Higher Chemistry

Past Paper Questions – Book 2

Specimen Paper

Higher 2015

Specimen

SECTION 1 — 20 marks

Attempt ALL questions

1. Which type of bonding is **never** found in elements?

A Metallic

B London dispersion forces

C Polar covalent

D Non-polar covalent

2. In which of the following molecules will the chlorine atom carry a partial positive charge ($\delta+$)?

A Cl—Br

B Cl—Cl

C Cl—F

D Cl—I

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

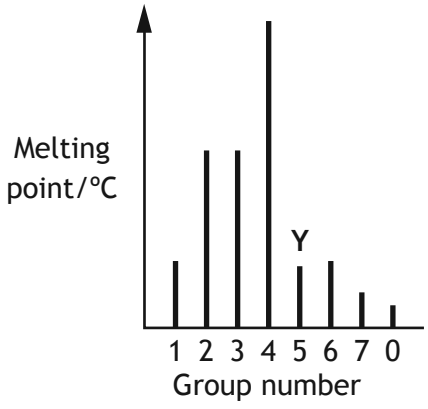
A Covalent bonding

B Hydrogen bonding

C London dispersion forces

D Permanent dipole-permanent dipole interactions

4. The diagram shows the melting points of successive elements across a period in the Periodic Table.



Which of the following is a correct reason for the low melting point of element **Y**?

A It has weak ionic bonds

B It has weak covalent bonds

C It has weakly-held outer electrons

D It has weak forces between molecules

5. In which of the following will **both** changes result in an increase in the rate of a chemical reaction?

A A decrease in activation energy and an increase in the frequency of collisions

B An increase in activation energy and a decrease in particle size

C An increase in temperature and an increase in the particle size

D An increase in concentration and a decrease in the surface area of the reactant particles

6. Which of the following is **not** a correct statement about the effect of a catalyst?

The catalyst

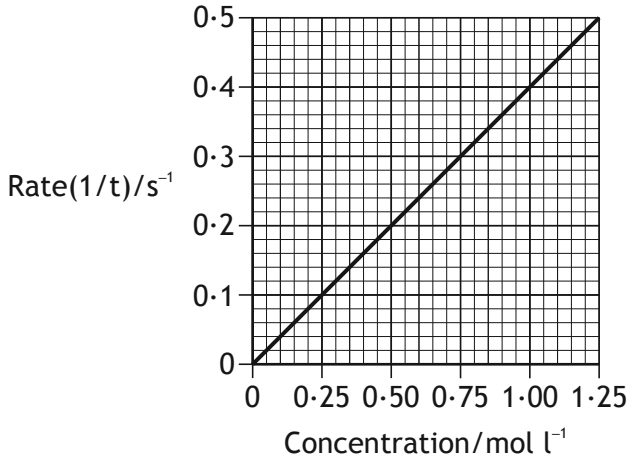
A provides energy so that more molecules have successful collisions

B lowers the energy that molecules need for successful collisions

C provides an alternative route to the products

D forms bonds with reacting molecules.

7. The graph shows how the rate of a reaction varies with the concentration of one of the reactants.



Calculate the reaction time, in seconds, when the concentration of the reactant was 0·50 mol l^{-1}.

A 0·2

B 0·5

C 2·0

D 5·0

8. In which line of the table are fat, protein and soap correctly classified?

	Amides	*Salts*	*Esters*
A	Fat	Soap	Protein
B	Fat	Protein	Soap
C	Soap	Fat	Protein
D	Protein	Soap	Fat

9. The arrangement of amino acids in a peptide is Z-X-W-V-Y where the letters V, W, X, Y and Z represent amino acids.

On partial hydrolysis of the peptide, which of the following sets of dipeptides is possible?

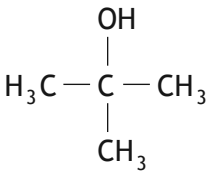
A V—Y, Z—X, W—Y, X—W

B Z—X, V—Y, W—V, X—W

C Z—X, X—V, W—V, V—Y

D X—W, X—Z, Z—W, Y—V

10.



Which of the following compounds is an isomer of the structure shown above?

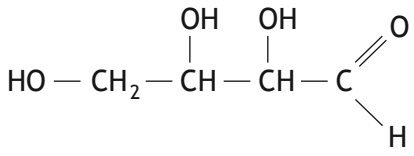
A Butanal

B Butanone

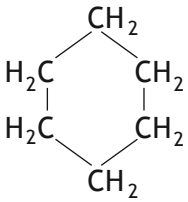
C Butan-1-ol

D Butanoic acid

11. Erythrose can be used in the production of a chewing gum that helps prevent tooth decay.

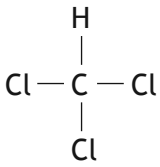


Which of the following compounds will be the best solvent for erythrose?

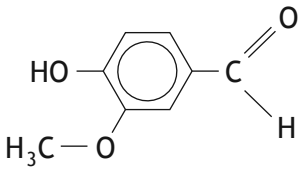
A 

B $CH_3-CH_2-CH_2-CH_2-CH_2-CH_3$

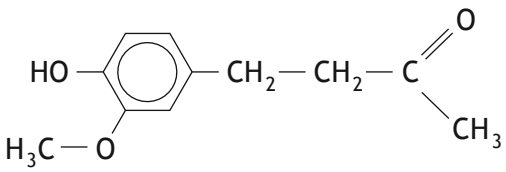
C CH_3-CH_2-OH

D 

12. Vanillin and zingerone are flavour molecules.



vanillin

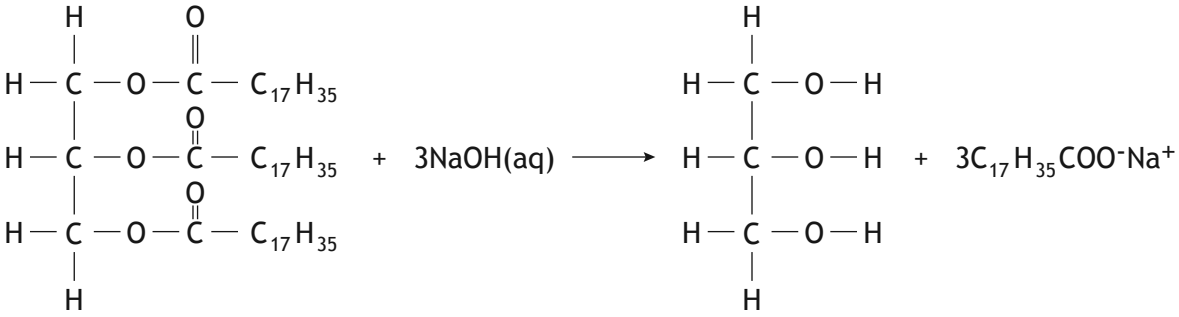


zingerone

Which line in the table correctly compares the properties of vanillin and zingerone?

	More soluble in water	*More volatile*
A	vanillin	vanillin
B	vanillin	zingerone
C	zingerone	vanillin
D	zingerone	zingerone

13. Soaps are produced by the following reaction.



This reaction is an example of

A condensation

B esterification

C hydrolysis

D oxidation.

14. During a redox process in acid solution, iodate ions, $IO_3^-(aq)$, are converted into iodine, $I_2(aq)$.

$$IO_3^-(aq) \rightarrow I_2(aq)$$

The numbers of $H^+(aq)$ and $H_2O(\ell)$ required to balance the ion-electron equation for the formation of 1 mol of $I_2(aq)$ are, respectively

A 3 and 6

B 6 and 3

C 6 and 12

D 12 and 6.

15. $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

The equation represents a mixture at equilibrium.

Which line in the table is true for the mixture after a further 2 hours of reaction?

	Rate of forward reaction	*Rate of back reaction*
A	decreases	decreases
B	increases	increases
C	unchanged	decreases
D	unchanged	unchanged

16. $5N_2O_4(\ell) + 4CH_3NHNH_2(\ell) \rightarrow 4CO_2(g) + 12H_2O(\ell) + 9N_2(g) \qquad \Delta H = -5116\,kJ$

The energy released when 2 moles of each reactant are mixed and ignited is

A 1137 kJ

B 2046 kJ

C 2258 kJ

D 2843 kJ.

17. 1670 kJ of energy are given out when 2 moles of aluminium react completely with 1·5 moles of oxygen.

$$2Al(s) + 1\tfrac{1}{2}O_2(g) \rightarrow Al_2O_3(s)$$

The enthalpy of combustion of aluminium, in kJ mol^{-1}, is

A −1113
B −835
C +835
D +1113.

18. Which of the following elements is the strongest reducing agent?

A Lithium
B Bromine
C Fluorine
D Aluminium

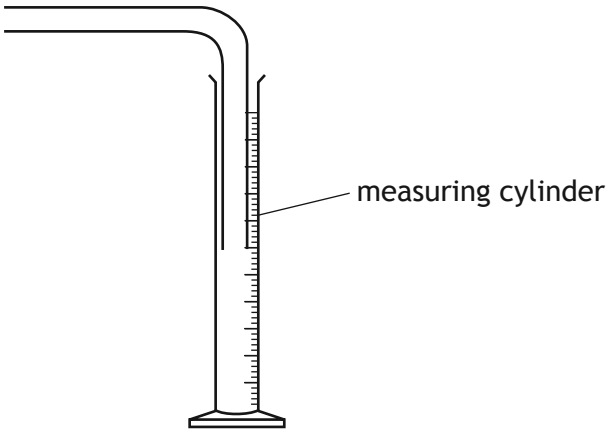
19. 45 cm^3 of a solution could be most accurately measured out using a

A 50 cm^3 beaker
B 50 cm^3 burette
C 50 cm^3 pipette
D 50 cm^3 measuring cylinder.

20. Sulphur dioxide gas is denser than air and is very soluble in water.

Which of the following diagrams shows the most appropriate apparatus for collecting and measuring the volume of sulphur dioxide given off in a reaction?

A



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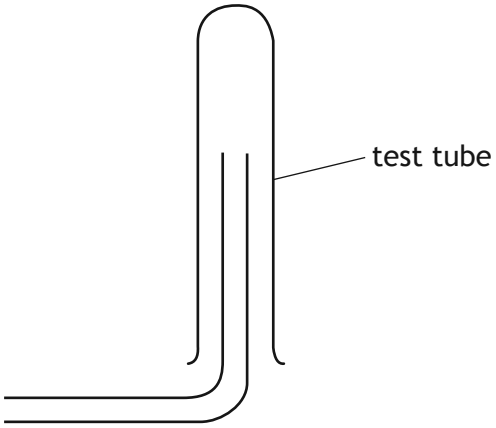

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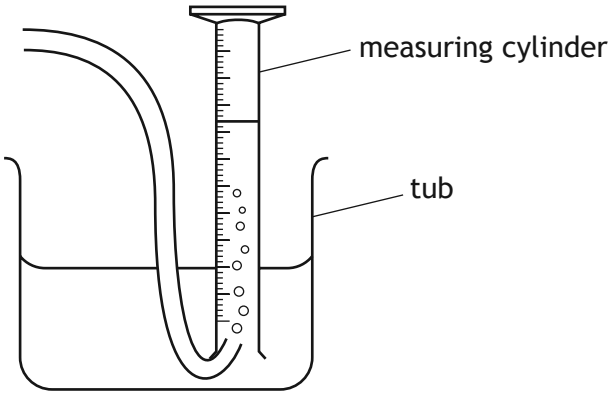
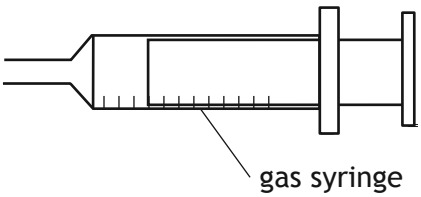


D



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

MARKS | DO NOT WRITE IN THIS MARGIN

SECTION 2 — 80 marks

Attempt ALL questions

1. Common salt, NaCl, is widely used in the food industry as a preservative and flavour enhancer.

(a) (i) Write the ion-electron equation for the first ionisation energy of sodium. **1**

(ii) **Explain clearly** why the first ionisation energy of sodium is much lower than its second ionisation energy. **3**

(b) The label on a tub of margarine states that 100 g of the margarine contains 0·70 g of sodium. The sodium is present as sodium chloride.

