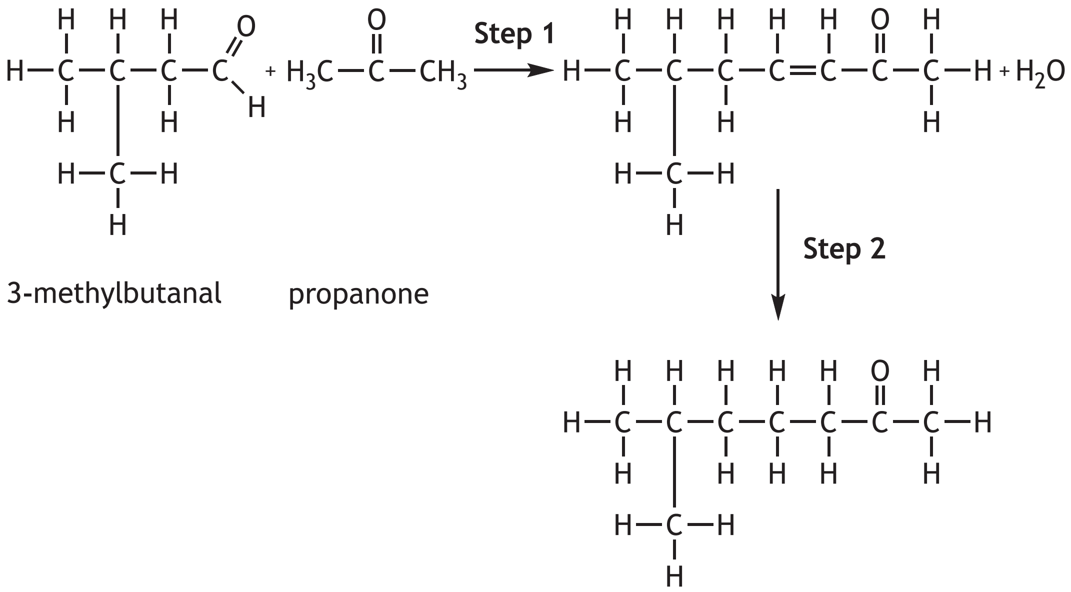
(c) Name the strongest intermolecular force that occurs between 3-methylbutanal molecules. **1**

4. (continued)

(d) 3-Methylbutanal is found in olive oil. **2**

Explain **fully** what can happen to 3-methylbutanal that will cause the olive oil to develop an unpleasant taste.

(e) 3-Methylbutanal can be used as a reactant in the production of other compounds. One reaction scheme involving 3-methylbutanal is shown.



3-methylbutanal propanone

product A

(i) Explain why **step 1** is described as a condensation reaction. **1**

(ii) Give the systematic name for **product A**. **1**

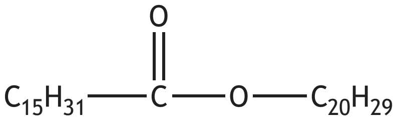
5. Many chemical compounds are related to each other by their structural features, the way they are made and how they are used.

Using your knowledge of chemistry, describe the relationships between fats, oils, detergents, soaps and emulsifiers. **3**

6. Skin creams contain many different chemicals.

(a) Retinol (vitamin A) promotes cell regeneration.

One method of supplying retinol to the skin is by using a skin cream containing the compound retinyl palmitate.



$$C_{15}H_{31}-\overset{\overset{\displaystyle O}{\|}}{C}-O-C_{20}H_{29}$$

retinyl palmitate

Retinyl palmitate is absorbed into the skin and then broken down to form retinol.

(i) Name the type of reaction that occurs when retinyl palmitate is broken down to form retinol. **1**

(ii) Write a molecular formula for retinol. **1**

(b) Skin creams often contain vitamin E to prevent damage to the skin caused by free radicals.

(i) Describe how free radicals are formed. **1**

6. (b) (continued)

(ii) Hydroxyl free radicals (•OH) can attack fatty acids present in cell membranes. One step in the chain reaction is shown below.

$$C_{18}H_{31}O_2 \quad + \quad \bullet OH \quad \rightarrow \quad C_{18}H_{30}O_2\bullet \quad + \quad H_2O$$

State the name given to this step in the chain reaction. **1**

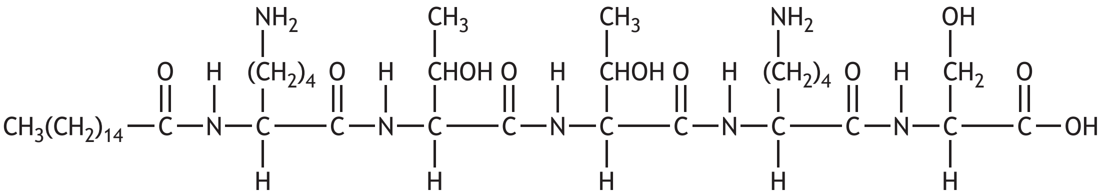
(iii) The antioxidant vitamin E is a free radical scavenger.

State how free radical scavengers prevent further chain reactions. **1**

[Turn over

6. (continued)

(c) Palmitoyl pentapeptide-4 is also used in skin creams.



$$CH_3(CH_2)_{14}CONHCH((CH_2)_4NH_2)CONHCH(CHOHCH_3)CONHCH(CHOHCH_3)CONHCH((CH_2)_4NH_2)CONHCH(CH_2OH)COOH$$

(i) Circle a peptide link in the above structure. **1**

(An additional diagram, if required, can be found on *page 37*).

(ii) Palmitoyl pentapeptide-4 is formed from palmitic acid and three different amino acids.

Molecule	*Number of molecules used to form one molecule of palmitoyl pentapeptide-4*
palmitic acid	1
threonine	2
serine	1
lysine	2

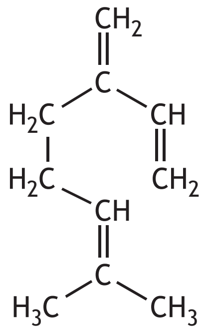
Draw a structural formula for the amino acid serine. **1**

7. Terpenes consist of joined isoprene units (2-methylbuta-1,3-diene). They are classified by the number of isoprene units in the molecule.

Class of terpene	*Number of isoprene units*
hemiterpene	1
monoterpene	2
sesquiterpene	3
diterpene	4
triterpene	6

(a) Myrcene and humulene are terpenes present in hops which give beer its characteristic flavour and aroma.

(i) Circle an isoprene unit on the myrcene structure below. **1**



(An additional diagram, if required, can be found on *page 38*).

(ii) Humulene has the molecular formula $C_{15}H_{24}$.

Name the class of terpene to which humulene belongs. **1**

[Turn over

7. (continued)

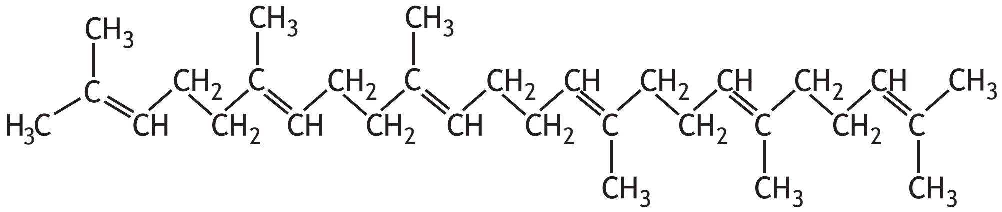
(b) (i) Squalene, a triterpene, is included in some flu vaccines to enhance the body's immune response. A single dose of flu vaccine contains 10·69 mg of squalene.

Calculate the mass of squalene required to produce a batch of 500 000 doses of flu vaccine.

Your answer must be given in kg. **2**

(ii) Squalane is a fully saturated hydrocarbon used in skin moisturising cream.

Squalane can be made by the reaction of squalene with hydrogen.

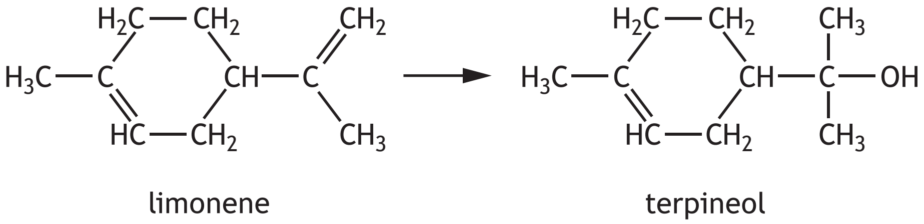


squalene

State the number of moles of hydrogen needed to fully saturate one mole of squalene to produce one mole of squalane. **1**

7. (continued)

(c) The monoterpene limonene, found in lemon oil, can be converted into the alcohol, terpineol.



(i) Name the type of reaction taking place. **1**

(ii) When terpineol is heated with copper(II) oxide, no reaction takes place.

Explain why no reaction takes place. **1**

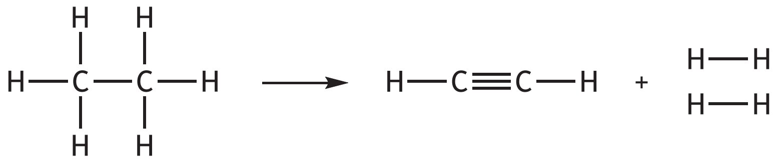
[Turn over

8. The alkynes are a homologous family of hydrocarbons.

(a) The simplest member of the family is ethyne, C_2H_2, used in welding torches.

$$H{-}C{\equiv}C{-}H$$

Ethyne can be produced from ethane.



Using bond enthalpies and mean bond enthalpies from the data book, calculate the enthalpy change, in kJ mol^{-1}, for this reaction. **2**

(b) Hess's Law can be used to calculate the enthalpy change for reactions that do not normally take place, such as the formation of propyne from its elements.

$$3C(s) \quad + \quad 2H_2(g) \quad \rightarrow \quad C_3H_4(g)$$

Calculate the enthalpy change, in kJ mol^{-1}, for this reaction using the following information. **2**

$C(s) + O_2(g)$	$\rightarrow$	$CO_2(g)$	$\Delta H = -394$ kJ mol^{-1}
$H_2(g) + ½O_2(g)$	$\rightarrow$	$H_2O(\ell)$	$\Delta H = -286$ kJ mol^{-1}
$C_3H_4(g) + 4O_2(g)$	$\rightarrow$	$3CO_2(g) + 2H_2O(\ell)$	$\Delta H = -1939$ kJ mol^{-1}

8. (continued)

(c) Propyne, C_3H_4 (1 mole = 40 g), has been suggested as a possible rocket fuel.

(i) The enthalpy of combustion of propyne is –1939 kJ mol^{-1}.

Calculate the energy released, in kJ, when 1 kg of propyne is burned completely. **1**

(ii) The mass of air required to burn 1 g of fuel can be calculated using the relationship shown.

Mass of air, in g = 4·3 × mass of oxygen, in g, for complete combustion of 1 g of fuel

Calculate the mass of air, in g, required to burn 1 g of propyne. **2**

$$C_3H_4(g) \quad + \quad 4O_2(g) \quad \rightarrow \quad 3CO_2(g) \quad + \quad 2H_2O(\ell)$$

8. (c) (continued)

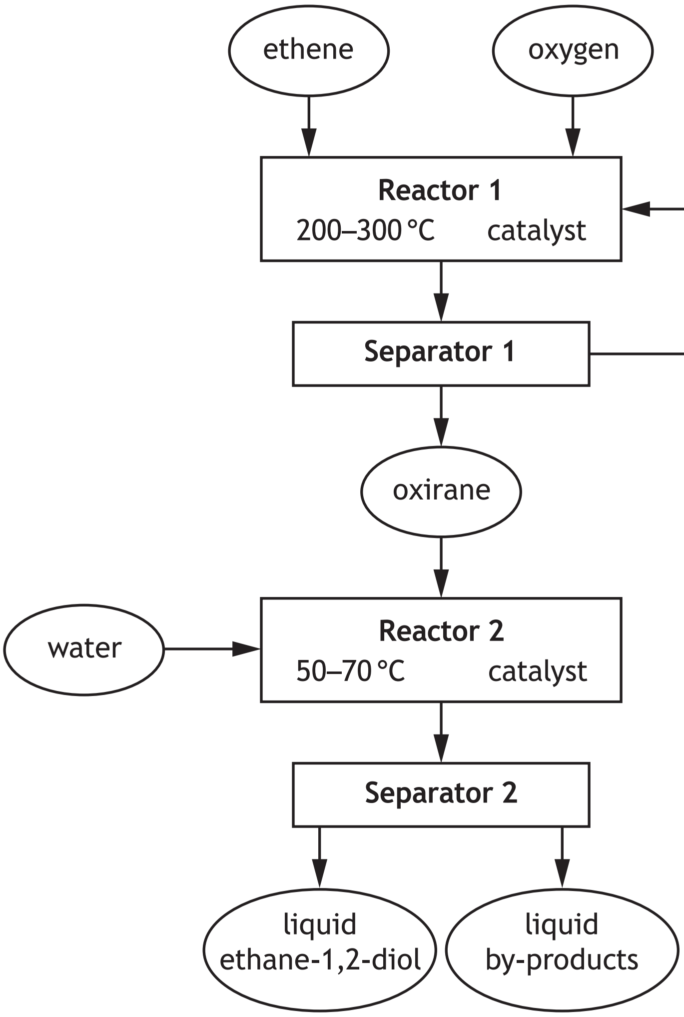
(iii) The table shows the mass of air required to burn 1 g of different fuels.

Fuel	*Mass of 1 mole (g)*	*Mass of air required to burn 1 g*
ethane	30	16·1
propane	44	15·6
methanol	32	6·5
ethanol	46	9·0

Suggest why methanol and ethanol, compared to the other fuels, require less air to burn 1 g. **1**

9. Ethane-1,2-diol can be made from ethene.

(a) The flow chart of an industrial process to produce ethane-1,2-diol is shown.



(i) Industrial processes are designed to maximise profit.

Using the flowchart, suggest two ways to maximise profit in this industrial process. **2**

9. (a) (continued)

(ii) Name the process used in **Separator 2** to separate ethane-1,2-diol from the larger liquid by-products. **1**

(b) Explain fully why ethane-1,2-diol is more viscous than propan-1-ol. **2**

(c) Draw a structural formula for a diol that contains three carbon atoms. **1**

[Turn over

9. (continued)

(d) Ethane-1,2-diol has been found to be harmful to animals. Treatment for affected animals involves using a 20% ethanol solution.

(i) The 20% ethanol solution is prepared by accurately measuring 20 cm^3 of ethanol and then making up to exactly 100 cm^3 with water.

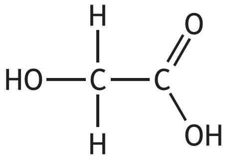
Describe the procedure which should be used to prepare 100 cm^3 of the 20% ethanol solution. **2**

(ii) An affected animal must be treated with 9 doses of 20% ethanol solution. Each dose contains 5 cm^3 of the ethanol solution for every kilogram body mass of the animal.

Calculate the total volume, in cm^3, of the 20% ethanol solution needed to treat a 3·5 kg animal. **1**

9. (d) (continued)

(iii) Ethane-1,2-diol is harmful because it is oxidised in the body to form glycolic acid.



glycolic acid

(A) Draw a structural formula for another possible product of oxidation of ethane-1,2-diol. **1**

(B) Glycolic acid can be neutralised by sodium hydroxide to form sodium glycolate.

Give a formula for sodium glycolate. **1**

[Turn over

10. The molar volume (in units of litres per mole) is the same for all gases at the same temperature and pressure.

Using your knowledge of chemistry, suggest how the molar volume of gases could be measured and compared. Any suitable chemicals and apparatus can be used. Some suggested chemicals and apparatus are given below. **3**

Chemicals	*Apparatus*
hydrochloric acid	gas syringe
zinc	measuring cylinder
magnesium	delivery tube
calcium	stoppers
water	500 cm^3 flask
sodium carbonate	vacuum pump
calcium carbonate	balance
cylinder of nitrogen	cork ring
cylinder of hydrogen	burette
cylinder of carbon dioxide	filter funnel

Go to Answers

Go to Topic Grid

10. (continued)

[Turn over

Go to Answers

11. Iodine is required for a healthy diet. Food grown in certain parts of the world is low in iodine. To prevent iodine deficiency in people's diets, table salt can be 'iodised' by the addition of very small quantities of potassium iodide, KI.

The number of moles of iodide in a sample of salt can be determined by the following procedure.

Step 1

Prepare a standard salt solution by dissolving an accurately weighed sample of iodised salt (50·0 g) in water to give a final volume of 250 cm^3.

Step 2

Transfer 50 cm^3 of salt solution to a conical flask and add excess bromine solution to convert the iodide ions to iodine.

Step 3

Titrate the iodine (I_2) released with sodium thiosulfate solution ($Na_2S_2O_3$).

