

# Higher Chemistry

## Unit 2 Past Paper Questions

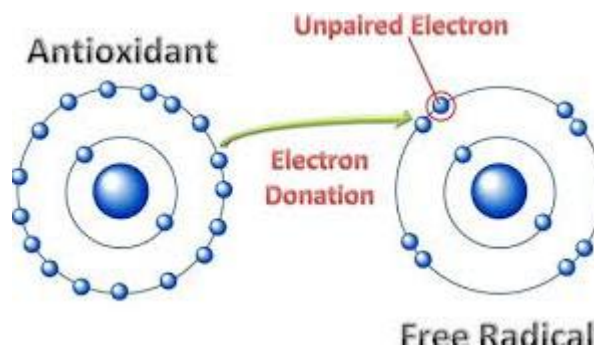
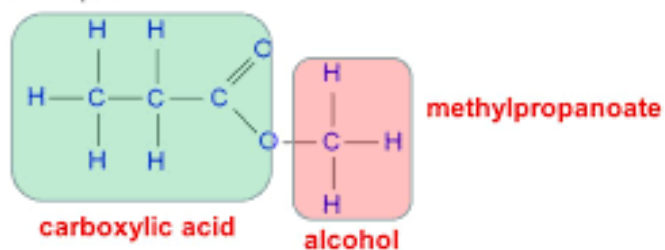
### Naming Esters

Form: (alcohol) (acid-anoate)

Drop -anol,  
replace with "yl"

Change from "-oic acid"  
to "-oate"

Example:



## Unit 2 – Nature's Chemistry

### SECTION 1

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

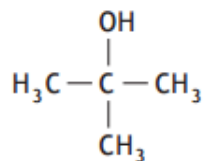
	<i>Amides</i>	<i>Salts</i>	<i>Esters</i>
A	Fat	Soap	Protein
B	Fat	Protein	Soap
C	Soap	Fat	Protein
D	Protein	Soap	Fat

2. 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

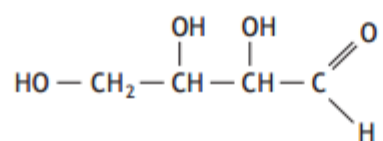
3.



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

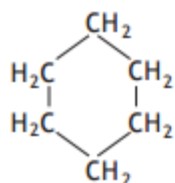
- A Butanal  
B Butanone  
C Butan-1-ol  
D Butanoic acid

4. 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?

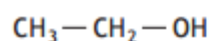
A



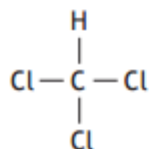
B



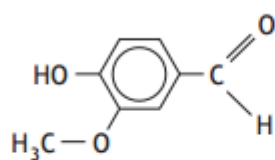
C



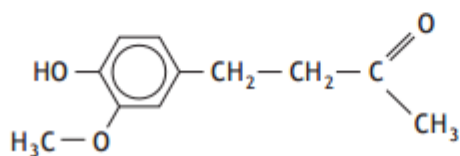
D



5. Vanillin and zingerone are flavour molecules.



vanillin

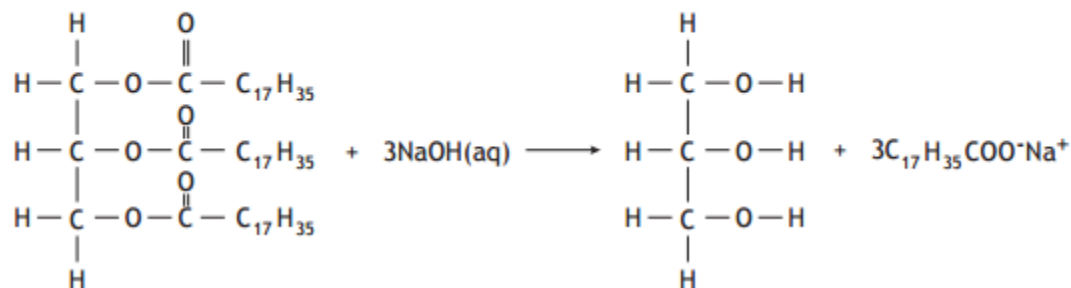


zingerone

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

	<i>More soluble in water</i>	<i>More volatile</i>
A	vanillin	vanillin
B	vanillin	zingerone
C	zingerone	vanillin
D	zingerone	zingerone

6. Soaps are produced by the following reaction.



This reaction is an example of

- A condensation  
 B esterification  
 C hydrolysis  
 D oxidation.
7. 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.
8. 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
9. 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.

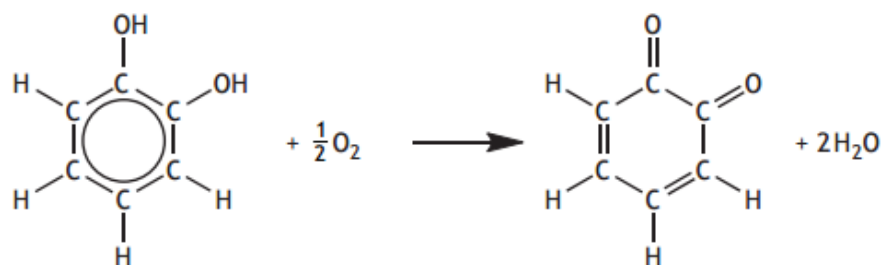
Which line in the table shows the oil that is likely to have the lowest melting point?

	<i>Oil</i>	<i>Iodine number</i>
A	Corn	123
B	Linseed	179
C	Olive	81
D	Soya	130

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

- A  $\begin{array}{c} \text{COOH} \\ | \\ \text{CHOH} \\ | \\ \text{COOH} \end{array}$
- B  $\begin{array}{c} \text{CH}_2\text{OH} \\ | \\ \text{CHOH} \\ | \\ \text{CH}_2\text{OH} \end{array}$
- C  $\text{C}_{17}\text{H}_{35}\text{COOH}$
- D  $\text{C}_{17}\text{H}_{33}\text{COOH}$

11. Enzymes are involved in the browning of cut fruit.  
One reaction taking place is:



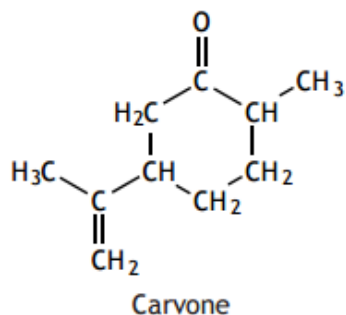
Which of the following correctly describes the above reaction?

- A Oxidation
- B Reduction
- C Hydrolysis
- D Condensation

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

- A They are formed by oxidation of tertiary alcohols.
- B They contain the group  $\begin{array}{c} \text{O} \\ // \\ \text{---C} \\ \backslash \\ \text{H} \end{array}$ .
- C They contain a carboxyl group.
- D They will not react with Fehling's solution.

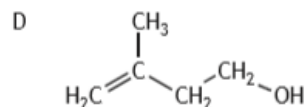
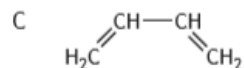
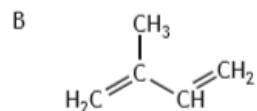
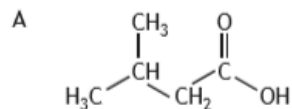
13. Carvone is a natural product that can be extracted from orange peel.



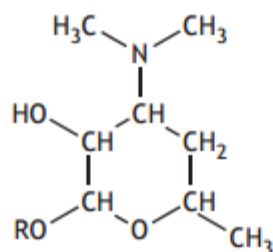
Which line in the table correctly describes the reaction of carvone with bromine solution and with acidified potassium dichromate solution?

	<i>Reaction with bromine solution</i>	<i>Reaction with acidified potassium dichromate solution</i>
A	no reaction	no reaction
B	no reaction	orange to green
C	decolourises	orange to green
D	decolourises	no reaction

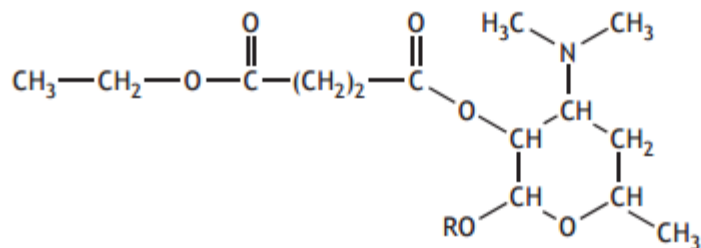
14. The structure of isoprene is



15. 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
16. Which of the following is an isomer of 2,2-dimethylpentan-1-ol?
- A  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$
  - B  $(\text{CH}_3)_3\text{CCH}(\text{CH}_3)\text{CH}_2\text{OH}$
  - C  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
  - D  $(\text{CH}_3)_2\text{CHC}(\text{CH}_3)_2\text{CH}_2\text{CH}_2\text{OH}$
17. vegetable oil  $\longrightarrow$  vegetable fat

Which of the following reactions brings about the above change?

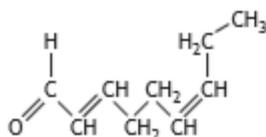
- A Hydrolysis
- B Condensation
- C Hydrogenation
- D Dehydrogenation

18.

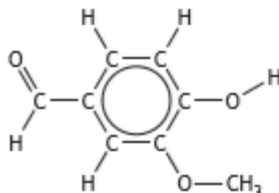
The following molecules give flavour to food.

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

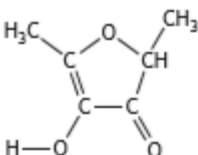
A



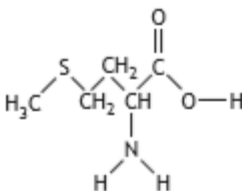
B



C



D



19.

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

- A Fat
- B Oil
- C Soap
- D Glycerol

20.

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

- A esters
- B glycerol
- C fatty acids
- D amino acids.

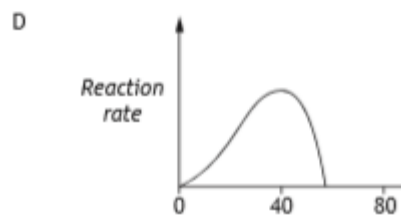
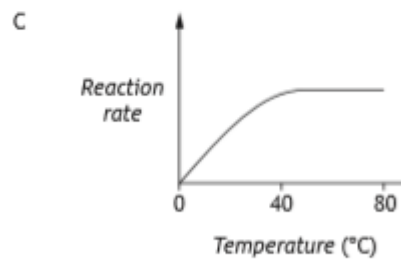
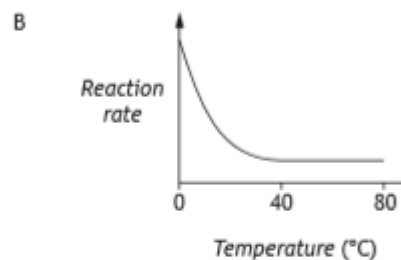
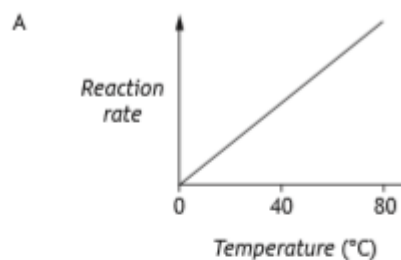
21.

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

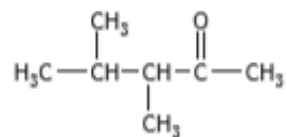
- A  $\text{Cu}^{2+}(\text{aq}) + \text{e}^{-} \rightarrow \text{Cu}^{+}(\text{aq})$
- B  $\text{Ag}^{+}(\text{aq}) + \text{e}^{-} \rightarrow \text{Ag}(\text{s})$
- C  $\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^{+}(\text{aq}) + 6\text{e}^{-} \rightarrow 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\ell)$
- D  $\text{MnO}_4^{-}(\text{aq}) + 8\text{H}^{+}(\text{aq}) + 5\text{e}^{-} \rightarrow \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\ell)$



22. The rate of hydrolysis of protein, using an enzyme, was studied at different temperatures. Which of the following graphs would be obtained?



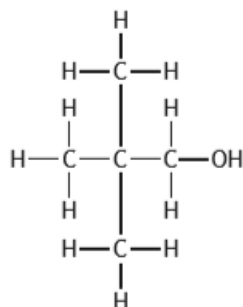
23. The name of the compound with structure:



is

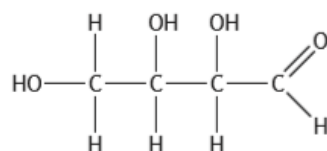
- A 2,3-dimethylpentan-4-one
- B 2,3-dimethylpentan-2-al
- C 3,4-dimethylpentan-2-one
- D 3,4-dimethylpentan-2-al.

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



- A 2,2,2-trimethylethanol  
B 2,2-dimethylpropan-1-ol  
C 2,2-dimethylpropan-3-ol  
D 2,2-dimethylpentan-1-ol
25. Which of the following fatty acids is the most unsaturated?
- A C<sub>15</sub>H<sub>29</sub>COOH  
B C<sub>15</sub>H<sub>31</sub>COOH  
C C<sub>17</sub>H<sub>31</sub>COOH  
D C<sub>17</sub>H<sub>35</sub>COOH
26. Which of the following is **not** a step in a free radical chain reaction?
- A Activation  
B Initiation  
C Propagation  
D Termination
27. Which of the following is an isomer of ethyl propanoate (CH<sub>3</sub>CH<sub>2</sub>COOCH<sub>2</sub>CH<sub>3</sub>)?
- A Methyl propanoate  
B Pentan-2-one  
C Pentanoic acid  
D Pentane-1,2-diol
28. Essential oils are
- A non-water soluble, non-volatile compounds  
B non-water soluble, volatile compounds  
C water soluble, non-volatile compounds  
D water soluble, volatile compounds.

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

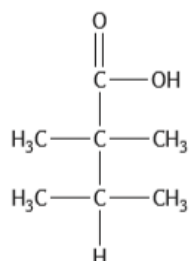


erythrose

The two functional groups present in erythrose are

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

- 30.



The name of the above compound is

- A 2,2,3-trimethylbutanoic acid  
B 2,3,3-trimethylbutanoic acid  
C 1,1,2,2-tetramethylpropanoic acid  
D 2,2,3,3-tetramethylpropanoic acid.
31. Which of the following is an isomer of pentan-3-ol?
- A  $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$   
B  $\text{CH}_3\text{CHCHCH}_2\text{CH}_2\text{OH}$   
C  $\text{CH}_3\text{CHCHCH}(\text{OH})\text{CH}_3$   
D  $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{OH}$

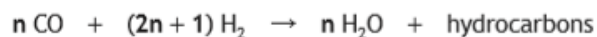
32. Oxidation of 4-methylpentan-2-ol to the corresponding ketone results in the alcohol

- A losing 2 g per mole  
B gaining 2 g per mole  
C losing 16 g per mole  
D gaining 16 g per mole.

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

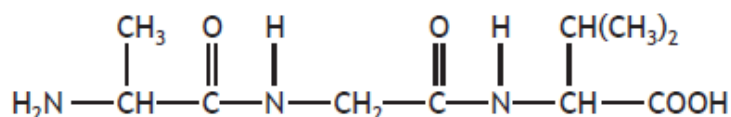
- A are necessary for building proteins  
B humans must acquire through their diet  
C plants cannot synthesise for themselves  
D are produced when any protein is hydrolysed.

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



What is the general formula for the hydrocarbons produced?

