National
Qualifications
SPECIMEN ONLY

SQ07/H/02

Chemistry
Section 1 — Questions

Date — Not applicable

Duration — 2 hours and 30 minutes

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

Instructions for the completion of Section 1 are given on *Page two* of your question and answer booklet SQ07/H/01.

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

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

SECTION 1 — 20 marks

Attempt ALL questions

1. 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?

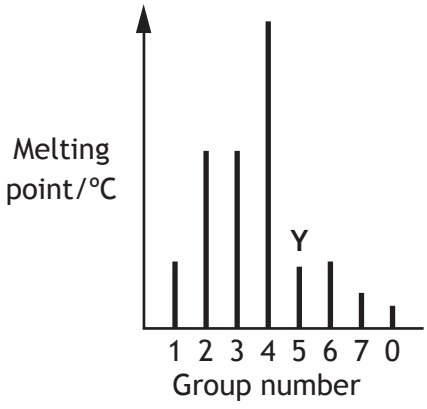
A Covalent bonding

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

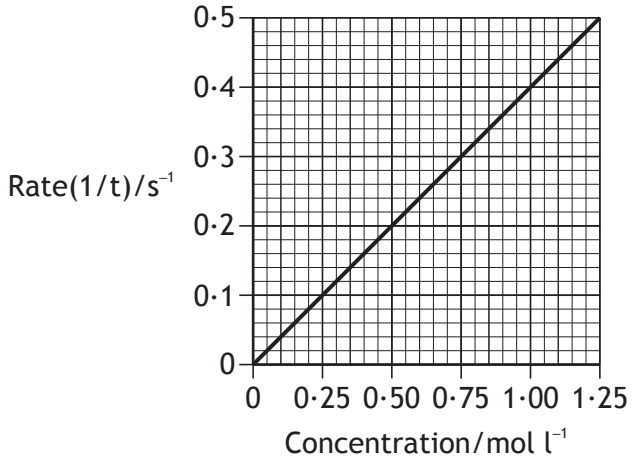
A provides energy so that more molecules have successful collisions

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?

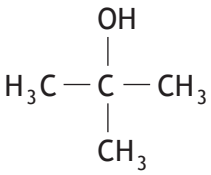
A V—Y, Z—X, W—Y, X—W

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?

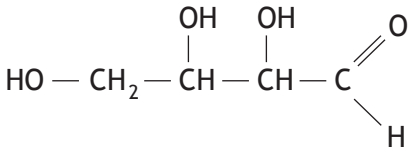
A Butanal

B Butanone

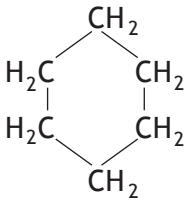
C Butan-1-ol

D Butanoic acid

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

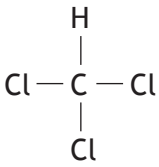


Which of the following compounds will be the best solvent for erythrose?

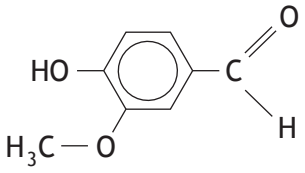
A 

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

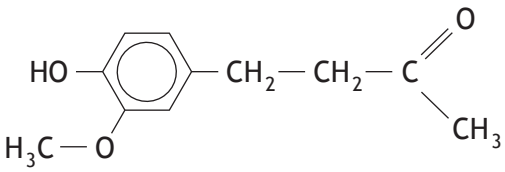
C CH_3-CH_2-OH

D 

12. Vanillin and zingerone are flavour molecules.



vanillin

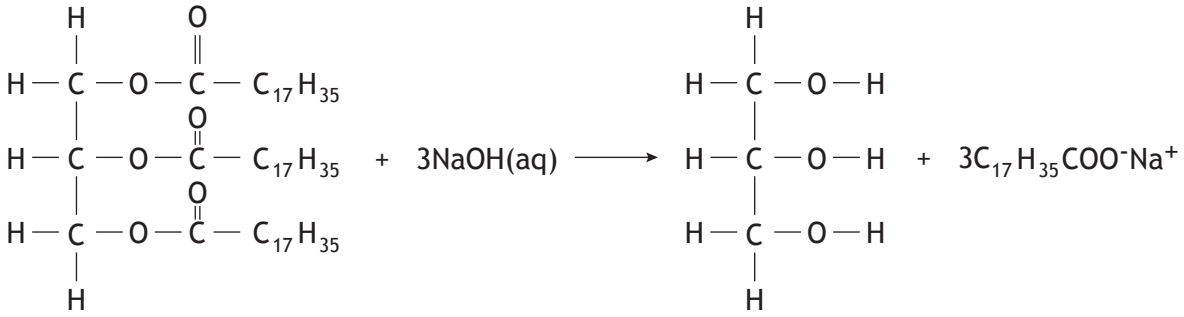


zingerone

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

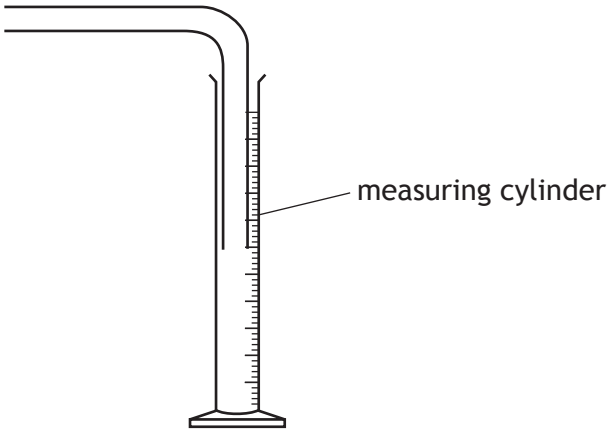
19. 45 cm^3 of a solution could be most accurately measured out using a

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

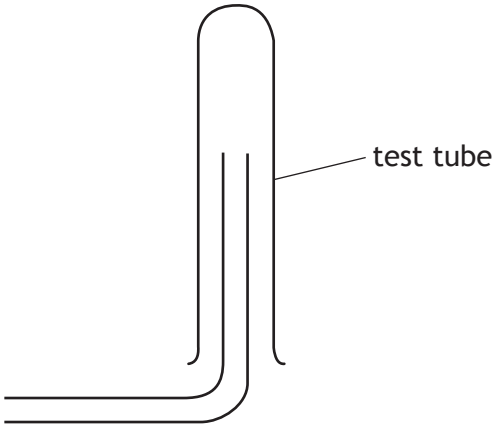
20. Sulphur dioxide gas is denser than air and is very soluble in water.