(a) Describe a procedure to accurately weigh out a 50·0 g sample of iodised table salt. **1**

(b) The overall equation for the reaction of bromine solution with iodide ions is shown.

$$2I^-(aq) \quad + \quad Br_2(aq) \quad \rightarrow \quad I_2(aq) \quad + \quad 2Br^-(aq)$$

Write the ion-electron equation for the oxidation reaction. **1**

11. (continued)

(c) Three samples were prepared as described in **step 2.** Each sample was titrated with 0·0010 mol l^{-1} sodium thiosulfate solution.

The results are shown below.

Sample	*Volume of sodium thiosulfate* (cm^3)
1	10·0
2	9·4
3	9·6

(i) Calculate the average volume, in cm^3, of sodium thiosulfate solution that should be used to determine the number of moles of iodine released. **1**

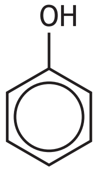
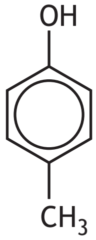
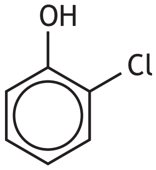
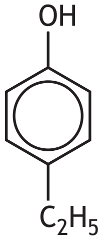
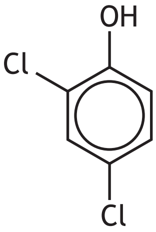
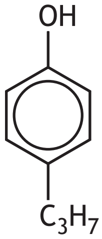
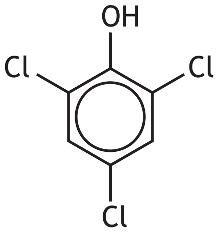
(ii) Calculate the number of moles of iodine released from 50 cm^3 of the standard salt solution. **2**

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

[Turn over

12. Many modern antiseptics are based on phenol. The table shows the germ-killing power of some phenol compounds.

(a)

Compound	*Structure*	*Germ-killing power (relative to phenol)*
phenol		1·0
4-methylphenol		2·5
2-chlorophenol		3·6
4-ethylphenol		7·5
2,4-dichlorophenol		13·0
4-propylphenol		20·0
2,4,6-trichlorophenol		23·0

12. (a) (continued)

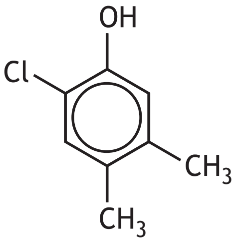
(i) Suggest two ways in which structural features increase germ-killing power of phenol compounds. **2**

(ii) The names of the phenol compounds in the table are derived from their structures using the following rules.

Phenol is used as the parent name for the compound.

1. The –OH functional group is assigned as being on carbon 1 of the ring.
2. The ring can be numbered clockwise or anticlockwise to assign numbers to the other atoms or groups. The numbers should be assigned so that the lowest possible numbers are used.
3. If two or more identical atoms or groups are present, use one of the prefixes di, tri or tetra.
4. The names of the atoms or groups attached to the ring are listed alphabetically (ignoring the prefixes for alphabetical purposes).

Using these rules, name this molecule.



1

[Turn over

12. (continued)

(b) There are different methods of producing phenol.

(i) In the early 1900s, phenol was produced by the following reaction.

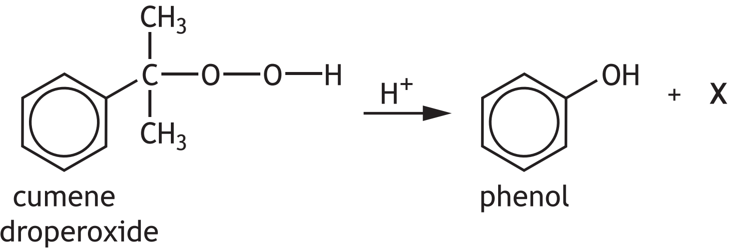
$$\underset{\text{benzene}}{C_6H_6} + H_2SO_4 + 2NaOH \rightarrow \underset{\text{phenol}}{C_6H_5OH} + Na_2SO_3 + 2H_2O$$

mass of one mole = 78·0 g (benzene)

mass of one mole = 94·0 g (phenol)

Calculate the mass of phenol, in kg, produced from 117 kg of benzene if the percentage yield is 90%. **2**

(ii) Phenol is now usually produced by the Cumene Process.



Name the other product, **X**, formed in the Cumene Process. **1**

[END OF QUESTION PAPER]

H

National
Qualifications
2018

2018 Chemistry

Higher

Finalised Marking Instructions

Go to Topic Grid

Marking Instructions for each question

Section 1

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

Go to Topic Grid

Section 2

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i)	Electronegativity is the measure of attraction an atom/nucleus has for the electrons in a bond/shared electrons.	**1**	
		(ii)	(More shells) so increased shielding/more shielding. **OR** Covalent radius increases/atom size increases/more shells so attraction of the nucleus/protons for the (outer/shared) electrons decreases.	**1**	
	(b)		(Intermolecular) forces/bonds increase (going down the group). **(1)** LDFs are the forces (broken) between the molecules. **(1)** The more electrons the stronger the LDFs. **(1)**	**3**	Use of VdW is acceptable for first mark. Mention of **increasing/stronger** intramolecular/covalent/ionic/ metallic bonds – cancels the first mark. This mark can only be awarded if no other forces are mentioned (as being broken). Use of VdW does not cancel but is not sufficient for the second mark.

Question			Expected response	Max mark	Additional guidance
2.	(a)		Increasing number of protons (in the nucleus). **OR** Increasing/greater/stronger/higher nuclear charge.	**1**	Mention must be made of **nuclear charge or number of protons.** Increased nuclear pull is not accepted on its own. Increased attraction of the electron for the nucleus is not an acceptable answer.
	(b)	(i)	Sulfur chloride should be circled.	**1**	Accept other indications of correct structure, eg tick, arrow. Do not accept circling of single atoms or bond in SCl_2 molecule on its own.
		(ii)	Silicon tetrachloride and hexane are non-polar. **(1)** Silicon tetrachloride is non-polar due to its shape/dipoles/polarities cancelling out. **(1)**	**2**	Like dissolves like on its own – zero marks - answer must mention polarity.

Go to Topic Grid

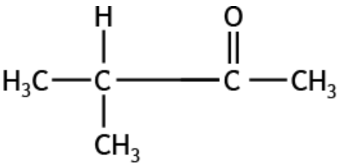
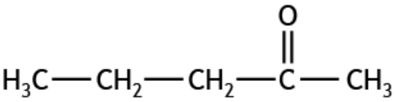
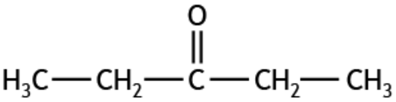
Question			Expected response	Max mark	Additional guidance
2.	(c)	(i)	Silicon nitride is a (covalent) network. **(1)** (Strong) covalent bonds are broken. **(1)**	**2**	'Covalent lattice' is acceptable, but 'lattice' on its own is not. Mention of silicon is cancelling for the first mark. Covalent network molecule is cancelling.
		(ii)	17·934/17·93/17·9/18 (%) -- Partial mark for correct use of atom economy relationship without correct use of stoichiometry (working must be shown). Partial marks Correct working with no correct answer given. $\frac{140\cdot3}{(3\times170\cdot1)+(16\times17\cdot0)}\times100$ $\frac{140\cdot3}{510\cdot3+272\cdot0}\times100$ $\frac{140\cdot3}{782\cdot3}\times100$ Incorrect use of stoichiometry. $\frac{140\cdot3}{170\cdot1+17\cdot0}x100=74\cdot99$ $\frac{140\cdot3}{3\times170\cdot1+17\cdot0}x100=26\cdot6$ $\frac{140\cdot3}{170\cdot1+16\times17\cdot0}x100=31\cdot7$ Answer and working must be shown. -- 0·179 **(1)**	**2**	No units required. Only 1 mark can be awarded for the correct answer if wrong unit is given. (Wrong units would only be penalised once in any paper).

Go to Topic Grid

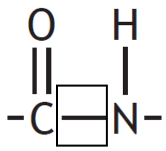
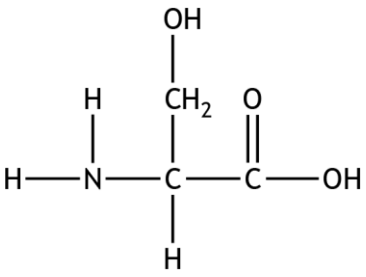
Question			Expected response	Max mark	Additional guidance
2.	(d)	(i)	Diagram shows a workable method for the passing of chlorine gas over heated aluminium. Aluminium must be labelled and there must be an indication of heat. Heated aluminium accepted. **(1)** Diagram allows aluminium chloride to be collected **in a flask** as a solid and chlorine gas to escape. **(1)**	**2**	Labels must be correct.
		(ii)	To provide (initial) activation energy/(sufficient) energy to form activated (activation) complex.	**1**	Accept activation energy is high.

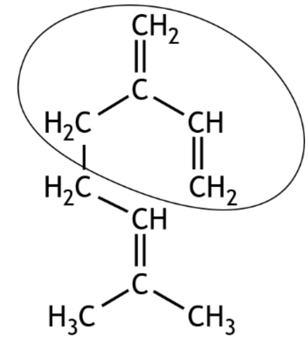
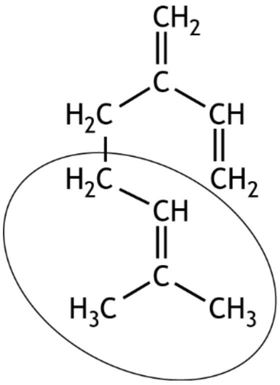
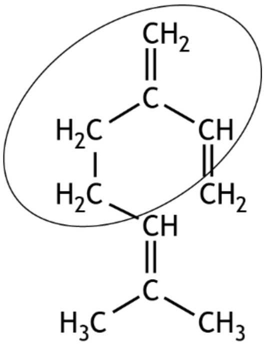
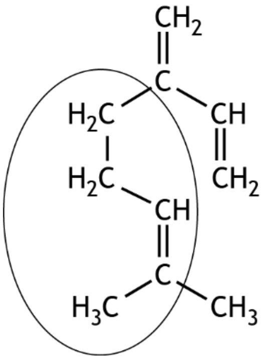
Question			Expected response	Max mark	Additional guidance
3.	(a)		Heating mantle or hot plate **OR** (hot) water bath.	**1**	Any mention of a naked flame would result in the loss of a mark.
	(b)		Condense reactants or products/acts as a condenser/to prevent escape of (volatile/gaseous) reactants or products/to prevent the escape of gas(es).	**1**	Accept correct description of condensation.
	(c)	(i)	Water	**1**	Accept formula H_2O
		(ii)	Correctly calculates number of moles of: Benzoic acid = 0·041 Methanol = 0·078. **OR** Working out that 1·31 g of methanol would be needed to react with 5 g of benzoic acid. **OR** Working out that 9·53 g of benzoic acid would be needed to react with 2·5 g of methanol. **(1)** Statement demonstrating understanding of limiting reactant eg there are less moles of benzoic acid therefore it is the limiting reactant. **OR** There are more moles of methanol therefore it is in excess. **OR** 0·078 moles of methanol would require 0·078 moles of benzoic acid. **(1)**	**2**	

Question			Expected response	Max mark	Additional guidance
3.	(c)	(iii)	(£)12·84 **(2)** Partial Marks Mass benzoic acid = 161·3(g). **OR** Cost to make 3·1g of methyl benzoate = (£) 0·398. **OR** Evidence of a calculated mass of benzoic acid × 7·96 or 8 (p). **(1)**	**2**	Accept 1284 p. Do not accept '1284' on its own; correct units are required. Allow follow through from an initial arithmetic error (for 1 mark). Rounding of final answer to the nearest penny is required.

Question			Expected response	Max mark	Additional guidance
4.	(a)		Correctly drawn structure of pentan- 2-one, pentan-3-one or 3- methylbutanone.  $H_3C-\underset{CH_3}{\overset{H}{C}}-\overset{O}{\overset{\|}{C}}-CH_3$  $H_3C-CH_2-CH_2-\overset{O}{\overset{\|}{C}}-CH_3$  $H_3C-CH_2-\overset{O}{\overset{\|}{C}}-CH_2-CH_3$	**1**	Accept full or shortened structural formulae.
	(b)		Fehling's solution/Tollens' reagent/ **acidified** dichromate solution.	**1**	Accept Benedict's solution/Schiff's reagent.
	(c)		Permanent dipole-permanent dipole (interactions/attractions).	**1**	Allow permanent dipole-dipole interaction. Accept pd-pd i's.
	(d)		Will react with oxygen/undergo oxidation. **(1)** Forming a **carboxylic** acid (which has unpleasant taste). **(1)**	**2**	Rancid not acceptable on its own but is not cancelling. Acid not acceptable on its own.
	(e)	(i)	Because it has two molecules joining together with the loss of a small/water molecule.	**1**	Candidates must indicate joining together and loss.
		(ii)	6-methylheptan-2-one	**1**	General marking principle (p) applies.

Question			Expected response	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 candidate 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, 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			Expected response	Max mark	Additional guidance
6.	(a)	(i)	(enzyme) hydrolysis	**1**	
		(ii)	$C_{20}H_{29}OH$ **OR** $C_{20}H_{30}O$	**1**	
	(b)	(i)	Bond breaking by UV (light) or example of initiation reaction (equation or diagram). eg chlorine splitting to give two free radicals is accepted, provided UV is shown.	**1**	UV on its own is not accepted. Bond breaking on its own is not accepted.
		(ii)	propagation	**1**	
		(iii)	Can react with free radicals forming stable molecules/free radicals (and prevent chain reactions). **OR** Donates electron(s). **OR** Acting as a reducing agent. **OR** Provide electrons to pair with an unpaired electron.	**1**	
	(c)	(i)	Circle any peptide link (CONH).	**1**	 Minimum acceptable structure identified.
		(ii)		**1**	Shortened structural formula accepted.

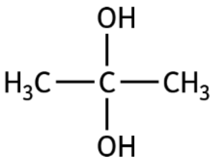
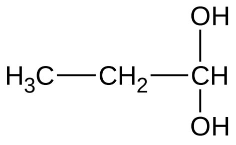
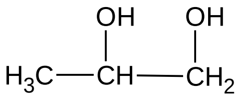
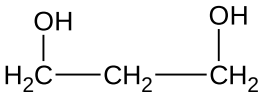
Question			Expected response	Max mark	Additional guidance
7.	(a)	(i)	 	**1**	0 marks awarded for  
		(ii)	Sesquiterpene	**1**	

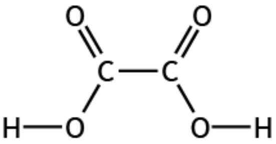
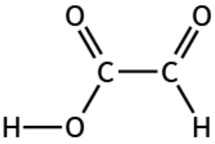
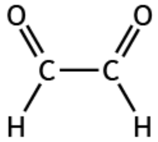
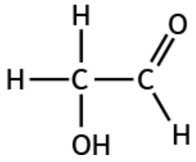
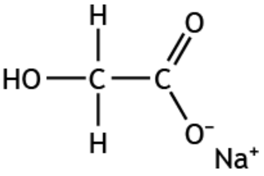
Question			Expected response	Max mark	Additional guidance
7.	(b)	(i)	5·345/5.35/5.3 (kg) **(2)** Partial marking Mass of squalene = 10·69 × 500 000 = 5 345 000 (mg) **(1)** **OR** For incorrectly calculating mass in mg but correctly converting to kg. **(1)** **OR** For incorrectly calculating mass of squalene but correctly multiplying this by 500 000. **(1)** **OR** Conversion of 10·69 mg to kg ie 10·69 × 10^{-6}.	**2**	Answer must be in kg to access both marks, 5345 g would be awarded 1 mark only.
		(ii)	6/six (moles)	**1**	
	(c)	(i)	Addition **OR** hydration.	**1**	Oxidation is not accepted.
		(ii)	(terpineol) is a tertiary alcohol (and cannot be oxidised).	**1**	‘cannot be oxidised’ on its own is awarded zero marks.