- A  $\text{C}_n\text{H}_{2n-2}$   
 B  $\text{C}_n\text{H}_{2n}$   
 C  $\text{C}_n\text{H}_{2n+1}$   
 D  $\text{C}_n\text{H}_{2n+2}$
35. Which of the following compounds is a tertiary alcohol?
- A 2,2-dimethylpropan-1-ol  
 B 2-methylbutan-2-ol  
 C pentan-3-ol  
 D 3-methylbutan-2-ol
36. Molecule X has the structure



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

- A  $\begin{array}{ccccccc} & \text{O} & \text{H} & \text{CH}(\text{CH}_3)_2 \\ & || & | & | \\ \text{H}_2\text{N} - & \text{CH}_2 - & \text{C} & - \text{N} & - \text{CH} - \text{COOH} \end{array}$
- B  $\begin{array}{ccccccc} & \text{O} & \text{H} & \text{CH}_3 \\ & || & | & | \\ \text{H}_2\text{N} - & \text{CH}_2 - & \text{C} & - \text{N} & - \text{CH} - \text{COOH} \end{array}$
- C  $\begin{array}{ccccccc} & \text{CH}_3 & \text{O} & \text{H} & \text{CH}(\text{CH}_3)_2 \\ & | & || & | & | \\ \text{H}_2\text{N} - & \text{CH} & - \text{C} & - \text{N} & - \text{CH} - \text{COOH} \end{array}$
- D  $\begin{array}{ccccccc} & \text{CH}(\text{CH}_3)_2 & \text{O} & \text{H} \\ & | & || & | \\ \text{H}_2\text{N} - & \text{CH} & - \text{C} & - \text{N} & - \text{CH}_2 - \text{COOH} \end{array}$

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

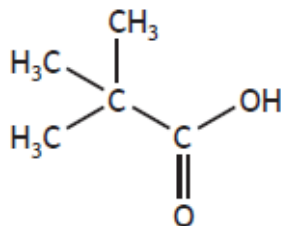
- A pentyl ethanoate
- B hexan-2-one
- C 3-methylpentan-2-ol
- D hexanoic acid.

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

Compound X could be

- A pentan-1-ol
- B pentan-2-ol
- C pentan-3-one
- D pentanoic acid.

39. The structure of pivalic acid is shown.

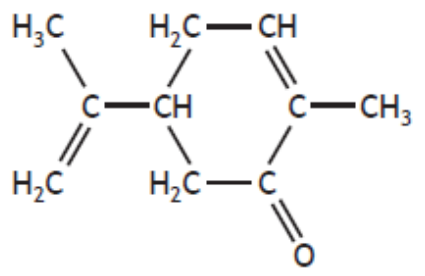
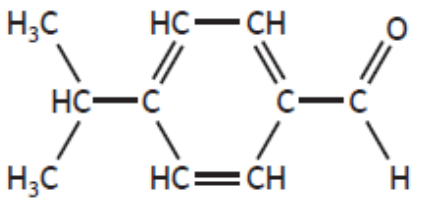
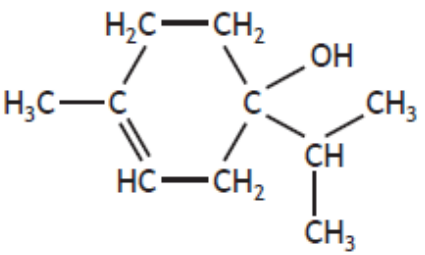
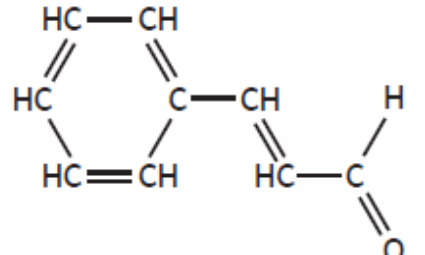


Which of the following is the correct systematic name of pivalic acid?

- A pentanoic acid
- B 2,2,2-trimethylethanoic acid
- C 2-ethylpropanoic acid
- D 2,2-dimethylpropanoic acid

40.

The table shows four compounds that contribute to the aroma of spices. Which compound is not derived from a terpene?

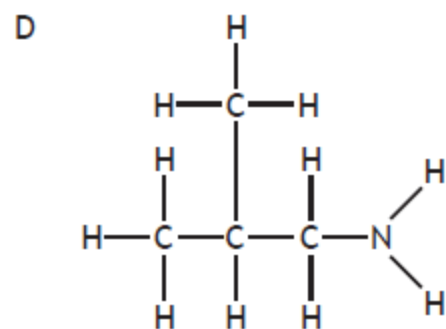
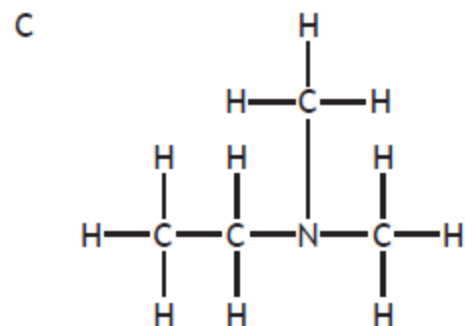
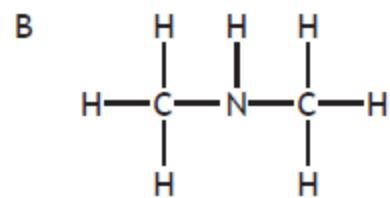
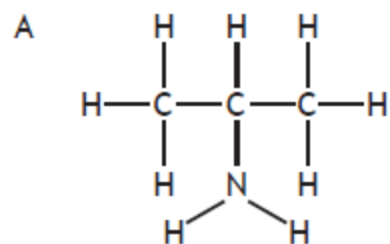
	Structural formula	Molecular formula
A		$C_{10}H_{14}O$
B		$C_{10}H_{12}O$
C		$C_{10}H_{18}O$
D		$C_9H_8O$

41.

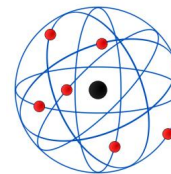
Which reaction can be classified as reduction?

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

42. A secondary amine has two carbon atoms directly bonded to the nitrogen atom. Which of the following is a secondary amine?

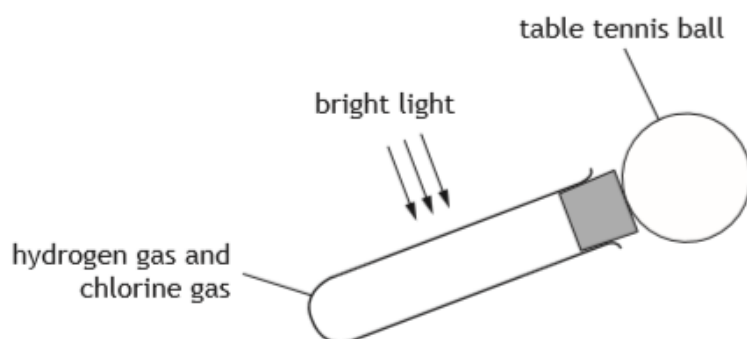


## Unit 2 – Nature’s Chemistry



### Section 2

1. 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.

<i>Reaction step</i>	<i>Name of step</i>
$\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$	
$\text{Cl}\cdot + \text{H}_2 \rightarrow \text{HCl} + \text{H}\cdot$ $\text{H}\cdot + \text{Cl}_2 \rightarrow \text{HCl} + \text{Cl}\cdot$	propagation
	termination

Complete the table by:

- |   |  |   |
|---|--|---|
| A | inserting the missing name for the first step; | 1 |
| B | showing a possible termination step.           | 1 |



2. 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.

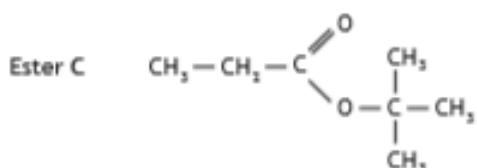
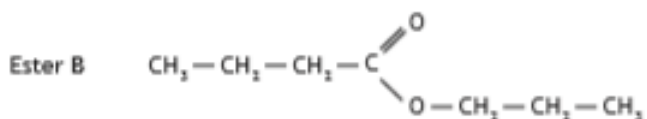
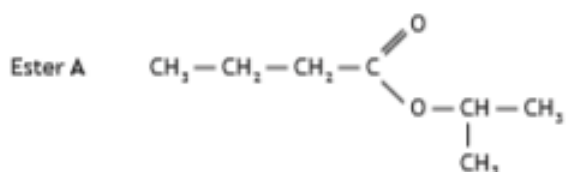
Structure	Fruit-smell rating
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{C} \\ \backslash \\ \text{O} - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \end{array}$	100
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{C} \\ \backslash \\ \text{O} - \text{CH} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \\   \\ \text{CH}_3 \end{array}$	34
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{C} \\ \backslash \\ \text{O} - \text{C} - \text{CH}_2 - \text{CH}_3 \\   \\ \text{CH}_3 \end{array}$	0
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{CH}_2 - \text{C} \\ \backslash \\ \text{O} - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \end{array}$	92
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{CH} - \text{C} \\   \quad \backslash \\ \text{CH}_3 \quad \text{O} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 \end{array}$	44
$\begin{array}{c} \text{CH}_3 \\   \\ \text{CH}_3 - \text{C} - \text{C} \\   \quad \parallel \\ \text{CH}_3 \quad \text{O} - \text{CH}_2 - \text{CH}_3 \end{array}$	32

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

1

(a) (continued)

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

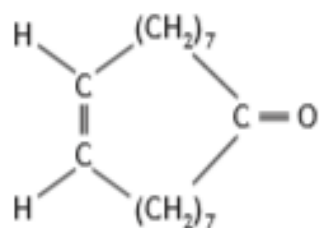


Arrange these esters in order of decreasing fruit-smell rating.

Ester  > Ester  > Ester

1

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



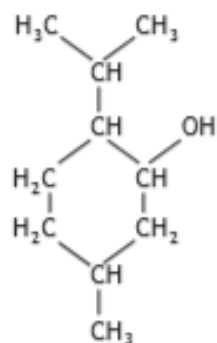
civetone

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

1

(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

3. Cooking changes the appearance and composition of foods.

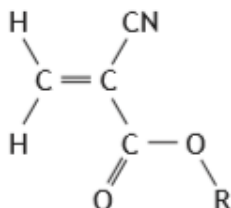
Using your knowledge of chemistry, comment on the changes to food that may occur during cooking.

3

4. Cyanoacrylate adhesives are a range of high performance “super glues”.

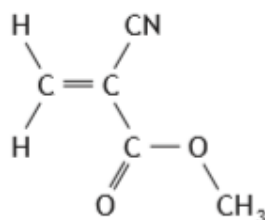
In its liquid form, super glue consists of cyanoacrylate monomers that rapidly polymerise in the presence of water to form a strong resin that joins two surfaces together.

Cyanoacrylates have the general structure



where R is a hydrocarbon group, eg  $-\text{CH}_3$ .

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

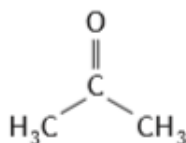


Circle the ester link in this structure.

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

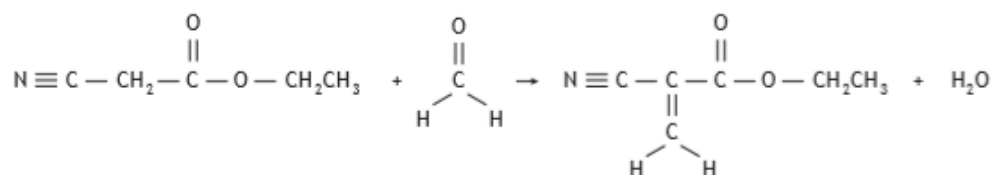
(i) Suggest why super glue reacts rapidly on the surface of the skin. 1

- (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

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

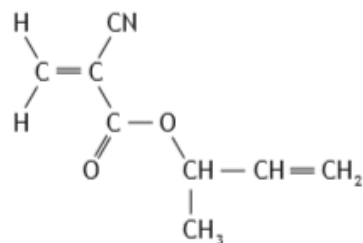
1

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

1

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

Hydrocarbon group	Shearing adhesive strength/ $\text{N cm}^{-2}$
$-\text{CH}_3$	1800
$-\text{CH}_2-\text{CH}_3$	1560
$-\text{CH}_2-\text{CH}_2-\text{CH}_3$	930
$-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_3$	270
$\begin{array}{c} -\text{CH}_2-\text{CH}_2-\text{CH}_3 \\   \\ \text{CH}_3 \end{array}$	420
$-\text{CH}_2-\text{CH}=\text{CH}_2$	1240
$-\text{CH}_2-\text{C}\equiv\text{CH}$	1670
$\begin{array}{c} -\text{HC}-\text{C}\equiv\text{CH} \\   \\ \text{CH}_3 \end{array}$	1140



Estimate the adhesive strength of super glue that contains the monomer shown to the side

1

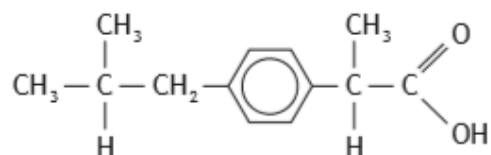
(e) Super glues have been developed for medical applications.

- (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

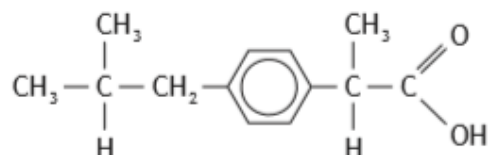
5. Ibuprofen is one of the best-selling pain killers in the UK.



- (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.

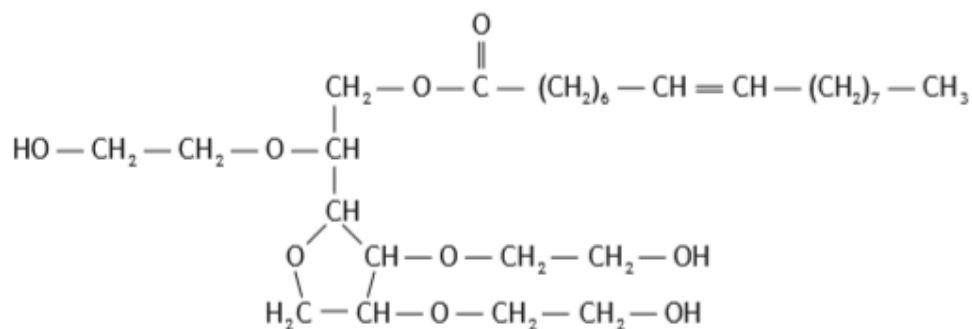


- (i) Suggest why ibuprofen is only slightly soluble in water.

1

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

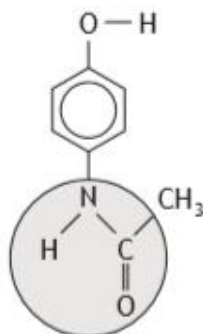
The emulsifier used is polysorbate 80. Its structure is shown below.



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

1

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



- (i) Name the functional group shaded in the structure.

1

6. 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.

<i>Fat or oil</i>	<i>Iodine number</i>	<i>Typical molecule found in the fat or oil</i>
Olive oil	84	$  \begin{array}{c}  \text{O} \\  \parallel \\  \text{H}_3\text{C}_{17}-\text{C}-\text{O}-\text{CH} \\    \\  \text{H}_2\text{C}-\text{O}-\text{C}-\text{C}_{17}\text{H}_{33} \\  \parallel \\  \text{O}  \end{array}  $
Shea butter	43	$  \begin{array}{c}  \text{O} \\  \parallel \\  \text{H}_3\text{C}_{17}-\text{C}-\text{O}-\text{CH} \\    \\  \text{H}_2\text{C}-\text{O}-\text{C}-\text{C}_{17}\text{H}_{33} \\  \parallel \\  \text{O}  \end{array}  $
Linseed oil	172	$  \begin{array}{c}  \text{O} \\  \parallel \\  \text{H}_2\text{C}_{17}-\text{C}-\text{O}-\text{CH} \\    \\  \text{H}_2\text{C}-\text{O}-\text{C}-\text{C}_{17}\text{H}_{31} \\  \parallel \\  \text{O}  \end{array}  $
Sunflower oil		$  \begin{array}{c}  \text{O} \\  \parallel \\  \text{H}_3\text{C}_{17}-\text{C}-\text{O}-\text{CH} \\    \\  \text{H}_2\text{C}-\text{O}-\text{C}-\text{C}_{17}\text{H}_{31} \\  \parallel \\  \text{O}  \end{array}  $

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

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

2

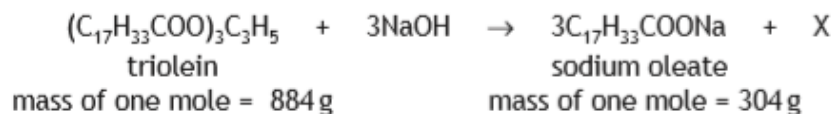
(ii) Predict the iodine number of sunflower oil.