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

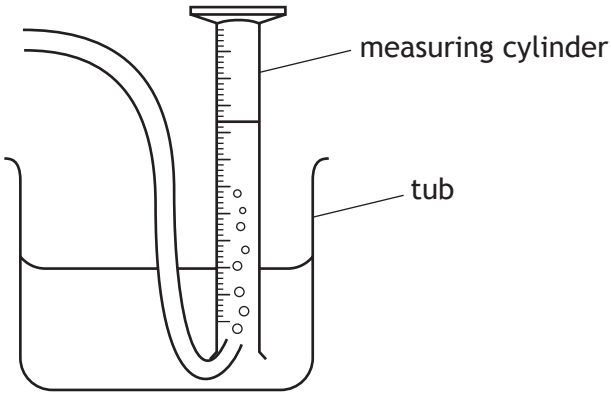
A



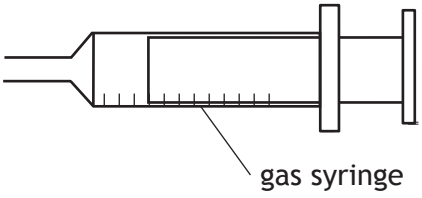
B



C



D



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

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Mark

SQ07/H/01

Chemistry
Section 1 — Answer Grid and Section 2

Date — Not applicable

Duration — 2 hours and 30 minutes

* S Q 0 7 H 0 1 *

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day	Month	Year
D D	M M	Y Y

Scottish candidate number

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

Total marks — 100

SECTION 1 — 20 marks

Attempt ALL questions.

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

SECTION 2 — 80 marks

Attempt ALL questions

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

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

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

SQA ©

SECTION 1— 20 marks

The questions for Section 1 are contained in the question paper SQ07/H/02.
Read these and record your answers on the answer grid on *Page three* opposite.
DO NOT use gel pens.

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

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

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

Sample Question

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

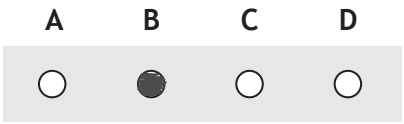
A fractional distillation

B chromatography

C fractional crystallisation

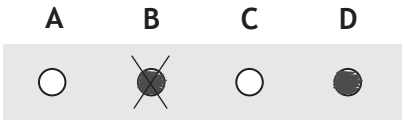
D filtration.

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

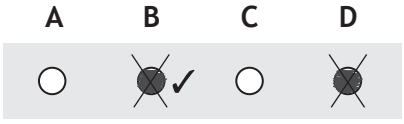


Changing an answer

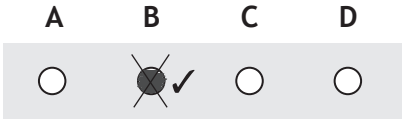
If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.



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



or



SECTION 1 — Answer Grid

OBJ20AD1

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

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

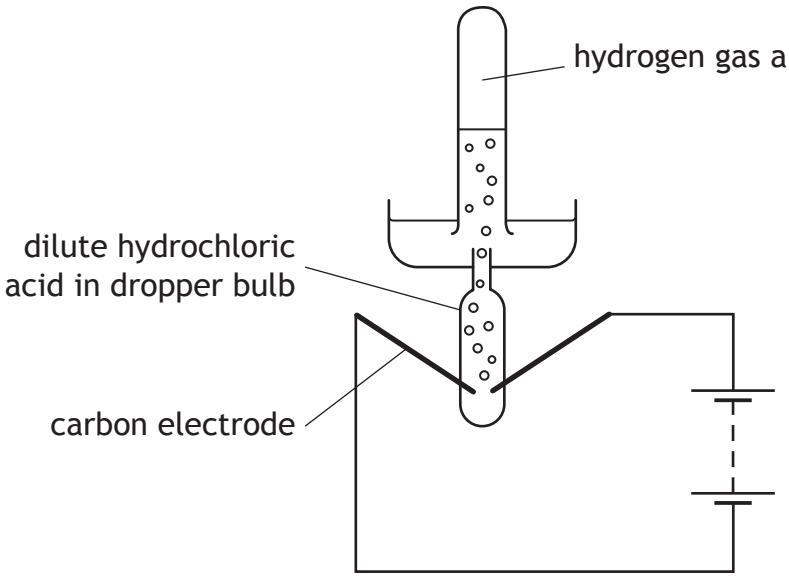
2. (a) Nitrogen dioxide gas and carbon monoxide gas can react when molecules collide.

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

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.



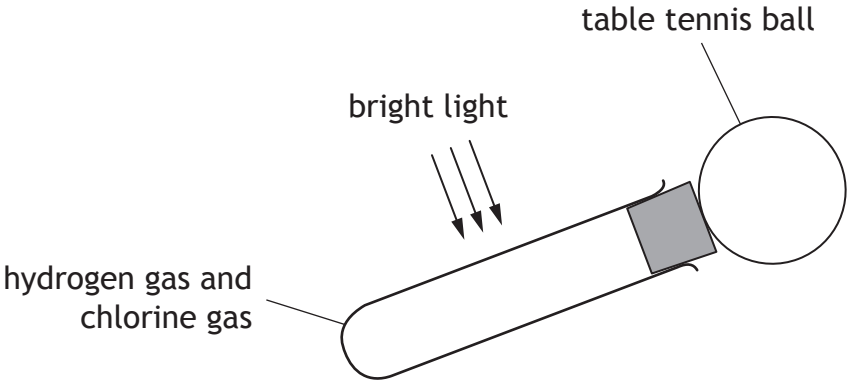
$$2HCl(aq) \rightarrow H_2(g) + Cl_2(g)$$

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.

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

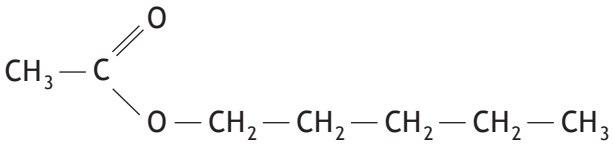
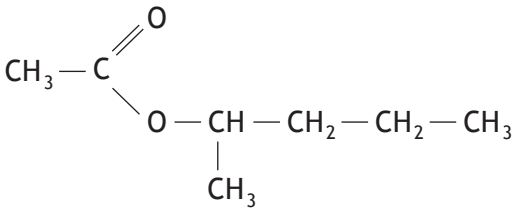
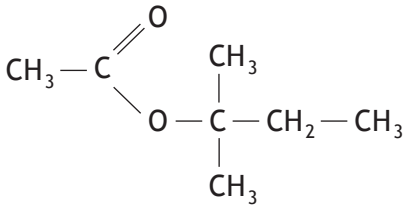
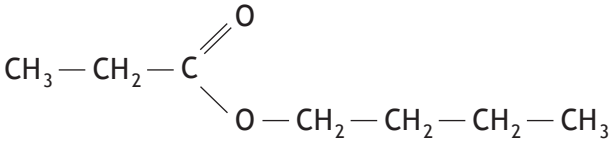
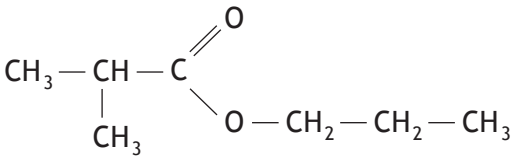
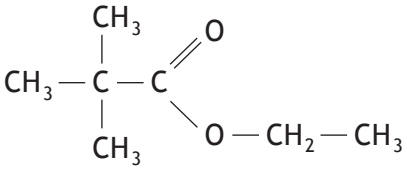
Using bond enthalpy values, calculate the enthalpy change, in kJ, for the reaction.

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.