Calculate the mass of sodium chloride, in grams, present in a 10 g portion of the margarine.

The mass of one mole of sodium chloride, NaCl, is 58·5 g. **1**

MARKS | DO NOT WRITE IN THIS MARGIN

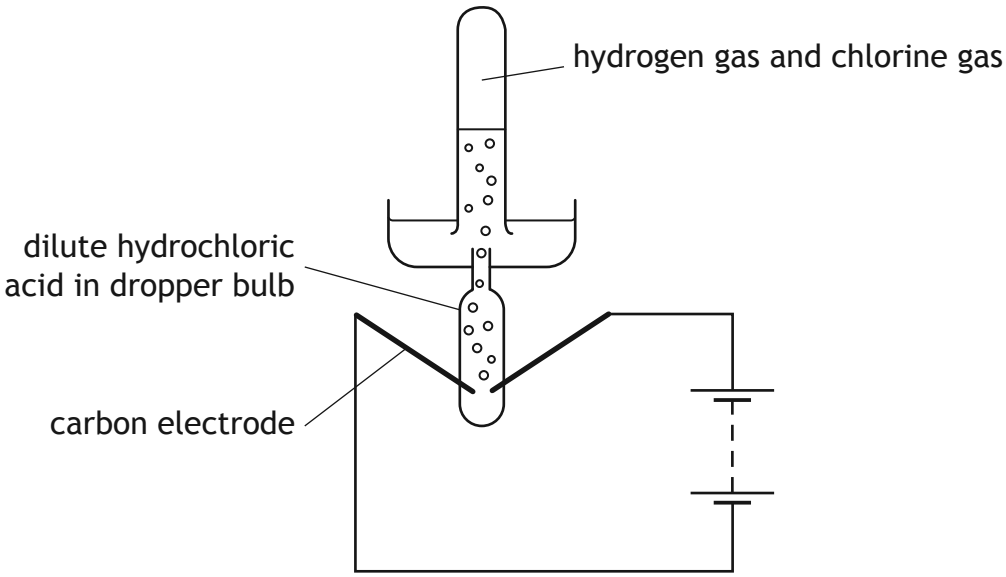
2. (a) Nitrogen dioxide gas and carbon monoxide gas can react when molecules collide.

$$NO_2(g) + CO(g) \rightarrow NO(g) + CO_2(g)$$

State **two** conditions necessary for a collision to be successful. **2**

(b) Hydrogen gas and chlorine gas react explosively in a photochemical reaction. In a demonstration experiment, the reaction was used to fire a table tennis ball across a room.

(i) A mixture of hydrogen gas and chlorine gas was generated by the electrolysis of hydrochloric acid.



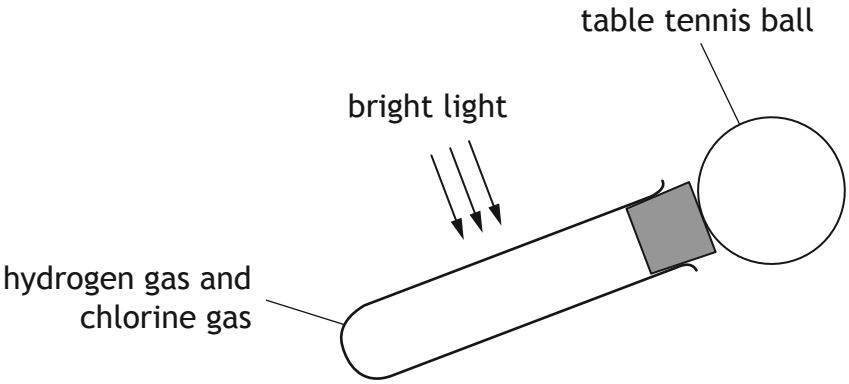
$$2HCl(aq) \rightarrow H_2(g) + Cl_2(g)$$

Calculate the number of moles of hydrochloric acid required to completely fill a 10 cm^3 test tube with the hydrogen gas and chlorine gas mixture.

(Take the molar volume of a gas to be 24 litres mol^{-1}) **2**

2. (b) **(continued)**

(ii) The filled test tube was fitted with a stopper to which a table tennis ball was attached. When a bright light was directed at the test tube, the gas mixture exploded and the ball was fired across the room.



Chlorine reacts with hydrogen in a free radical chain reaction. Some steps in the chain reaction are shown in the table.

Reaction step	*Name of step*
$Cl_2 \rightarrow 2Cl\bullet$	
$Cl\bullet + H_2 \rightarrow HCl + H\bullet$ $H\bullet + Cl_2 \rightarrow HCl + Cl\bullet$	propagation
	termination

Complete the table by:

A inserting the missing name for the first step; **1**

B showing a possible termination step. **1**

2. (b) (continued)

(iii) The production of hydrogen chloride from hydrogen and chlorine is exothermic.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

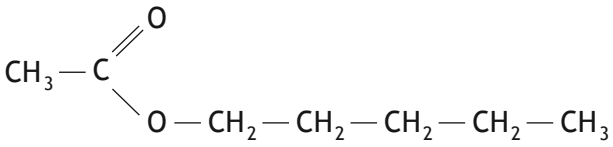
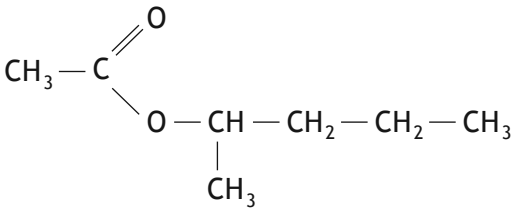
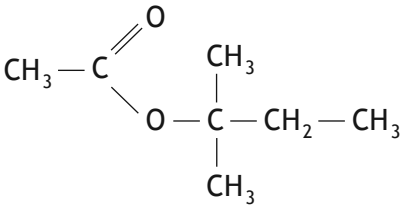
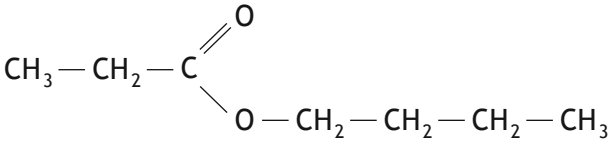
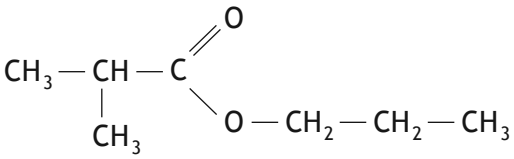
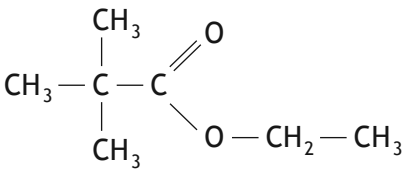
Using bond enthalpy values, calculate the enthalpy change, in kJ, for the reaction.

Show your working clearly. **2**

3. A team of chemists is developing a fragrance for use in a shower gel for men.

(a) To give the gel a fruity smell the chemists are considering adding an ester.

They synthesise six isomeric esters. Volunteers smell each ester and give it a rating out of one hundred depending on how fruity the smell is.

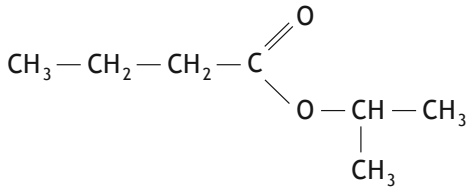
Structure	*Fruit-smell rating*
	100
	34
	0
	92
	44
	32

(i) Name the ester with the fruit-smell rating of 92. **1**

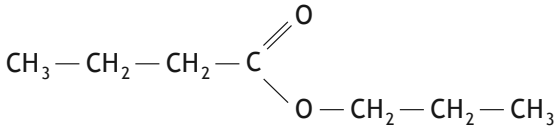
3. (a) (continued)

(ii) Shown below are the structures of three more isomers.

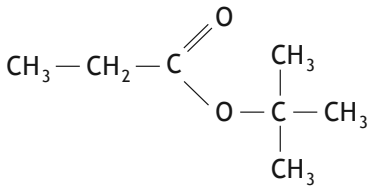
Ester **A**



Ester **B**



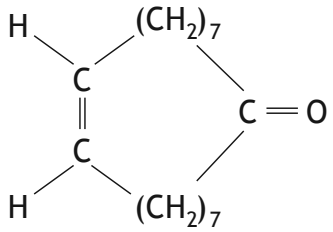
Ester **C**



Arrange these esters in order of **decreasing** fruit-smell rating.

Ester ☐ > Ester ☐ > Ester ☐ **1**

(b) To create a fragrance for men, the compound civetone is added.

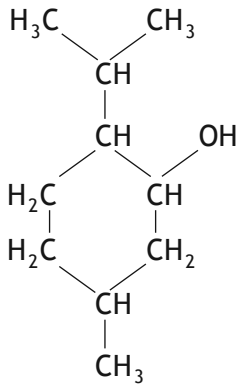


civetone

Draw a structural formula for the alcohol that can be oxidised to form civetone. **1**

3. (continued)

(c) To make the shower gel produce a cold, tingling sensation when applied to the skin, menthol is added.



Like terpenes, menthol is formed from isoprene (2-methylbuta-1,3-diene).

Circle an isoprene unit on the menthol structure above. **1**

4. Cooking changes the appearance and composition of foods.

Using your knowledge of chemistry, comment on the changes to food that may occur during cooking. **3**

MARKS | DO NOT WRITE IN THIS MARGIN

5. 2-Methylpropan-1-ol and ethanol are renewable fuels that are used as alternatives to petrol in car engines.

(a) A car was fuelled with 15 litres of ethanol. The ethanol burned to produce 351 000 kJ of energy.

Use the data in the table to calculate the volume of 2-methylpropan-1-ol that would burn to release the same energy.

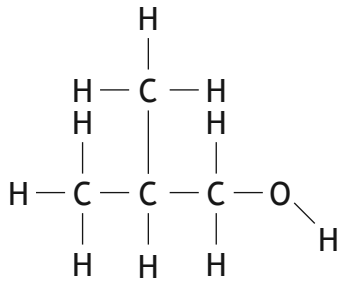
Volume of 1 g of 2-methylpropan-1-ol	1·25 cm^3
Energy from 1 g of 2-methylpropan-1-ol	3·61 kJ

3

(b) Fuels containing alcohols have a tendency to absorb water, which can cause the engine to rust.