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.



(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

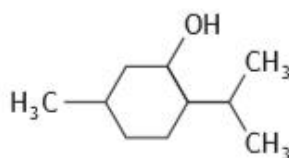
7.

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.

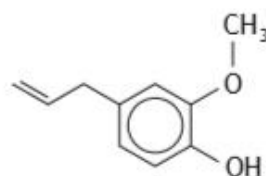
Substances used in pharmacies over a hundred years ago included:

- Essential oils dissolved in ethanol.

Some molecules included in these essential oils were:

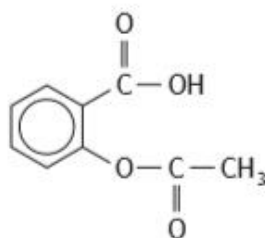


menthol



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



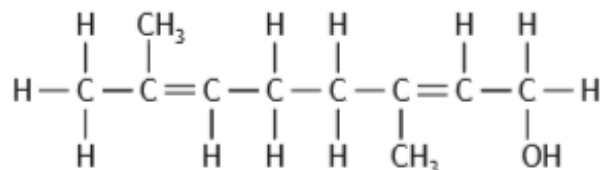
8. Proteins are an important part of a healthy diet because they provide essential amino acids.

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

9. Many of the compounds in perfumes are molecules consisting of joined isoprene units.

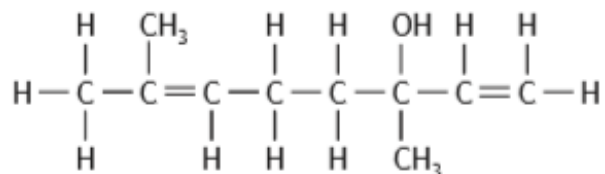
(i) State the name that is given to molecules consisting of joined isoprene units. 1

- (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

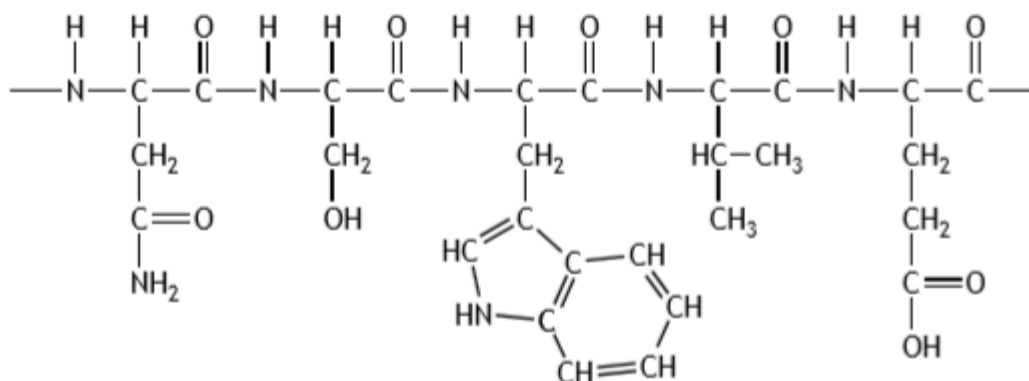
10. Uncooked egg white is mainly composed of dissolved proteins. During cooking processes, the proteins become denatured as the protein chains unwind, and the egg white solidifies.

(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.

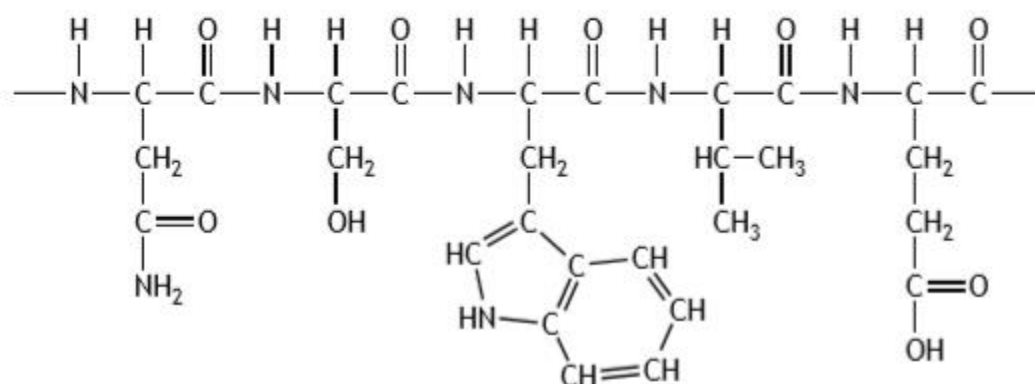
1

- (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

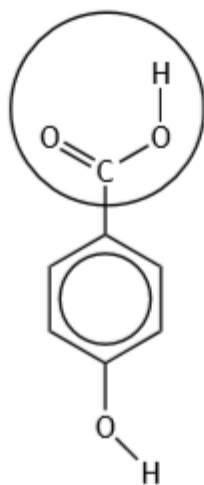
11. Occasionally, seabirds can become contaminated with hydrocarbons from oil spills. This causes problems for birds because their feathers lose their waterproofing, making the birds susceptible to temperature changes and affecting their buoyancy. If the birds attempt to clean themselves to remove the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

12.



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

(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.

<i>Paraben</i>	<i>Absorption (<math>\mu\text{g cm}^{-2}</math>)</i>
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

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

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



State what is meant by the term free radical.

1

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



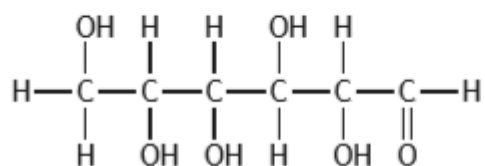
State the name for this type of step in a free radical reaction.

1

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

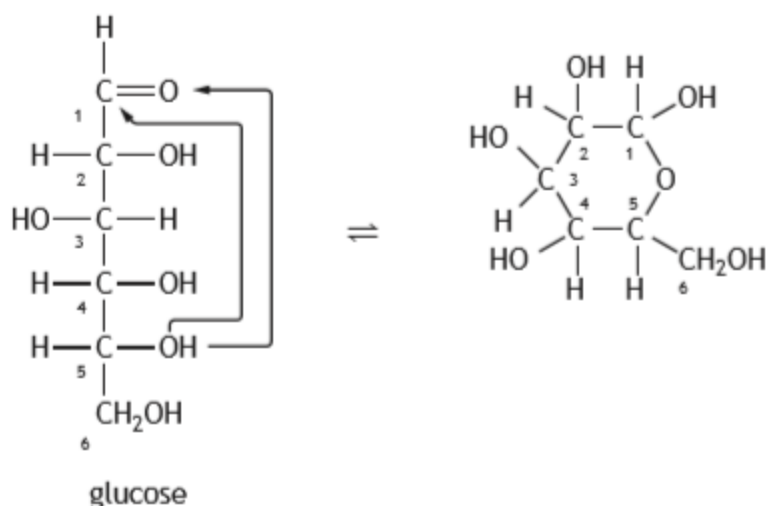
Circle the part of the glucose molecule that reacts with Fehling's solution.

1



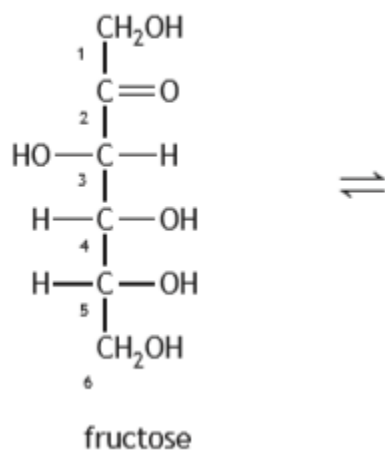
- (b) In solution, sugar molecules exist in an equilibrium in straight-chain and ring forms.

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.



Draw the structure of a ring form for fructose.

1



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

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

1

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

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

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

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

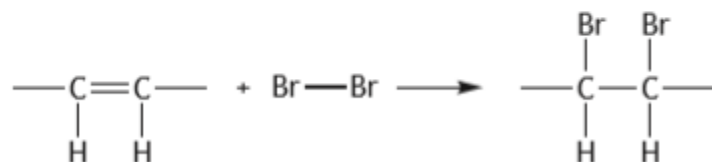
1

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

State the systematic name for caprylic acid.

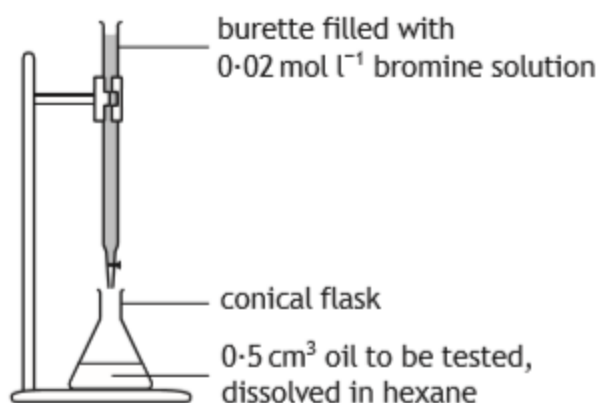
1

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



(c) (continued)

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



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

2

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

1

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

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

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

alanine-glycine-valine-proline-tyrosine-serine

1



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

leucine-glycine-valine

isoleucine-leucine

glycine-valine-serine

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

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

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

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

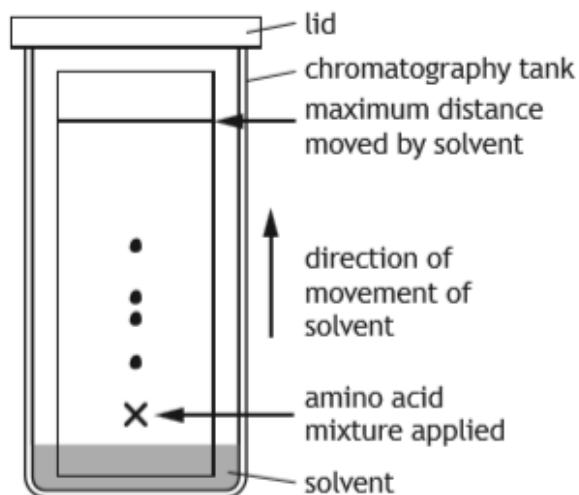
On a chromatogram, the retention factor  $R_f$ , for a substance can be a useful method of identifying the substance.

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

The structure of the pentapeptide methionine enkephalin was investigated.

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

The chromatogram obtained is shown below.

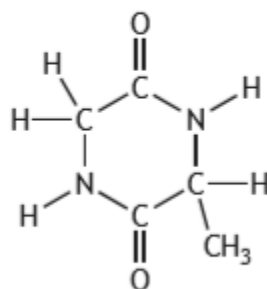


(i) Suggest why only four spots were obtained on the chromatogram of the hydrolysed pentapeptide. 1

(ii) It is known that this amino acid mixture contains the amino acid methionine. The  $R_f$  value for methionine in this solvent is 0.40.  
Draw a circle around the spot on the chromatogram that corresponds to methionine. 1

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

(i) A simple cyclic dipeptide is shown.



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

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



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

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

Suggest why the Skin Care Foundation makes this recommendation.

1

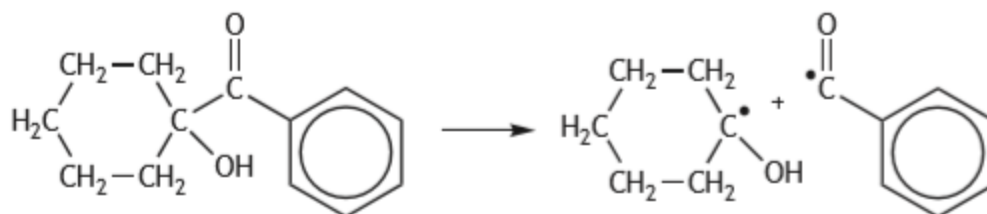
- (b) A *free radical* chain reaction takes place and the varnish hardens.

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

1

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

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

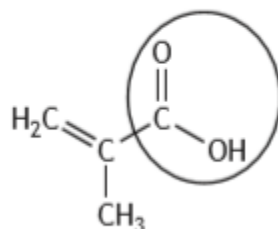


State the term used to describe this type of step in a free radical chain reaction.

1

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

One example of a small molecule used is



Name the functional group circled above.

1

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

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

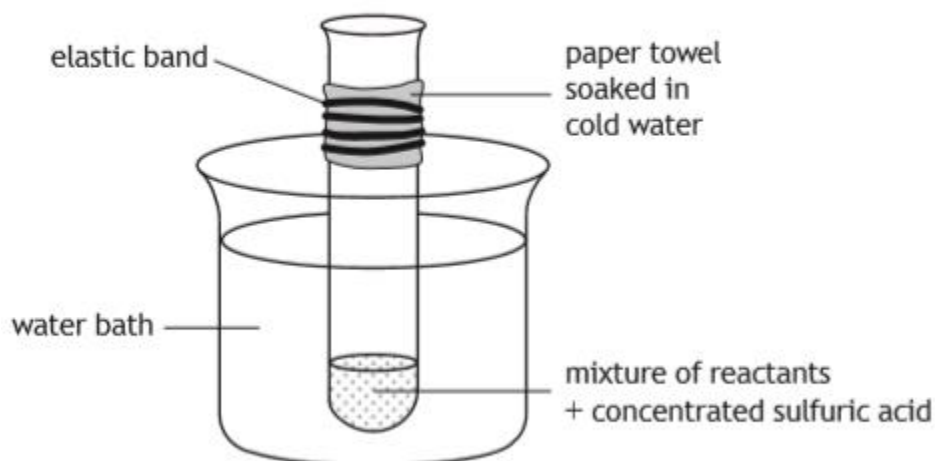
1

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

(i) Draw a structural formula for butyl ethanoate.

1

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



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

1

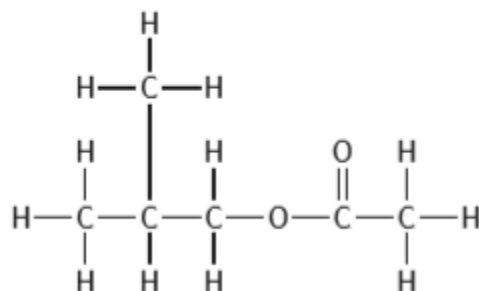
18. (a) The table shows the boiling points and structures of some isomers with molecular formula  $C_6H_{12}O_2$ .