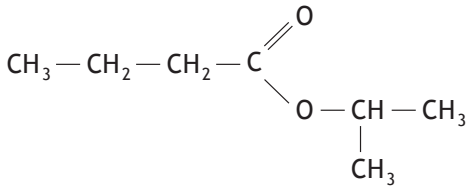
Structure	*Fruit-smell rating*
	100
	34
	0
	92
	44
	32

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

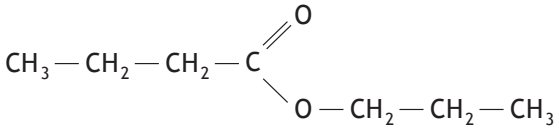
3. (a) (continued)

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

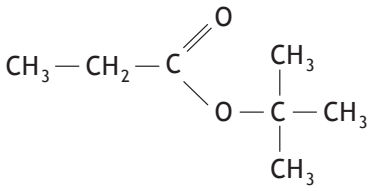
Ester **A**



Ester **B**



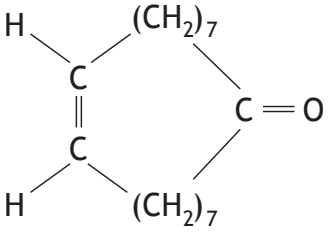
Ester **C**



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.

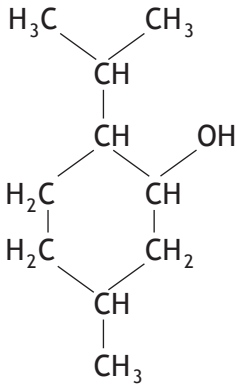


civetone

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.

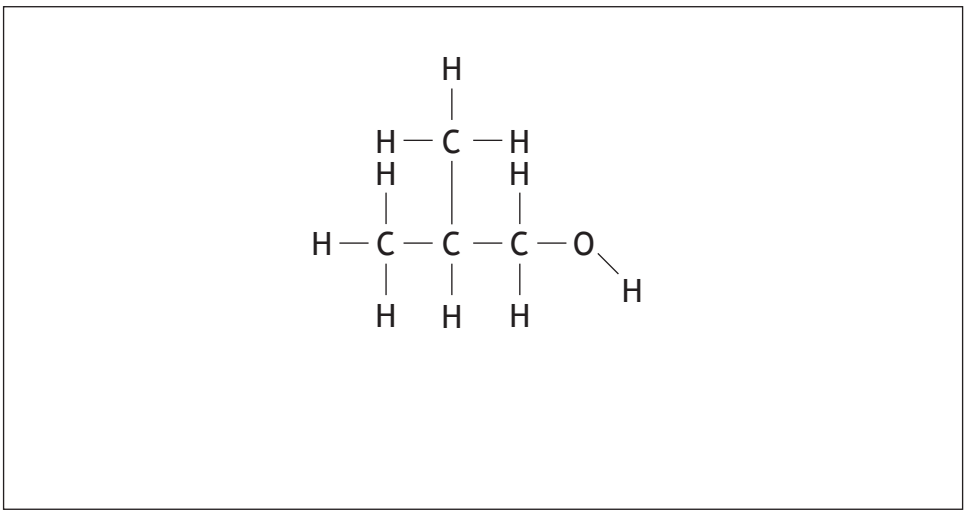
Volume of 1 g of 2-methylpropan-1-ol	1·25 cm^3
Energy from 1 g of 2-methylpropan-1-ol	3·61 kJ

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.

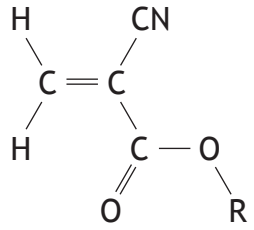
A student was asked to design an experiment to compare the viscosity of some fuels. Suggest an experiment that could be done to compare viscosities.

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

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

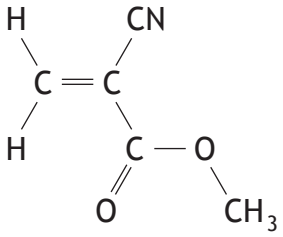
In its liquid form, super glue consists of cyanoacrylate monomers that rapidly polymerise in the presence of water to form a strong resin that joins two surfaces together.

Cyanoacrylates have the general structure



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

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

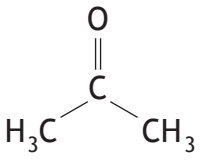


Circle the ester link in this structure. **1**

(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**

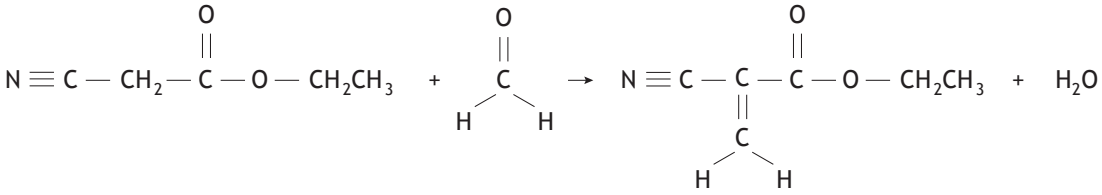
(ii) Super glue can be removed from the skin using propanone as a solvent.



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.

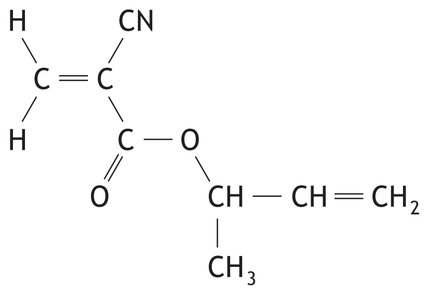
Show your working clearly. **2**

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
$-CH_2-CH_2-CH_3$ $\vert$ CH_3	420
$-CH_2-CH=CH_2$	1240
$-CH_2-C\equiv CH$	1670
$-HC-C\equiv CH$ $\vert$ CH_3	1140

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



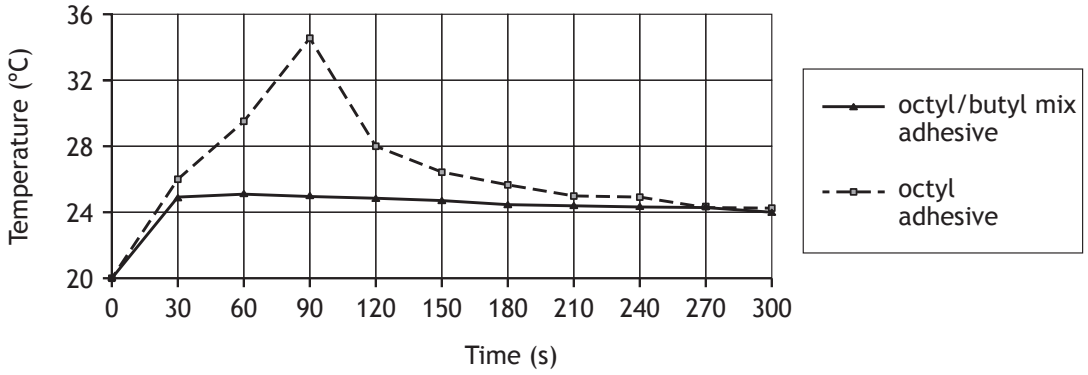
6. (continued)

(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}.