Question			Expected response	Max mark	Additional guidance
8.	(a)		286 (kJ mol^{-1}) Partial mark 1 mark Evidence of the use of **all** the correct bond enthalpies (or correct multiples thereof) (412, 348, 838, 436 (ignore signs)). **OR** If only three values are retrieved, the candidate recognises that bond breaking is endothermic and bond formation is exothermic and correctly manipulates the bond enthalpy values they have used to give their answer.	**2**	-286 (kJ mol^{-1}) 1 mark No units required. Only 1 mark can be awarded for the correct answer if wrong unit is given. (Wrong units would only be penalised once in any paper). kJ is acceptable in place of kJ mol^{-1} (KJ or Kj or KJ mol^{-1} or Kj mol^{-1} accepted). If fewer than three bond enthalpy values are retrieved then zero marks can be awarded.
	(b)		(+) 185 (kJ mol^{-1}) [(-1182) + (-572) + (+1939)] = (+) 185 (kJ mol^{-1}) Partial marks Treat as two concepts. Either would be acceptable for 1 mark. Evidence of understanding of reversal of third enthalpy value ie +1939 or 1939 must be seen. The other two enthalpy values (regardless of value) **must** be negative, or this partial mark cannot be awarded. **OR** Evidence of understanding of multiplying the first enthalpy value by 3 and the second enthalpy value by 2. Ignore the enthalpy signs associated with these numbers ie any combination of 3 (±394) **and** 2 (±286) **OR** ±1182 **and** ±572 Multiplication of the third enthalpy value by any factor is taken as cancelling of this partial mark.	**2**	If answer given is −185, maximum of 1 mark can be awarded. No units required. Only 1 mark can be awarded for the correct answer if wrong unit is given. (wrong units would only be penalised once in any paper) kJ is acceptable in place of kJ mol^{-1} (KJ or Kj or KJ mol^{-1} or Kj mol^{-1} accepted).

Question			Expected response	Max mark	Additional guidance
8.	(c)	(i)	48475 (kJ)	**1**	–48475 (kJ) is accepted. No units required. Zero marks can be awarded for the correct answer if wrong unit is given. kJ mol^{-1} is not an acceptable unit in this question. (Wrong units would only be penalised once in any paper).
		(ii)	13·76/13·8/14 (g) Partial mark - 1 mark Mass of oxygen required = 3·2 (g) **OR** 550·4 (g)	**2**	Accept correctly calculated answer in mg or kg, providing units are shown with answer. This is obtained from an incorrect mass of oxygen (4 × 32 = 128) being calculated.
		(iii)	Methanol and ethanol contain oxygen in their structure, (so less additional oxygen is required).	**1**	Contains hydroxyl (groups) not sufficient on its own. Contains -OH is not considered sufficient on its own.

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	**1 mark each** for any two of the following points. • recycle (waste) gases • use catalyst • low/reduce energy requirements • reactors are run at low temperatures/the temperatures in the reactors is lowered • inexpensive feedstocks • selling/using by-products	**2**	Recycle by-products is not accepted.
		(ii)	(fractional) distillation	**1**	Evaporation followed by condensation or a correct description of distillation are accepted.
	(b)		Propan-1-ol has fewer hydroxyl groups than ethane-1,2-diol / ethane-1,2-diol has more hydroxyl groups/propan-1-ol has 1 hydroxyl group and ethane-1,2-diol has 2. **(1)** Weaker/fewer hydrogen bonds between propan-1-ol molecules. **OR** Stronger/more hydrogen bonds between ethane-1,2-diol molecules. **(1)**	**2**	“It”, if given in answer is taken to refer to ethane-1,2-diol.

Question			Expected response	Max mark	Additional guidance
9.	(c)		Structure of propane-1,2-diol or propane-1,3-diol or propane-1,1-diol or propane-2,2-diol.  $H_3C-\overset{OH}{\underset{OH}{C}}-CH_3$  $H_3C-CH_2-\overset{OH}{\underset{OH}{CH}}$  $H_3C-\overset{OH}{CH}-\overset{OH}{CH_2}$  $\overset{OH}{H_2C}-CH_2-\overset{OH}{CH_2}$	**1**	With structures involving an – OH group, no mark can be awarded if the 'O' is not bonded to a carbon, ie OH-CH_2.
	(d)	(i)	Pipette (used to measure 20cm^3 of ethanol.) **(1)** Statement of use of **volumetric/ standard** flask to make up to / fill to the mark/ to 100cm^3. **(1)**	**2**	Not acceptable to use burette.
		(ii)	157·5(cm^3)	**1**	No units required. No mark can be awarded for the correct answer if wrong unit is given. (Wrong units would only be penalised once in any paper).

Question			Expected response	Max mark	Additional guidance
9.	(d)	(iii) (A)	 **OR**  **OR**  **OR** 	**1**	Accept correct shortened structural formula. With structures involving an – OH group, no mark can be awarded if the 'O' is not bonded to a carbon, ie $OH\text{-}CH_2$. General marking instruction (l) is suspended here.
		(iii) (B)	Correct molecular formula ($NaC_2H_3O_3$) **OR** shortened structural formula ($HOCH_2COONa$) **OR** any full structural formula which shows the correct salt. 	**1**	Structures showing covalent bonds between Na and glycolate are not accepted. Charges are not required but if shown must both be shown and correct.

Question			Expected response	Max mark	Additional guidance
10.			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) 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			Expected response	Max mark	Additional guidance
11.	(a)		Correct description of weighing by difference. **OR** Correct description of use of the Tare function.	**1**	'weighing by difference' on its own is accepted.
	(b)		$2I^- (aq) \rightarrow I_2(aq) + 2e^-$ **OR** $2I^- (aq) \rightarrow I_2(s) + 2e^-$	**1**	State symbols not required. Negative sign on electron not required.
	(c)	(i)	9·5(cm^3)	**1**	No units required but no mark is awarded if wrong unit is given. (Wrong units would only be penalised once in any paper).
		(ii)	$4{\cdot}75 \times 10^{-6}$ moles Partial mark for correct use of mole ratio. **OR** Determination of number of moles without using the mole ratio.	**2**	Allow follow through from c (i).

Question			Expected response	Max mark	Additional guidance
12.	(a)	(i)	More/adding chlorine(s). **(1)** More/adding carbon(s). **OR** Adding an alkyl/hydrocarbon chain/group. **OR** Longer/bigger carbon/hydrocarbon/alkyl (chain/group). **(1)**	**2**	(More) branches is not accepted.
		(ii)	2-chloro-4,5-dimethylphenol	**1**	Apply general marking instruction (p).
	(b)	(i)	126·9/127(kg) Partial mark either for: Calculation of the theoretical yield 141 (no unit required) **(1)** **OR** for correctly calculating 90% of an incorrectly calculated theoretical yield. **(1)**	**2**	No units required but a maximum of 1 mark is awarded if wrong unit is given. (Wrong units would only be penalised once in any paper). Accept correctly calculated answer in g, providing units are shown with answer, eg 126900 g.
		(ii)	Propanone **OR** Acetone **OR** propan-2-one.	**1**	Structure is not acceptable on its own.

[END OF MARKING INSTRUCTIONS]

H

National
Qualifications
2019

X813/76/12

Chemistry
Paper 1 — Multiple choice

FRIDAY, 10 MAY

9:00 AM – 9:40 AM

Total marks — 25

Attempt ALL questions.

You may use a calculator.

Instructions for the completion of Paper 1 are given on *page 02* of your answer booklet X813/76/02.

Record your answers on the answer grid on *page 03* of your answer booklet.

You may refer to the Chemistry Data Booklet for Higher and Advanced Higher.

Space for rough work is provided at the end of this booklet.

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

Go to Topic Grid

Total marks — 25

Attempt ALL questions

1. Hydrogen will form a non-polar covalent bond with an element that has an electronegativity value of

A 0·9

B 1·5

C 2·2

D 2·5.

2. Which of the following is a polar molecule?

A CCl_4

B NH_3

C CO_2

D CH_4

3. Which of the following is most likely to act as a reducing agent?

A CO

B MnO_4^-

C H_2O_2

D $Cr_2O_7^{2-}$

4. The following reactions take place when nitric acid is added to zinc.

$$NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(\ell)$$

$$Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$$

How many moles of Zn(s) are oxidised by one mole of NO_3^- (aq)?

A 0·67

B 1·0

C 1·5

D 2·0

Go to Answers

5. Which of the following compounds is a tertiary alcohol?

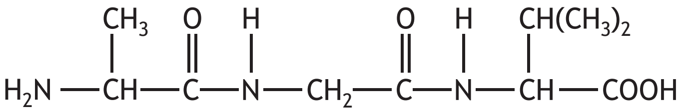
A 2,2-dimethylpropan-1-ol

B 2-methylbutan-2-ol

C pentan-3-ol

D 3-methylbutan-2-ol

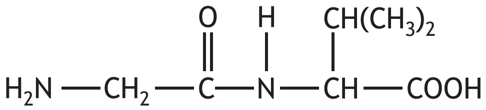
6. Molecule **X** has the structure



$$H_2N-\overset{CH_3}{\overset{|}{C}H}-\overset{O}{\overset{\|}{C}}-\overset{H}{\overset{|}{N}}-CH_2-\overset{O}{\overset{\|}{C}}-\overset{H}{\overset{|}{N}}-\overset{CH(CH_3)_2}{\overset{|}{C}H}-COOH$$

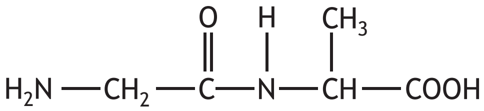
Which of the following could be produced by partial hydrolysis of **X**?

A



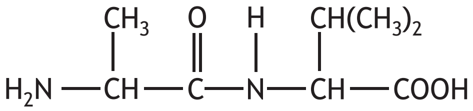
$$H_2N-CH_2-\overset{O}{\overset{\|}{C}}-\overset{H}{\overset{|}{N}}-\overset{CH(CH_3)_2}{\overset{|}{C}H}-COOH$$

B



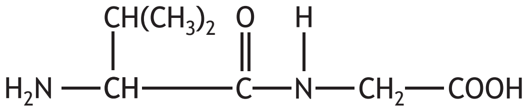
$$H_2N-CH_2-\overset{O}{\overset{\|}{C}}-\overset{H}{\overset{|}{N}}-\overset{CH_3}{\overset{|}{C}H}-COOH$$

C



$$H_2N-\overset{CH_3}{\overset{|}{C}H}-\overset{O}{\overset{\|}{C}}-\overset{H}{\overset{|}{N}}-\overset{CH(CH_3)_2}{\overset{|}{C}H}-COOH$$

D



$$H_2N-\overset{CH(CH_3)_2}{\overset{|}{C}H}-\overset{O}{\overset{\|}{C}}-\overset{H}{\overset{|}{N}}-CH_2-COOH$$

7. A compound with molecular formula $C_6H_{12}O_2$ could be

A pentyl ethanoate

B hexan-2-one

C 3-methylpentan-2-ol

D hexanoic acid.

[Turn over

Go to Answers

8. Compound X reacted with hot copper(II) oxide and the resulting product did **not** give a colour change when heated with Fehling's solution.

Compound X could be

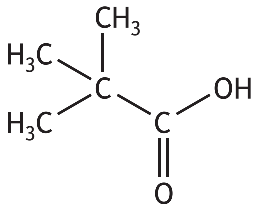
A pentan-1-ol

B pentan-2-ol

C pentan-3-one

D pentanoic acid.

9. The structure of pivalic acid is shown.



Which of the following is the correct systematic name of pivalic acid?

A pentanoic acid

B 2,2,2-trimethylethanoic acid

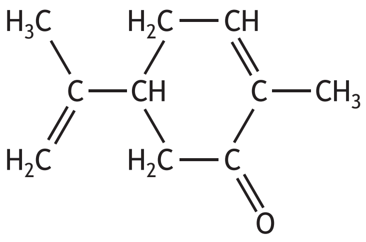
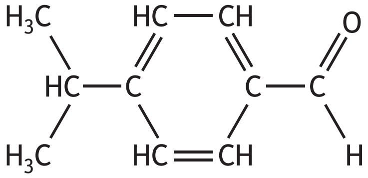
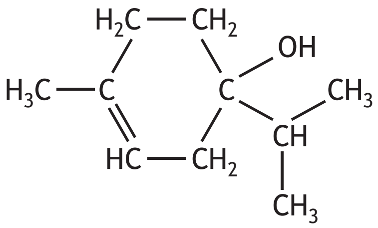
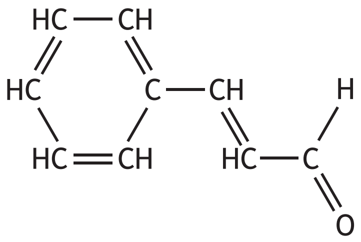
C 2-ethylpropanoic acid

D 2,2-dimethylpropanoic acid

Go to Topic Grid

10. The table shows four compounds that contribute to the aroma of spices.

Which compound is **not** derived from a terpene?

	Structural formula	**Molecular formula**
A		$C_{10}H_{14}O$
B		$C_{10}H_{12}O$
C		$C_{10}H_{18}O$
D		C_9H_8O

11. Which reaction can be classified as reduction?

A	methanol	→	methanoic acid
B	propanal	→	propanoic acid
C	butan-2-one	→	butan-2-ol
D	propan-2-ol	→	propanone

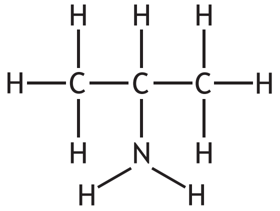
[Turn over

Go to Answers

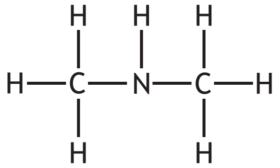
12. A secondary amine has two carbon atoms directly bonded to the nitrogen atom.

Which of the following is a secondary amine?

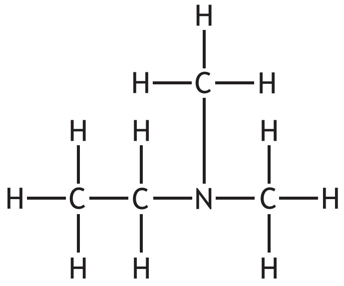
A



B



C



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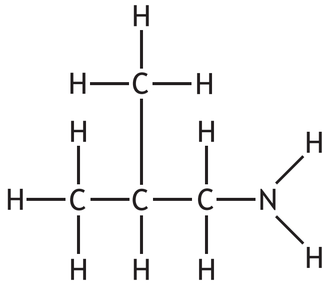


13. The number of moles of ions in 1 mol of copper(II) phosphate is

A 1

B 2

C 3

D 5.

Go to Answers

Go to Topic Grid

14. Which of the following gas samples has the same volume as 4·0 g of methane, CH_4?

(All volumes are measured at the same temperature and pressure.)

A 1·0 g of helium
B 1·0 g of hydrogen
C 3·5 g of nitrogen
D 35·5 g of chlorine

15. Magnesium carbonate reacts with nitric acid.

$$MgCO_3(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2O(\ell) + CO_2(g)$$

0·05 mol of magnesium carbonate was added to a solution containing 0·06 mol of nitric acid.

Which of the following statements is true?

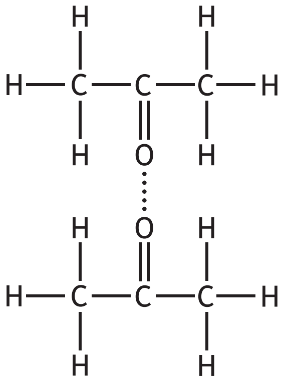
A 0·05 mol of carbon dioxide is produced
B 0·06 mol of magnesium nitrate is produced
C Magnesium carbonate is in excess by 0·02 mol
D Nitric acid is in excess by 0·01 mol

[Turn over

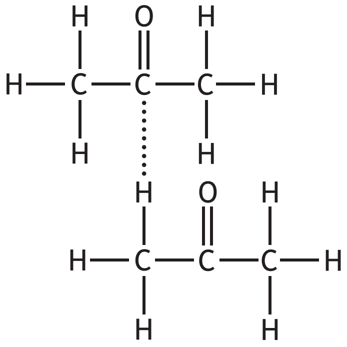
Go to Answers

16. In which of the following diagrams does the dotted line represent a permanent dipole-permanent dipole interaction between propanone molecules?

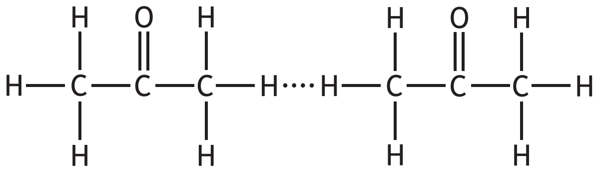
A



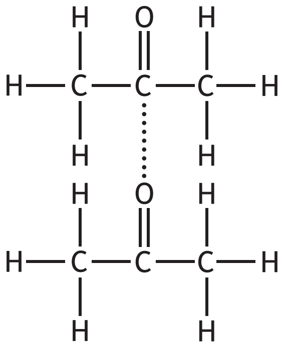
B



C



D



17. Iron can be produced from iron(III) oxide.

$$\begin{array}{ccccccc} 2Fe_2O_3(s) & + & 3C(s) & \rightarrow & 4Fe(s) & + & 3CO_2(g) \\ \text{GFM} = 159{\cdot}6\,\text{g} & & \text{GFM} = 12{\cdot}0\,\text{g} & & \text{GFM} = 55{\cdot}8\,\text{g} & & \text{GFM} = 44{\cdot}0\,\text{g} \end{array}$$

The atom economy for the production of iron is

A 69·9%

B 62·8%

C 58·2%

D 32·5%.