Water is absorbed by alcohols due to hydrogen bonds forming between the alcohol and water molecules.

In the box below, use a dotted line to show a hydrogen bond between a water molecule and 2-methylpropan-1-ol. **1**



5. (continued)

(c) 2-Methylpropan-1-ol can also be converted to produce diesel and jet fuel.

The first step in the process is the production of 2-methylpropene.

$$\underset{\text{2-methylpropan-1-ol}}{C_4H_{10}O(\ell)} \rightarrow \underset{\text{2-methylpropene}}{C_4H_8(g)} + H_2O(g)$$

Using the data below, calculate the enthalpy change, in kJ mol^{-1}, for the production of 2-methylpropene from 2-methylpropan-1-ol.

$4C(s) + 5H_2(g) + \frac{1}{2}O_2(g) \rightarrow C_4H_{10}O(\ell) \quad \Delta H = -335 \text{ kJ mol}^{-1}$

$4C(s) + 4H_2(g) \rightarrow C_4H_8(g) \quad \Delta H = -17 \text{ kJ mol}^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g) \quad \Delta H = -242 \text{ kJ mol}^{-1}$ **2**

(d) If the viscosity of a fuel is not within a certain range then it can result in damage to the fuel pump and engine.

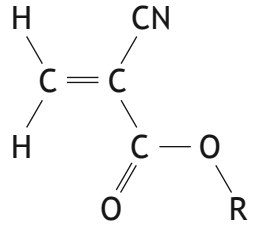
A student was asked to design an experiment to compare the viscosity of some fuels. Suggest an experiment that could be done to compare viscosities.

(You may wish to use a diagram to help with your description.) **2**

6. Cyanoacrylate adhesives are a range of high performance "super glues".

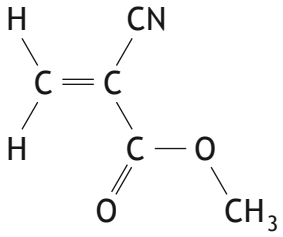
In its liquid form, super glue consists of cyanoacrylate monomers that rapidly polymerise in the presence of water to form a strong resin that joins two surfaces together.

Cyanoacrylates have the general structure



where R is a hydrocarbon group, eg $-CH_3$.

(a) Some super glues contain methyl 2-cyanoacrylate.

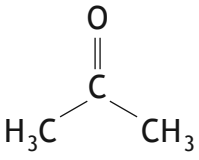


Circle the ester link in this structure. **1**

(b) If used incorrectly, super glue can rapidly cause your fingers to stick together.

(i) Suggest why super glue reacts rapidly on the surface of the skin. **1**

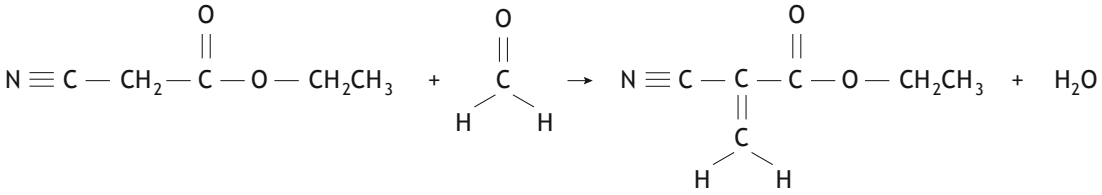
(ii) Super glue can be removed from the skin using propanone as a solvent.



Name the main type of van der Waals' forces that would be formed between propanone and super glue. **1**

6. (continued)

(c) Ethyl 2-cyanoacrylate is synthesised from ethyl 2-cyanoethanoate by a process based on the Knovenagel reaction.



ethyl 2-cyanoethanoate mass of one mole = 113 g	reactant **A** mass of one mole = 30 g	ethyl 2-cyanoacrylate mass of one mole = 125 g	water mass of one mole = 18 g

(i) Name reactant **A**. **1**

(ii) Name this **type** of chemical reaction. **1**

(iii) Calculate the atom economy for the formation of ethyl 2-cyanoacrylate using this process.

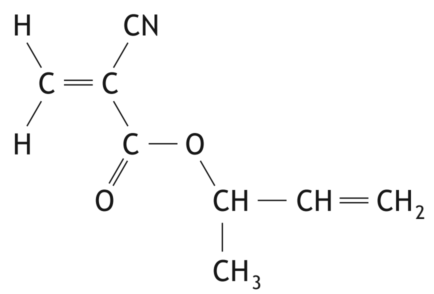
Show your working clearly. **2**

6. (continued)

(d) The adhesive strength of super glue can be altered by introducing different alkyl groups to the monomer.

Hydrocarbon group	*Shearing adhesive strength*/N cm^{-2}
$-CH_3$	1800
$-CH_2-CH_3$	1560
$-CH_2-CH_2-CH_3$	930
$-CH_2-CH_2-CH_2-CH_3$	270
$-CH(CH_3)-CH_2-CH_3$ (CH$_3$ branch on the first carbon)	420
$-CH_2-CH=CH_2$	1240
$-CH_2-C\equiv CH$	1670
$-CH(CH_3)-C\equiv CH$	1140

Estimate the adhesive strength of super glue that contains the monomer shown below. **1**



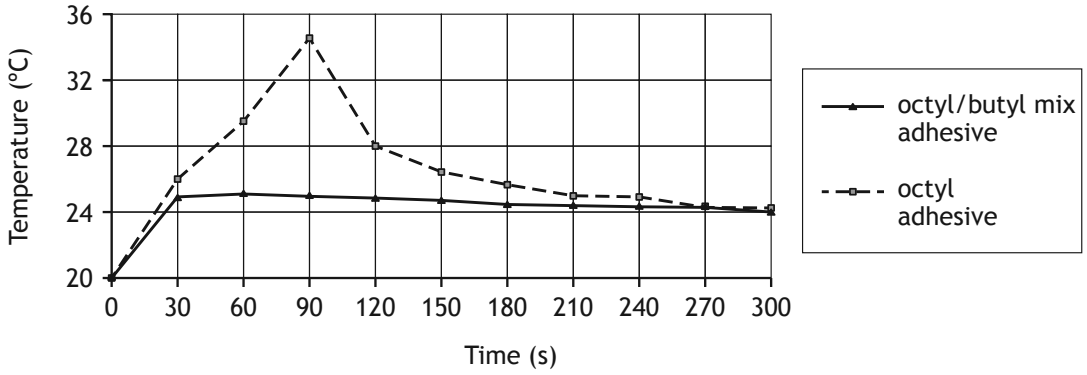
6. (continued)

(e) Super glues have been developed for medical applications.

(i) Medical tissue adhesive, containing octyl 2-cyanoacrylate, can be used for wound closures instead of sutures or stitches.

Draw a structural formula for octyl 2-cyanoacrylate. **1**

(ii) The graph below compares the temperature change during the polymerisation reaction for two different brands of medical tissue adhesive.



Suggest an advantage to the patient of using the octyl/butyl mix adhesive. **1**

MARKS | DO NOT WRITE IN THIS MARGIN

7. A student analysed a local water supply to determine fluoride and nitrite ion levels.

(a) The concentration of fluoride ions in water was determined by adding a red coloured compound that absorbs light to the water samples. The fluoride ions reacted with the red compound to produce a colourless compound. Higher concentrations of fluoride ions produce less coloured solutions which absorb less light.

The student initially prepared a standard solution of sodium fluoride with fluoride ion concentration of 100 mg l^{-1}.

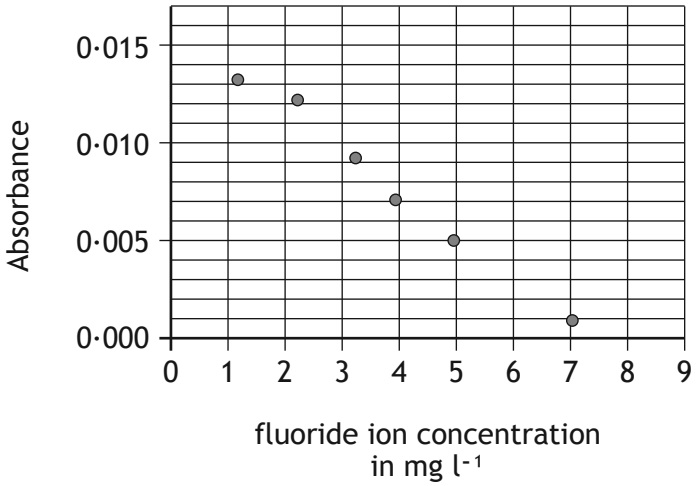
(i) State what is meant by the term **standard solution**. **1**

(ii) Describe how the standard solution is prepared from a weighed sample of sodium fluoride. **2**

(iii) Explain why the student should use distilled or deionised water rather than tap water when preparing the standard solution. **2**

7. (a) (continued)

(iv) The student prepared a series of standard solutions of fluoride ions and reacted each with a sample of the red compound. The light absorbance of each solution was measured and the results graphed.



Determine the concentration of fluoride ions in a solution with absorbance 0·012. **1**

7. (continued)

(b) The concentration of nitrite ions in the water supply was determined by titrating water samples with acidified permanganate solutions.

(i) An average of $21{\cdot}6\,cm^3$ of $0{\cdot}015\,mol\,l^{-1}$ acidified permanganate solution was required to react completely with the nitrite ions in a $25{\cdot}0\ cm^3$ sample of water.

The equation for the reaction taking place is

$$2MnO_4^-(aq) + 5NO_2^-(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5NO_3^-(aq) + 3H_2O(\ell)$$

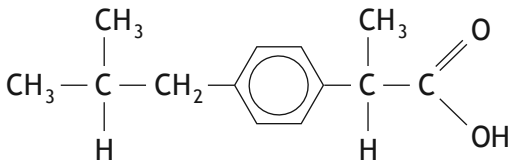
Calculate the nitrite ion concentration, in $mol\,l^{-1}$, in the water.

Show your working clearly. **3**

(ii) During the reaction the nitrite ion is oxidised to the nitrate ion. Complete the ion-electron equation for the oxidation of the nitrite ion.

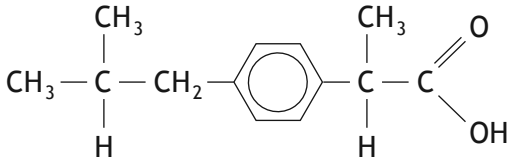
$NO_2^-(aq) \rightarrow NO_3^-(aq)$ **1**

8. Ibuprofen is one of the best-selling pain killers in the UK.



(a) Ibuprofen tablets should not be taken by people who suffer from acid indigestion. Name the functional group present in ibuprofen that makes this drug unsuitable for these people. **1**

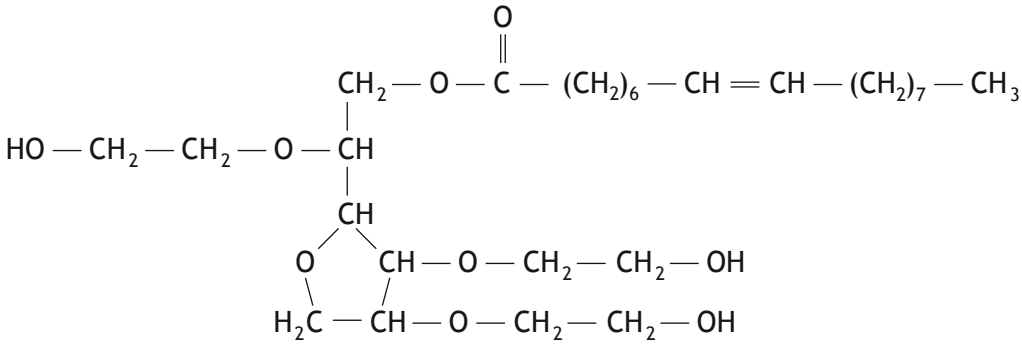
(b) Ibuprofen is normally taken as tablets or pills and it is only slightly soluble in water.