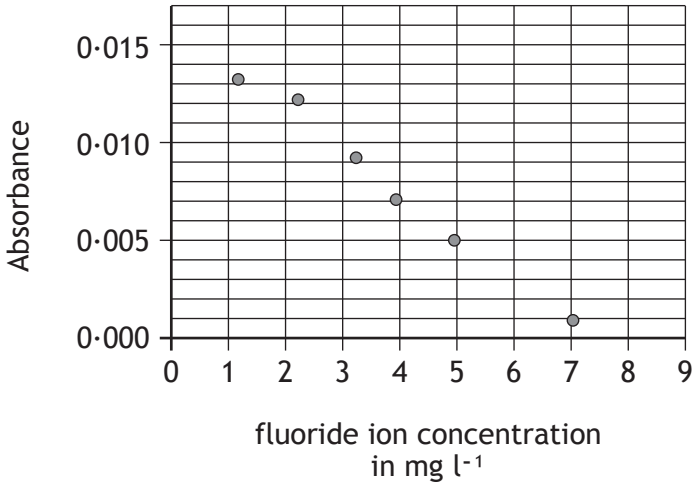
(i) State what is meant by the term **standard solution**. **1**

(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.

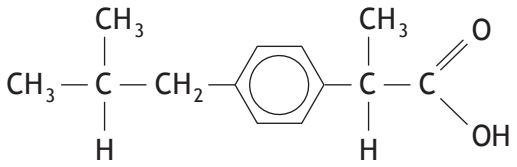
Show your working clearly. **3**

(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**

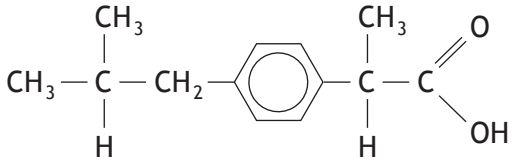
MARKS | DO NOT WRITE IN THIS MARGIN

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**

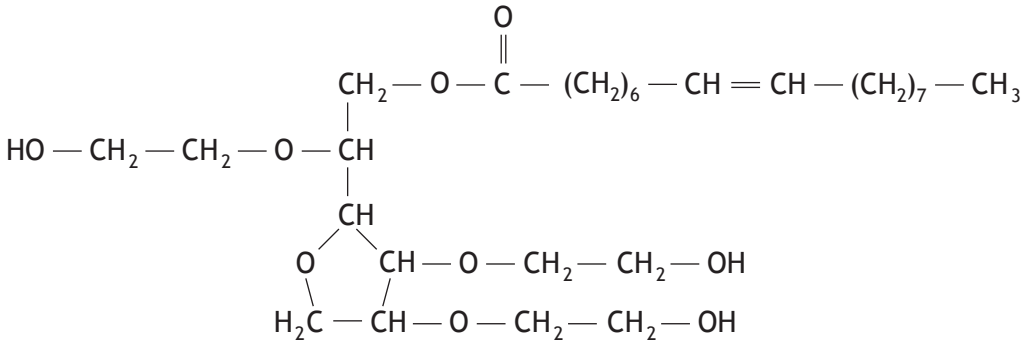
(b) Ibuprofen is normally taken as tablets or pills and it is only slightly soluble in water.



(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)

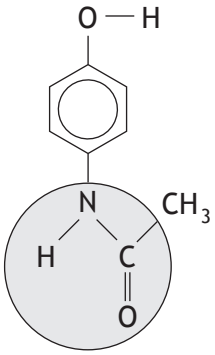
MARKS | DO NOT WRITE IN THIS MARGIN

(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.

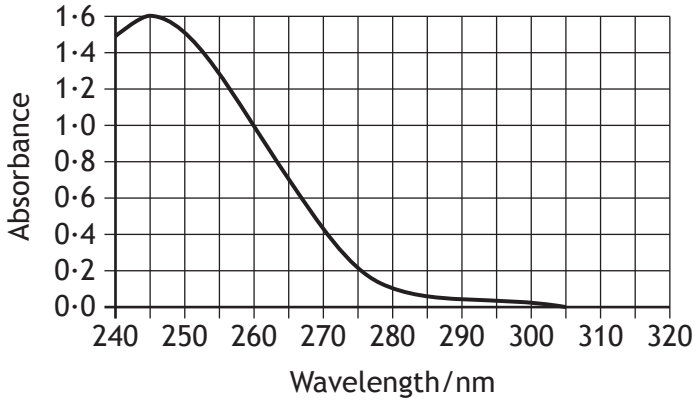


(i) Name the functional group shaded in the structure. **1**

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.

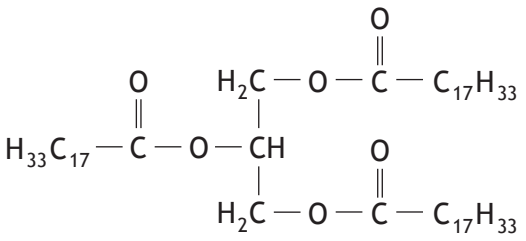
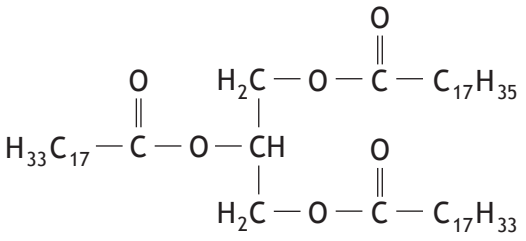
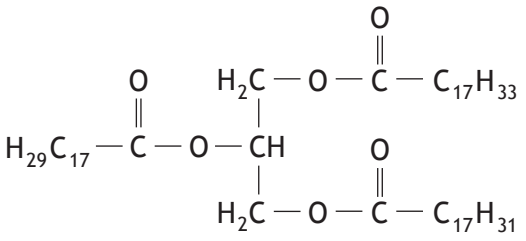
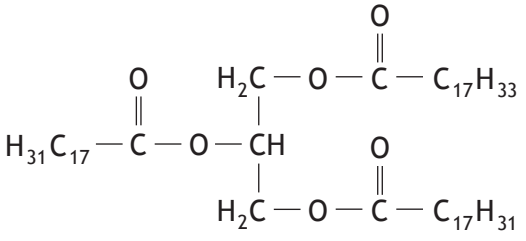


The absorbance of a second sample of paracetamol solution measured at 245 nm was 0·90.