18. 100 cm^3 of propane is mixed with 600 cm^3 of oxygen and the mixture is ignited.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(\ell)$$

At the end of the reaction, the total volume of gas would be

A 300 cm^3

B 400 cm^3

C 700 cm^3

D 800 cm^3.

19. A two-step reaction is shown below.

$$A \xrightarrow[\text{step 1}]{} B \xrightarrow[\text{step 2}]{} C$$

The first step gave a yield of 60% and the second step a yield of 90%.

The overall yield would be

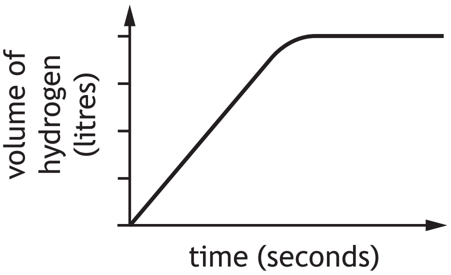
A 30%

B 54%

C 67%

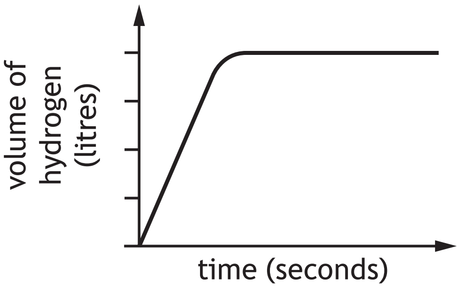
D 150%.

20. The volume of hydrogen gas given off against time when an excess of zinc lumps is added to 100 cm^3 of 1 mol l^{-1} hydrochloric acid is shown.

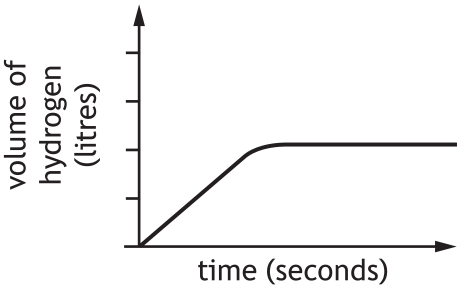


Which of the following graphs would show the volume of hydrogen gas given off when an excess of zinc powder was added to 50 cm^3 of 1 mol l^{-1} hydrochloric acid?

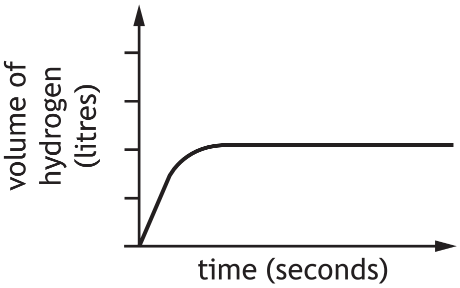
A



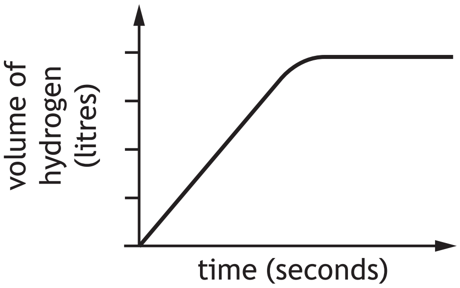
B



C

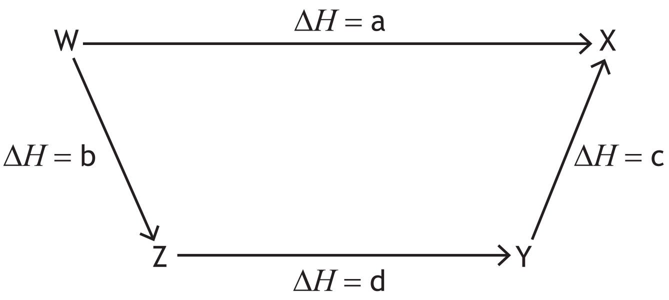


D



Go to Answers

21. Consider the reaction pathway shown below.



According to Hess's Law

A $b = a - c - d$

B $b = a + c + d$

C $b = d - c + a$

D $b = d + c - a$.

22. Which of the following is **not** a factor that affects the rate of a reaction?

A Activation energy

B Kinetic energies of reactant molecules

C Concentration of reactants

D Enthalpy change of reaction

23. In which of the following reactions would the yield of product be increased by lowering the pressure?

A $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

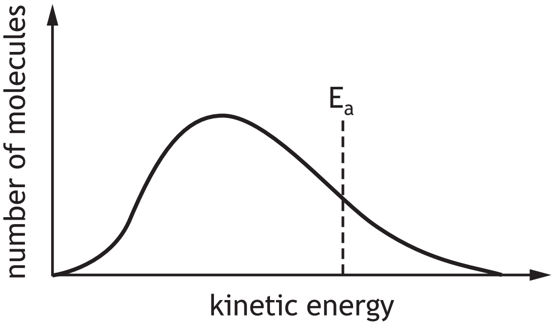
B $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

C $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

D $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$

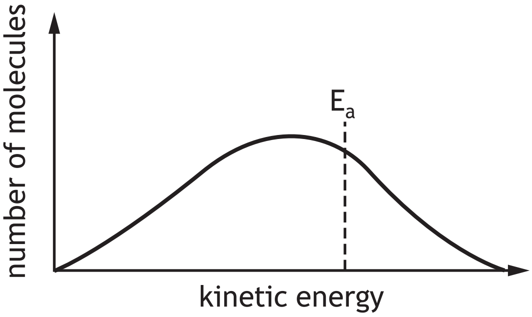
[Turn over

24. The graph shows the distribution of kinetic energies for a reaction involving two gases.

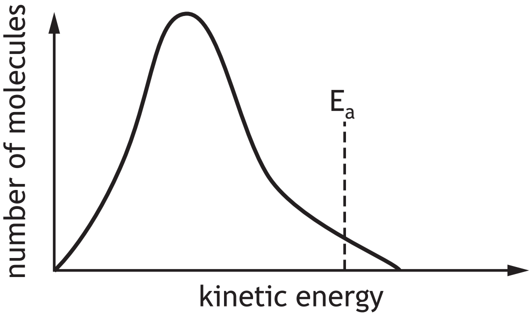


Which graph would show the effect of increasing temperature?

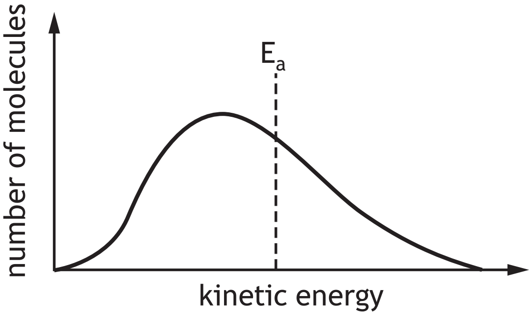
A



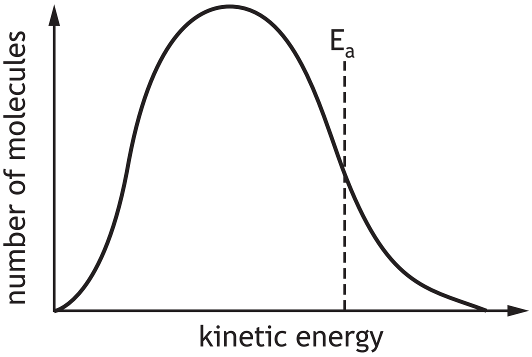
B



C



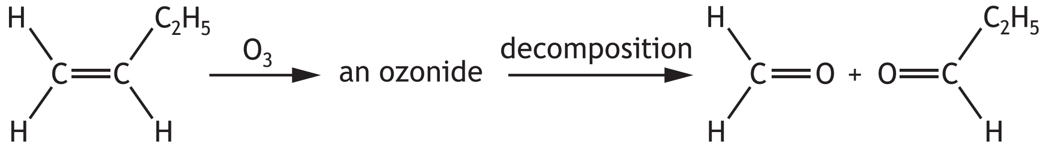
D



Go to Answers

Go to Topic Grid

25. Alkenes react with ozone, O_3, to form ozonides which can be decomposed to give carbonyl compounds.

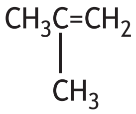


Which of the following alkenes would produce a mixture of ethanal and propanone?

A $CH_3CH{=}CHCH_2CH_3$

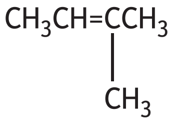
B $CH_3CH{=}CHCH_3$

C



$CH_3\underset{\displaystyle CH_3}{\underset{|}{C}}{=}CH_2$

D



$CH_3CH{=}\underset{\displaystyle CH_3}{\underset{|}{C}}CH_3$

[END OF QUESTION PAPER]

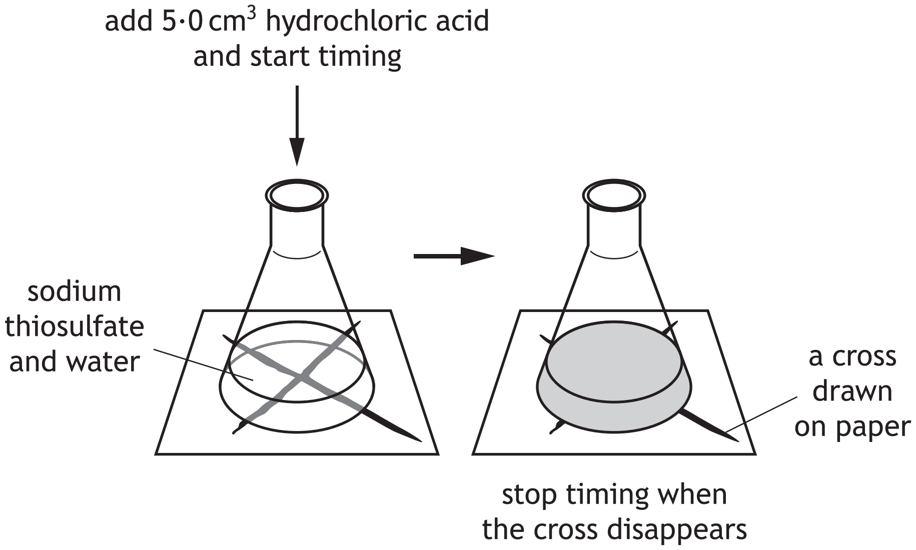
Go to Answers

Total marks — 95

Attempt ALL questions

1. Sodium thiosulfate, $Na_2S_2O_3$, can be used to investigate the effect of reaction conditions on the rate of reaction.

(a) Sodium thiosulfate solution reacts with hydrochloric acid to form a precipitate of solid sulfur. By placing the reaction mixture in a conical flask over a cross and recording the time taken for the cross to disappear, the effect of changing the reaction conditions can be investigated.



(i) The equation for the reaction is

$$Na_2S_2O_3(aq) + HCl(aq) \rightarrow S(s) + SO_2(g) + NaCl(aq) + H_2O(\ell)$$

Balance the equation. **1**

1. (a) (continued)

(ii) In one set of experiments, the effect of varying the concentration of sodium thiosulfate was investigated.

Experiment	Volume of 0·15 mol l^{-1} $Na_2S_2O_3$ (cm^3)	Volume of water (cm^3)	Rate (s^{-1})
A	50	0	0·0454
B	40		0·0370
C	30		0·0285
D	20		0·0169
E	10	40	0·0063

(A) Complete the table to show the volumes of water that would have been used to vary the concentration of sodium thiosulfate. **1**

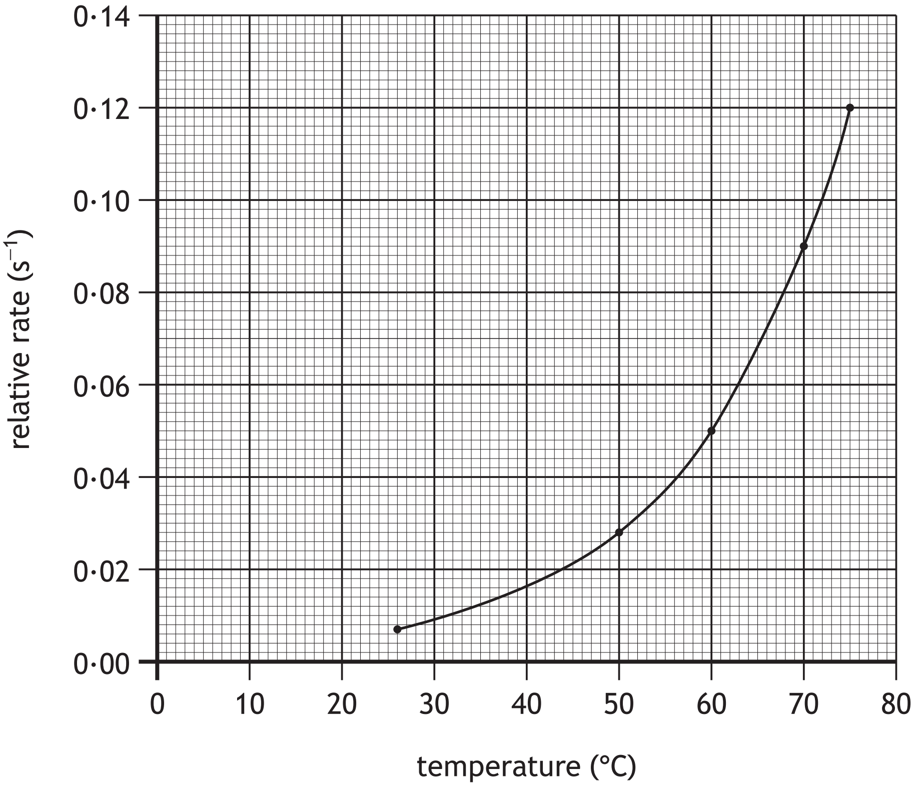
(B) Calculate the time, in seconds, for the cross to disappear in experiment C. **1**

[Turn over

1. (a) (continued)

(iii) The reaction can also be used to investigate the effect of changing temperature on the rate of reaction.

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



Use the graph to determine the temperature rise, in °C, required to double the rate of the reaction. **1**

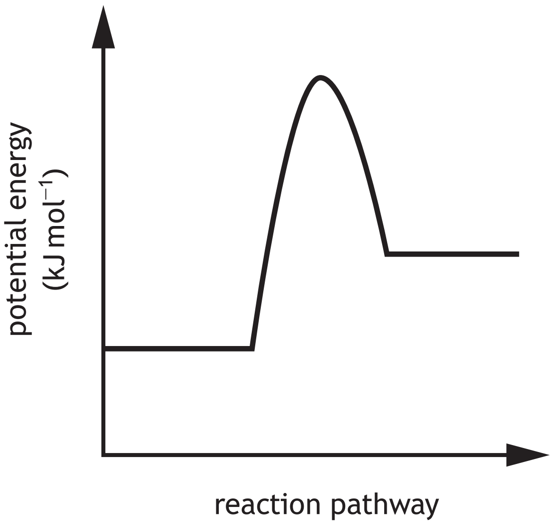
(b) Collision theory states that for particles to react they must first collide with each other.

State **two** conditions necessary for the collisions to result in the formation of products. **2**

1. (continued)

(c) Sodium thiosulfate also reacts with iron(III) nitrate.

The potential energy diagram below shows the change in potential energy during the reaction carried out without a catalyst.



(i) Draw an **X** on the potential energy diagram above to show where the activated complex is formed. **1**

(An additional diagram, if required, can be found on *page 41*).

(ii) Cu^{2+} ions catalyse the reaction.

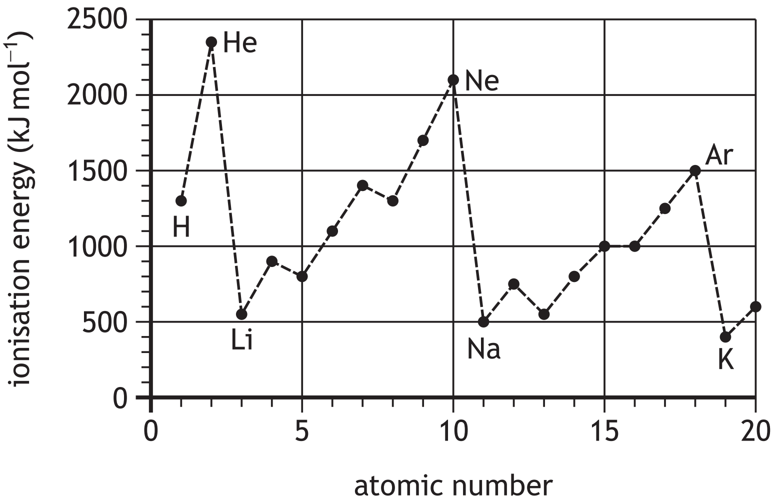
Add a dotted line to the diagram to show the change in potential energy with the catalyst. **1**

(An additional diagram, if required, can be found on *page 41*).

[Turn over

2. 2019 is the 150th anniversary of the periodic table's creation by Dmitri Mendeleev. The patterns identified by Mendeleev form the basis of the modern periodic table. The major periodic trends include ionisation energy and covalent radius.