(i) Suggest why ibuprofen is only slightly soluble in water. **1**

(ii) Ibuprofen is also available as an "infant formula" emulsion for young children.

The emulsifier used is polysorbate 80. Its structure is shown below.



Circle the part of the polysorbate 80 molecule that is hydrophobic. **1**

8. (b) (continued)

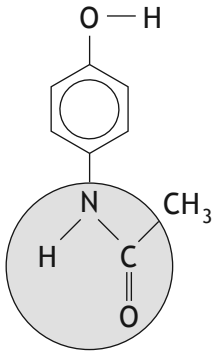
MARKS | DO NOT WRITE IN THIS MARGIN

(iii) The emulsion contains 2·0 g of ibuprofen in every 100 cm^3 of emulsion.

The recommended dose for treating a three month old baby is 0·050 g.

Calculate the volume, in cm^3, of "infant formula" needed to treat a three month old baby. **1**

(c) Paracetamol is another widely used painkiller. Its structure is shown below.

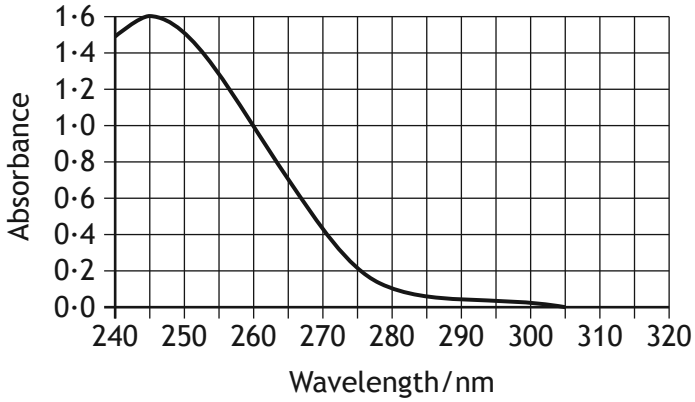


(i) Name the functional group shaded in the structure. **1**

8. (b) (continued)

(ii) The concentration of paracetamol in a solution can be determined by measuring how much UV radiation it absorbs. The quantity of UV radiation absorbed is directly proportional to the concentration of paracetamol.

The graph shows how the absorbance of a sample containing $0{\cdot}040\,g\,l^{-1}$ paracetamol varies with wavelength.

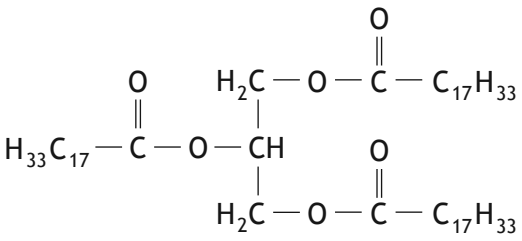
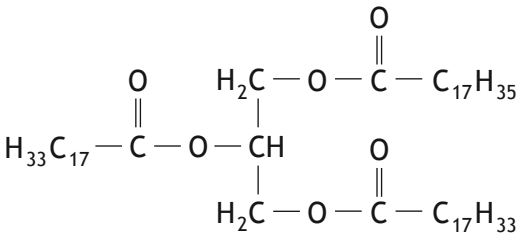
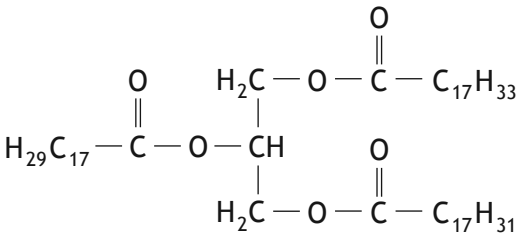
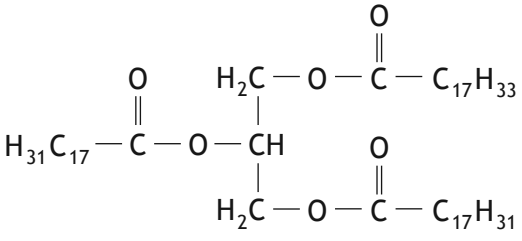


The absorbance of a second sample of paracetamol solution measured at 245 nm was 0·90.

Determine the concentration, in $g\,l^{-1}$, of this second paracetamol solution. **1**

9. A student carried out some experiments using different fats and oils.

(a) The first experiment allowed the iodine number to be calculated. The iodine number is the mass of iodine, in grams, that will react with 100 g of the fat or oil. The student's results are shown.

Fat or oil	*Iodine number*	*Typical molecule found in the fat or oil*
Olive oil	84	
Shea butter	43	
Linseed oil	172	
Sunflower oil		

(i) Shea butter is a solid at room temperature.

Explain why the melting point of shea butter is higher than room temperature. **2**

9. (a) (continued)

(ii) Predict the iodine number of sunflower oil. **1**

(iii) Name the substance that reacts with oils to turn them rancid. **1**

(b) In the second experiment some oils were used to make soap. The oil, triolein, was reacted with sodium hydroxide.

$$(C_{17}H_{33}COO)_3C_3H_5 + 3NaOH \rightarrow 3C_{17}H_{33}COONa + X$$

triolein — mass of one mole = 884 g

sodium oleate — mass of one mole = 304 g

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

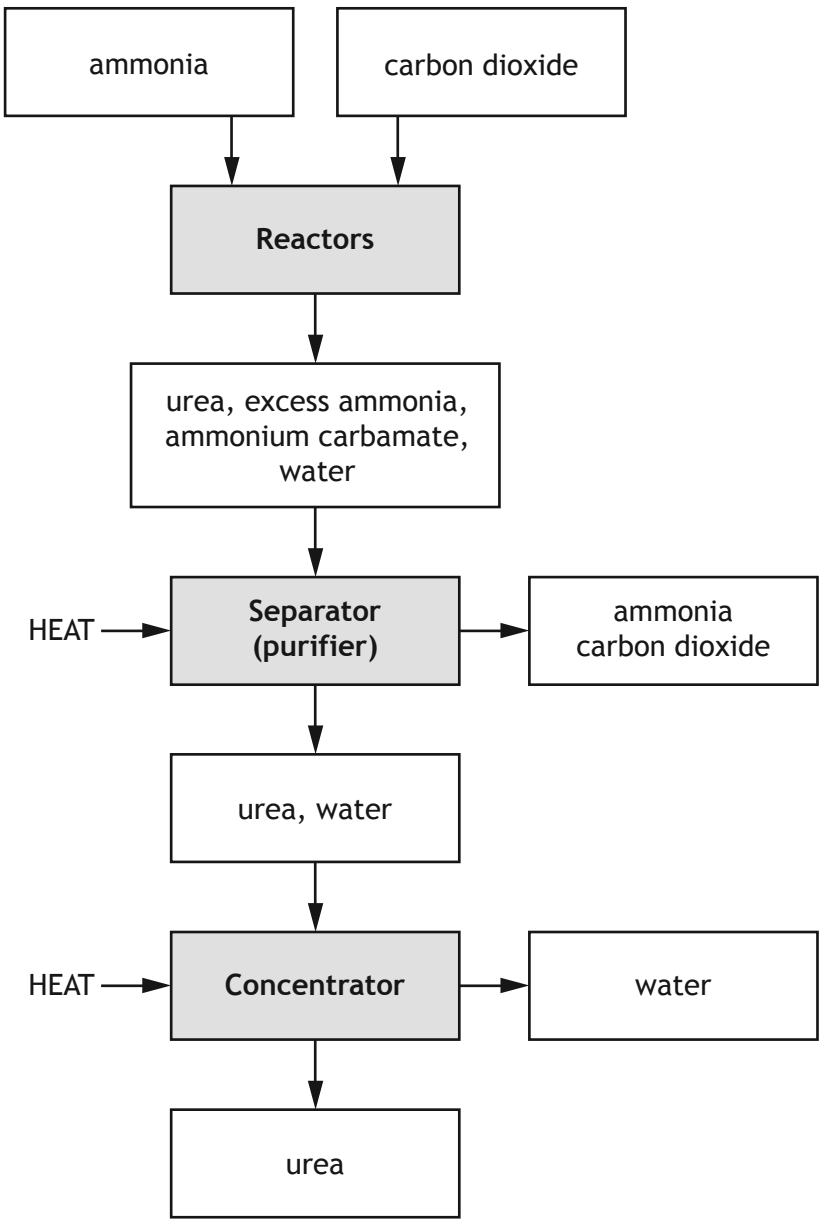
(ii) 5·0 g of triolein was dissolved in ethanol and placed in a test tube with excess sodium hydroxide. The mixture was heated to 80 °C.

State a suitable method for heating the reaction mixture. **1**

(iii) The experiment produced 1·28 g of sodium oleate.

Calculate the percentage yield. **2**

10. Urea, $(NH_2)_2CO$, is an important industrial chemical that is mainly used in fertilisers. It is made by the Bosch-Meiser process.



10. (continued)

(a) (i) In the reactors, the production of urea involves two reversible reactions.

In the first reaction ammonium carbamate is produced.

$$2NH_3(g) + CO_2(g) \rightleftharpoons H_2NCOONH_4(g)$$

In the second reaction the ammonium carbamate decomposes to form urea.

$$H_2NCOONH_4(g) \rightleftharpoons (NH_2)_2CO(g) + H_2O(g)$$

A chemical plant produces 530 tonnes of urea per day.

Calculate the theoretical mass, in tonnes, of ammonia required to produce 530 tonnes of urea. **2**

(ii) An undesirable side reaction is the production of biuret, a compound that can burn the leaves of plants.

$$2(NH_2)_2CO(aq) \rightleftharpoons \underset{\text{biuret}}{NH_2CONHCONH_2(aq)} + NH_3(g)$$

State why having an excess of ammonia in the reactors will decrease the amount of biuret produced. **1**

10. (a) (continued)

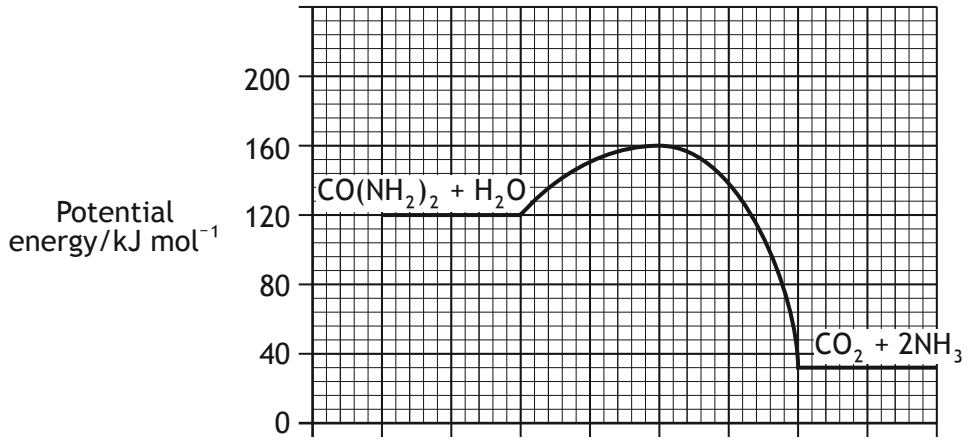
(iii) In the separator the ammonium carbamate from the reactors decomposes to form ammonia and carbon dioxide.

$$NH_2COONH_4(aq) \rightleftharpoons 2NH_3(g) + CO_2(g)$$

Explain clearly why a low pressure is used in the separator. **2**

(iv) Add a line to the flow chart, to show how the Bosch-Meiser process can be made more economical. **1**

(b) Soil bacteria are mainly responsible for releasing nitrogen in urea into the soil so that it can be taken up by plants. The first stage in the process is the hydrolysis of urea using the enzyme urease.