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**

MARKS | DO NOT WRITE IN THIS MARGIN

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**

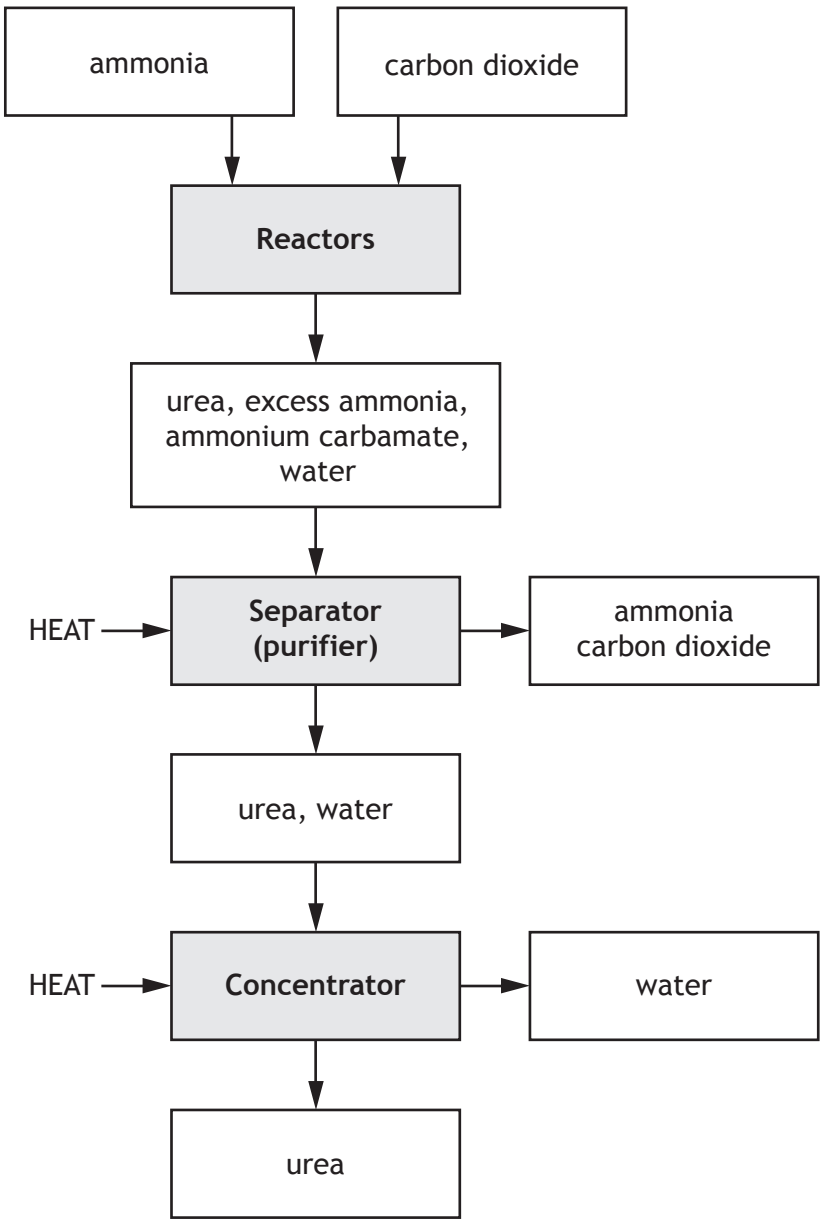
(ii) 5·0 g of triolein was dissolved in ethanol and placed in a test tube with excess sodium hydroxide. The mixture was heated to 80 °C.

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)

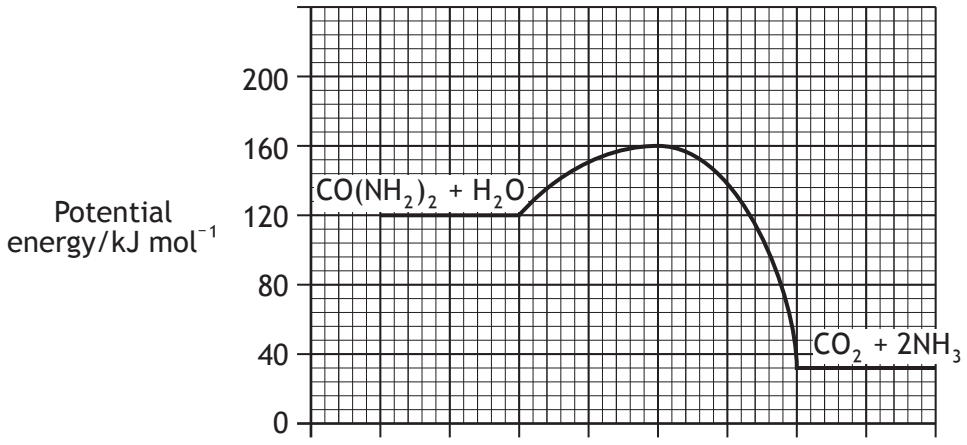
(iii) In the separator the ammonium carbamate from the reactors decomposes to form ammonia and carbon dioxide.

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

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**

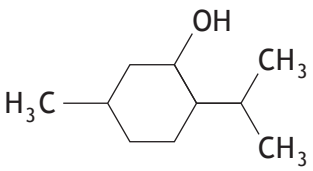
(ii) Acid is a less effective catalyst than urease for this reaction. Add a curve to the potential energy diagram to show the change in potential energy when acid is used as the catalyst. **1**

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.

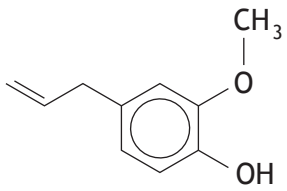
Substances used in pharmacies over a hundred years ago included:

- Essential oils dissolved in ethanol.

  Some molecules included in these essential oils were:

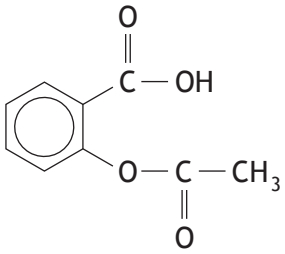


menthol



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**

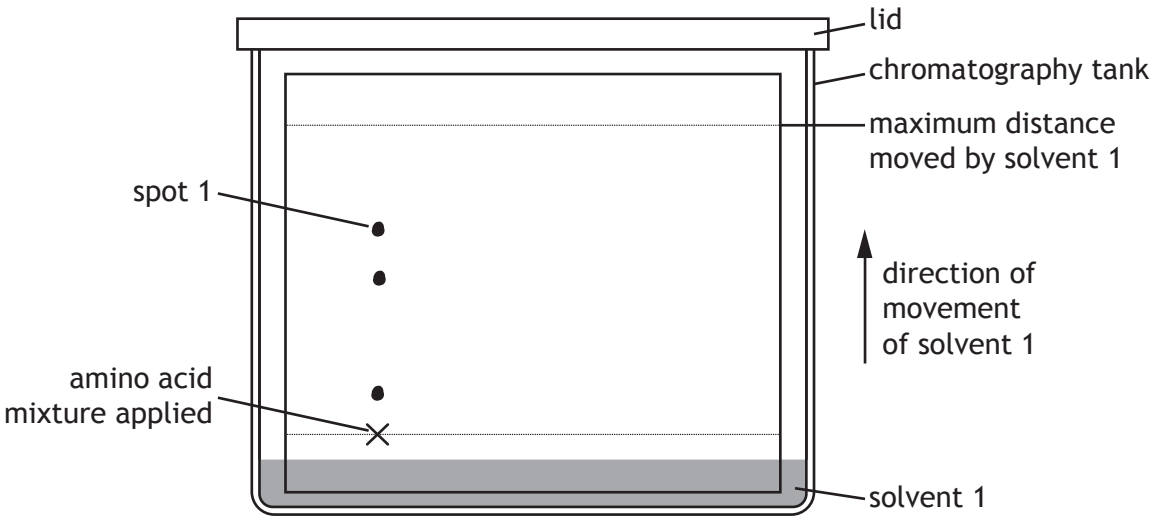
12. (continued)

(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.