(a) The first ionisation energies of elements with atomic number 1 to 20 are shown in the graph.

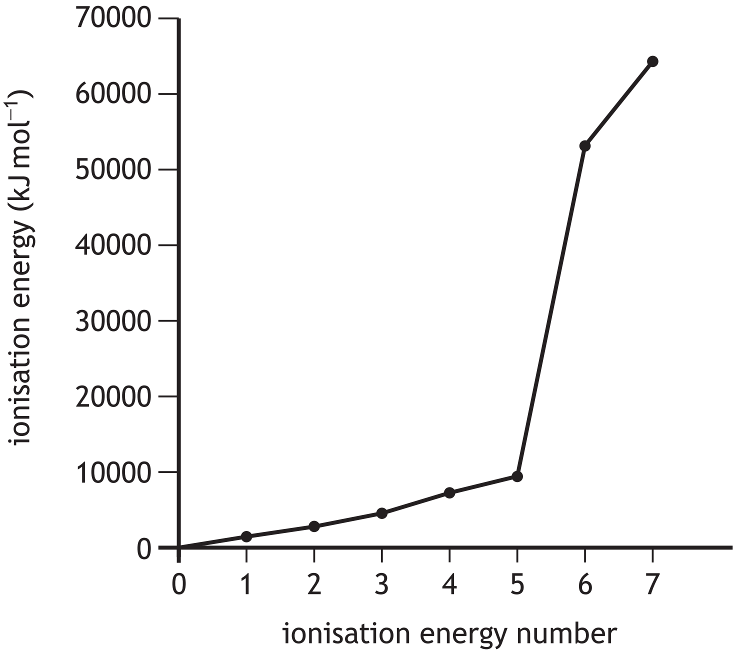


(i) Explain why the first ionisation energy shows an increase going from lithium to neon. **1**

(ii) Explain why the first ionisation energy of potassium is less than the first ionisation energy of lithium. **1**

2. (continued)

(b) A graph showing the ionisation energies for nitrogen is shown.



(i) Write the equation for the second ionisation energy of nitrogen. **1**

(ii) Explain **fully** the increase between the 5th and 6th ionisation energies of nitrogen. **2**

[Turn over

2. (continued)

(c) Ionic radius is a measure of the size of an ion.

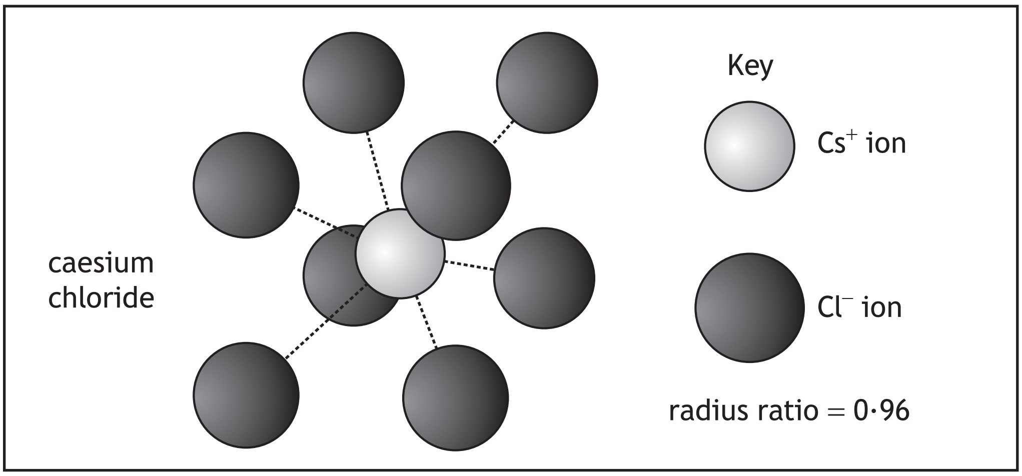
Explain **fully** why the ionic radius of phosphorus is greater than the ionic radius of aluminium. **2**

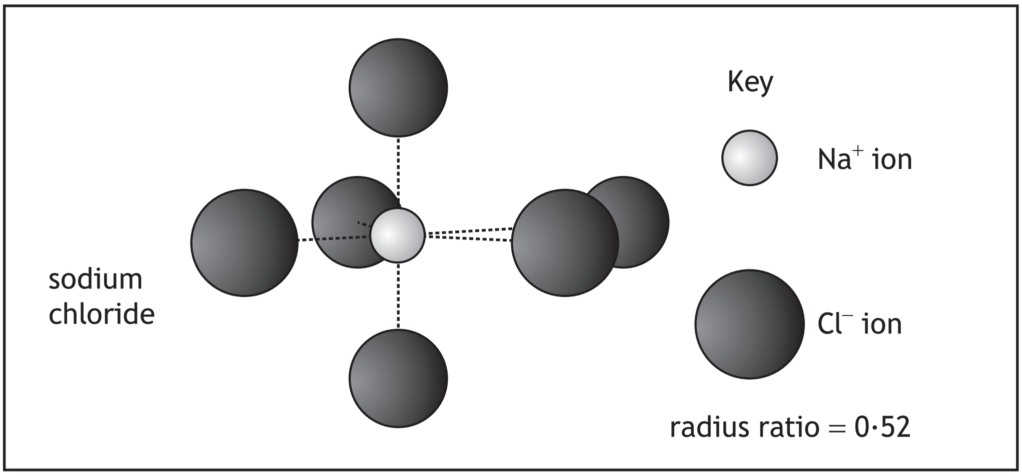
Go to Answers

2. (continued)

(d) The structure of an ionic compound consists of a giant lattice of oppositely charged ions. The arrangement of ions is determined by the 'radius ratio' of the ions involved.

$$\text{radius ratio} = \frac{\text{radius of positive ion}}{\text{radius of negative ion}}$$





By using the table of ionic radii on *page 17* of the data booklet, predict whether the structure of barium oxide, BaO, is similar to caesium chloride or sodium chloride.

Your answer **must** include a calculated radius ratio. **1**

Go to Topic Grid

3. The melting point of **non-metal elements** depends on structure and bonding.

Using your knowledge of chemistry, comment on this statement. 3

Go to Answers

4. Cider is made from apples in a process that involves crushing and pressing the apples, converting the sugars into alcohol, maturing and bottling.

(a) Brewers add yeast, which contains a mixture of enzymes to convert the sugars in the apples into alcohol and carbon dioxide.

(i) State what is meant by the term enzyme. **1**

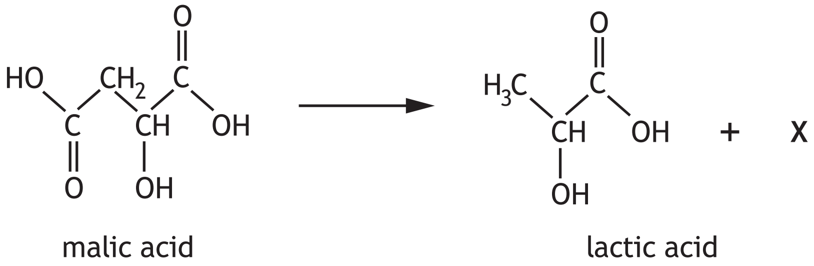
(ii) The % mass of alcohol in the cider can be calculated using the formula

$$\% \text{ mass of alcohol} = \frac{\text{mass of alcohol}}{\text{mass of cider}} \times 100$$

A 50·0 cm^3 sample of cider was found to contain 3·05 g of alcohol. 1·0 cm^3 of the cider weighed 1·36 g.

Calculate the % mass of alcohol in the cider. **1**

(b) During the maturing process malic acid is converted to lactic acid and another product.

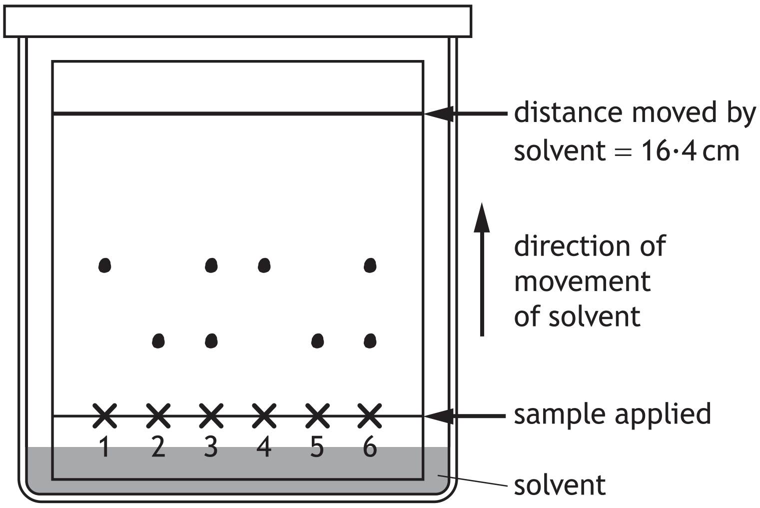


(i) Name compound **X**. **1**

4. (b) (continued)

(ii) The maturing process in cider samples can be monitored using thin layer chromatography.

Samples of lactic acid, malic acid and ciders A, B, C, and D are spotted on a silica plate and the solvent allowed to travel up the plate. The chromatogram obtained is shown below.



Number	Sample applied	Distance moved by spot(s) (cm)
1	lactic acid	8·2
2	malic acid	4·1
3	cider A	4·1, 8·2
4	cider B	8·2
5	cider C	4·1
6	cider D	4·1, 8·2

4. (b) (ii) (continued)

The retention factor, R_f, for a substance can be a useful method of identifying the substance.

$$R_f = \frac{\text{distance moved by the substance}}{\text{distance moved by the solvent}}$$

(A) Calculate the R_f value of malic acid. **1**

(B) The maturing process is complete when all of the malic acid has been converted to lactic acid. The cider is now ready to be bottled.

Use the chromatogram to determine which cider is ready to be bottled. **1**

[Turn over

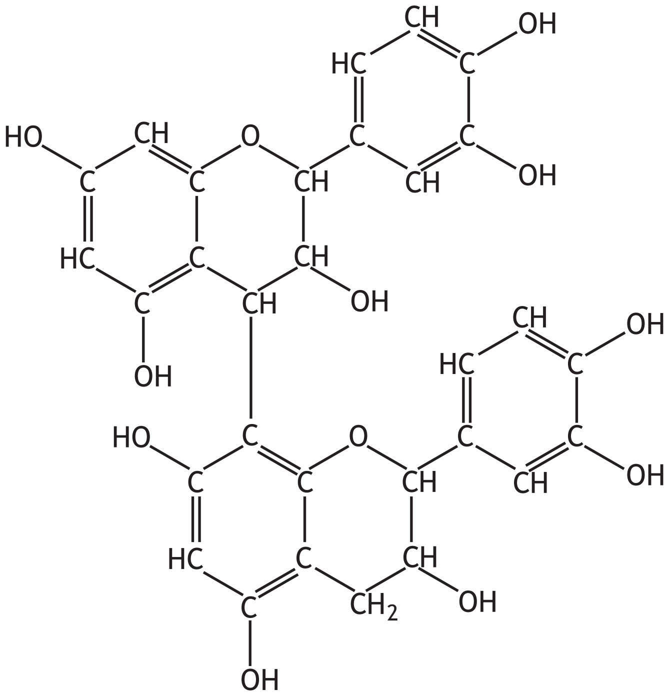
4. (continued)

(c) Glycerol can be added to cider before bottling to produce a sweeter tasting cider.

State the systematic name for glycerol. **1**

(d) Cider contains many naturally occurring compounds that affect taste and aroma.

(i) Procyanidin B2 provides a bitter taste to cider.

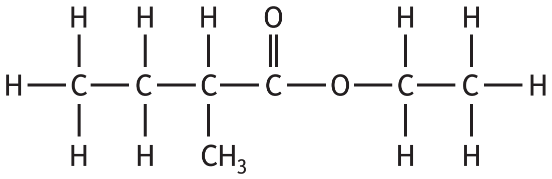


procyanidin B2

Explain **fully** why procyanidin B2 is water soluble. **2**

4. (d) (continued)

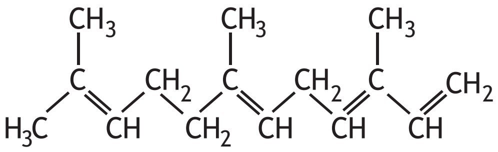
(ii) Cider smells of apples because it contains ethyl 2-methylbutanoate.



ethyl 2-methylbutanoate

Name the carboxylic acid used to make ethyl 2-methylbutanoate. **1**

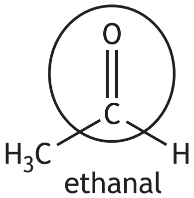
(iii) Farnesene is a terpene responsible for the ripe apple aroma of cider.



farnesene

Name the molecule on which terpenes are based. **1**

(e) Ethanol in cider can be oxidised to ethanal, spoiling the aroma.



ethanal

(i) Name the functional group circled in the ethanal molecule. **1**

(ii) Further oxidation of ethanal can produce another product that spoils the flavour of cider.

Name this product. **1**

Go to Answers

[Turn over

5. The combustion reactions of methane and heptane can be studied in different ways.

(a) The combustion of methane produces carbon dioxide and water vapour when carried out at temperatures above 100 °C.

$$CH_4(g) \quad + \quad 2O_2(g) \quad \rightarrow \quad CO_2(g) \quad + \quad 2H_2O(g)$$

(i) Using bond enthalpies and mean bond enthalpies from the data booklet, calculate the enthalpy change, in kJ mol^{-1}, for this reaction. **2**

(ii) Explain the difference between bond enthalpy and mean bond enthalpy. **1**

5. (a) (continued)

(iii) Calculate the mass, in g, of carbon dioxide produced by combustion of 200 cm^3 methane in excess oxygen. **2**

Take the volume of 1 mole of methane gas to be 24 litres.

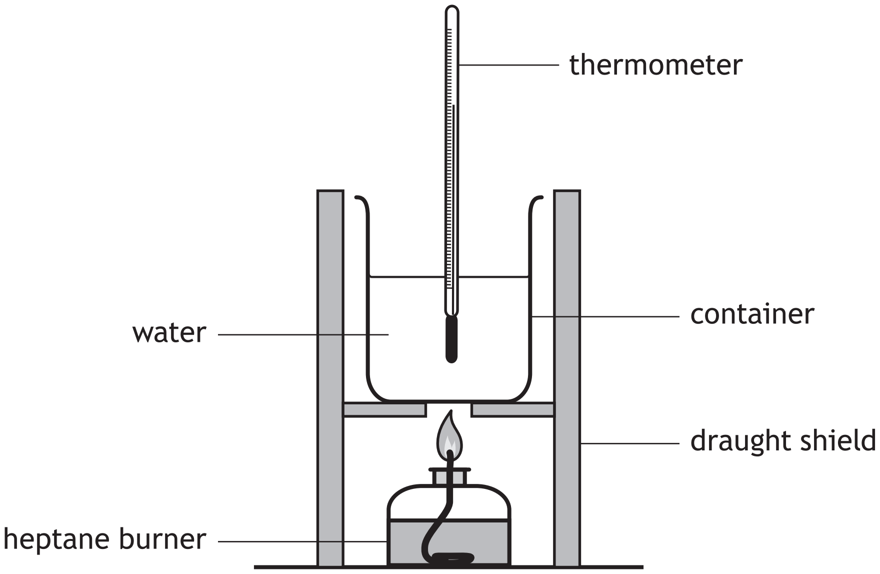
$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

GFM = 44·0 g

[Turn over

5. (continued)

(b) The enthalpy of combustion of heptane, C_7H_{16}, can be determined using a calorimeter.



The following results were obtained.

Mass of heptane burned (g)	1·1
Mass of 1 mole of heptane (g)	100·0
Volume of water used (cm^3)	400
Initial temperature of water (°C)	26
Final temperature of water (°C)	49

(i) State the measurements required to calculate the mass of heptane burned in this experiment. **1**

5. (b) (continued)

(ii) Calculate the enthalpy of combustion, in kJ mol^{-1}, for heptane from the experimental results given. **3**

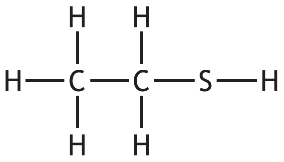
(iii) The theoretical value for the enthalpy of combustion of heptane is significantly higher than the experimental value.