Isomer	Structure	Boiling point ( $^{\circ}C$ )
1	$  \begin{array}{ccccccc}  & H & H & H & H & H & O \\  &   &   &   &   &   & // \\  H & - C & - C & - C & - C & - C & - C \\  &   &   &   &   &   & \backslash \\  & H & H & H & H & H & OH  \end{array}  $	205
2	$  \begin{array}{ccccccc}  & & H & & & & \\  & &   & & & & \\  & H & - C & - H & & & \\  & &   & & H & H & \\  & H & - C & - C & - C & - C & \\  &   &   &   &   & & \\  & H & H & H & H & & \\  & & & & & O & \\  & & & & & // & \\  & & & & & C & \\  & & & & & \backslash & \\  & & & & & & OH  \end{array}  $	201
3	$  \begin{array}{ccccccc}  & & H & & & & \\  & &   & & & & \\  & H & - C & - H & & & \\  & &   & & H & H & \\  & H & - C & - C & - C & - C & \\  &   &   &   &   & & \\  & H & H & H & H & & \\  & & & & & O & \\  & & & & & // & \\  & & & & & C & \\  & & & & & \backslash & \\  & & & & & & OH  \end{array}  $	187
4	$  \begin{array}{ccccccc}  & H & H & H & H & H & O \\  &   &   &   &   &   & // \\  H & - C & - C & - C & - C & - C & - O - C - H \\  &   &   &   &   &   & \\  & H & H & H & H & H &  \end{array}  $	132
5	$  \begin{array}{ccccccc}  & & H & & & & \\  & &   & & & & \\  & H & - C & - H & & & \\  & &   & & H & H & \\  & H & - C & - C & - C & - C & \\  &   &   &   &   & & \\  & H & H & H & H & & \\  & & & & & O & \\  & & & & & // & \\  & & & & & C & \\  & & & & & \backslash & \\  & & & & & & OH  \end{array}  $	125
6	$  \begin{array}{ccccccc}  & & H & & & & \\  & &   & & & & \\  & H & - C & - H & & & \\  & &   & & H & H & \\  & H & - C & - C & - C & - C & \\  &   &   &   &   & & \\  & H & H & H & H & & \\  & & & & & O & \\  & & & & & // & \\  & & & & & C & \\  & & & & & \backslash & \\  & & & & & & OH  \end{array}  $	119
7	$  \begin{array}{ccccccc}  & H & H & H & H & O & H \\  &   &   &   &   & // &   \\  H & - C & - C & - C & - C & - O - C & - C - H \\  &   &   &   &   & &   \\  & H & H & H & H & & H  \end{array}  $	126
8	$  \begin{array}{ccccccc}  & & H & & & & \\  & &   & & & & \\  & H & - C & - H & & & \\  & &   & & H & H & \\  & H & - C & - C & - O - C & - C & \\  &   &   &   &   &   & \\  & H & H & H & H & H & \\  & & & & & O & \\  & & & & & // & \\  & & & & & C & \\  & & & & & \backslash & \\  & & & & & & OH  \end{array}  $	98

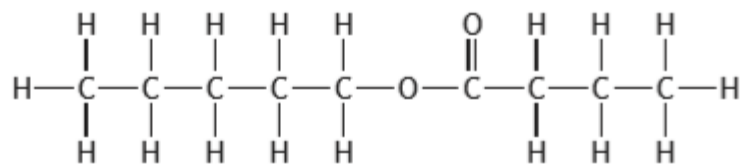
(i) Name the intermolecular force which accounts for the higher boiling points of isomers 1, 2 and 3. 1

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

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



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



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

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

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

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

(i) Name this class of compounds. 1

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

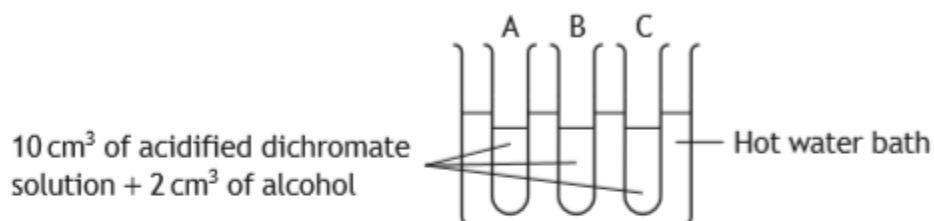
State a use for sodium salts of fatty acids. 1

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

- (a) The student was given three alcohols labelled as **A**, **B** and **C**. These alcohols were all isomers with the formula  $\text{C}_4\text{H}_9\text{OH}$ .

(i) Draw a structural formula for the secondary alcohol with the formula  $\text{C}_4\text{H}_9\text{OH}$ . 1

(ii) The student set up the following experiment.



<i>Alcohol</i>	<i>Observation</i>
<b>A</b>	Colour change
<b>B</b>	No change
<b>C</b>	Colour change

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

1

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

1

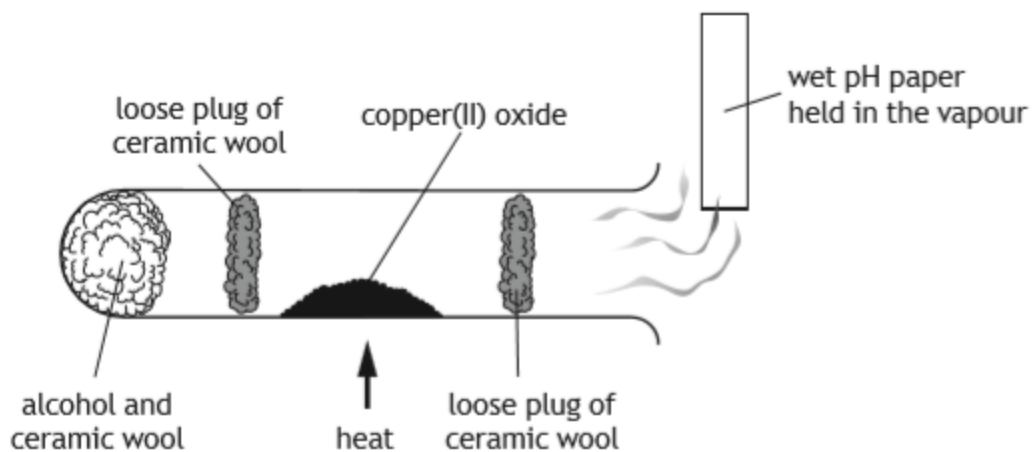
(C) Alcohol **B** is not oxidised.

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

1



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



Hot copper(II) oxide is an oxidising agent.

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

Suggest a name for the product.

1

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

1



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

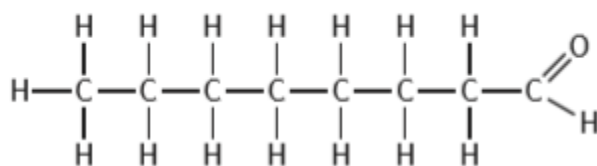
<i>Aldehyde</i>	<i>Molecular formula</i>	<i>Boiling point (°C)</i>
$  \begin{array}{ccccccc}  & \text{H} & \text{H} & \text{H} & \text{H} & & \\  &   &   &   &   & & \\  \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & \\  &   &   &   &   & & \\  & \text{H} & \text{H} & \text{H} & \text{H} & & \text{O} \\  & & & & & & // \\  & & & & & & \text{H}  \end{array}  $	$\text{C}_5\text{H}_{10}\text{O}$	102
$  \begin{array}{ccccccc}  & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \\  &   &   &   &   &   & \\  \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} \\  &   &   &   &   &   & \\  & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{O} \\  & & & & & & // \\  & & & & & & \text{H}  \end{array}  $	$\text{C}_6\text{H}_{12}\text{O}$	130
$  \begin{array}{ccccccc}  & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\  &   &   &   &   &   &   \\  \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} \\  &   &   &   &   &   & \\  & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{O} \\  & & & & & & // \\  & & & & & & \text{H}  \end{array}  $	$\text{C}_7\text{H}_{14}\text{O}$	153
$  \begin{array}{ccccccc}  & \text{H} & \text{H} & \text{H} & & & \\  &   &   &   & & & \\  \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & & \\  &   &   &   & & & \\  & \text{H} & \text{H} & \text{CH}_3 & & & \text{O} \\  & & & & & & // \\  & & & & & & \text{H}  \end{array}  $	$\text{C}_5\text{H}_{10}\text{O}$	95
$  \begin{array}{ccccccc}  & \text{H} & \text{CH}_3 & & & & \\  &   &   & & & & \\  \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & & \\  &   &   & & & & \\  & \text{H} & \text{CH}_3 & & & & \text{O} \\  & & & & & & // \\  & & & & & & \text{H}  \end{array}  $	$\text{C}_5\text{H}_{10}\text{O}$	75
$  \begin{array}{ccccccc}  & \text{H} & \text{H} & \text{H} & \text{H} & & \\  &   &   &   &   & & \\  \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & \\  &   &   &   &   & & \\  & \text{H} & \text{H} & \text{H} & \text{CH}_3 & & \text{O} \\  & & & & & & // \\  & & & & & & \text{H}  \end{array}  $	$\text{C}_6\text{H}_{12}\text{O}$	119
$  \begin{array}{ccccccc}  & \text{H} & \text{H} & \text{CH}_3 & & & \\  &   &   &   & & & \\  \text{H} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & & \\  &   &   &   & & & \\  & \text{H} & \text{H} & \text{CH}_3 & & & \text{O} \\  & & & & & & // \\  & & & & & & \text{H}  \end{array}  $	$\text{C}_6\text{H}_{12}\text{O}$	111

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

1

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

1



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

1

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

1

21. Skin care products contain a mixture of polar covalent, non-polar covalent and ionic compounds. The compounds need to stay mixed within the product. Skin care products also need to spread easily and remain on the skin for a period of time, as well as provide physical and chemical protection from the sun. In order to do this, skin care products contain a range of chemicals including water, fats and oils, antioxidants, minerals and sun block.

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

3

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

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

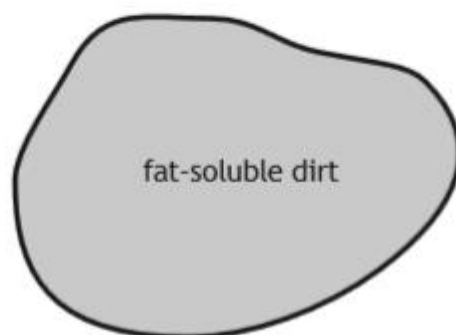
- (i) During the cleaning process, the detergent molecules combine with fat-soluble dirt.

A simplified diagram of a detergent molecule is shown.

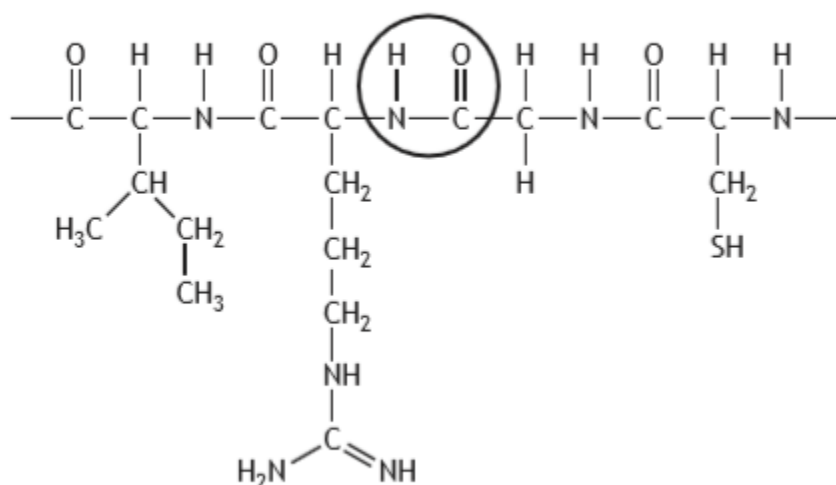


Complete the diagram below to show how detergent molecules combine with fat-soluble dirt.

1



- (ii) State the term used to describe the non-polar, hydrocarbon tail of a detergent molecule. 1
- (b) Dishwasher tablets produce the bleach hydrogen peroxide,  $\text{H}_2\text{O}_2$ . One action of this oxidising agent is to oxidise food.
- (i) Suggest another action of the bleach produced by the dishwasher tablets. 1
- (c) Enzymes are commonly added to dishwasher tablets. These are used to break down proteins.
- (i) The proteins are broken down into small, water-soluble molecules. Name the small, water-soluble molecules made when proteins are broken down completely. 1
- (ii) The structure of a section of protein chain found in egg white is shown.



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

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

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

1

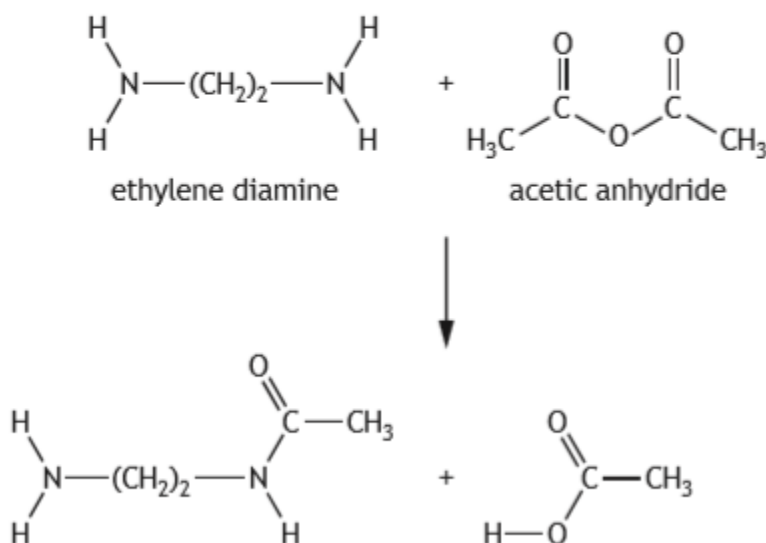
(B) Suggest a change in conditions which would cause the enzyme molecules to change shape.

1

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

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

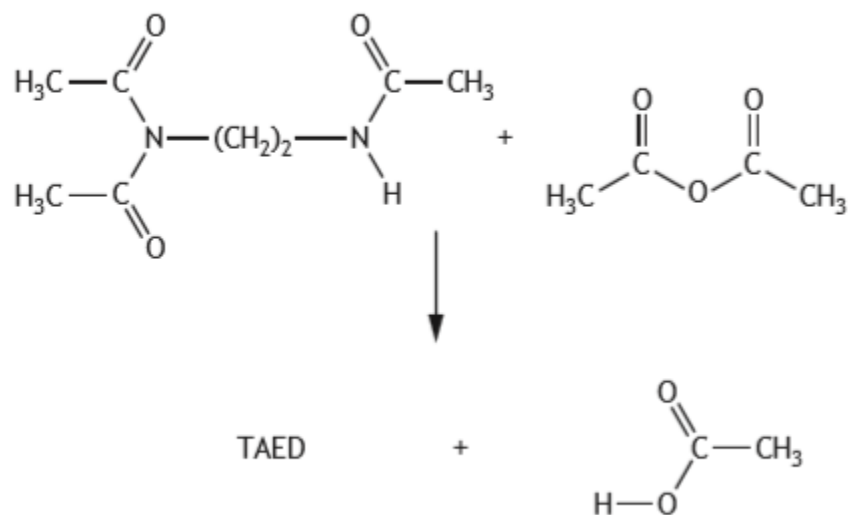
(i) The first stage in producing TAED is shown below.



Suggest a name for this type of reaction.

1

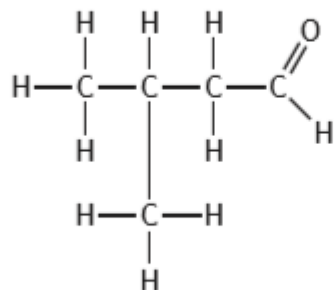
(ii) The final stage in the process producing TAED is shown below.



Draw a structural formula for TAED.

1

23. 3-Methylbutanal is a compound that is found in low concentrations in many types of food. The structure of 3-methylbutanal is shown.