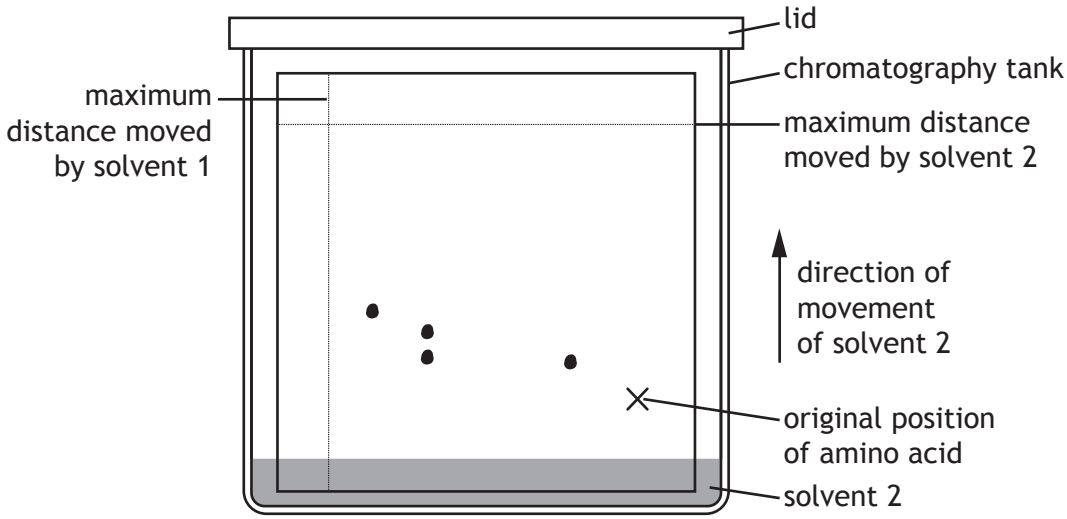
Amino Acid	R_f (*solvent 1*)
alanine	0·51
arganine	0·16
threonine	0·51
tyrosine	0·68

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]

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

National
Qualifications
SPECIMEN ONLY

SQ07/H/01 Chemistry

Marking Instructions

These Marking Instructions have been provided to show how SQA would mark this Specimen Question Paper.

SQA ©

General Marking Principles for Higher Chemistry

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

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

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

c) Half marks may not be awarded.

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

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

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

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

h) If a correct answer followed by a wrong answer should be treated as a cancelling error and no marks should be given. **For example**, in response to the question, 'State the colour seen when blue Fehling's solution is warmed with an aldehyde', the answer 'red, green' gains no marks.

However, if a correct answer is followed by additional information which does not conflict with that, the additional information should be ignored, whether correct or not. **For example,** in response to a question concerned with melting point, 'State why the tube should not be made of copper', the response 'Copper has a low melting point and is coloured grey' would **not** be treated as having a cancelling error.

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

j) Ignore the omission of one H atom from a full structural formula provided the bond is shown.

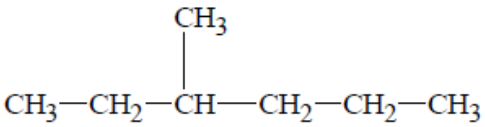
k) A symbol or correct formula should be accepted in place of a name **unless stated otherwise in the detailed marking instructions**.

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

m) If an answer comes directly from the text of the question, no marks should be given.

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

n) A guiding principle in marking is to give credit for correct elements of a response rather than to look for reasons not to give marks. **Example 1:** The structure of a hydrocarbon found in petrol is shown below.



Name the hydrocarbon.

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

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

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

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

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

o) Unless the question is clearly about a non-chemistry issue, eg costs in an industrial chemical process, a non-chemical answer gains no marks.

For example, in response to the question, 'Why does the (catalytic) converter have a honeycomb structure?', 'to make it work' may be correct but it is not a chemical answer and the mark should not be given.

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

- **identify**, **name**, **give**, or **state**, they need only name or present in brief form;
- **describe**, they must provide a statement or structure of characteristics and/or features;

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

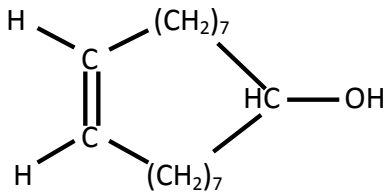
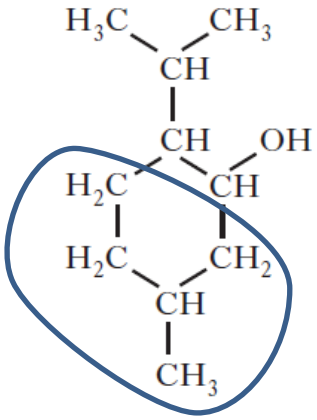
Marking Instructions for each question

Section 1

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

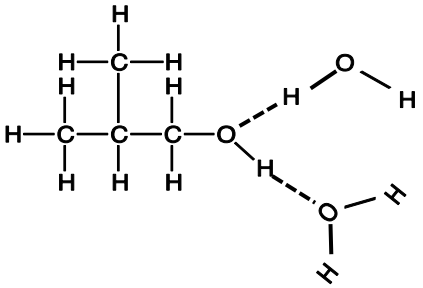
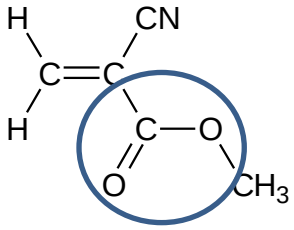
Section 2

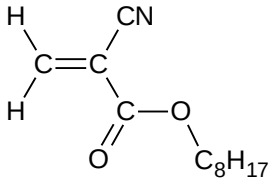
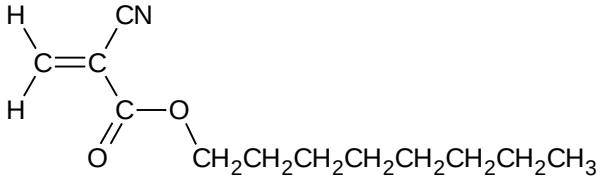
Question			Expected response	Max mark	Additional Guidance
1	a	i	$Na(g) \rightarrow Na^+(g) + e^-$	1	No necessity to show negative charge on e
1	a	ii	Idea that ionisation energy is removal of an electron (1 mark) Idea that 1st ionisation energy is removal of electron from 3rd (outermost) shell and second is removal of electron from an inner shell. (1 mark) Idea of shielding effect of inner electrons ie that second electron is less well shielded from nuclear pull and therefore more energy is needed to remove electron. or The removal from a full shell requires more energy than removal from an incomplete shell. (1 mark)	3	
1	b		0·178 g (0·18 g)	1	
2	a		Molecules must collide with energy greater than activation energy (sufficient energy to react) (1 mark) and molecules must collide with correct orientation (1 mark)	2	Energy mark must convey the idea that there is a minimum energy required for the molecules to react
2	b	i	2 moles acid give 2 moles gas (1 mark) Answer = 0·00041 (0·0004) mol (1 mark)	2	
2	b	ii	**Reaction step** / **Name of step** $Cl_2 \rightarrow 2Cl\bullet$ — **Initiation** (1 mark) $Cl\bullet + H_2 \rightarrow HCl + H\bullet$ $H\bullet + Cl_2 \rightarrow HCl + Cl\bullet$ — propagation $H\bullet + Cl\bullet \rightarrow HCl$ (1 mark) (or any appropriate reaction step in which two free radicals combine to give a molecule) — termination	2	
2	b	iii	Correct bond enthalpies selected (432; 243; 428 kJ mol^{-1}) (1 mark) Answer = −181	2	Negative sign required in the answer