Suggest why the experimental value is different to the theoretical value. **1**

[Turn over

6. Thiols are compounds that contain an –SH functional group. They often have very strong, unpleasant odours.

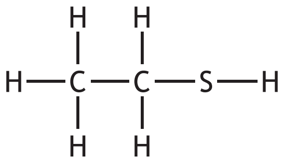
(a) Ethanethiol is used to add a smell to gaseous fuels in order to give warnings of gas leaks.



$$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-S-H$$

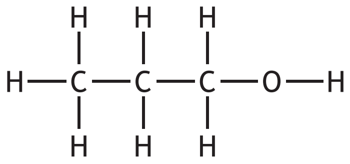
ethanethiol

(i) A student used the boiling points of ethanethiol and propan-1-ol to compare the strength of intermolecular forces.



$$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-S-H$$

ethanethiol
boiling point = 35 °C



$$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-O-H$$

propan-1-ol
boiling point = 97 °C

(A) State the reason why propan-1-ol was a suitable alcohol to compare with ethanethiol. **1**

(B) Explain why propan-1-ol has a higher boiling point than ethanethiol. Your answer should include the names of the intermolecular forces broken when each liquid boils. **2**

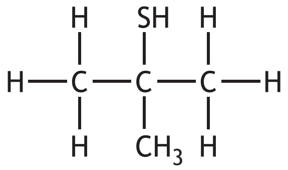
6. (a) (continued)

(ii) Name the thiol that contains only one carbon atom. **1**

(iii) The minimum concentration of ethanethiol in air that can be detected by humans is $2{\cdot}7 \times 10^{-7}$ mg per cm^3 of air.

Calculate the minimum mass of ethanethiol that needs to be present in a room containing 43 900 litres of air in order for it to be detected. **2**

(b) 2-methyl-2-propanethiol is also used to add a smell to gaseous fuels.



2-methyl-2-propanethiol

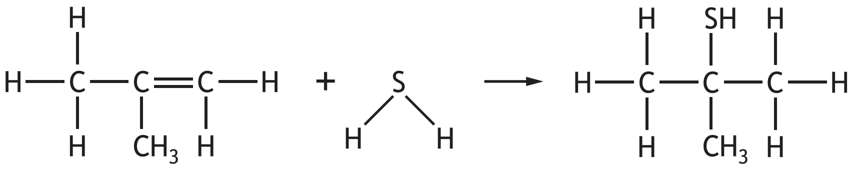
(i) Suggest why 2-methyl-2-propanethiol is classified as a tertiary thiol. **1**

[Turn over

6. (b) (continued)

(ii) Thiols can be made by the addition of hydrogen sulfide to alkenes.

2-methyl-2-propanethiol can be made by the addition reaction shown.



2-methylpropene
GFM = 56·0 g

2-methyl-2-propanethiol
GFM = 90·1 g

(A) Draw the structure for the other isomer formed in this addition reaction. **1**

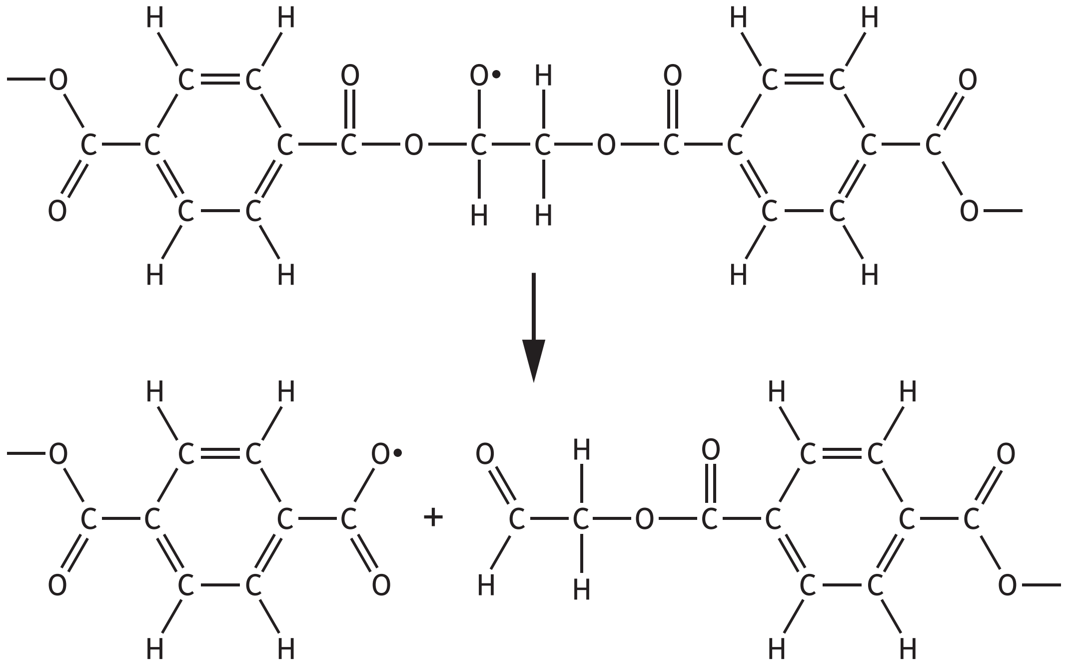
(B) A chemist obtained an 84% yield of 2-methyl-2-propanethiol after starting with 30·5 g of 2-methylpropene.

Calculate the mass, in g, of 2-methyl-2-propanethiol made by the chemist. **2**

7. Esters can be synthetic or natural.

(a) The synthetic polyester PET, poly(ethylene terephthalate), has many ester links. PET can break down by a free radical reaction.

One of the steps involved in breaking down PET is shown.



(i) State the name for this step. **1**

(ii) Name the component of sunlight that can cause plastics such as PET to break down. **1**

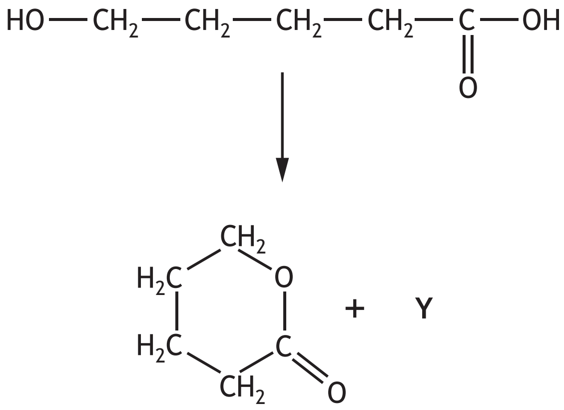
(iii) Name the type of substance that can be added to plastics to prevent them breaking down in this way. **1**

[Turn over

7. (continued)

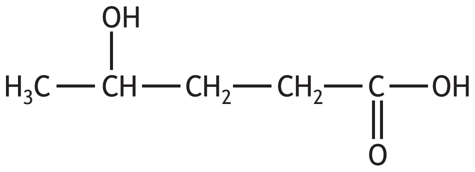
(b) (i) Natural cyclic esters called lactones can be formed from hydroxycarboxylic acids.

5-hydroxypentanoic acid is a hydroxycarboxylic acid that when heated, with dilute acid, will form a cyclic ester.



Name product **Y** in this reaction. **1**

(ii) Draw the structure for the cyclic compound formed when 4-hydroxypentanoic acid is heated with dilute acid. **1**

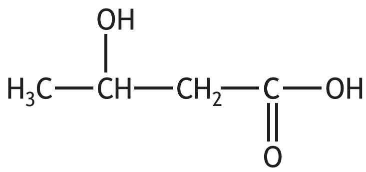


$H_3C-CH(OH)-CH_2-CH_2-C(=O)-OH$

4-hydroxypentanoic acid

7. (b) (continued)

(iii) Name the hydroxycarboxylic acid shown below. **1**

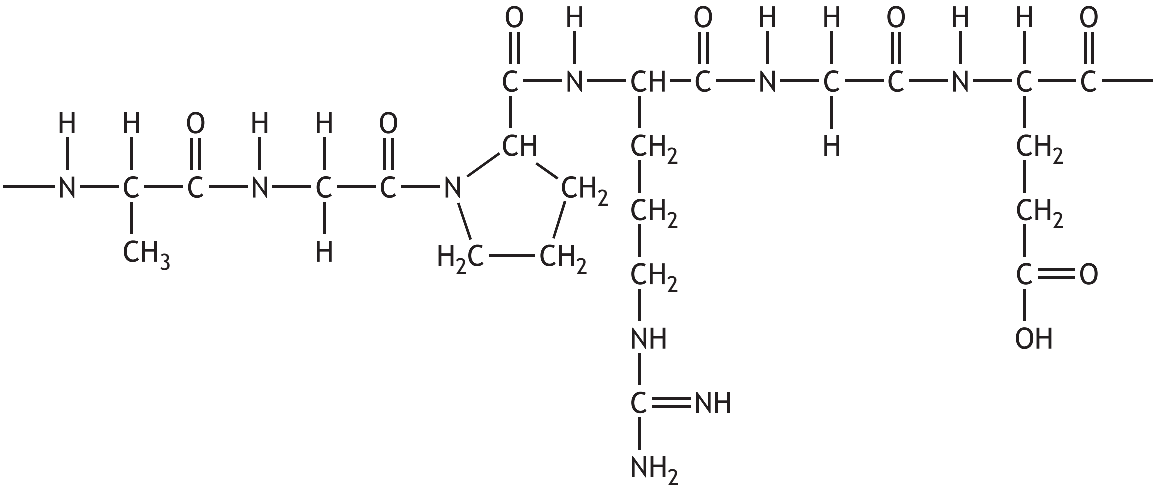


$$\mathrm{H_3C-\overset{OH}{\overset{|}{C}H}-CH_2-\underset{\underset{O}{\|}}{C}-OH}$$

[Turn over

8. Gelatin is a soluble protein that can be added to different food products.

(a) A structure for a section of a protein chain in gelatin is shown.



(i) State the number of amino acids that joined together to form the section of the protein chain shown. **1**

(ii) Name the weakest van der Waals' force between water and gelatin molecules. **1**

(b) A student was investigating the viscosity of different concentrations of gelatin solution.

(i) The student was asked to prepare a 2% gelatin solution, which is a solution that contains 2 g of gelatin per 100 cm^3 of solution.

The student prepared this solution by adding 100 cm^3 of distilled water into a volumetric flask, then adding 2 g of gelatin.

Describe how the student **should** have made up the solution. **3**

8. (b) (continued)

(ii) The results obtained from the student's viscosity experiment are shown.

Concentration of gelatin solution (%)	**Viscosity (units)**
2·0	1·0
4·0	2·0
6·0	4·0
8·0	7·0
10·0	

Predict the student's result for the viscosity, in units, of a 10·0% gelatin solution. 1

(c) Bromelain is a mixture of enzymes found in pineapple that aid digestion.

(i) Adding raw pineapple to gelatin results in the gelatin molecules being hydrolysed. The rate of hydrolysis is reduced if the pineapple is cooked.

Explain why the rate of hydrolysis is reduced. 1

(ii) Bromelain can be purchased as tablets that contain 500 mg of bromelain. The flesh from a pineapple contains 13·2 mg of bromelain per gram.

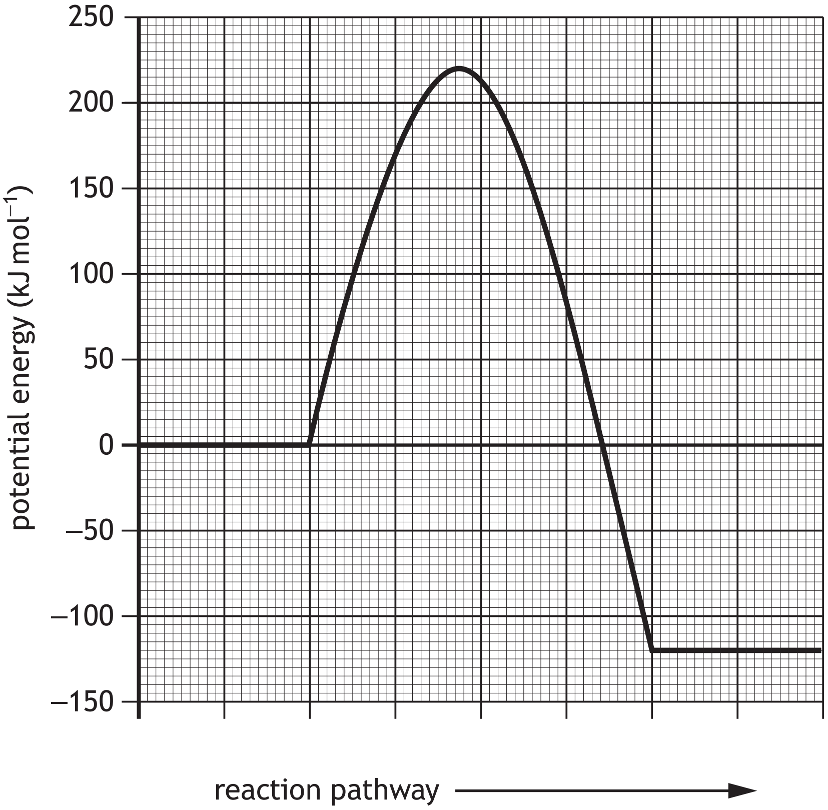
Calculate the mass, in g, of this pineapple that would be needed to provide 500 mg of bromelain. 1

[Turn over

9. Chlorine is used in the production of many other chemicals.

(a) Chlorine can be produced by the reaction of hydrogen chloride with air using the Deacon process.

$$4HCl(g) + O_2(g) \rightleftharpoons 2Cl_2(g) + 2H_2O(g)$$

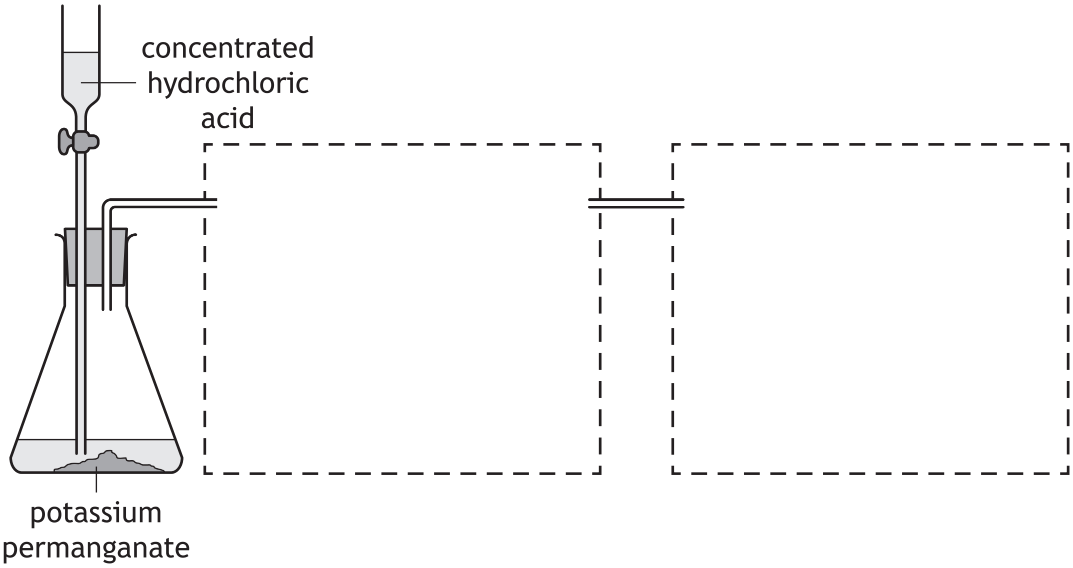


(i) Using the potential energy diagram, determine the activation energy, in kJ mol^{-1}, for the **forward** reaction. **1**

(ii) Explain why increasing the temperature in the Deacon process results in less chlorine being produced. **1**

9. (continued)

(b) One laboratory method for the preparation of chlorine gas involves adding concentrated hydrochloric acid to potassium permanganate. The chlorine gas produced also contains small amounts of hydrogen chloride gas. To remove the hydrogen chloride gas the gases are bubbled through water. Finally, insoluble chlorine gas is collected.



Complete a labelled diagram to show an apparatus suitable for carrying out this preparation. **2**

(An additional diagram, if required, can be found on *page 41*)

[Turn over

9. (continued)

(c) Carbon tetrachloride, CCl_4, is prepared by the reaction of chlorine gas, Cl_2, with methane, CH_4.

$$CH_4(g) + 4Cl_2(g) \rightarrow CCl_4(g) + 4HCl(g)$$

Calculate the enthalpy change, in $kJ\,mol^{-1}$, for this reaction using the following information. **2**

$C(s) + 2H_2(g) \rightarrow CH_4(g) \quad \Delta H = -75\ kJ\,mol^{-1}$

$C(s) + 2Cl_2(g) \rightarrow CCl_4(g) \quad \Delta H = -98\ kJ\,mol^{-1}$

$\frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g) \rightarrow HCl(g) \quad \Delta H = -92\ kJ\,mol^{-1}$

10. A student investigated the purity of a sample of magnesium chloride, $MgCl_2$. The sample was dissolved in water and then an excess of silver nitrate, $AgNO_3$, was added to produce a precipitate of silver chloride, AgCl. The precipitate was collected, dried and weighed.

$$MgCl_2(aq) + 2AgNO_3(aq) \rightarrow 2AgCl(s) + Mg(NO_3)_2(aq)$$

(a) The student prepared the magnesium chloride solution by dissolving 2·503 g of impure magnesium chloride in water.