(i) Determine the enthalpy change, in kJ mol^{-1}, for the reaction. **1**

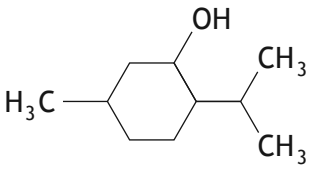
(ii) Acid is a less effective catalyst than urease for this reaction. Add a curve to the potential energy diagram to show the change in potential energy when acid is used as the catalyst. **1**

11. A TV programme was reproducing a pharmacy from the 19th century and planned to use the original 19th century pharmacy jars that had been kept in a museum. The TV company wanted to know what compounds the jars were likely to contain now.

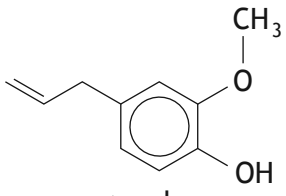
Substances used in pharmacies over a hundred years ago included:

- Essential oils dissolved in ethanol.

  Some molecules included in these essential oils were:

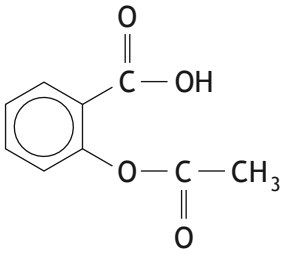


menthol



eugenol

- Aspirin.



- Ointments that contained animal fats like lard, beef fat or beeswax.

Using your knowledge of chemistry, comment on what compounds the old pharmacy jars might contain now. **3**

MARKS | DO NOT WRITE IN THIS MARGIN

12. Proteins are an important part of a healthy diet because they provide essential amino acids.

(a) State what is meant by an **essential amino acid**. **1**

(b) Eggs and fish are good dietary sources of the essential amino acid, methionine.

The recommended daily allowance of methionine for an adult is 15 mg per kg of body mass.

Tuna contains 755 mg of methionine per 100 g portion.

Calculate the mass, in grams, of tuna that would provide the recommended daily allowance of methionine for a 60 kg adult. **2**

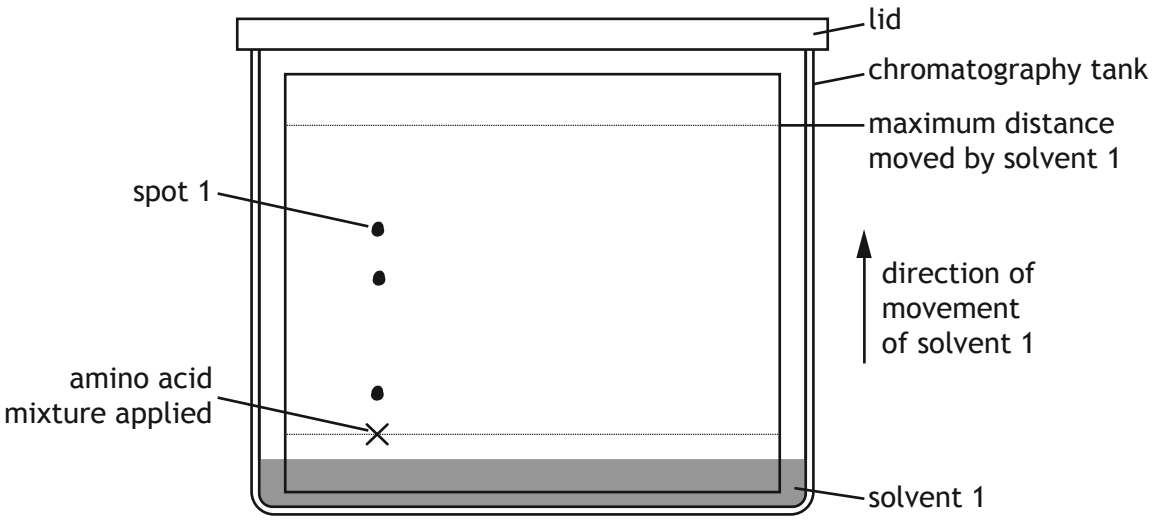
12. (continued)

(c) Mixtures of amino acids can be separated using paper chromatography. On a chromatogram, the retention factor, R_f, for a substance can be a useful method of identifying the substance.

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

(i) A solution containing a mixture of four amino acids was applied to a piece of chromatography paper that was then placed in solvent 1.

Chromatogram 1 is shown below.



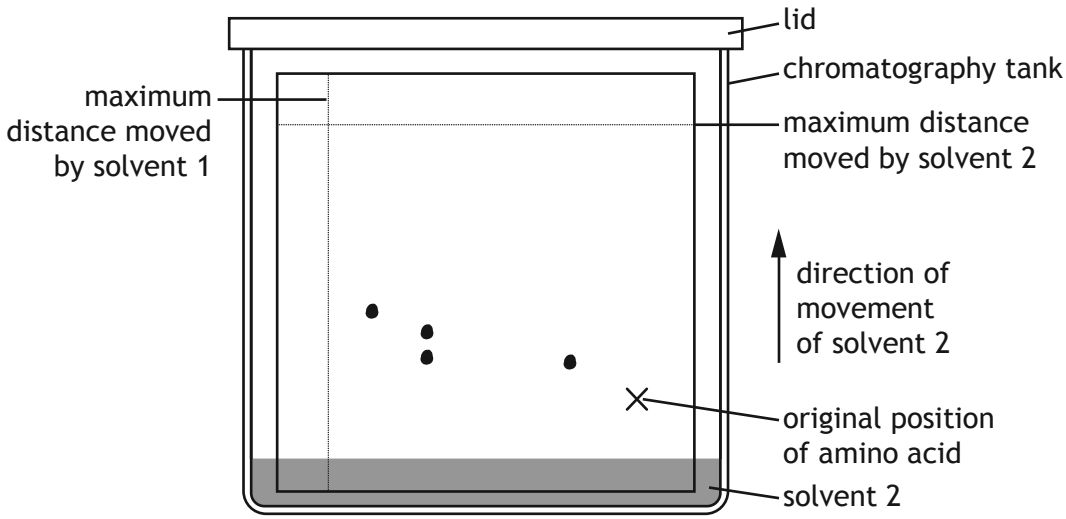
Amino Acid	R_f (*solvent 1*)
alanine	0·51
arganine	0·16
threonine	0·51
tyrosine	0·68

Identify the amino acid that corresponds to spot 1 on the chromatogram. **1**

12. (c) **(continued)**

(ii) The chromatogram was dried, rotated through 90° and then placed in solvent 2.

Chromatogram 2 is shown below.



Amino Acid	R_f (*solvent 2*)
alanine	0·21
arganine	0·21
threonine	0·34
tyrosine	0·43

The retention factors for each of the amino acids in solvent 2 are shown in the table.

Draw a circle around the spot on chromatogram 2 that corresponds to the amino acid alanine. **1**

(iii) Explain why only three spots are present in chromatogram 1 while four spots are present in chromatogram 2. **2**

[END OF SPECIMEN QUESTION PAPER]

2015

SECTION 1 — 20 marks

Attempt ALL questions

1. The elements nitrogen, oxygen, fluorine and neon

A can form negative ions

B are made up of diatomic molecules

C have single bonds between the atoms

D are gases at room temperature.

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

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

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

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

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

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

A Carbon

B Nitrogen

C Phosphorus

D Silicon

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

A Covalent bond

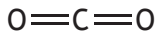
B Hydrogen bond

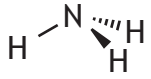
C London dispersion force

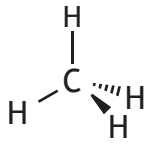
D Permanent dipole – permanent dipole attraction

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

A 

B 

C 

D 

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

During the reaction the oil molecules

A are reduced

B become rancid

C are hydrolysed

D become unsaturated.

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

A Propanol and sodium ethanoate

B Ethanoic acid and sodium propanoate

C Sodium hydroxide and propyl ethanoate

D Sodium hydroxide and ethyl propanoate

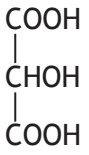
8. Oils contain carbon to carbon double bonds which can undergo addition reactions with iodine.

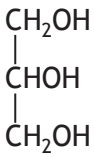
The iodine number of an oil is the mass of iodine in grams that will react with 100 g of oil.

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

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

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

A 

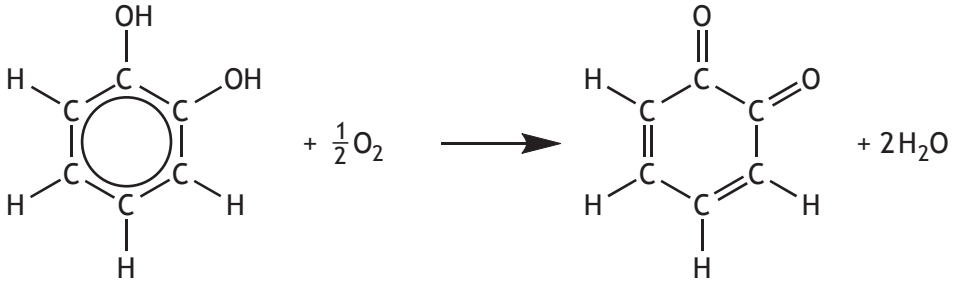
B 

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

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

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

One reaction taking place is:



Which of the following correctly describes the above reaction?

A Oxidation

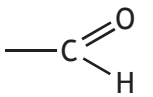
B Reduction

C Hydrolysis

D Condensation

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

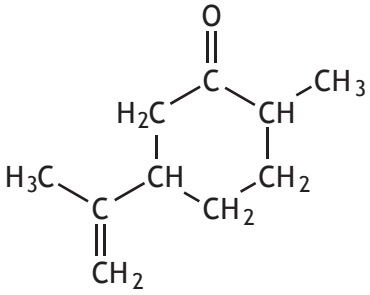
A They are formed by oxidation of tertiary alcohols.

B They contain the group  .

C They contain a carboxyl group.

D They will not react with Fehling's solution.

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

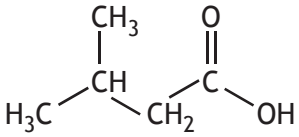


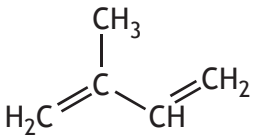
Carvone

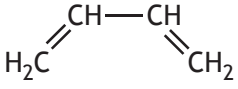
Which line in the table correctly describes the reaction of carvone with bromine solution and with acidified potassium dichromate solution?