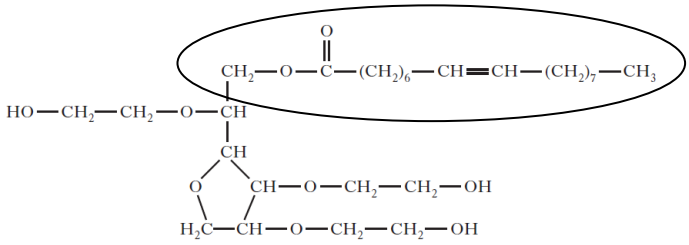
Question			Expected response	Max mark	Additional Guidance
3	a	i	Butyl propanoate (1 mark)	1	
3	a	ii	B > A > C (1 mark)	1	
3	b			1	H must be shown on C to which hydroxyl group is attached.
3	c		 (1 mark)	1	Any group of 5 carbons with 1 branch. OH to be ignored.

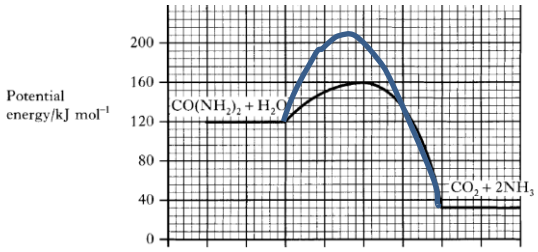
4	**The whole candidate response should first be read to establish its overall quality in terms of accuracy and relevance to the problem/situation presented.** There may be strengths and weaknesses in the candidate response: *assessors should focus as far as possible on the strengths, taking account of weaknesses (errors or omissions) only where they detract from the overall answer in a significant way, which should then be taken into account when determining whether the response demonstrates **reasonable**, **limited** or **no** understanding.* **Assessors should use their professional judgement to apply the guidance below to the wide range of possible candidate responses.**	This open-ended question requires comment on **the changes to food that may occur during cooking.** Candidate responses are expected to make comment on the basis of relevant chemistry ideas/concepts which might include one or more of: denaturing proteins; solubility of flavouring molecules; effect on antioxidants; emulsification; or other relevant ideas/concepts. Note that 'cooking' should be taken to mean any steps in a recipe.
	3 marks: The candidate has demonstrated a **good** conceptual understanding of the chemistry involved, providing a logically correct response to the problem/situation presented. This type of response might include a	In response to this question, a **good** understanding might be demonstrated by a candidate response that: • makes comments based on one relevant chemistry idea/concept, in a **detailed/developed** response that is

	statement of principle(s) involved, a relationship or equation, and the application of these to respond to the problem/situation. This does not mean the answer has to be what might be termed an 'excellent' answer or a 'complete' one.	**correct or largely correct** (any weaknesses are minor and do not detract from the overall response), **OR** • makes comments based on a range of relevant chemistry ideas/concepts, in a response that is **correct or largely correct** (any weaknesses are minor and do not detract from the overall response), **OR** • otherwise demonstrates a good understanding of the chemistry involved.
	2 marks: The candidate has demonstrated a **reasonable** understanding of the chemistry involved, showing that the problem/situation is understood. This type of response might make some statement(s) that is/are relevant to the problem/situation, for example, a statement of relevant principle(s) or identification of a relevant relationship or equation.	In response to this question, a **reasonable** understanding might be demonstrated by a candidate response that: • makes comments based on one or more relevant chemistry idea(s)/concept(s), in a response that is **largely correct** but has **weaknesses** which detract to a small extent from the overall response, **OR** • otherwise demonstrates a reasonable understanding of the chemistry involved.
	1 mark: The candidate has demonstrated a **limited** understanding of the chemistry involved, showing that a little of the chemistry that is relevant to the problem/situation is understood. The candidate has made some statement(s) that is/are relevant to the problem/situation.	In response to this question, a **limited** understanding might be demonstrated by a candidate response that: • makes comments based on one or more relevant chemistry idea(s)/concept(s), in a response that has **weaknesses** which detract to a large extent from the overall response, **OR** • otherwise demonstrates a limited understanding of the chemistry involved.
	0 marks: The candidate has demonstrated **no** understanding of the chemistry that is relevant to the problem/situation. The candidate has made no statement(s) that is/are relevant to the problem/situation.	Where the candidate has *only* demonstrated knowledge and understanding of chemistry **that is not relevant to the problem/situation presented**, 0 marks should be awarded.

Question			Expected response	Max mark	Additional Guidance
5	a		(351 000/36·1) * 1·25 (1 mark) = 12 154 cm^3 or 12·15 litres 1 mark for correctly calculated figure 1 mark for correct units	3	
5	b		 One or the other hydrogen bonds may be shown	1	Only one water molecule with the hydrogen bond need be shown.
5	c		ΔH = [+ 335 + (−17) + (−242)] (1 mark) = (+) 76 ($kJ\,mol^{-1}$) (1 mark)	2	Sign and units need not be given in answer but if given must be correct
5	d		1 mark for design of experiment. Eg inverting sealed tubes and measuring time taken for an air bubble to rise through the tube or dropping a ballbearing into the fuels and timing how long they take to drop or any other reasonable experiment. 1 mark for stating how experiment allows viscosities to be compared.	2	
6	a		 (1 mark)	1	
6	b	i	moisture/water on the surface of the skin / cyanoacrylate monomers rapidly polymerise in the presence of water (1 mark)	1	
6	b	ii	permanent dipole – permanent dipole attractions (1 mark)	1	
6	c	i	Methanal (1 mark)	1	
6	c	ii	Condensation (1 mark)	1	
6	c	iii	Atom economy = [mass of ethyl-2-cyanoacrylate/total mass of reactants] x 100 (1 mark) = [125 / 143] x100 = 87·41% (1 mark)	2	
6	d		Value between 420 and 1140 Ncm^{-2} (1 mark)	1	units not required