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

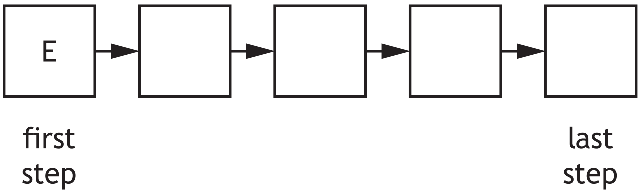
(b) (i) Complete the table to show the **most appropriate** piece of apparatus that could be used to measure the required volumes. **2**

Measurement	Apparatus
20·0 cm^3 **(accurately)**	
35 cm^3 **(approximately)**	

(ii) The steps required to collect, dry and weigh the precipitate are listed below. However, the steps are in the **wrong order**.

A. Weigh the precipitate and the filter paper
B. Wash the precipitate with water to remove any impurities
C. Filter the precipitate
D. Dry the precipitate in an oven
E. Weigh the filter paper

Complete the flow chart below to show the correct order of steps the student should carry out to collect, dry and weigh the precipitate. **1**



(An additional diagram, if required, can be found on *page 41*)

10. (b) (continued)

(iii) 1·393 g of silver chloride precipitate was produced from the magnesium chloride solution.

$$MgCl_2(aq) + 2AgNO_3(aq) \rightarrow 2AgCl(s) + Mg(NO_3)_2(aq)$$

GFM = 95·3 g GFM = 143·4 g

Calculate the mass of magnesium chloride, in g, present in the magnesium chloride solution. **2**

(c) The average mass of magnesium chloride in 2·503 g of the original impure sample was calculated to be 2·403 g.

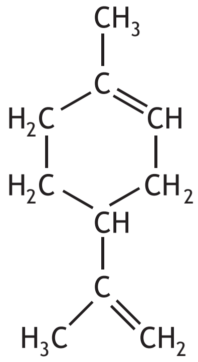
Calculate the % of magnesium chloride present in the original sample. **1**

[Turn over

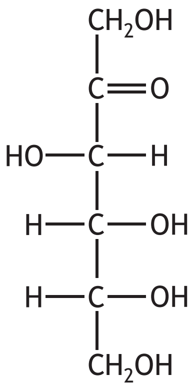
11. Differences in physical and chemical properties can be used to distinguish one compound from another.

The compounds extracted from orange juice include antioxidants, flavour molecules, essential oils, aroma molecules and coloured molecules.

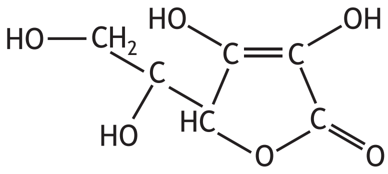
Some examples of these are shown below.



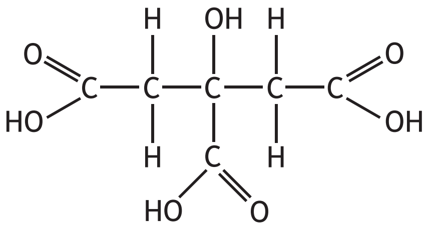
limonene



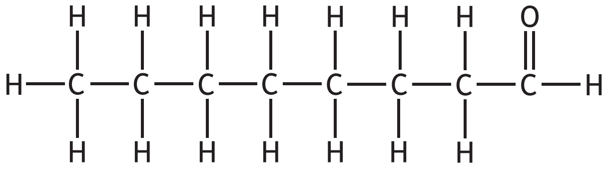
fructose



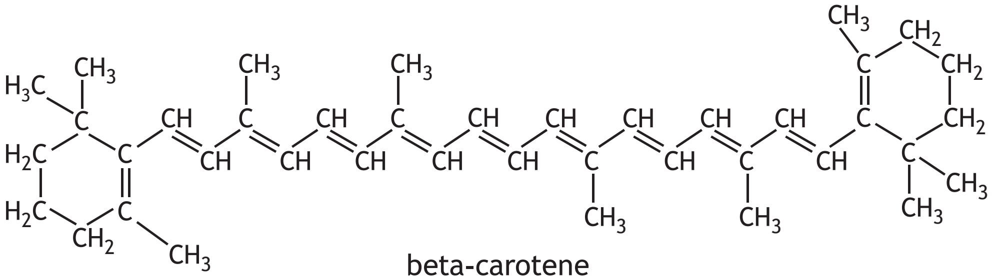
vitamin C



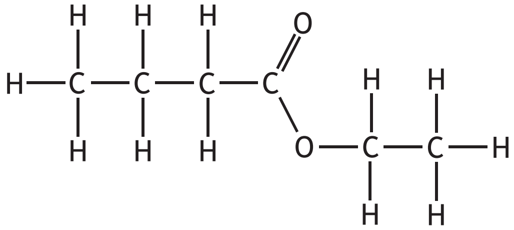
citric acid



octanal



beta-carotene



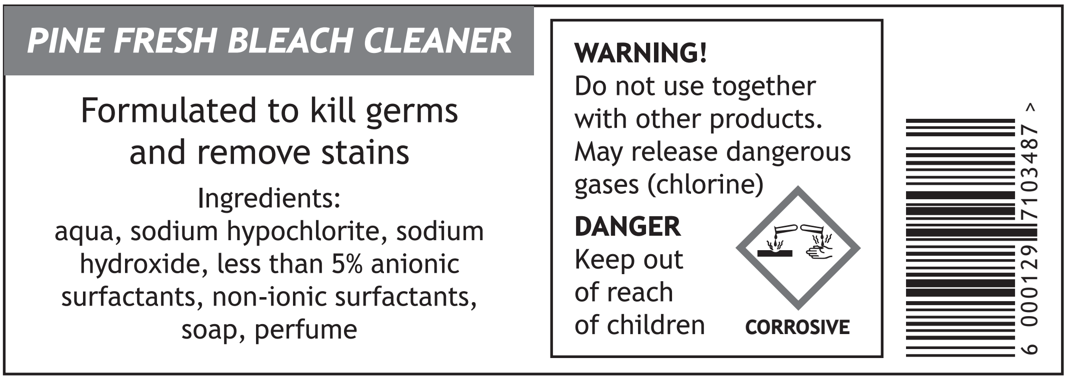
ethyl butanoate

11. (continued)

Using your knowledge of chemistry, comment on how the differences in physical and chemical properties can be used to distinguish between the compounds extracted from orange juice. **3**

[Turn over

12. The label from a bottle of pine fresh bleach cleaner is shown.



PINE FRESH BLEACH CLEANER

Formulated to kill germs and remove stains

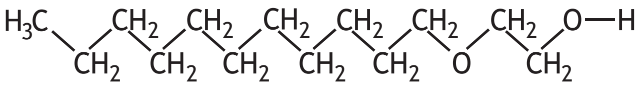
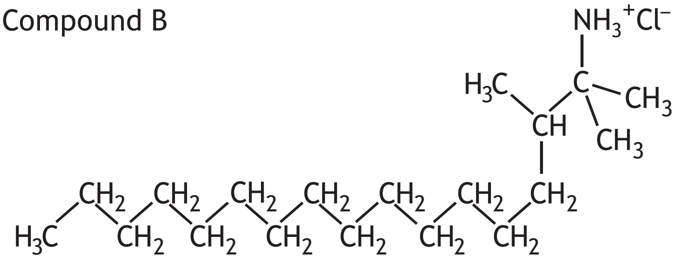
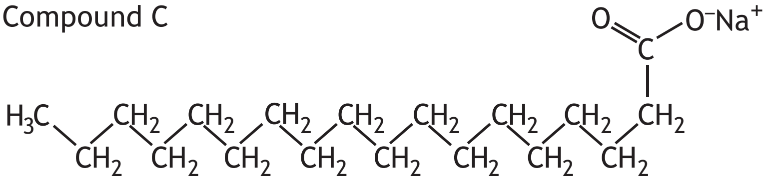
Ingredients:
aqua, sodium hypochlorite, sodium hydroxide, less than 5% anionic surfactants, non-ionic surfactants, soap, perfume

WARNING!
Do not use together with other products. May release dangerous gases (chlorine)

DANGER
Keep out of reach of children

(a) Surfactant molecules are added to bleach cleaner to act as detergents, soaps or emulsifiers.

Information on three of the surfactants in the bleach cleaner is shown in the table.

Surfactant structure	Type of surfactant	Head group
Compound A 	non-ionic	polar
Compound B 		
Compound C 	ionic	negatively charged

12. (a) (continued)

(i) Complete the table for compound B. **1**

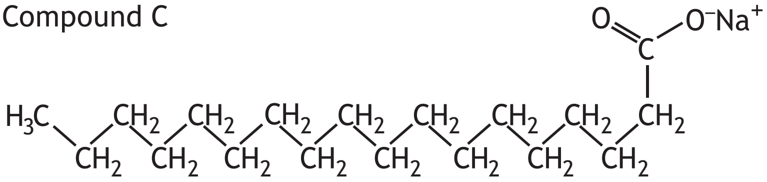
(ii) Compound C is a soap molecule.

(A) Soaps can be made from fats and oils.

Name the reaction used to make soaps from fats and oils. **1**

(B) Soap molecules allow oil to mix with water.

Compound C



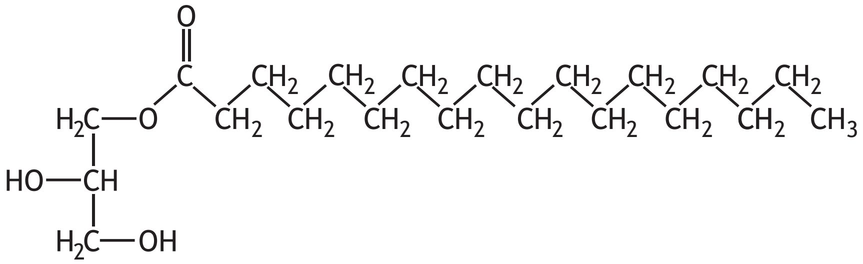
Explain fully the cleaning action of compound C. **3**

You may wish to use diagrams to illustrate your answers.

[Turn over

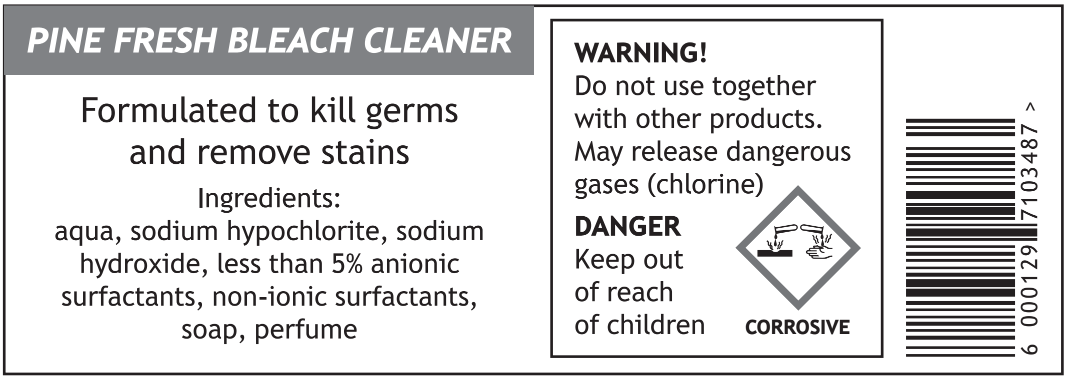
12. (a) (continued)

(iii) The structure of an emulsifier molecule is shown below.



State how emulsifiers are made from edible oils. **1**

(b) Sodium hypochlorite, Na^+OCl^-, is the main active compound in bleach.



PINE FRESH BLEACH CLEANER

Formulated to kill germs and remove stains

Ingredients:
aqua, sodium hypochlorite, sodium hydroxide, less than 5% anionic surfactants, non-ionic surfactants, soap, perfume

WARNING!
Do not use together with other products.
May release dangerous gases (chlorine)

DANGER
Keep out of reach of children

CORROSIVE

Sodium hypochlorite, Na^+OCl^-, is produced by reacting chlorine with sodium hydroxide solution.

$$Cl_2(g) + 2Na^+OH^-(aq) \rightarrow Na^+OCl^-(aq) + Na^+Cl^-(aq) + H_2O(\ell)$$

(i) A chlorine molecule has a pure covalent bond.

Explain what is meant by a pure covalent bond. **1**

12. (b) (continued)

(ii) When the chlorine is reacted with sodium hydroxide solution an excess of sodium hydroxide is used.

Suggest why an excess of sodium hydroxide is used. **1**

(c) In the bleach cleaner an equilibrium exists.

$$2H^+(aq) + OCl^-(aq) + Cl^-(aq) \rightleftharpoons Cl_2(g) + H_2O(\ell)$$

The label warns that the bleach cleaner should not be used with other products as it may release chlorine gas.

Explain clearly why mixing the bleach with an acid would shift the equilibrium to the right, resulting in the release of chlorine gas from the bleach cleaner. **2**

[Turn over for next question

12. (continued)

(d) The concentration of hypochlorite, OCl^-, in bleach can be determined by a redox reaction that involves two steps.

Step 1

An excess of acidified potassium iodide is added to the bleach. This converts the iodide ions into iodine.

$$OCl^-(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + Cl^-(aq) + H_2O(\ell)$$

Step 2

The iodine produced in step 1 is titrated with sodium thiosulfate, $Na_2S_2O_3$.

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

(i) Write the ion-electron equation for the reduction reaction taking place in **Step 1**. **1**

(ii) A 25 cm^3 sample of a diluted bleach was transferred into a conical flask and excess acidified potassium iodide added. The iodine produced was titrated with 0·098 mol l^{-1} $Na_2S_2O_3$, requiring an average volume of 9·0 cm^3 to reach the end point.

Calculate the concentration, in mol l^{-1}, of sodium hypochlorite in the diluted bleach. **3**

[END OF QUESTION PAPER]

National
Qualifications
2019

2019 Chemistry

Higher - Paper 1 – Multiple choice

Finalised Marking Instructions

Marking instructions for each question

Question	Response	Mark
1.	C	1
2.	B	1
3.	A	1
4.	C	1
5.	B	1
6.	A	1
7.	D	1
8.	B	1
9.	D	1
10.	D	1
11.	C	1
12.	B	1
13.	D	1
14.	A	1
15.	C	1
16.	D	1
17.	B	1
18.	B	1
19.	B	1
20.	C	1
21.	A	1
22.	D	1
23.	C	1
24.	A	1
25.	D	1

[END OF MARKING INSTRUCTIONS]

Marking instructions for each question

<table>
<tr><th colspan="3">Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>1.</td><td>(a)</td><td>(i)</td><td>$Na_2S_2O_3 + \mathbf{2}HCl \rightarrow S + SO_2 + \mathbf{2}NaCl + H_2O$</td><td>1</td><td>Correct multiples accepted.
Ignore state symbols if equation re-written.</td></tr>
<tr><td></td><td></td><td>(ii)
A</td><td><table><tr><th>Experiment</th><th>Volume of water (cm^3)</th></tr><tr><td>A</td><td>0</td></tr><tr><td>B</td><td>10</td></tr><tr><td>C</td><td>20</td></tr><tr><td>D</td><td>30</td></tr><tr><td>E</td><td>40</td></tr></table>
All entries correct 1 Mark.</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>B</td><td>35/35·1/35·09 (seconds or s)</td><td>1</td><td>No units required. No mark can be awarded for correct answer if wrong unit is given (where no unit required, wrong units would only be penalised once in any paper).

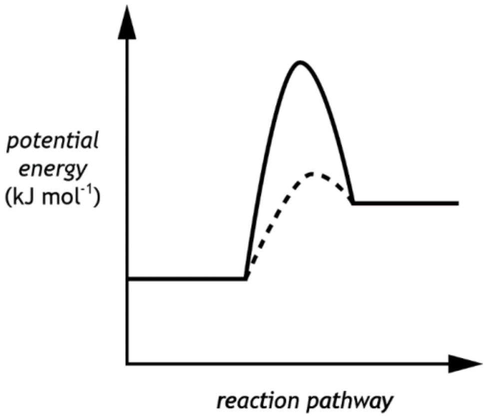
sec or secs not accepted.</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>12 +/- 1 (°C)</td><td>1</td><td>Award 0 marks if 10°C given.

No units required. No mark can be awarded for correct answer if wrong unit is given (where no unit required, wrong units would only be penalised once in any paper).

Degrees or ° not accepted</td></tr>
<tr><td></td><td>(b)</td><td></td><td>(Particles must have) sufficient or enough energy (to react).
OR
(Particles must have) energy equal to or greater than the activation energy or E_A.
OR
(Particles must have) minimum/ enough energy to form an activated complex. (1)

(Collision must occur with) suitable/correct/geometry/ orientation (1)</td><td>2</td><td>Do not accept ‘with correct speed’, ‘with high energy’ or “sufficient activation energy”.