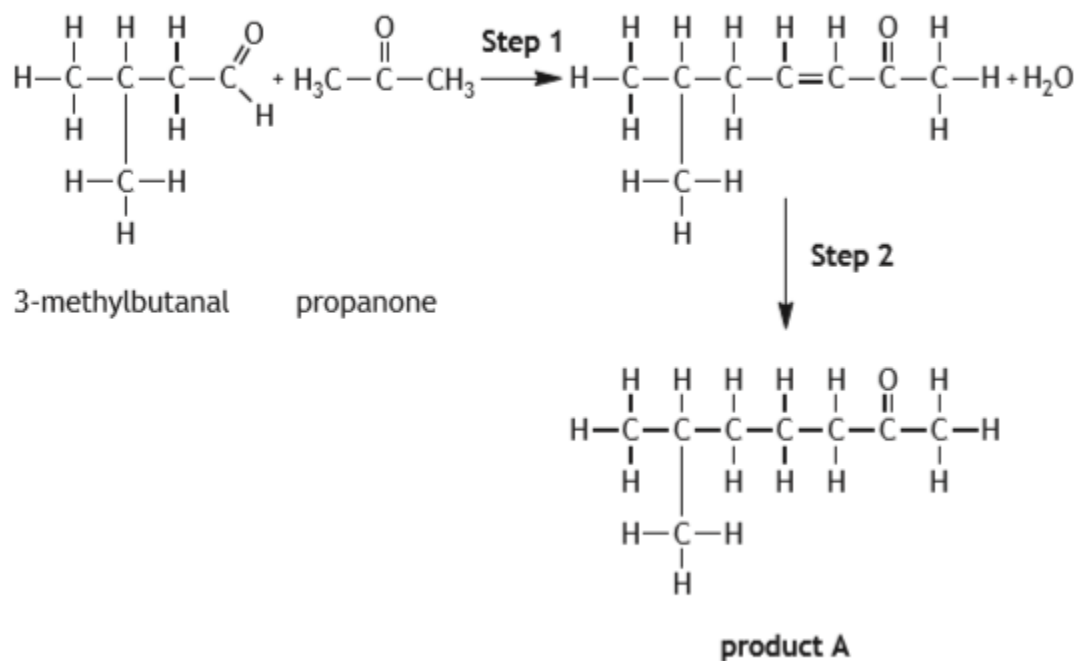
- (a) Draw a structural formula for a ketone that is an isomer of 3-methylbutanal. 1
- (b) Name a reagent which could be used to distinguish between 3-methylbutanal and a ketone. 1
- (c) Name the strongest intermolecular force that occurs between 3-methylbutanal molecules. 1

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

2

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

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



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

1

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

1

24.

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

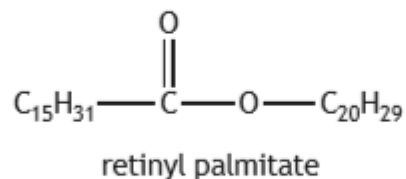
**Using your knowledge of chemistry**, describe the relationships between fats, oils, detergents, soaps and emulsifiers.

3

25. Skin creams contain many different chemicals.

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

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



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

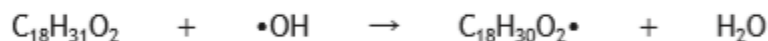
(i) Name the type of reaction that occurs when retinyl palmitate is broken down to form retinol. 1

(ii) Write a molecular formula for retinol. 1

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

(i) Describe how free radicals are formed. 1

(ii) Hydroxyl free radicals ( $\bullet\text{OH}$ ) can attack fatty acids present in cell membranes. One step in the chain reaction is shown below.



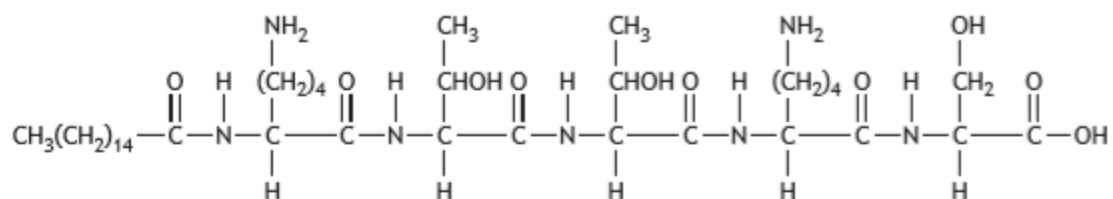
State the name given to this step in the chain reaction. 1

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

State how free radical scavengers prevent further chain reactions. 1



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



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

1

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

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

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

Draw a structural formula for the amino acid serine.

1

26.

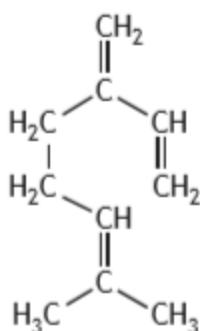
Terpenes consist of joined isoprene units (2-methylbuta-1,3-diene). They are classified by the number of isoprene units in the molecule.

<i>Class of terpene</i>	<i>Number of isoprene units</i>
hemiterpene	1
monoterpene	2
sesquiterpene	3
diterpene	4
triterpene	6

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

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

1



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

Name the class of terpene to which humulene belongs.

1

- (b) (i) Squalene, a triterpene, is included in some flu vaccines to enhance the body's immune response. A single dose of flu vaccine contains 10.69 mg of squalene.

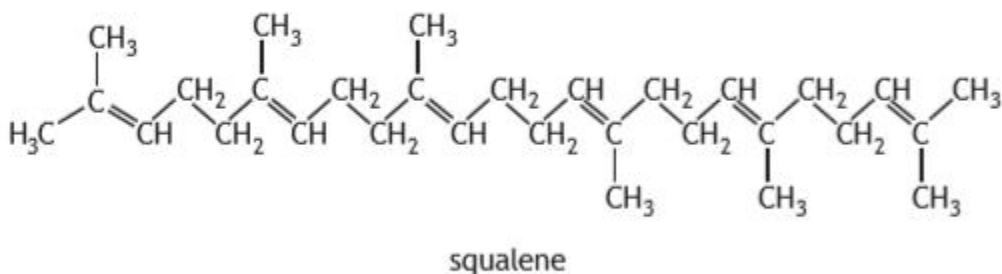
Calculate the mass of squalene required to produce a batch of 500 000 doses of flu vaccine.

Your answer must be given in kg.

2

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

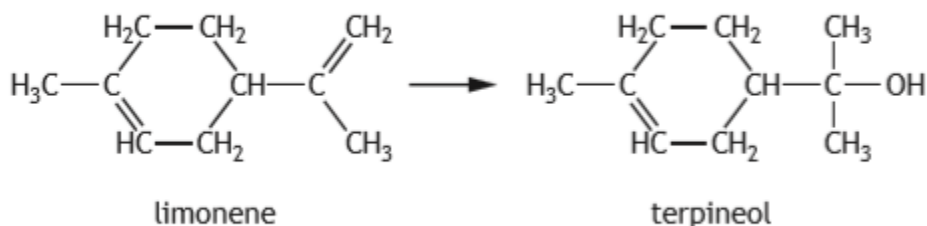
Squalane can be made by the reaction of squalene with hydrogen.



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

1

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



- (i) Name the type of reaction taking place.

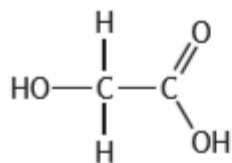
1

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

Explain why no reaction takes place.

1

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



glycolic acid

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

1

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



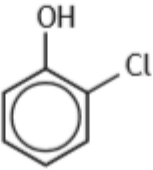

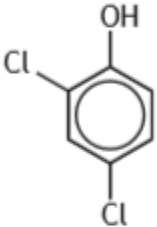

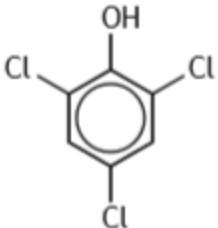
Give a formula for sodium glycolate.

1

28.

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

(a)

<i>Compound</i>	<i>Structure</i>	<i>Germ-killing power (relative to phenol)</i>
phenol		1.0
4-methylphenol		2.5
2-chlorophenol		3.6
4-ethylphenol		7.5
2,4-dichlorophenol		13.0
4-propylphenol		20.0
2,4,6-trichlorophenol		23.0

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

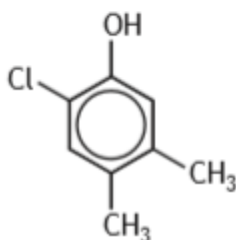
2

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

Phenol is used as the parent name for the compound.

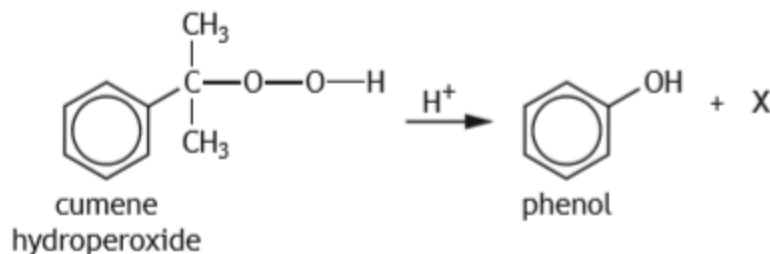
1. The  $\text{-OH}$  functional group is assigned as being on carbon 1 of the ring.
2. The ring can be numbered clockwise or anticlockwise to assign numbers to the other atoms or groups. The numbers should be assigned so that the lowest possible numbers are used.
3. If two or more identical atoms or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

Using these rules, name this molecule.



1

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



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

1

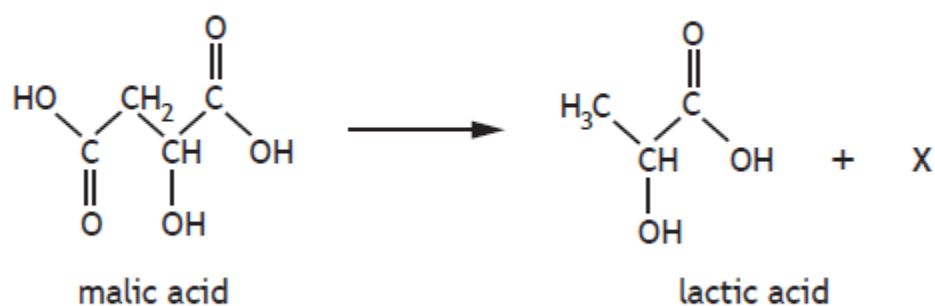
29. Cider is made from apples in a process that involves crushing and pressing the apples, converting the sugars into alcohol, maturing and bottling.

(a) Brewers add yeast, which contains a mixture of enzymes to convert the sugars in the apples into alcohol and carbon dioxide.

(i) State what is meant by the term enzyme.

1

(b) During the maturing process malic acid is converted to lactic acid and another product.



(i) Name compound X.

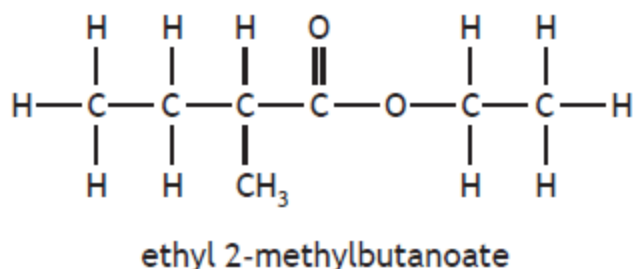
1

(c) Glycerol can be added to cider before bottling to produce a sweeter tasting cider.

State the systematic name for glycerol.

1

(d) (ii) Cider smells of apples because it contains ethyl 2-methylbutanoate.

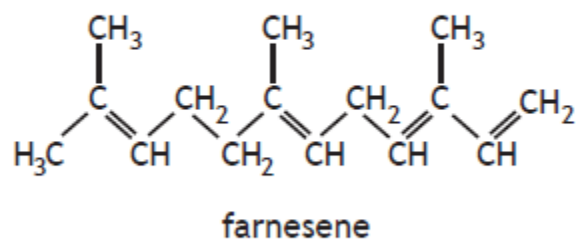


Name the carboxylic acid used to make ethyl 2-methylbutanoate.

1

29. (d) (continued)

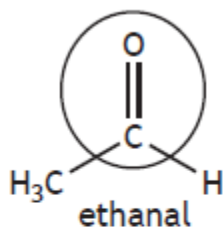
- (iii) Farnesene is a terpene responsible for the ripe apple aroma of cider.



Name the molecule on which terpenes are based.

1

- (e) Ethanol in cider can be oxidised to ethanal, spoiling the aroma.



- (i) Name the functional group circled in the ethanal molecule.

1

- (ii) Further oxidation of ethanal can produce another product that spoils the flavour of cider.

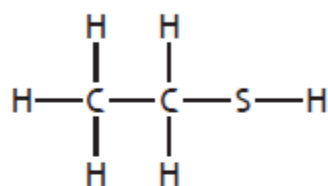
Name this product.

1



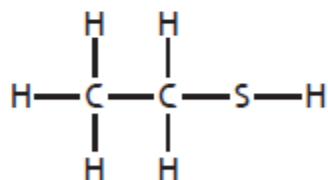
30. Thiols are compounds that contain an  $-SH$  functional group. They often have very strong, unpleasant odours.

- (a) Ethanethiol is used to add a smell to gaseous fuels in order to give warnings of gas leaks.



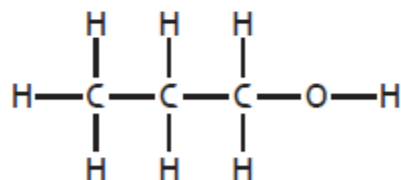
ethanethiol

- (i) A student used the boiling points of ethanethiol and propan-1-ol to compare the strength of intermolecular forces.



ethanethiol

boiling point =  $35^{\circ}\text{C}$



propan-1-ol

boiling point =  $97^{\circ}\text{C}$

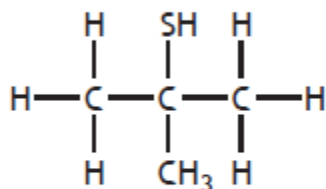
- (A) State the reason why propan-1-ol was a suitable alcohol to compare with ethanethiol.

1

- (ii) Name the thiol that contains only one carbon atom.

1

- (b) 2-methyl-2-propanethiol is also used to add a smell to gaseous fuels.



2-methyl-2-propanethiol

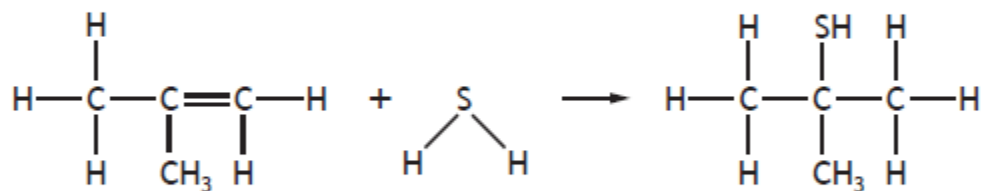
- (i) Suggest why 2-methyl-2-propanethiol is classified as a tertiary thiol.

1

30. (b) (continued)

(ii) Thiols can be made by the addition of hydrogen sulfide to alkenes.

2-methyl-2-propanethiol can be made by the addition reaction shown.



2-methylpropene  
GFM = 56.0 g

2-methyl-2-propanethiol  
GFM = 90.1 g

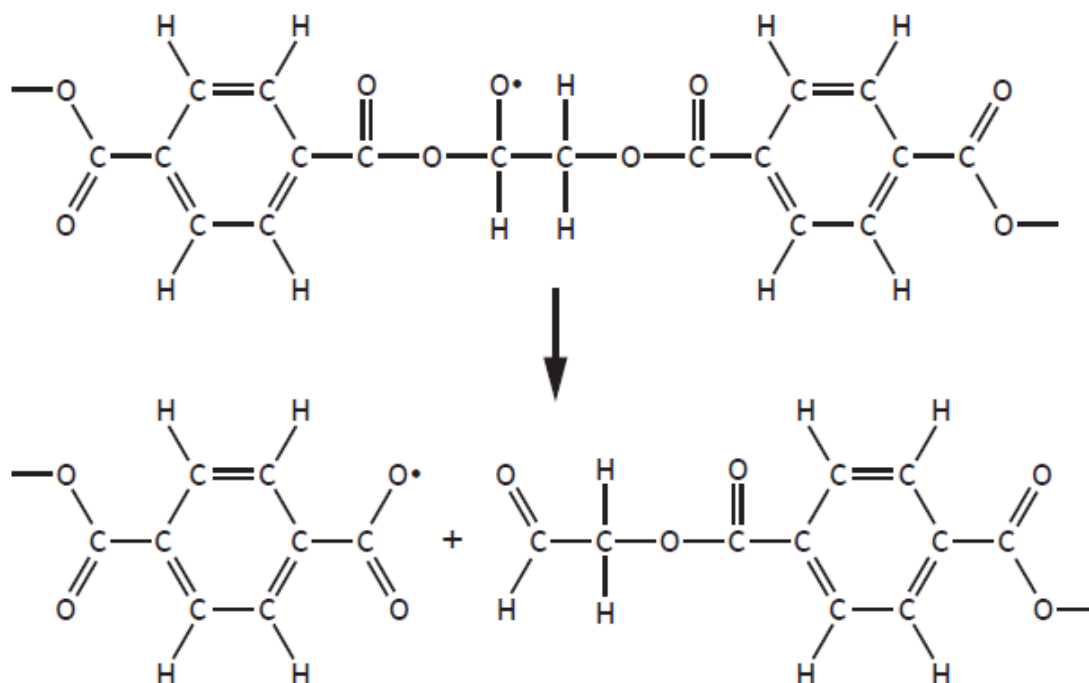
(A) Draw the structure for the other isomer formed in this addition reaction.