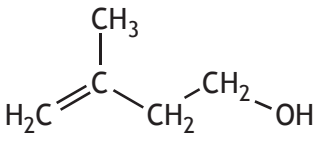
	Reaction with bromine solution	*Reaction with acidified potassium dichromate solution*
A	no reaction	no reaction
B	no reaction	orange to green
C	decolourises	orange to green
D	decolourises	no reaction

13. The structure of isoprene is

A 

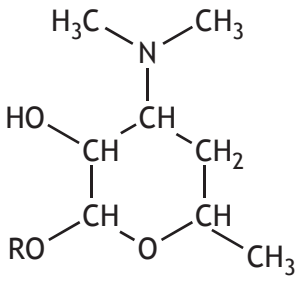
B 

C 

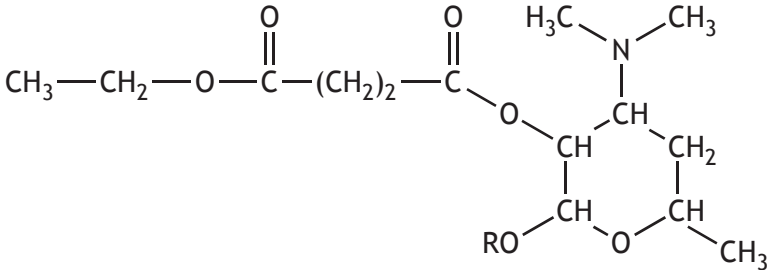
D 

[Turn over

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



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



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

A Alcohol

B Aldehyde

C Carboxylic acid

D Ketone

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

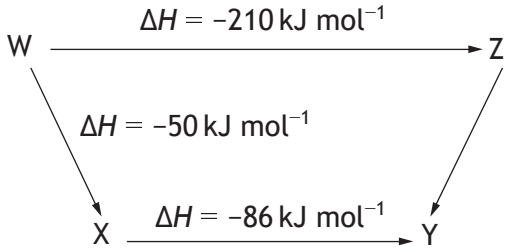
A $CH_3CH_2CH_2CH(CH_3)CH_2OH$

B $(CH_3)_3CCH(CH_3)CH_2OH$

C $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2OH$

D $(CH_3)_2CHC(CH_3)_2CH_2CH_2OH$

16. Consider the reaction pathway shown below.



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

A +74

B −74

C +346

D −346.

[Turn over

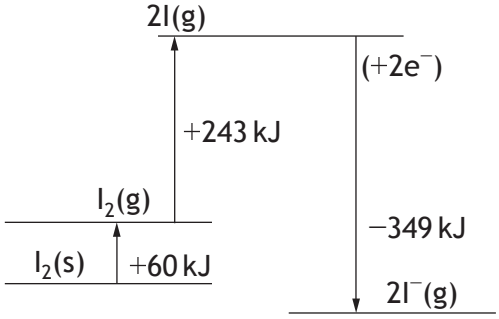
17. $I_2(s) \rightarrow I_2(g)$ $\Delta H = +60\ kJ\ mol^{-1}$

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

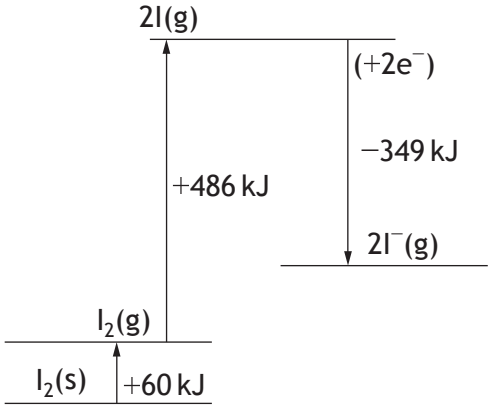
$I(g) + e^- \rightarrow I^-(g)$ $\Delta H = -349\ kJ\ mol^{-1}$

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

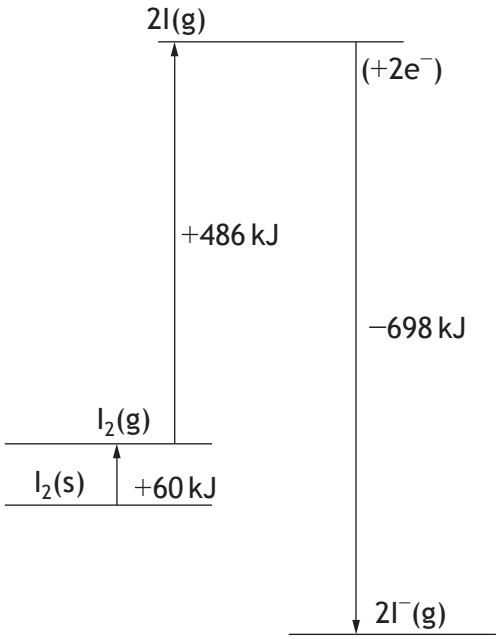
A



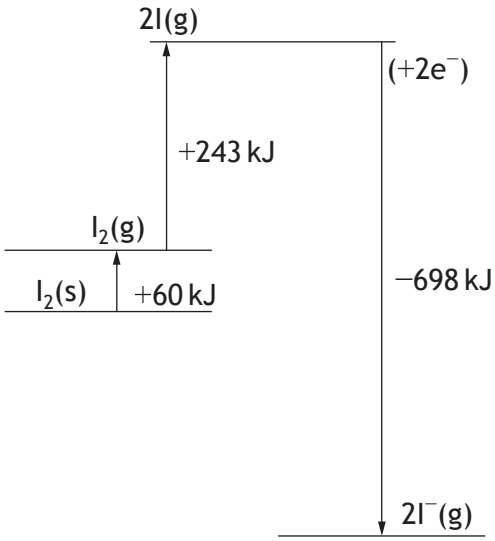
B



C



D



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

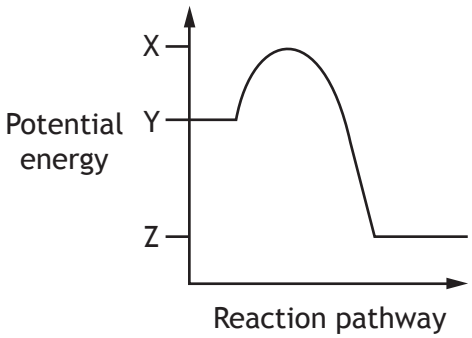
A The rates of the forward and reverse reactions are equal.

B The concentration of reactants and products are equal.

C The forward and reverse reactions have stopped.

D The addition of a catalyst changes the position of the equilibrium.

19. A reaction has the following potential energy diagram.



The activation energy for the forward reaction is

A X – Y

B Y – X

C Y – Z

D Z – Y.

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

A OH^-

B SO_3^{2-}

C Fe^{2+}

D Mn^{2+}

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

MARKS DO NOT WRITE IN THIS MARGIN

SECTION 2 — 80 marks

Attempt ALL questions

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

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

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

2

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

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

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

1. (b) (continued)

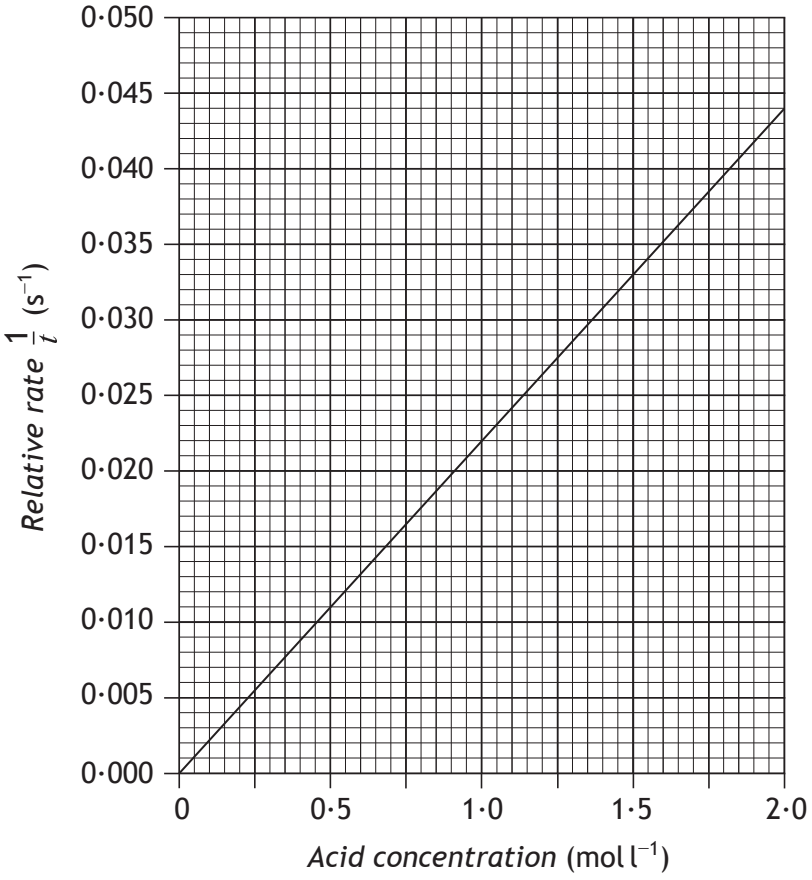
(iii) The melting point of sulfur is much higher than that of phosphorus.

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

[Turn over

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

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

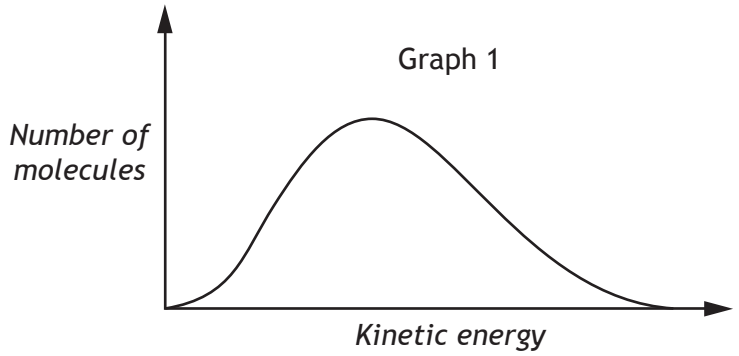


Use information from the graph to calculate the reaction time, in seconds, when the concentration of the acid was 1·0 mol l^{-1}. **1**

2. (continued)

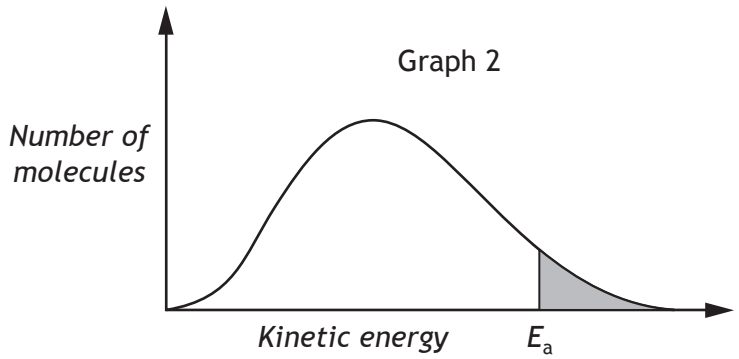
(b) The rate of reaction can also be altered by changing the temperature or using a catalyst.