“They”/”reactants” accepted for particles.</td></tr>
</table>

Question			Expected response	Max mark	Additional guidance
1.	(c)	(i)	X shown at peak of curve	**1**	Must be centred and within the y-axis. Clear indication of the correct position of the activated complex is accepted.
		(ii)		**1**	The peak drawn shows a lower activation energy. Line drawn does not need to be a dotted/dashed line. The line drawn by the candidate must start and finish at the same potential energies as on the original diagram.

Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	Increasing/greater/stronger/larger nuclear charge (holds electrons more tightly) **OR** Increasing number of protons	**1**	Increased nuclear pull is not accepted on its own. Mention must be made of nuclear charge **or** number of protons. Increased attraction of the electron **for** the nucleus would be considered cancelling.
		(ii)	(More shells) so increased/more screening/shielding. **OR** Covalent radius increases/atom size increases/more shells so attraction of the nucleus/protons for the **outer electron** decreases.	**1**	'Shielding effect' by itself is not acceptable. If candidate says 'it' assume the candidate is talking about potassium.
	(b)	(i)	$N^+(g) \rightarrow N^{2+}(g) + e^-$	**1**	State symbols must be shown. Negative charge on the electron is not required.
		(ii)	The 6th ionisation energy involves removing an electron from the shell which is inner/full (whole)/(more) stable/closer to the nucleus **OR** the 6th electron is removed from the electron shell which is inner/full (whole)/(more) stable/closer to the nucleus. **(1)** The 6th electron is less shielded **OR** the 6th electron is more strongly attracted to/pulled towards the nucleus. **(1)**	**2**	Correct statements made about the 5th ionisation energy/electron can also be credited. Stating that the 6th electron requires more energy than the 5th electron is not sufficient on its own.
	(c)		Al forms Al^{3+}/loses electrons to form an ion **and** P forms P^{3-}/gains electrons to form an ion. **(1)** Aluminium ion has one less energy level than phosphide/phosphorus ion. **OR** Phosphide/phosphorus ion has one more energy level than aluminium ion. **(1)**	**2**	A diagram or electron arrangement of **both** ions would be sufficient to gain this first mark.

Question			Expected response	Max mark	Additional guidance
2.	(d)		(Radius ratio =) 0·96, (hence) caesium chloride (or correct formula).	**1**	Calculated value (of 0·96) or 135/140 must be written for radius ratio required for mark.

Question			Expected response	Max mark	Additional guidance
3.			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			Expected response	Max mark	Additional guidance
4.	(a)	(i)	biological catalyst	**1**	Biochemical catalyst/protein that acts as a catalyst accepted
		(ii)	4·5/4·49/4·485 (%)	**1**	No units required. No mark can be awarded for correct answer if wrong unit is given (where no unit required, wrong units would only be penalised once in any paper).
	(b)	(i)	Carbon dioxide/CO_2	**1**	
		(ii) A	0·25/0·3	**1**	Ignore any units.
		B	(Cider) B or (sample) 4	**1**	
	(c)		propan-1,2,3-triol **OR** propane-1,2,3-triol **OR** 1,2,3-propanetriol	**1**	
	(d)	(i)	(procyanidin B2) molecule is polar due to its **hydroxyl** groups **OR** (procyanidin B2) can form hydrogen bonds due to its **hydroxyl** groups **(1)** an explanation which links solubility of the molecule (procyanidin B2) to the polarity of water/hydrogen bonding of water **(1)**	**2**	(-)**OH** accepted as hydroxyl "Like dissolves like" on its own is not sufficient for 1 mark.
		(ii)	2-methylbutanoic acid	**1**	
		(iii)	Isoprene(s) **OR** 2-methylbuta-1,3-diene	**1**	Structure not accepted. Ignore any structure(s) drawn.
	(e)	(i)	carbonyl	**1**	
		(ii)	ethanoic acid/CH_3COOH	**1**	

Question			Expected response	Max mark	Additional guidance
5.	(a)	(i)	-694 (kJ mol^{-1}) Bond breaking (4 x 412) + (2 x 498) = 2644 Bond forming [(2 x 743) + (4 x 463)] = -3338 A single mark is available if either of the following operations is correctly executed **Either** The four relevant values for bond enthalpies of the C-H, O=O, C=O, and O-H (or multiples thereof) are retrieved from the data booklet (412, 498, 743, 463 – ignore signs). **OR** If only three correct values are retrieved, the candidate recognises that bond breaking is endothermic and bond forming is exothermic and have correctly manipulated the bond enthalpies and multiples that they have used with working shown.	**2**	+694 would qualify for 1 mark No units required. Only 1 mark can be awarded for the correct answer if wrong unit is given. (wrong units would only be penalised once in any paper) kJ is acceptable in place of kJ mol^{-1} (KJ or Kj or KJ mol^{-1} or Kj mol^{-1} accepted). If less than three bond enthalpies are retrieved then no mark can be awarded.
		(ii)	Mean bond enthalpy must refer to an average energy and to a number of compounds and bond enthalpy must relate to one compound/diatomic molecule.	**1**	

Question			Expected response	Max mark	Additional guidance
5.	(a)	(iii)	0·367/0·37/0·4 (g) **(2)** Partial marking n = V/V_m = 0·2/24 = 0·008333….**(1)** an incorrectly calculated number of moles **based on gas volume** x 44 **(1)** or by proportion 24 l → 44 g **(1)** Follow through from incorrect multiples of 24 l **or** 44 g **(1)**	**2**	No units required. No mark can be awarded for correct answer if wrong unit is given (where no unit required, wrong units would only be penalised once in any paper). Working must be shown for incorrectly calculated number of moles based on gas volume.
	(b)	(i)	(Record the) mass/weight of the burner before and after (heating the water)	**1**	
		(ii)	-3496 (kJ mol^{-1}) (3 marks) **If final answer is wrong a maximum of 2 marks for the following concepts may be awarded** **1 mark** for a demonstration of the correct use of the relationship E_h = cmΔT as shown by (4·18 x (an order of magnitude of 4) x 23) (ignore units for this mark). **1 mark** for evidence of the knowledge that enthalpy of combustion relates to 1 mole, evidenced by the scaling up of a calculated value of energy released.	**3**	An answer of +3496 would gain 2 marks. No units required. A maximum of 2 marks can be awarded for **correct answer** if wrong unit is given (where no unit required, wrong units would only be penalised once in any paper). kJ is acceptable in place of kJ mol^{-1} (KJ or Kj or KJ mol^{-1} or Kj mol^{-1} accepted).
		(iii)	**1 mark** for any of the following • Loss of heat/energy to the surroundings • Incomplete combustion (of heptane/alkane) • Loss (of heptane/alkane) by evaporation • No lid on container • No stirring • Absorption of heat glass/beaker or copper can	**1**	'Not using a bomb calorimeter' on its own would not be awarded a mark. "Loss of heat" on its own is not sufficient but would not be cancelling.

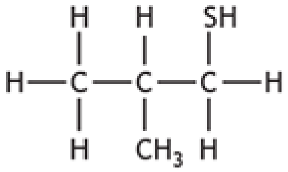
Question			Expected response	Max mark	Additional guidance
6.	(a)	(i) A	Same number of electrons (34) **(1)** **OR** same strength of London dispersion forces/LDFs **(1)**	**1**	
		(i) B	Propan-1-ol has stronger intermolecular/Van der Waal's forces than ethanethiol or vice versa. **OR** The intermolecular forces in propan-1-ol take more energy to break than those in ethanethiol or vice versa. **(1)** **1 mark** for identifying that the intermolecular forces in propan-1-ol are hydrogen bonds AND those in ethanethiol are permanent dipole - permanent dipole interactions/ attractions. **(1)**	**2**	If candidate says 'it/its' assume the candidate is talking about propan-1-ol. Any mention of breaking covalent/ ionic/metallic bonds is cancelling. Accept London Dispersion Forces/ LDFs in place of permanent dipole-permanent dipole interactions.
		(ii)	methanethiol	**1**	Accept methanthiol

<table>
<tr><th colspan="3">Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td></td><td></td><td>(iii)</td><td>11·853/11·85/11·9/12 mg - units required (2)

Correctly calculated mass of ethanethiol without units (1)

Appropriate units (1)
<table>
<tr><th>Mass (1)</th><th>Units (1)</th></tr>
<tr><td>12</td><td>mg</td></tr>
<tr><td>0·012</td><td>g</td></tr>
<tr><td>1·2 x 10⁻⁵</td><td>kg</td></tr>
</table></td><td>2</td><td>If an incorrect mass is calculated but the units used are appropriate to the calculation then 1 mark would be awarded.

If the candidate’s working is unclear then the mark for units cannot be awarded.</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>SH group is on a carbon connected to 3 other carbons/SH group is opposite the branch in a chain.

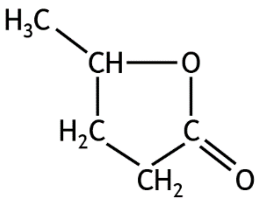
The SH group is attached to a carbon which has no hydrogens attached.</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(ii)
A</td><td></td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>(ii)
B</td><td>41·2 (g) (2)

OR

correct calculation of

Theoretical mass = 49·07 (g) (1)

Allow follow on from incorrect calculation of theoretical mass for 1 mark</td><td>2</td><td>Award 0 marks if candidate gives 25·6 grams (84% of reactant mass)</td></tr>
</table>

Question			Expected response	Max mark	Additional guidance
7.	(a)	(i)	propagation	**1**	
		(ii)	UV/ultraviolet	**1**	
		(iii)	Anti-oxidant/free radical scavenger/reducing agent/electron donor	**1**	
	(b)	(i)	Water/H_2O	**1**	
		(ii)		**1**	
		(iii)	3-hydroxybutanoic acid	**1**	

Question			Expected response	Max mark	Additional guidance
8.	(a)	(i)	6	***1***	
		(ii)	London dispersion forces	**1**	Accept LDF
	(b)	(i)	dissolve the gelatin (in a small volume of water) **(1)** transfer quantitatively/with rinsings/washings **(1)** fill to the mark/line (of the volumetric flask) **(1)**	**3**	
		(ii)	11·0/11	**1**	
	(c)	(i)	Bromelain/enzyme changes shape or denatured. Bromelain/enzyme hydrogen bonds broken.	**1**	
		(ii)	38/37·9/37·88 (g)	**1**	No units required. No mark can be awarded for correct answer if wrong unit is given (where no unit required, wrong units would only be penalised once in any paper).

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	(+) 220 (+/- 2) (kJ mol^{-1})	**1**	No units required. No mark can be awarded for correct answer if wrong unit is given (where no unit required, wrong units would only be penalised once in any paper). kJ is acceptable in place of kJ mol^{-1} (KJ or Kj or KJ mol^{-1} or Kj mol^{-1} accepted).
		(ii)	(Increasing temperature) favours the endothermic/reverse reaction **OR** The (forward) reaction is exothermic. **OR** The reverse reaction is endothermic.	**1**	
	(b)		Diagram shows a workable method for removal of HCl(g) allowing transfer of chlorine gas. Water/H_2O must be labelled. **(1)** Diagram shows a workable method of collecting a gas (eg a gas syringe). **(1)**	**2**	Treat each mark separately. Mark not awarded if delivery tube passes through the wall of measuring cylinder/test tube A closed system would not be a suitable method for collecting a gas.

Question			Expected response	Max mark	Additional guidance
	(c)		-391 (kJ mol^{-1}) **(2 marks)** Partial marks Treat as two concepts. Either would be acceptable for **1 mark**. Evidence of understanding of reversal of first enthalpy value. ie +75 must be seen. The other two enthalpy values (regardless of value) **must** be negative, or this partial mark cannot be awarded. **OR** Evidence of understanding of multiplying the third enthalpy value by 4(± 92). **OR** ± 368 Multiplication of any other enthalpy value by any factor is taken as cancelling of this partial mark.	**2**	**Only one concept mark can be awarded if the final answer is incorrect.** If answer given is +391, maximum of 1 mark can be awarded. No units required. Only 1 mark can be awarded for the correct answer if wrong unit is given. (wrong units would only be penalised once in any paper) kJ is acceptable in place of kJ mol^{-1} (KJ or Kj or KJ mol^{-1} or Kj mol^{-1} accepted).

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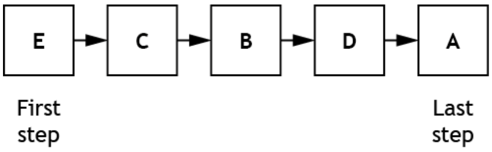
<table>
<tr><th colspan="3">Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>**10.**</td><td>(a)</td><td></td><td>Chloride ions/magnesium ions/metal ions/salts may be present in tap water or not present/less in deionised/distilled water.</td><td>**1**</td><td>“ions” on its own is not sufficient
Accept chlorine but not chlorine ion(s).
If ions are shown, charges must be correct.</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td><table><tr><th>*Measurement*</th><th>*Apparatus*</th></tr><tr><td>20·0 cm^3 (accurately)</td><td>**Pipette**</td></tr><tr><td>35 cm^3 (approximately)</td><td>**Measuring cylinder**</td></tr></table>
1 mark for each correct entry</td><td>**2**</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>
All correct for **1 mark**</td><td>**1**</td><td></td></tr>
<tr><td></td><td></td><td>(iii)</td><td>0·463/0·46/0·5 (g)
Partial marking (**1 mark**)
1 mark for knowledge of relationship between moles of silver chloride and magnesium chloride. This could be shown by a calculated number of moles of silver chloride correctly divided by 2
OR
Incorrect mole ratio used but the relationship between moles and mass used correctly twice
OR
by proportion
95·3 ↔ 286·8 (2 x 143·4)
OR
Mole ratio not applied correctly but proportion used correctly</td><td>**2**</td><td>No units required. Only 1 mark can be awarded for correct answer if wrong unit is given (where no unit required, wrong units would only be penalised once in any paper).</td></tr>
<tr><td></td><td></td><td>(c)</td><td>96/96·0 (%)</td><td>**1**</td><td></td></tr>
</table>

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Question			Expected response	Max mark	Additional guidance
11.			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			Expected response	Max mark	Additional guidance
12	(a)	(i)	Ionic and positively charged Both needed	**1**	Accept positive/+ve/+
		(ii) A	alkaline hydrolysis/saponification	**1**	Do not accept "hydrolysis" on its own. Hydrolysis with named strong alkali would be acceptable.
		(ii) B	(Compound C) has an ionic/hydrophilic part **and** a non polar/hydrophobic part (or alternative wording/diagram showing knowledge of these parts of the molecule) **(1)** Correctly identifies the part of the molecule/head/COO^- dissolves in water/ is hydrophilic and the part of the molecule/tail/hydrocarbon chain dissolves in oil/hydrophobic. **(1)** Agitation separates oil from the surface/cause small oil droplets to form **OR** The (negatively-charged) ball-like structures repel each other (and the oil or grease is kept suspended in the water) **OR** Soaps/compound C allow(s) emulsions to form or break(s) oil into micelles. **(1)** Accept correct diagrams with annotations that show above.	**3**	
		(iii)	Reacting them (edible oils) with glycerol/ propan-1,2,3-triol/propane-1,2,3-triol/ 1,2,3-propanetriol/$C_3H_8O_3$	**1**	

Question			Expected response	Max mark	Additional guidance
12.	(b)	(i)	Both nuclei have the same attraction for the bonding electrons. **OR** Both atoms have same electronegativity/ or electronegativity values given **OR** Bonding electrons shared evenly.	**1**	Diagram on its own not sufficient
		(ii)	**1 mark** for any of the following • To ensure all chlorine is used up/to prevent chlorine being released • NaOH is the cheaper/less expensive reactant • To ensure that the bleach cleaner contains sodium hydroxide • Excess NaOH would neutralise any acid added to cleaner • Excess NaOH helps break up oil/grease	**1**	
	(c)		(Adding acid) adds/increases H^+ (ions) **(1)** Rate of forward reaction is increased/ speeds up (by addition of acid) **(1)**	**2**	
	(d)	(i)	$OCl^-_{(aq)} + 2H^+_{(aq)} + 2e^- \rightarrow Cl^-_{(aq)} + H_2O_{(l)}$	**1**	State symbols not required but **any** given must be correct. Charge on electron not required.

Question			Expected response	Max mark	Additional guidance
12	(d)	(ii)	1·76 x 10^{-2} (mol l^{-1}) (3 marks) 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 0·098 × 0·009 = 0·000882 **OR** calculation of concentration of iodine solution eg 0·000441/0·025 **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 0·000882/2 = 0·000441 **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**	No units required but only two marks can be awarded for correct answer if wrong unit is given. (wrong units would only be penalised once in the paper).

[END OF MARKING INSTRUCTIONS]