1

31. Esters can be synthetic or natural.

(a) The synthetic polyester PET, poly(ethylene terephthalate), has many ester links. PET can break down by a free radical reaction.

One of the steps involved in breaking down PET is shown.



31. (continued)

- (i) State the name for this step.

1

- (ii) Name the component of sunlight that can cause plastics such as PET to break down.

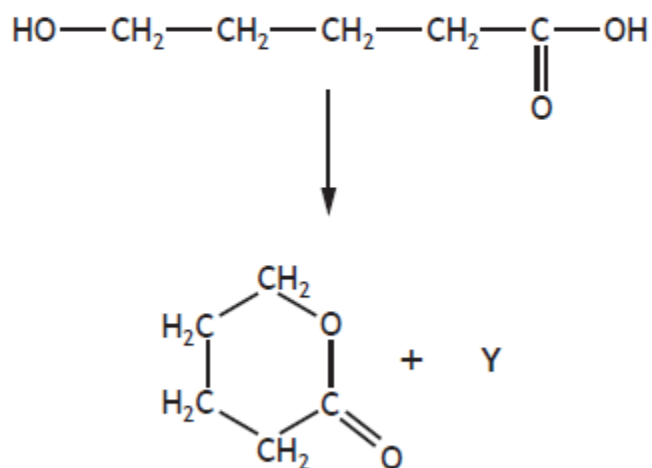
1

- (iii) Name the type of substance that can be added to plastics to prevent them breaking down in this way.

1

- (b) (i) Natural cyclic esters called lactones can be formed from hydroxycarboxylic acids.

5-hydroxypentanoic acid is a hydroxycarboxylic acid that when heated, with dilute acid, will form a cyclic ester.



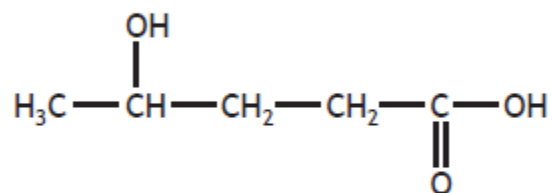
Name product Y in this reaction.

1

31. (b) (continued)

- (ii) Draw the structure for the cyclic compound formed when 4-hydroxypentanoic acid is heated with dilute acid.

1

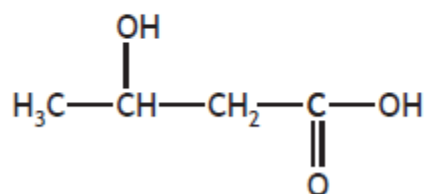


4-hydroxypentanoic acid



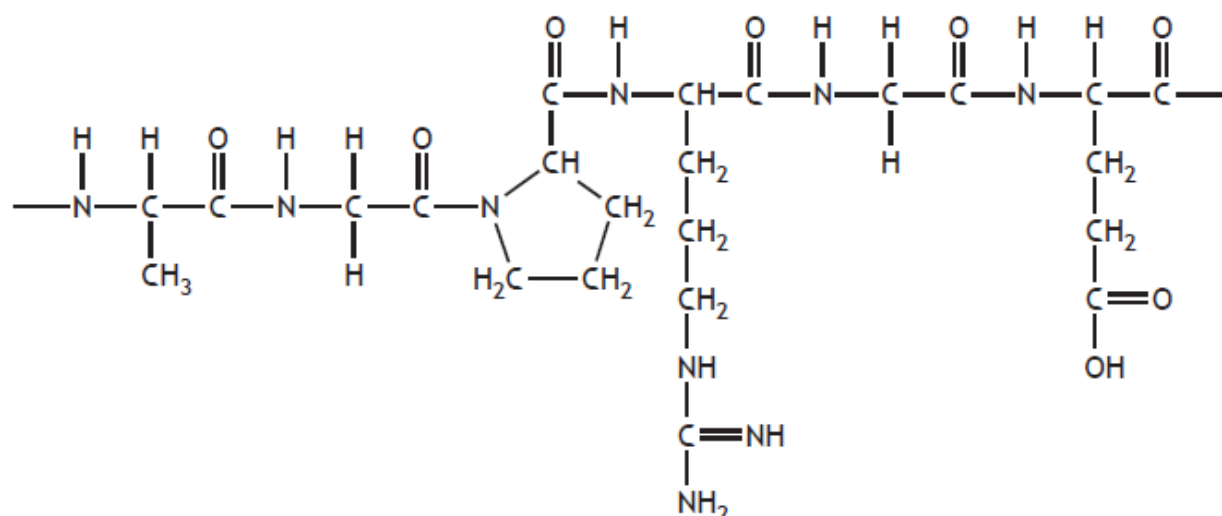
- (iii) Name the hydroxycarboxylic acid shown below.

1



32. Gelatin is a soluble protein that can be added to different food products.

(a) A structure for a section of a protein chain in gelatin is shown.



(i) State the number of amino acids that joined together to form the section of the protein chain shown.

1

(c) Bromelain is a mixture of enzymes found in pineapple that aid digestion.

(i) Adding raw pineapple to gelatin results in the gelatin molecules being hydrolysed. The rate of hydrolysis is reduced if the pineapple is cooked.

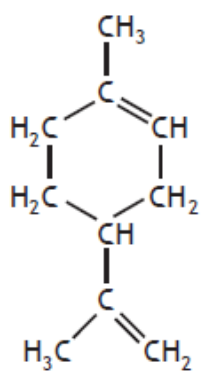
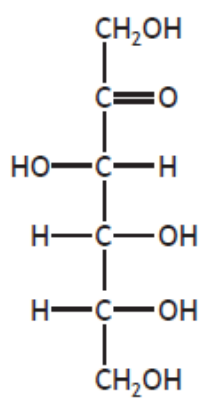
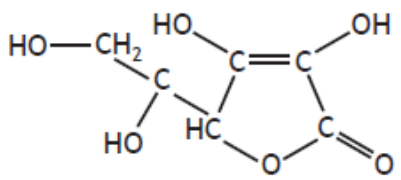
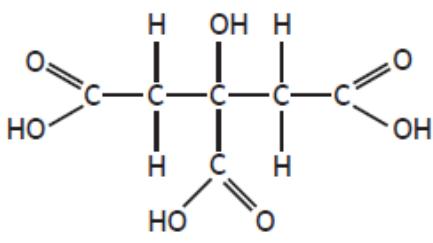
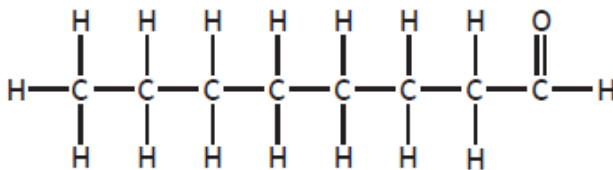
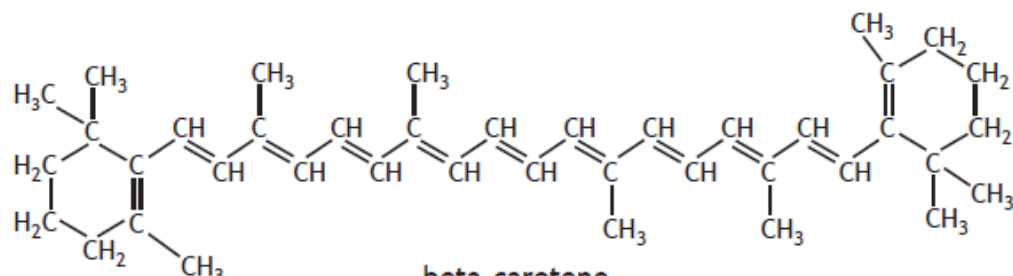
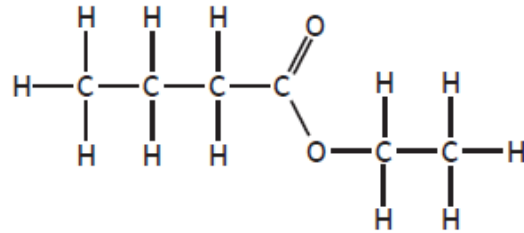
Explain why the rate of hydrolysis is reduced.

1

33. Differences in physical and chemical properties can be used to distinguish one compound from another.

The compounds extracted from orange juice include antioxidants, flavour molecules, essential oils, aroma molecules and coloured molecules.

Some examples of these are shown below.



 <p>limonene</p>	 <p>fructose</p>
 <p>vitamin C</p>	 <p>citric acid</p>
 <p>octanal</p>	
 <p>beta-carotene</p>	
 <p>ethyl butanoate</p>	

33. (continued)

Using your knowledge of chemistry, comment on how the differences in physical and chemical properties can be used to distinguish between the compounds extracted from orange juice.

3

34. The label from a bottle of pine fresh bleach cleaner is shown.

<b>PINE FRESH BLEACH CLEANER</b>		
<p><b>Formulated to kill germs and remove stains</b></p> <p>Ingredients: aqua, sodium hypochlorite, sodium hydroxide, less than 5% anionic surfactants, non-ionic surfactants, soap, perfume</p>	<p><b>WARNING!</b> Do not use together with other products. May release dangerous gases (chlorine)</p> <p><b>DANGER</b> Keep out of reach of children</p> <div style="text-align: center;">   <b>CORROSIVE</b> </div>	

(a) Surfactant molecules are added to bleach cleaner to act as detergents, soaps or emulsifiers.

Information on three of the surfactants in the bleach cleaner is shown in the table.

Surfactant structure	Type of surfactant	Head group
<p>Compound A</p> $\text{H}_3\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{O}-\text{CH}_2-\text{CH}_2-\text{O}-\text{H}$	non-ionic	polar
<p>Compound B</p> $\text{H}_3\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{C}(\text{CH}_3)_3-\text{NH}_3^+\text{Cl}^-$		
<p>Compound C</p> $\text{H}_3\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{C}(=\text{O})\text{O}^-\text{Na}^+$	ionic	negatively charged

34. (a) (continued)

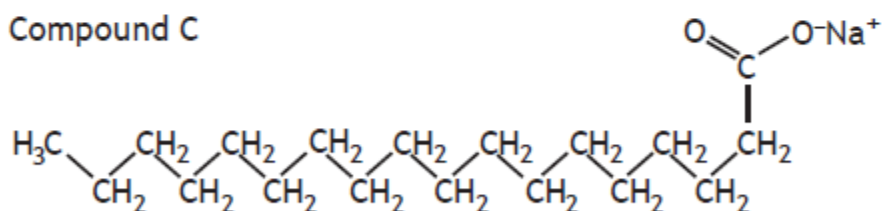
- (i) Complete the table for compound B. 1
- (ii) Compound C is a soap molecule.

(A) Soaps can be made from fats and oils.

Name the reaction used to make soaps from fats and oils. 1

(B) Soap molecules allow oil to mix with water.

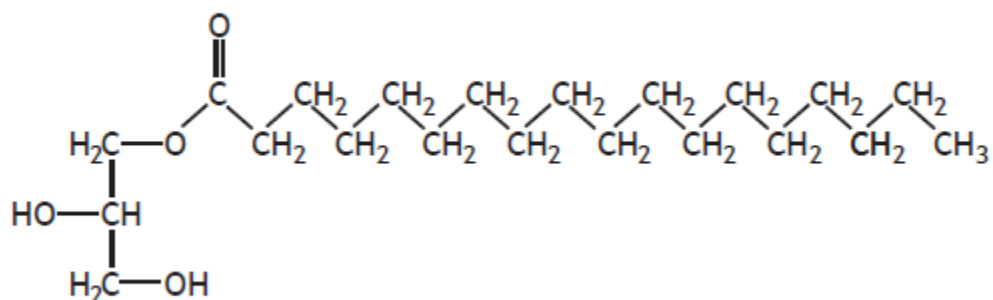
### Compound C



Explain fully the cleaning action of compound C. 3

You may wish to use diagrams to illustrate your answers.



- (iii) The structure of an emulsifier molecule is shown below.



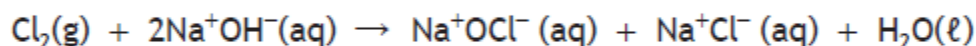
State how emulsifiers are made from edible oils. 1



- (b) Sodium hypochlorite,  $\text{Na}^+\text{OCl}^-$ , is the main active compound in bleach.

<p><b>PINE FRESH BLEACH CLEANER</b></p> <p><b>Formulated to kill germs and remove stains</b></p> <p>Ingredients: aqua, sodium hypochlorite, sodium hydroxide, less than 5% anionic surfactants, non-ionic surfactants, soap, perfume</p>	<p><b>WARNING!</b> Do not use together with other products. May release dangerous gases (chlorine)</p> <p><b>DANGER</b> Keep out of reach of children</p>  <p><b>CORROSIVE</b></p>	
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Sodium hypochlorite,  $\text{Na}^+\text{OCl}^-$ , is produced by reacting chlorine with sodium hydroxide solution.



- (i) A chlorine molecule has a pure covalent bond.

Explain what is meant by a pure covalent bond.

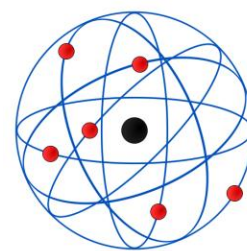
1

- (ii) When the chlorine is reacted with sodium hydroxide solution an excess of sodium hydroxide is used.

Suggest why an excess of sodium hydroxide is used.