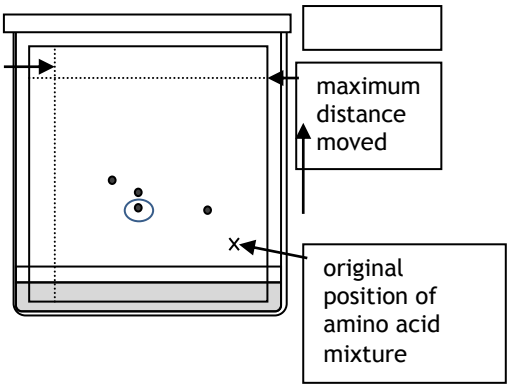
Question			Expected response	Max mark	Additional Guidance
6	e	i	 or  (1 mark)	1	accept any saturated C-8 side-chain
6	e	ii	Less heat is given out/less exothermic reaction using the octyl/butyl mix so less damage/pain/burning will occur to the wound/patient's skin or the reaction takes place more quickly sealing the wound (1 mark)	1	
7	a	i	A solution of accurately known concentration (1 mark)	1	
7	a	ii	The weighed sample is dissolved in a small volume of (deionised) water in a beaker and the solution transferred to a standard flask. The beaker is rinsed and the rinsings also poured into the standard flask. (1 mark) The flask is made up to the mark adding the last few drops of water using a dropping pipette. The flask is stoppered and inverted several times to ensure thorough mixing of the solution. (1 mark)	2	
7	a	iii	Tap water contains dissolved salts (1mark) that may react with sodium fluoride and affect the concentration of the solution. (1 mark)	2	
7	a	iv	2 mg l^{-1} (1 mark)	1	
7	b	i	Moles $MnO_4^-(aq)$ = 0·00034 mol (1 mark) Moles $NO_2^-(aq)$ in 25 cm^3 = 0·0081 mol (1 mark) Concentration = 0·0324 mol l^{-1} (1 mark)	3	
7	b	ii	$NO_2^-(aq) + H_2O(l) \rightarrow NO_3^-(aq) + 2H^+(aq) + 2e^-$ (1 mark)	1	State symbols and charge on electron are not essential
8	a		Carboxyl (group) (1 mark)	1	
8	b	i	Large hydrocarbon section attached to the carboxyl group making this section insoluble in water. (1 mark)	1	

Question			Expected response	Max mark	Additional Guidance
8	b	ii	 (1 mark)	1	Identified portion does not need to include the ester link.
8	b	iii	$2{\cdot}5\ cm^3$ (1 mark)	1	
8	c	i	Amide/peptide (link) (1 mark)	1	
8	c	ii	0·023(0·0225)	1	
9	a	i	Shea butter has fewer double bonds/is not very unsaturated (1 mark) The London dispersion forces or van der Waals' forces between its molecules are stronger than in oils, therefore melting point higher. (1 mark)	2	
9	a	ii	85-171	1	Actual answer is approx. 134
9	a	iii	oxygen	1	
9	b	i	Glycerol/propane-1,2,3-triol	1	
9	b	ii	Waterbath/Heating mantle	1	Bunsen burner is not acceptable
9	b	iii	= 24·8/25% (2 marks) Calculates the theoretical yield of soap (= 5·16g) OR correctly calculates the number of moles of reactant (= 0·00566) **and** product (= 0·00421) [1·28/304] (1 mark) 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 (1 mark)	2	Not acceptable for % yield mark to use 1·28/5 or 3 x 1·28/5.
10	a	i	2 mol NH_3 gives 1 mol $(NH_2)_2CO$ (1 mark) or 34 g gives 60 g (1 mark) 300 tonnes (1 mark)	2	Units not required
10	a	ii	An excess of ammonia will push the equilibrium to the left (1 mark)	1	

Question			Expected response	Max mark	Additional Guidance
10	a	iii	Low pressure favours the reaction that produces gas molecules thereby increasing the pressure. or there are more moles of gas on the right-hand side of the equation (1 mark) The forward reaction will be favoured by low pressure causing the carbamate to break down (1 mark)	2	
10	a	iv	A line from the ammonia carbon dioxide coming from the separator back to the Reactors (1 mark)	1	
10	b	i	−88 kJ mol^{-1} (1 mark)		Negative sign required; units not required
10	b	ii	 (1 mark)	1	Curve showing higher activation energy

11	**The whole candidate response should first be read to establish its overall quality in terms of accuracy and relevance to the problem/situation presented.** There may be strengths and weaknesses in the candidate response: *assessors should focus as far as possible on the strengths, taking account of weaknesses (errors or omissions) only where they detract from the overall answer in a significant way, which should then be taken into account when determining whether the response demonstrates **reasonable**, **limited** or **no** understanding.* **Assessors should use their professional judgement to apply the guidance below to the wide range of possible candidate responses.**	This open-ended question requires comment on **what compounds the old pharmacy jars might contain now.** Candidate responses are expected to make comment, on the basis of relevant chemistry ideas/concepts which might include one or more of: reactions of molecules with ethanol; or reaction of molecules with each other; or with oxygen if this has entered; or length of time for reactions to happen; or other relevant ideas/concepts.
	3 marks: The candidate has demonstrated a **good** conceptual understanding of the chemistry involved, providing a logically correct response to the problem/situation presented. This type of response might include a statement of principle(s) involved, a relationship or equation, and the application of these to respond to the	In response to this question, a **good** understanding might be demonstrated by a candidate response that: • makes comments based on one relevant chemistry idea/concept, in a **detailed/developed** response that is **correct or largely correct** (any weaknesses are minor and do not

	problem/situation. This does not mean the answer has to be what might be termed an 'excellent' answer or a 'complete' one.	detract from the overall response), **OR** • makes comments based on a range of relevant chemistry ideas/concepts, in a response that is **correct or largely correct** (any weaknesses are minor and do not detract from the overall response), **OR** • otherwise demonstrates a good understanding of the chemistry involved.
	2 marks: The candidate has demonstrated a **reasonable** understanding of the chemistry involved, showing that the problem/situation is understood. This type of response might make some statement(s) that is/are relevant to the problem/situation, for example, a statement of relevant principle(s) or identification of a relevant relationship or equation.	In response to this question, a **reasonable** understanding might be demonstrated by a candidate response that: • makes comments based on one or more relevant chemistry idea(s)/concept(s), in a response that is **largely correct** but has **weaknesses** which detract to a small extent from the overall response, **OR** • otherwise demonstrates a reasonable understanding of the chemistry involved.
	1 mark: The candidate has demonstrated a **limited** understanding of the chemistry involved, showing that a little of the chemistry that is relevant to the problem/situation is understood. The candidate has made some statement(s) that is/are relevant to the problem/situation.	In response to this question, a **limited** understanding might be demonstrated by a candidate response that: • makes comments based on one or more relevant chemistry idea(s)/concept(s), in a response that has **weaknesses** which detract to a large extent from the overall response, **OR** • otherwise demonstrates a limited understanding of the chemistry involved.
	0 marks: The candidate has demonstrated **no** understanding of the chemistry that is relevant to the problem/situation. The candidate has made no statement(s) that is/are relevant to the problem/situation.	Where the candidate has *only* demonstrated knowledge and understanding of chemistry **that is not relevant to the problem/situation presented**, 0 marks should be awarded.

Question			Expected response	Max mark	Additional Guidance
12	a		An amino acid that must be obtained through our diet OR cannot be synthesised by the body (1 mark)	1	
12	b		RDA (60kg adult) = 900 mg (1 mark) Mass of tuna = 119 (119·2) g (1 mark)	2	
12	c	i	Tyrosine (1 mark)	1	
12	c	ii	 (1 mark)	1	
12	c	iii	With solvent, alanine and threonine have the same R_f value and travel the same distance and show as a single spot. When they are placed in solvent 2 the spot splits into 2 since alanine and threonine have different R_f values. (1 mark)	1	

[END OF SPECIMEN MARKING INSTRUCTIONS]