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



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

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



Draw a line to show how a catalyst affects the activation energy. **1**

[Turn over

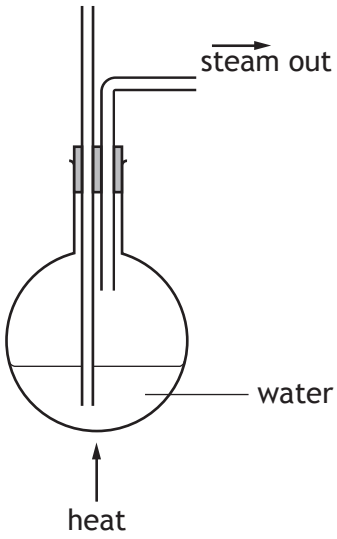
MARKS | DO NOT WRITE IN THIS MARGIN

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

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

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

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



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

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

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

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

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

3. (b) (continued)

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

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

Calculate the percentage yield. **2**

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

Cinnamic acid costs £35·00 per 250 g.

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

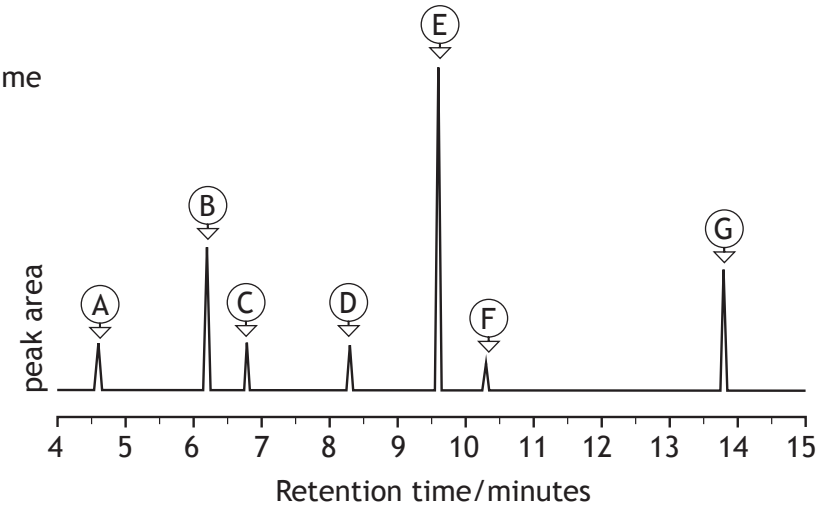
[Turn over

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

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

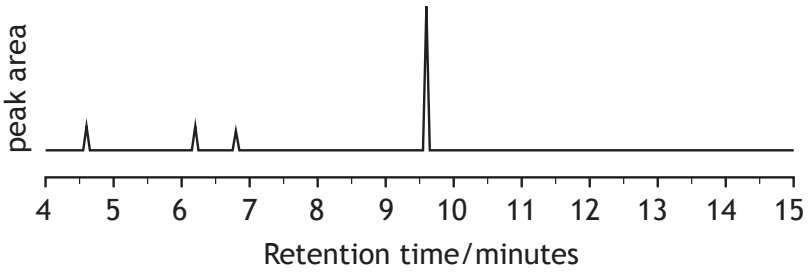
DO NOT WRITE IN THIS MARGIN

Brand name perfume

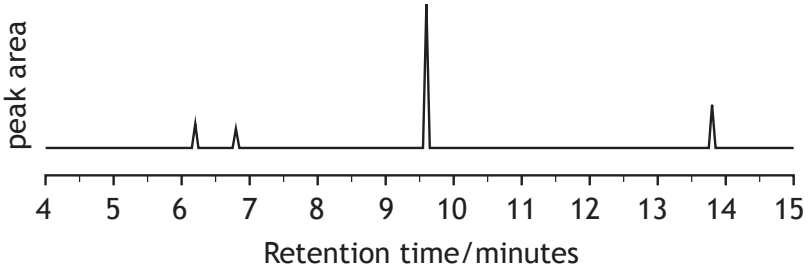


(A) linalool
(B) citronellol
(C) geraniol
(D) eugenol
(E) anisyl alcohol
(F) coumarin
(G) benzyl salicylate

Counterfeit A



Counterfeit B



4. (continued)

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

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

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

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

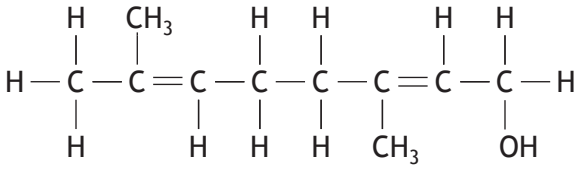
(ii) Apart from the polarity of the molecules, state another factor that would affect the retention time of molecules during gas chromatography. **1**

4. (continued)

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

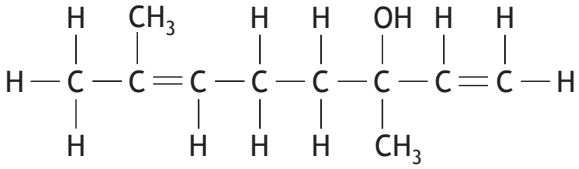
(i) State the name that is given to molecules consisting of joined isoprene units. **1**

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



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

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



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

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

4. (continued)

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

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

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

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

5. Patterns in the Periodic Table

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

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

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

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

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

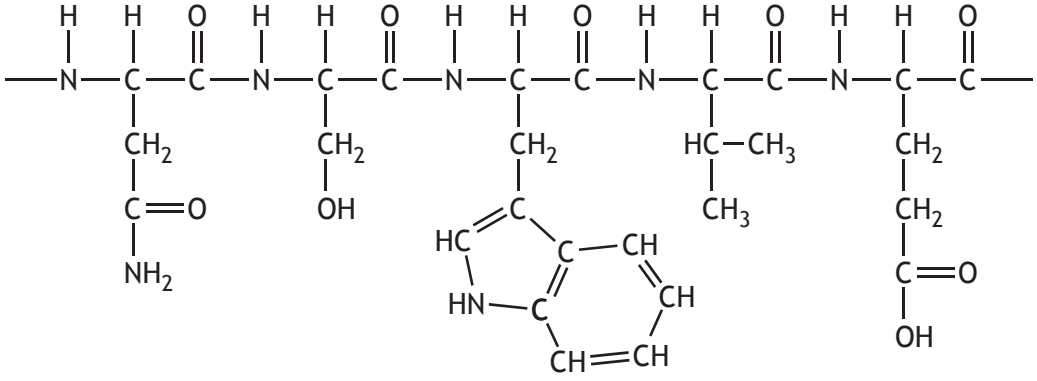
MARKS | DO NOT WRITE IN THIS MARGIN

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

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

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

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

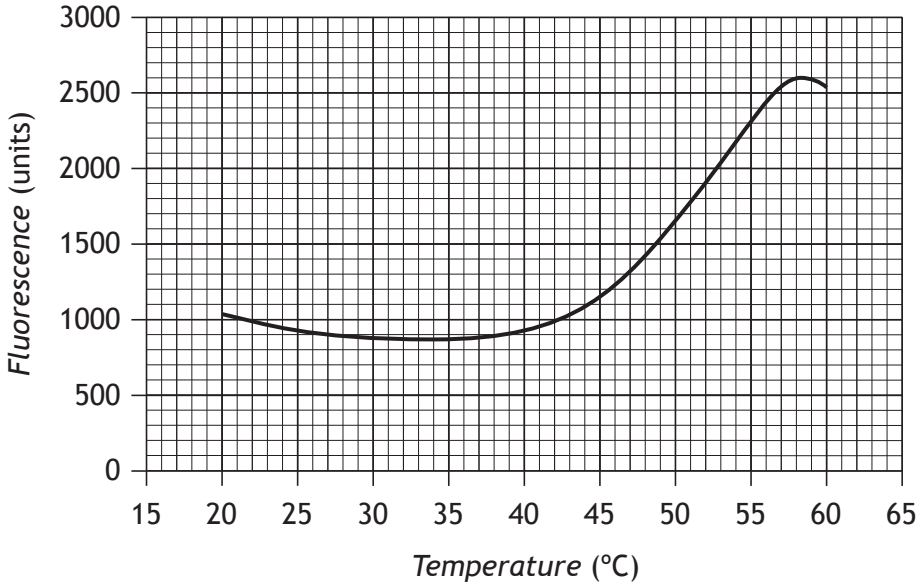


Circle the part of the structure to which the hydrophobic dye is most likely to attach. **1**

[Turn over

6. (b) (continued)

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



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

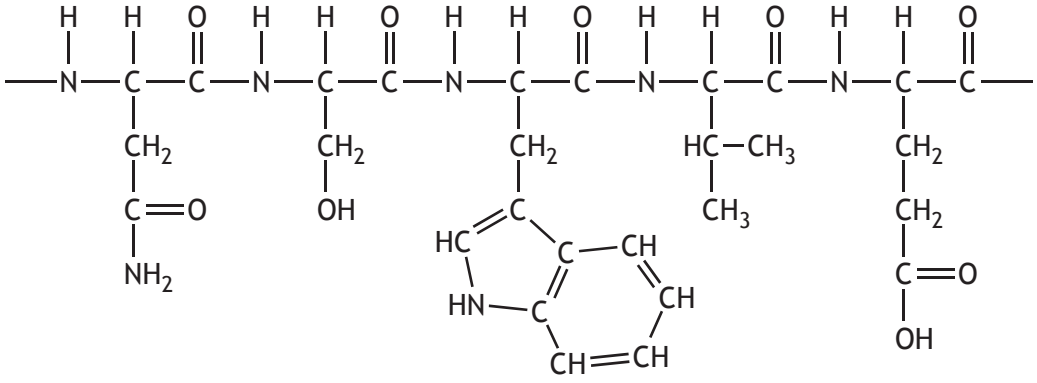
Determine the melting temperature, in °C, for this protein. **1**

6. (continued)

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

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

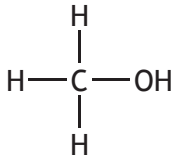
(ii)



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

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

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



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

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

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

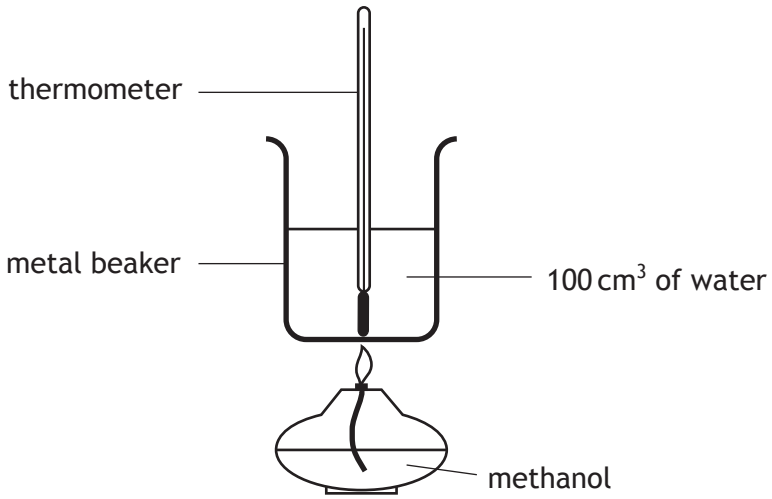
$$2CH_3OH(\ell) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(\ell)$$

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

7. (continued)

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

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



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

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

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

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

[Turn over

7. (b) (i) (continued)

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

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

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

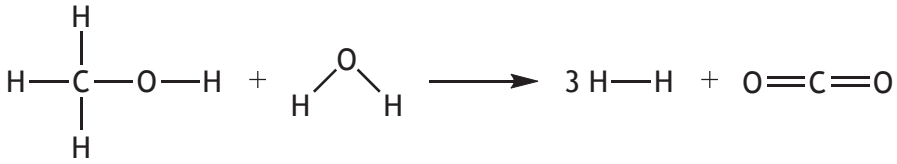
The student's results are shown below.