1

# Higher Chemistry



## Unit 2 Past Paper Answers

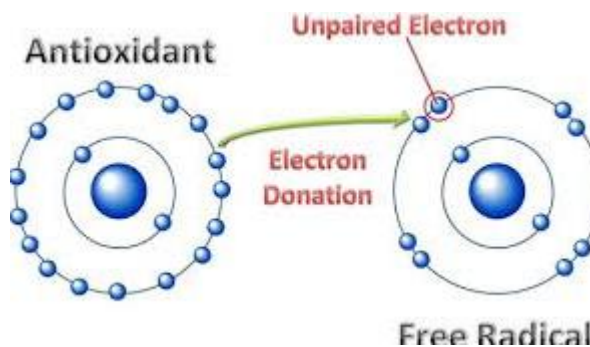
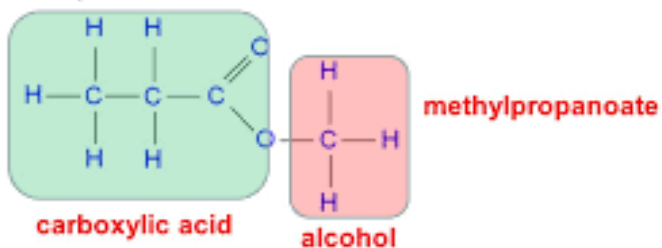
### Naming Esters

Form: (alcohol) (acid-anoate)

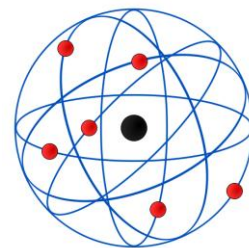
Drop -anol,  
replace with "yl"

Change from "-oic acid"  
to "-oate"

Example:

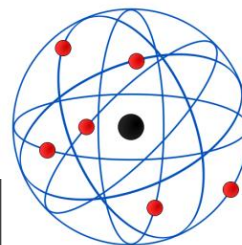


## Section 1 Answers



<b>1</b>	<b>D</b>	<b>11</b>	<b>A</b>	<b>21</b>	<b>B</b>	<b>31</b>	<b>D</b>	<b>41</b>	<b>C</b>
<b>2</b>	<b>B</b>	<b>12</b>	<b>D</b>	<b>22</b>	<b>D</b>	<b>32</b>	<b>A</b>	<b>42</b>	<b>B</b>
<b>3</b>	<b>C</b>	<b>13</b>	<b>D</b>	<b>23</b>	<b>C</b>	<b>33</b>	<b>B</b>		
<b>4</b>	<b>C</b>	<b>14</b>	<b>B</b>	<b>24</b>	<b>B</b>	<b>34</b>	<b>D</b>		
<b>5</b>	<b>A</b>	<b>15</b>	<b>C</b>	<b>25</b>	<b>C</b>	<b>35</b>	<b>B</b>		
<b>6</b>	<b>C</b>	<b>16</b>	<b>B</b>	<b>26</b>	<b>A</b>	<b>36</b>	<b>A</b>		
<b>7</b>	<b>B</b>	<b>17</b>	<b>C</b>	<b>27</b>	<b>C</b>	<b>37</b>	<b>D</b>		
<b>8</b>	<b>A</b>	<b>18</b>	<b>A</b>	<b>28</b>	<b>B</b>	<b>38</b>	<b>B</b>		
<b>9</b>	<b>B</b>	<b>19</b>	<b>C</b>	<b>29</b>	<b>C</b>	<b>39</b>	<b>D</b>		
<b>10</b>	<b>B</b>	<b>20</b>	<b>B</b>	<b>30</b>	<b>A</b>	<b>40</b>	<b>D</b>		

## Section 2 Answers



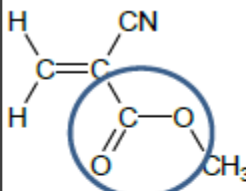
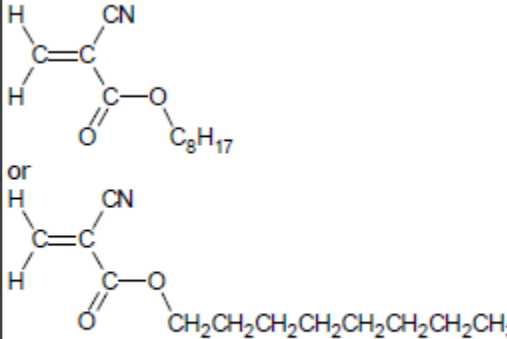
1.	b	ii	<table><tr><th>Reaction step</th><th>Name of step</th></tr><tr><td><math>\text{Cl}_2 \rightarrow 2\text{Cl}\cdot</math></td><td>Initiation (1 mark)</td></tr><tr><td><math>\text{Cl}\cdot + \text{H}_2 \rightarrow \text{HCl} + \text{H}\cdot</math> <math>\text{H}\cdot + \text{Cl}_2 \rightarrow \text{HCl} + \text{Cl}\cdot</math></td><td>propagation</td></tr><tr><td><math>\text{H}\cdot + \text{Cl}\cdot \rightarrow \text{HCl}</math> (1 mark) (or any appropriate reaction step in which two free radicals combine to give a molecule)</td><td>termination</td></tr></table>	Reaction step	Name of step	$\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$	Initiation (1 mark)	$\text{Cl}\cdot + \text{H}_2 \rightarrow \text{HCl} + \text{H}\cdot$ $\text{H}\cdot + \text{Cl}_2 \rightarrow \text{HCl} + \text{Cl}\cdot$	propagation	$\text{H}\cdot + \text{Cl}\cdot \rightarrow \text{HCl}$ (1 mark) (or any appropriate reaction step in which two free radicals combine to give a molecule)	termination	2	
Reaction step	Name of step												
$\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$	Initiation (1 mark)												
$\text{Cl}\cdot + \text{H}_2 \rightarrow \text{HCl} + \text{H}\cdot$ $\text{H}\cdot + \text{Cl}_2 \rightarrow \text{HCl} + \text{Cl}\cdot$	propagation												
$\text{H}\cdot + \text{Cl}\cdot \rightarrow \text{HCl}$ (1 mark) (or any appropriate reaction step in which two free radicals combine to give a molecule)	termination												

2.	a	i	Butyl propanoate	(1 mark)	1	
	a	ii	$\text{B} > \text{A} > \text{C}$	(1 mark)	1	
	b				1	H must be shown on C to which hydroxyl group is attached.
	c			(1 mark)	1	Any group of 5 carbons with 1 branch. OH to be ignored.

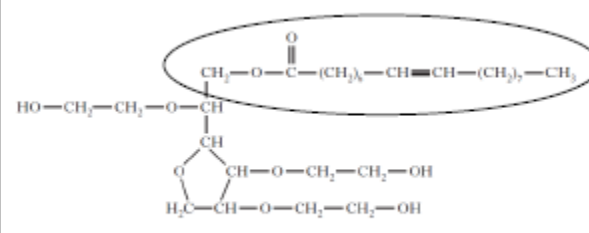
3.

<p>3 marks: The candidate has demonstrated a good conceptual understanding of the chemistry involved, providing a logically correct response to the problem/situation presented.</p> <p>This type of response might include a</p>	<p>In response to this question, a good understanding might be demonstrated by a candidate response that:</p> <ul style="list-style-type: none"> <li>• makes comments based on one relevant chemistry idea/concept, in a detailed/developed response that is</li> </ul>
<p>statement of principle(s) involved, a relationship or equation, and the application of these to respond to the problem/situation.</p> <p>This does not mean the answer has to be what might be termed an 'excellent' answer or a 'complete' one.</p>	<p>correct or largely correct (any weaknesses are minor and do not detract from the overall response),</p> <p>OR</p> <ul style="list-style-type: none"> <li>• 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),</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>• otherwise demonstrates a good understanding of the chemistry involved.</li> </ul>
<p>2 marks: The candidate has demonstrated a reasonable understanding of the chemistry involved, showing that the problem/situation is understood.</p> <p>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.</p>	<p>In response to this question, a reasonable understanding might be demonstrated by a candidate response that:</p> <ul style="list-style-type: none"> <li>• 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,</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>• otherwise demonstrates a reasonable understanding of the chemistry involved.</li> </ul>
<p>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.</p> <p>The candidate has made some statement(s) that is/are relevant to the problem/situation.</p>	<p>In response to this question, a limited understanding might be demonstrated by a candidate response that:</p> <ul style="list-style-type: none"> <li>• 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,</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>• otherwise demonstrates a limited understanding of the chemistry involved.</li> </ul>
<p>0 marks: The candidate has demonstrated no understanding of the chemistry that is relevant to the problem/situation.</p> <p>The candidate has made no statement(s) that is/are relevant to the problem/situation.</p>	<p>Where the candidate has <i>only</i> demonstrated knowledge and understanding of chemistry that is not relevant to the problem/situation presented, 0 marks should be awarded.</p>

4.

a		 (1 mark)	1	
b	i	moisture/water on the surface of the skin / cyanoacrylate monomers rapidly polymerise in the presence of water (1 mark)	1	
b	ii	permanent dipole - permanent dipole attractions (1 mark)	1	
c	i	Methanal (1 mark)	1	
c	ii	Condensation (1 mark)	1	
d		Value between 420 and 1140 $\text{Ncm}^{-2}$ (1 mark)	1	units not required
e	i	 (1 mark)	1	accept any saturated C-8 side-chain

5.

a		Carboxyl (group) (1 mark)	1	
b	i	Large hydrocarbon section attached to the carboxyl group making this section insoluble in water. (1 mark)	1	
b	ii	 (1 mark)	1	Identified portion does not need to include the ester link.
c	i	Amide/peptide (link) (1 mark)	1	

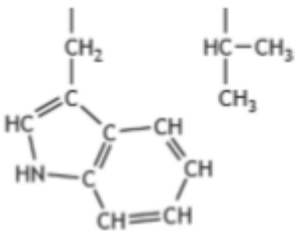
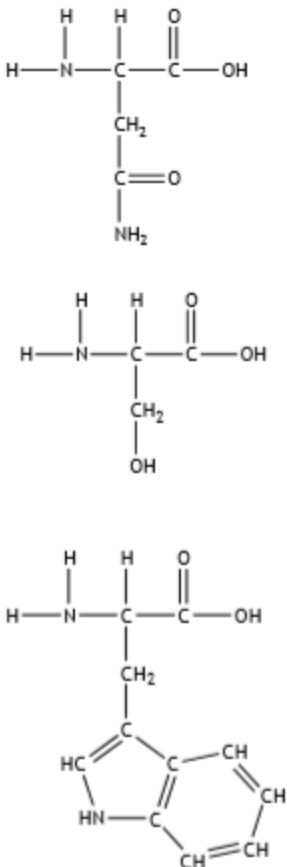
6.	a	i	Shea butter has fewer double bonds/is not very unsaturated (1 mark) The London dispersion forces or van der Waals' forces between its molecules are stronger than in oils, therefore melting point higher. (1 mark)	2	
	a	ii	85-171	1	Actual answer is approx. 134
	a	iii	oxygen	1	
	b	i	Glycerol/propane-1,2,3-triol	1	
	b	ii	Waterbath/Heating mantle	1	Bunsen burner is not acceptable

7. See answer for 3.

8.	a		An amino acid that must be obtained through our diet OR cannot be synthesised by the body (1 mark)	1	
----	---	--	--	---	--

9.	(i)	Terpenes	1	
	(ii) (A)	3,7-dimethylocta-1,6-dien-3-ol	1	
	(ii) (B)	Hydroxyl attached to C which is attached to 3 other C atoms  or hydroxyl attached to a C that has no H atoms attached	1	

10.

(a)		Heat breaks hydrogen bonds	1	
(b)	(i)	Either of structures shown circled	1	
				
	(ii)	$50.5 \pm 1^\circ\text{C}$	1	
(c)	(i)	Hydrolysis	1	
	(ii) (A)	5	1	
	(ii) (B)	<p>Correctly drawn amino acid structure</p> 	1	Ignore bond positioning in side chains



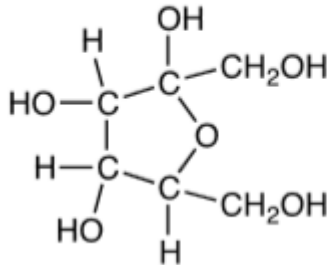
		$  \begin{array}{c}  \text{H} \quad \text{H} \quad \text{O} \\    \quad   \quad    \\  \text{H}-\text{N}-\text{C}-\text{C}-\text{OH} \\    \\  \text{CH}-\text{CH}_3 \\    \\  \text{CH}_3  \end{array}  $		
		$  \begin{array}{c}  \text{H} \quad \text{H} \quad \text{O} \\    \quad   \quad    \\  \text{H}-\text{N}-\text{C}-\text{C}-\text{OH} \\    \\  \text{CH}_2 \\    \\  \text{CH}_2 \\    \\  \text{C}=\text{O} \\    \\  \text{OH}  \end{array}  $		

11. See answer for question 3.

12.


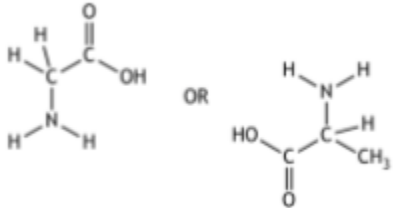
(a)		Carboxyl / carboxylic (acid) group	1	
(b)		Esterification / condensation	1	
(c)		$  \begin{array}{c}  \text{O}=\text{C}-\text{O}-\text{CH}_2-\text{CH}_3 \\    \\  \text{C}_6\text{H}_4 \\    \\  \text{O}-\text{H}  \end{array}  $	1	
(d)		As molecular size (no. of carbon atoms) increases, the absorption decreases.	1	

13.	(ii)	Substances that have unpaired electrons	1	
	(iii)	Propagation	1	

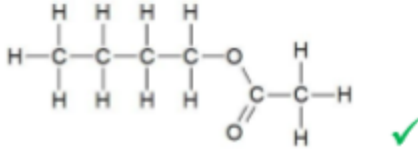
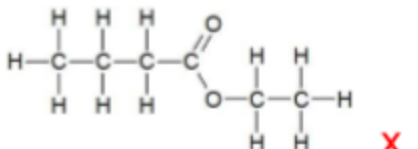
14.	(a)	Aldehyde group correctly identified	1	
	(b)	Ring form correctly drawn 	1	

15.	(a)	Glycerol or glycerine or propan(e)-1,2,3-triol.	1	
	(b) (i)	Polyunsaturated.	1	
	(ii)	Octanoic acid.	1	
	(c) (i)	Bromine solution is added to both until the bromine is no longer decolourised. (or reddish-brown colour remains) <b>(1 mark)</b>  More bromine would be required for the more unsaturated/olive oil  <b>OR</b>  Less bromine would be required for the more saturated/coconut oil. <b>(1 mark)</b>	2	
	(ii)	Hexane is a non-polar (solvent)/ water is a polar (solvent).	1	Answers in terms of "Like dissolves like" are only acceptable if explanation in terms of polarity is given.  Oil and water don't mix would not be awarded a mark.

16.

(a)		Hexapeptide.	1	
(b)		isoleucine-leucine-glycine-valine-serine  <b>OR</b>  serine-valine-glycine-leucine-isoleucine.	1	
(c)		Essential.	1	
(d)	(i)	The peptide molecule: must have contained an amino acid that is repeated in the sequence  <b>OR</b>  contained only four different amino acids (accept four different peptides).  <b>OR</b>  The peptide contains two amino acids: with the same $R_f$ value  <b>OR</b>  that moved the same distance.	1	
	(ii)		1	
(e)	(i)		1	

17.

(a)		Any reason from list  UV light is damaging/harmful to skin. UV light causes sunburn. UV light can break bonds/molecules in skin. UV light damages collagen. UV light can cause skin cancer. UV light ages skin. UV light causes photo ageing. UV light creates free radicals/initiates free-radical chain reactions. Sunblocks contain free-radical scavengers.	1	
(b)	(i)	Species (Atoms/molecules etc) with unpaired electrons.	1	
	(ii)	Initiation.	1	
	(iii)	Carboxylic acid <b>OR</b> carboxyl group.	1	
	(iv)	The hydroxyl/functional group is attached to a carbon that is attached to two other carbons <b>OR</b> The hydroxyl/functional group is attached to a carbon which has only one hydrogen attached.	1	The answer required is an answer based on structure not an answer based on a chemical property. ie, an answer stating it can be oxidised to give a ketone would not be awarded the mark.
(c)	(i)	A correct structural formula for butyl ethanoate.	1	 
	(ii)	To condense any vapours or reactants/products which evaporate <b>OR</b> To act as a condenser.	1	Must be indication that gases are being turned to liquid.

18.

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

19.

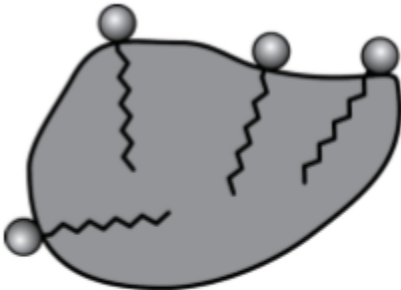
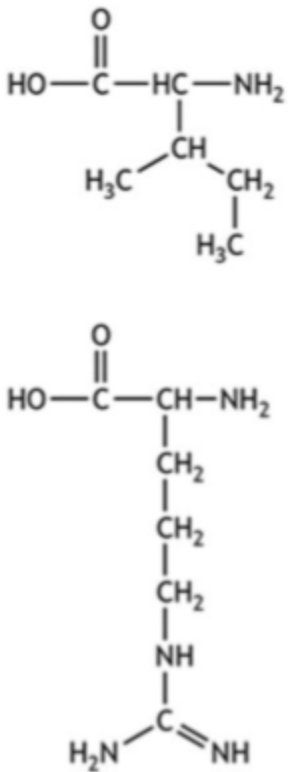
(a)	(i)	Pentan-1-ol	1	Pentanol is not acceptable.
	(ii)	$\text{Na}^+ \quad \text{O}^- - \overset{\text{O}}{\parallel} \text{C} - \underset{\text{H}}{\underset{ }{\text{C}}} - \underset{\text{H}}{\underset{ }{\text{C}}} - \underset{\text{H}}{\underset{ }{\text{C}}} - \text{H}$	1	<p>Candidates should be awarded zero marks if they draw a covalent bond between O and Na.</p> <p>Charges not required but if shown they must <b>both</b> be correct.</p> <p>Accept shortened structural formulae.</p>
(b)	(i)	ester	1	
	(ii)	soap	1	Accept emulsifier or detergent.

20.

(a)	(i)	$  \begin{array}{cccc}  & \text{H} & \text{H} & \text{H} & \text{H} \\  &   &   &   &   \\  \text{H} & - \text{C} & - \text{C} & - \text{C} & - \text{C} - \text{H} \\  &   &   &   &   \\  & \text{H} & \text{OH} & \text{H} & \text{H}  \end{array}  $	1	Accept a correct shortened structural formula
	(ii) (A)	Reactants or products are flammable/could catch fire.	1	
	(ii) (B)	orange to green/ blue-green/blue	1	
	(ii) (C)	Tertiary	1	
	(iii) (A)	Butanoic acid <b>OR</b> (2-)methylpropanoic acid	1	
	(iii) (B)	$\text{C}_4\text{H}_9\text{OH} + \text{H}_2\text{O} \rightarrow \text{C}_4\text{H}_8\text{O}_2 + 4\text{H}^+ + 4\text{e}^-$	1	Negative sign on electron not required. Positive sign on $\text{H}^+$ required.
(b)	(i)	2-methylpentanal	1	2-methylpentan-1-al is not acceptable.
	(ii)	Any temperature between 166 and 181 ( $^{\circ}\text{C}$ )	1	No units required. No mark can be awarded if wrong unit is given.  (wrong units would only be penalised once in any paper)
	(iii)	(More) branching lowers the boiling point (of isomeric aldehydes).	1	
	(iv)	Silver mirror/silver precipitate	1	Accept silver on its own

21. See answer for question 3

22.

(a)	(i)	<p>A drawing similar to</p>  <p>Diagram shows <b>at least one</b> detergent molecule. All tails shown should be <b>fully</b> inside the fat-soluble dirt.</p>	1	
	(ii)	hydrophobic	1	
(b)	(i)	To break down coloured compounds/ removes stains/kill bacteria/kill fungi/inactivate viruses/germs	1	<p>Stating only that oxidation occurs would be seen as restating the information from the stem.</p> <p>Discolour is not accepted.</p>
(c)	(i)	amino acids	1	
	(ii) (A)	Amide/amide link/peptide link	1	Amine/amino not acceptable
	(ii) (B)	<p>Any of the shown amino acids:</p> 	1	

		$\text{HO}-\overset{\overset{\text{O}}{\parallel}}{\text{C}}-\text{CH}_2-\text{NH}_2$ $\text{HO}-\overset{\overset{\text{O}}{\parallel}}{\text{C}}-\underset{\underset{\text{CH}_2}{\mid}}{\text{HC}}-\text{NH}_2$ $\mid$ $\text{SH}$		
	(iii) (A)	Denaturing	1	
	(iii) (B)	Temperature increase/pH	1	Temperature on its own is not acceptable. High/higher/above optimum temperature are also accepted.
(d)	(i)	Condensation	1	
	(ii)	$\begin{array}{ccc} \text{H}_3\text{C}-\overset{\overset{\text{O}}{\parallel}}{\text{C}} & & \text{O}=\overset{\overset{\text{O}}{\parallel}}{\text{C}}-\text{CH}_3 \\ & \diagdown \quad \diagup & \\ & \text{N}-(\text{CH}_2)_2-\text{N} & \\ & \diagup \quad \diagdown & \\ \text{H}_3\text{C}-\overset{\overset{\text{O}}{\parallel}}{\text{C}} & & \text{O}=\overset{\overset{\text{O}}{\parallel}}{\text{C}}-\text{CH}_3 \end{array}$	1	

23.

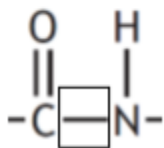
(a)		<p>Correctly drawn structure of pentan- 2-one, pentan-3-one or 3- methylbutanone.</p> $\begin{array}{c} \text{H} \qquad \qquad \text{O} \\ \mid \qquad \qquad \parallel \\ \text{H}_3\text{C}-\text{C}-\text{C}-\text{CH}_3 \\ \mid \\ \text{CH}_3 \end{array}$ $\text{H}_3\text{C}-\text{CH}_2-\text{CH}_2-\overset{\overset{\text{O}}{\parallel}}{\text{C}}-\text{CH}_3$ $\text{H}_3\text{C}-\text{CH}_2-\overset{\overset{\text{O}}{\parallel}}{\text{C}}-\text{CH}_2-\text{CH}_3$	1	Accept full or shortened structural formulae.
(b)		Fehling's solution/Tollens' reagent/ <b>acidified</b> dichromate solution.	1	Accept Benedict's solution/Schiff's reagent.
(c)		Permanent dipole-permanent dipole (interactions/attractions).	1	Allow permanent dipole-dipole interaction. Accept pd-pd i's.

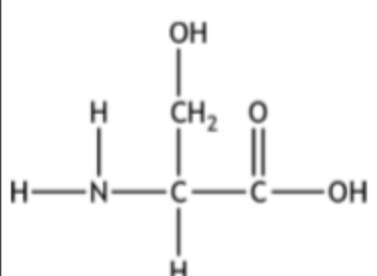


(d)		Will react with oxygen/undergo oxidation. (1)  Forming a <b>carboxylic</b> acid (which has unpleasant taste). (1)	2	Rancid not acceptable on its own but is not cancelling.  Acid not acceptable on its own.
(e)	(i)	Because it has two molecules joining together with the loss of a small/water molecule.	1	Candidates must indicate joining together and loss.
	(ii)	6-methylheptan-2-one	1	General marking principle (p) applies.

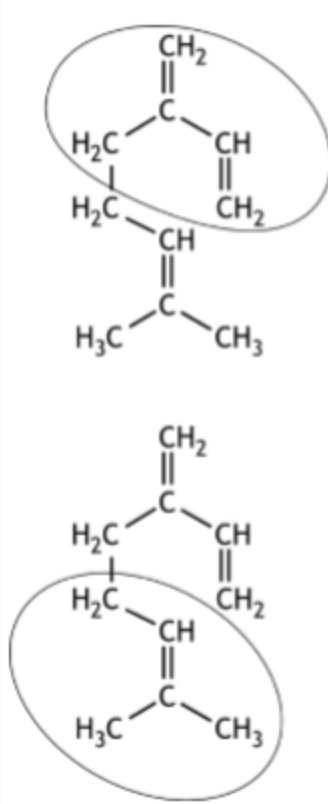
24. See answer for question 3.

25.

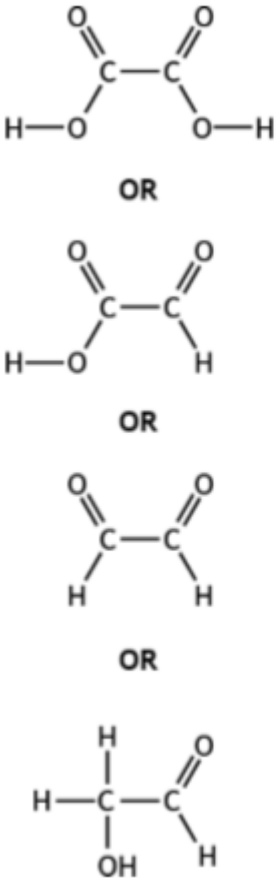
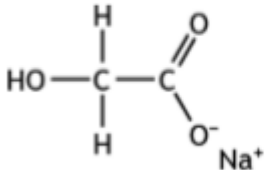
(a)	(i)	(enzyme) hydrolysis	1	
	(ii)	C <sub>20</sub> H <sub>29</sub> OH  <b>OR</b>  C <sub>20</sub> H <sub>30</sub> O	1	
(b)	(i)	Bond breaking by UV (light) or example of initiation reaction (equation or diagram). eg chlorine splitting to give two free radicals is accepted, provided UV is shown.	1	UV on its own is not accepted.  Bond breaking on its own is not accepted.
	(ii)	propagation	1	
	(iii)	Can react with free radicals forming stable molecules/free radicals (and prevent chain reactions).  <b>OR</b>  Donates electron(s).  <b>OR</b>  Acting as a reducing agent.  <b>OR</b>  Provide electrons to pair with an unpaired electron.	1	
(c)	(i)	Circle any peptide link (CONH).	1	 <p>Minimum acceptable structure identified.</p>

	(ii)		1	Shortened structural formula accepted.
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26.

(a)	(i)		1	0 marks awarded for
	(ii)	Sesquiterpene	1	

(b)	(i)	<p>5.345/5.35/5.3 (kg) (2)</p> <p>Partial marking</p> <p>Mass of squalene</p> <p>= <math>10.69 \times 500\,000</math></p> <p>= 5 345 000 (mg) (1)</p> <p><b>OR</b></p> <p>For incorrectly calculating mass in mg but correctly converting to kg. (1)</p> <p><b>OR</b></p> <p>For incorrectly calculating mass of squalene but correctly multiplying this by 500 000. (1)</p> <p><b>OR</b></p> <p>Conversion of 10.69 mg to kg ie <math>10.69 \times 10^{-6}</math>.</p>	2	Answer must be in kg to access both marks, 5345 g would be awarded 1 mark only.
	(ii)	6/six (moles)	1	
(c)	(i)	<p>Addition</p> <p><b>OR</b></p> <p>hydration.</p>	1	Oxidation is not accepted.
	(ii)	(terpineol) is a tertiary alcohol (and cannot be oxidised).	1	'cannot be oxidised' on its own is awarded zero marks.

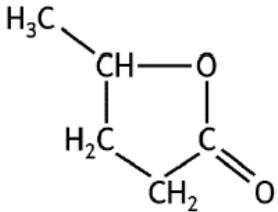
(d)	(iii) (A)	 <p>OR</p> <p>OR</p> <p>OR</p> <p>OR</p>	1	<p>Accept correct shortened structural formula.</p> <p>With structures involving an - OH group, no mark can be awarded if the 'O' is not bonded to a carbon, ie OH-CH<sub>2</sub>.</p> <p>General marking instruction (I) is suspended here.</p>
	(iii) (B)	<p>Correct molecular formula (NaC<sub>2</sub>H<sub>3</sub>O<sub>3</sub>)</p> <p>OR</p> <p>shortened structural formula (HOCH<sub>2</sub>COONa)</p> <p>OR</p> <p>any full structural formula which shows the correct salt.</p> 	1	<p>Structures showing covalent bonds between Na and glycolate are not accepted.</p> <p>Charges are not required but if shown must both be shown and correct.</p>

28.

(a)	(i)	More/adding chlorine(s). (1)  More/adding carbon(s).  <b>OR</b>  Adding an alkyl/hydrocarbon chain/group.  <b>OR</b>  Longer/bigger carbon/hydrocarbon/alkyl (chain/group). (1)	2	(More) branches is not accepted.
	(ii)	2-chloro-4,5-dimethylphenol	1	Apply general marking instruction (p).
(b)	(i)	126.9/127(kg)  Partial mark either for:  Calculation of the theoretical yield 141 (no unit required) (1)  <b>OR</b>  for correctly calculating 90% of an incorrectly calculated theoretical yield. (1)	2	No units required but a maximum of 1 mark is awarded if wrong unit is given. (Wrong units would only be penalised once in any paper).  Accept correctly calculated answer in g, providing units are shown with answer, eg 126900 g.
	(ii)	Propanone  <b>OR</b>  Acetone  <b>OR</b>  propan-2-one.	1	Structure is not acceptable on its own.

29.	(a)	(i)	biological catalyst	1	Biochemical catalyst/protein that acts as a catalyst accepted
	(b)	(i)	Carbon dioxide/CO <sub>2</sub>	1	
	(c)		propan-1,2,3-triol  OR  propane-1,2,3-triol  OR  1,2,3-propanetriol	1	

30.	(a)	(i) A	Same number of electrons (34) (1)  OR  same strength of London dispersion forces/LDFs (1)	1	
	(ii)		methanethiol	1	Accept methanthiol
	(b)	(i)	SH group is on a carbon connected to 3 other carbons/SH group is opposite the branch in a chain.  The SH group is attached to a carbon which has no hydrogens attached.	1	
		(ii) A	$  \begin{array}{ccccc}  & \text{H} & & \text{H} & & \text{SH} \\  &   & &   & &   \\  \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\  &   & &   & &   \\  & \text{H} & & \text{CH}_3 & & \text{H}  \end{array}  $	1	

31.	(a)	(i)	propagation	1	
		(ii)	UV/ultraviolet	1	
		(iii)	Anti-oxidant/free radical scavenger/reducing agent/electron donor	1	
	(b)	(i)	Water/H <sub>2</sub> O	1	
		(ii)		1	
		(iii)	3-hydroxybutanoic acid	1	

32.	(a)	(i)	6	1	
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33.	<p>This is an open ended question</p> <p><b>1 mark:</b> The student has demonstrated, at an appropriate level, a limited understanding of the chemistry involved. The student has made some statement(s) which is/are relevant to the situation, showing that at least a little of the chemistry within the problem is understood.</p> <p><b>2 marks:</b> The student has demonstrated a reasonable understanding, at an appropriate level, of the chemistry involved. The student makes some statement(s) which is/are relevant to the situation, showing that the problem is understood.</p> <p><b>3 marks:</b> The maximum available mark would be awarded to a student who has demonstrated a good understanding, at an appropriate level, of the chemistry involved. The student shows a good comprehension of the chemistry of the situation and has provided a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. This does not mean the answer has to be what might be termed an "excellent" answer or a "complete" one.</p>	3	<p>Zero marks should be awarded if:</p> <p>The student has demonstrated no understanding of the chemistry involved. There is no evidence that the student has recognised the area of chemistry involved or has given any statement of a relevant chemistry principle. This mark would also be given when the student merely restates the chemistry given in the question.</p>
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34.	(a)	(i) Ionic and positively charged Both needed	1	Accept positive/+ve/+
		(ii) alkaline hydrolysis/saponification A	1	Do not accept “hydrolysis” on its own. Hydrolysis with named strong alkali would be acceptable.
		(ii) (Compound C) has an ionic/hydrophilic part <b>and</b> a non polar/hydrophobic part (or alternative wording/diagram showing knowledge of these parts of the molecule) B (1)  Correctly identifies the part of the molecule/head/COO <sup>-</sup> dissolves in water/ is hydrophilic and the part of the molecule/tail/hydrocarbon chain dissolves in oil/hydrophobic. (1)  Agitation separates oil from the surface/cause small oil droplets to form  <b>OR</b>  The (negatively-charged) ball-like structures repel each other (and the oil or grease is kept suspended in the water)  <b>OR</b>  Soaps/compound C allow(s) emulsions to form or break(s) oil into micelles. (1)  Accept correct diagrams with annotations that show above.	3	
		(iii) Reacting them (edible oils) with glycerol/ propan-1,2,3-triol/propane-1,2,3-triol/ 1,2,3-propanetriol/C <sub>3</sub> H <sub>8</sub> O <sub>3</sub>	1	

The END