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

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

7. (continued)

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



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

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

[Turn over

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

MARKS DO NOT WRITE IN THIS MARGIN

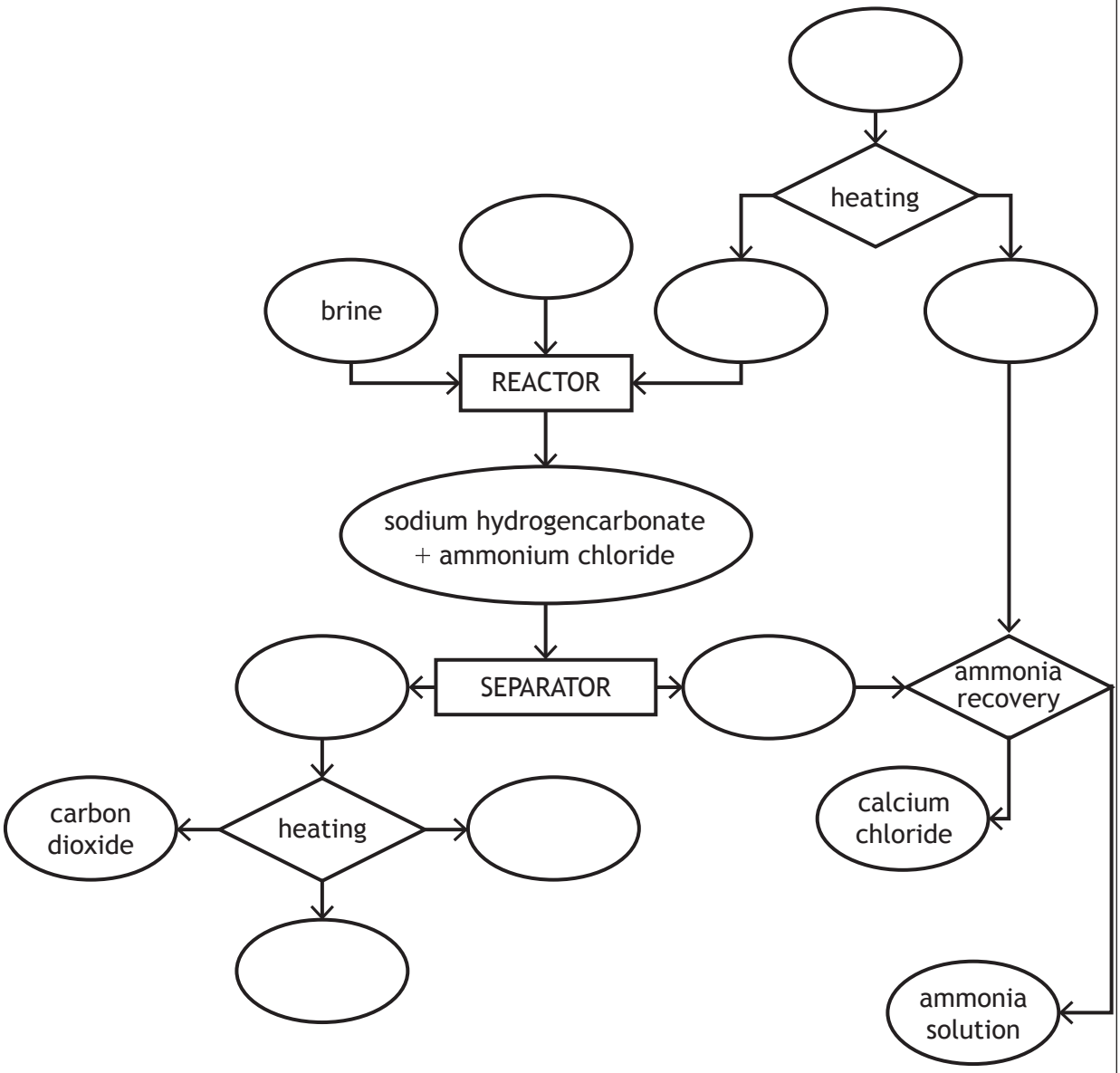
One industrial process used to make sodium carbonate is the Solvay process.

The Solvay process involves several different chemical reactions.

It starts with heating calcium carbonate to produce carbon dioxide, which is transferred to a reactor where it reacts with ammonia and brine. The products of the reactor are solid sodium hydrogencarbonate and ammonium chloride which are passed into a separator.

The sodium hydrogencarbonate is heated to decompose it into the product sodium carbonate along with carbon dioxide and water. To recover ammonia the ammonium chloride from the reactor is reacted with calcium oxide produced by heating the calcium carbonate. Calcium chloride is a by-product of the ammonia recovery process.

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



8 (continued)

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

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

Brine is a concentrated sodium chloride solution.

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

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

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

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

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

MARKS | DO NOT WRITE IN THIS MARGIN

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

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

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

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

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

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

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

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

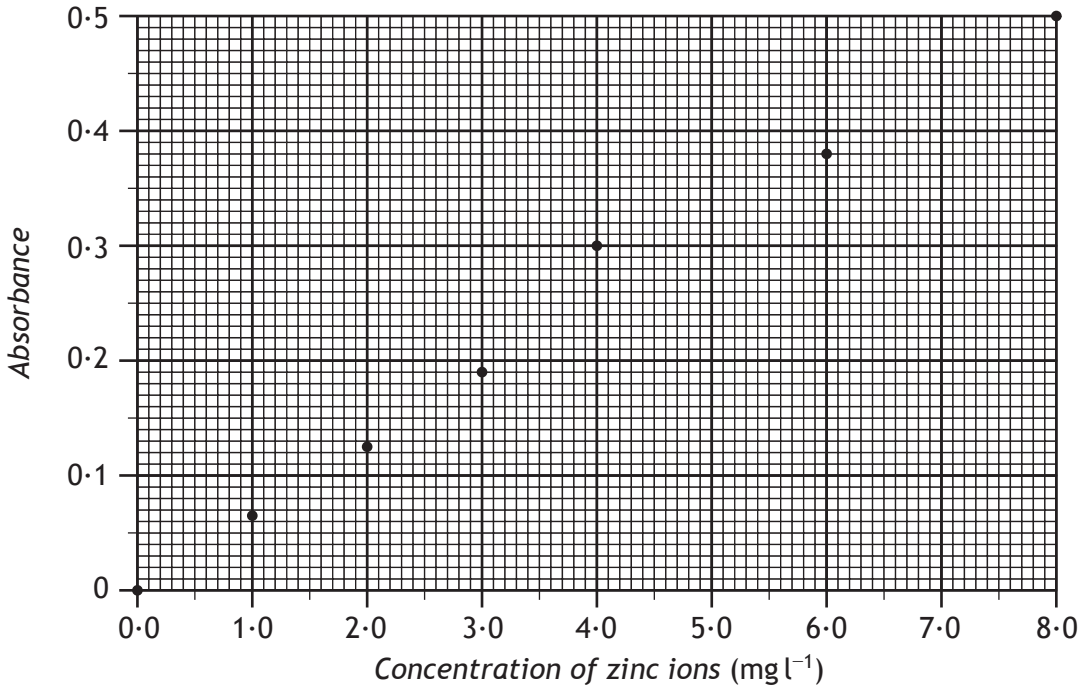
(b) Solutions of known zinc ion concentration were prepared by transferring accurate volumes of the stock solution to standard flasks and diluting with water.

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

10. (b) (continued)

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

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

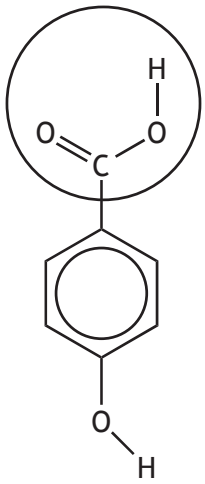


A solution prepared from a soil sample was tested to determine the concentration of zinc ions. The solution had an absorbance of 0·3.

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

MARKS | DO NOT WRITE IN THIS MARGIN

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.

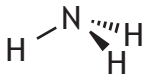
$OCl^-(aq) + NH_3(aq) \rightarrow NH_2Cl(aq) + OH^-(aq)$
monochloramine

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

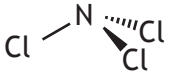
$OCl^-(aq) + NHCl_2(aq) \rightarrow NCl_3(aq) + OH^-(aq)$
trichloramine

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.



ammonia



trichloramine

2

12. (c) (continued)

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

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

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

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

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

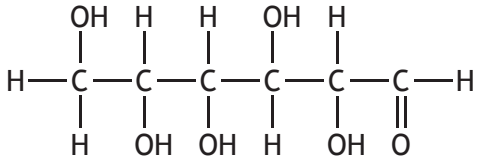
$$NH_2Cl + \bullet Cl \longrightarrow \bullet NHCl + HCl$$

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

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

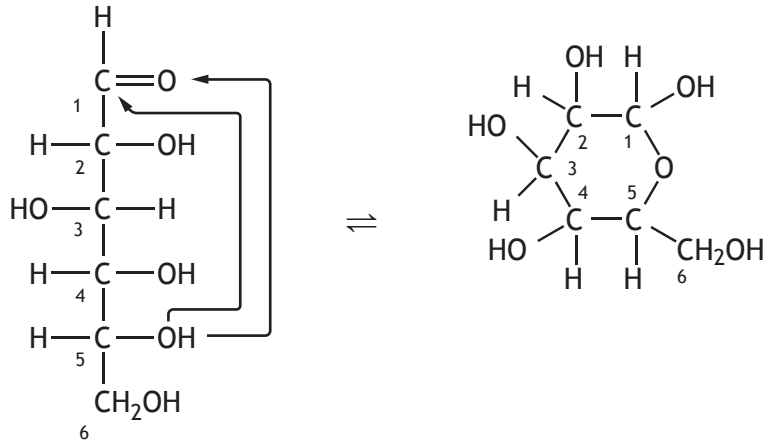
13. (a) One test for glucose involves Fehling's solution.

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



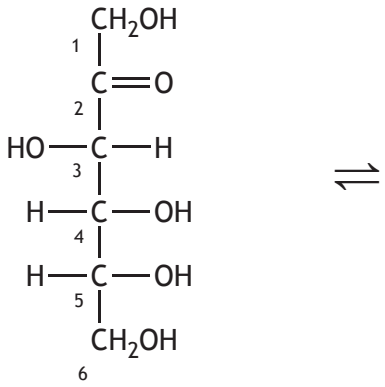
(b) In solution, sugar molecules exist in an equilibrium in straight-chain and ring forms.

To change from the straight-chain form to the ring form, the oxygen of the hydroxyl on carbon number 5 joins to the carbonyl carbon. This is shown below for glucose.



glucose

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



fructose

[END OF QUESTION PAPER]