

Kirkcaldy High School



Chemistry

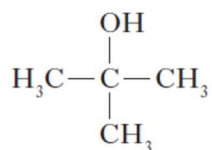
Higher

Unit 2 - Nature's Chemistry

TUTORIAL QUESTIONS

(a) Alcohols

1.



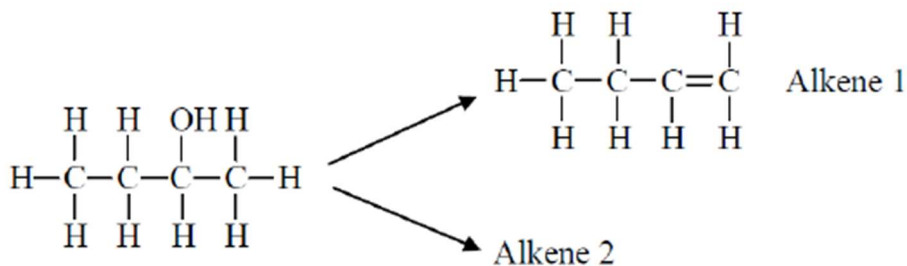
Which of the following compounds is an isomer of the structure shown above?

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

2.

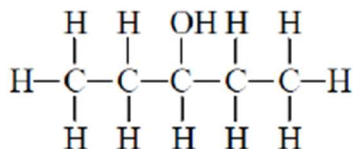
Dehydration is the removal of water from a compound. When an alcohol is dehydrated the OH from one carbon and an H from an adjacent carbon are lost and the product is an alkene.

A molecule of butan-2-ol can produce two different alkenes when dehydrated:



(a) Draw a full structural formula for alkene 2.

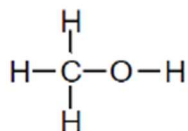
(b) How many alkenes will be formed when pentan-3-ol is dehydrated?



3. Draw a structural formula for butan-1-ol

4.

(a) The structural formula of methanol is shown below.

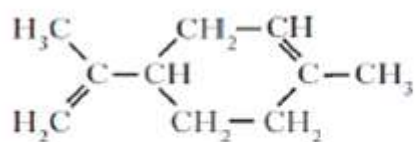


Copy the structure and draw another molecule of methanol beside it and then use a dotted line to show how a hydrogen bond can form between the molecules.

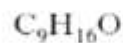
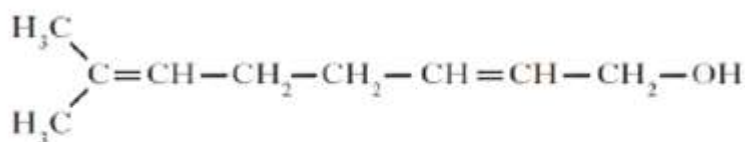
(b) Propan-2-ol is used in some hand gels. Why is propan-2-ol more suitable than hexan-2-ol for this purpose?

5.

Two typical compounds that are present in many perfumes are shown.



limonene



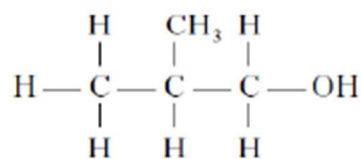
geraniol

Why does geraniol evaporate more slowly than limonene?

6.

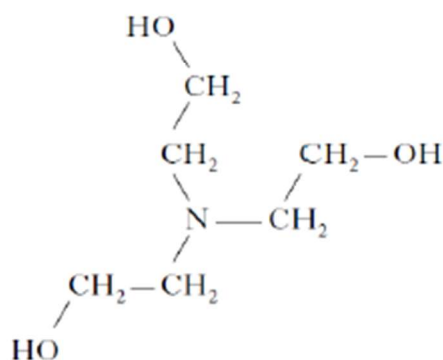
Hairspray is a mixture of chemicals.

- (a) A primary alcohol, 2-methylpropan-1-ol, is added to hairspray to help it dry quickly on the hair.

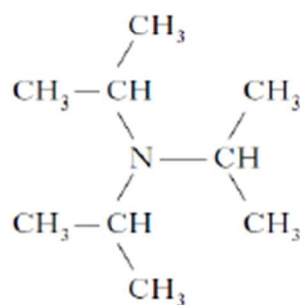


Draw a structural formula for a secondary alcohol that is an isomer of 2-methylpropan-1-ol.

- (b) Triethanol amine and triisopropyl amine are bases used to neutralise acidic compounds in the hairspray to prevent damage to the hair.



triethanol amine



triisopropyl amine

molecular mass 149

boiling point 335 °C

molecular mass 143

boiling point 47 °C

In terms of the intermolecular bonding present, **explain clearly** why triethanol amine has a much higher boiling point than triisopropyl amine.

(b) Carboxylic Acids

1.

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

- A hexanal
- B hexan-2-ol
- C hexan-2-one
- D hexanoic acid.

2.

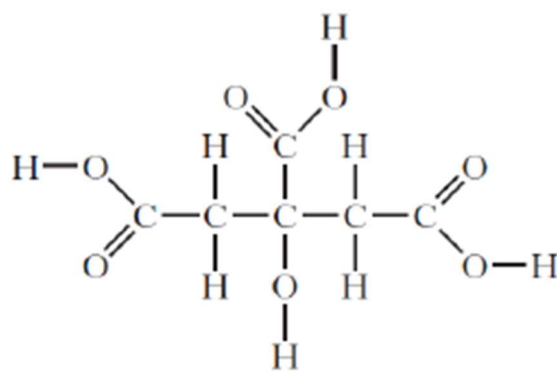
Which of the following could be the formula for a carboxylic acid but **not** for an ester?

- A CH_2O_2
- B $C_2H_4O_2$
- C $C_3H_6O_2$
- D $C_4H_8O_2$

3. Draw a structural formula for 2-methylpentanoic acid

4. Sherbet is a sweet powder that fizzes on the tongue

Sherbet contains citric acid



citric acid

- (a) Name the two types of functional group present in the citric acid molecule
- (b) Explain why citric acid is very soluble in water.

(c) Esters, Fats and Oils

1.

Fats are formed by the condensation reaction between glycerol molecules and fatty acid molecules.

In this reaction the mole ratio of glycerol molecules to fatty acid molecules is

- A 1 : 1
- B 1 : 2
- C 1 : 3
- D 3 : 1.

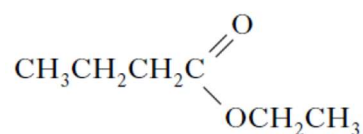
2.

Which of the following reactions takes place during the 'hardening' of vegetable oil?

- A Addition
- B Hydrolysis
- C Dehydration
- D Oxidation

3.

Rum flavouring is based on the compound with the formula shown.



It can be made from

- A ethanol and butanoic acid
- B propanol and ethanoic acid
- C butanol and methanoic acid
- D propanol and propanoic acid.

4.

Which of the following fatty acids is unsaturated?

- A $\text{C}_{19}\text{H}_{39}\text{COOH}$
- B $\text{C}_{21}\text{H}_{43}\text{COOH}$
- C $\text{C}_{17}\text{H}_{31}\text{COOH}$
- D $\text{C}_{13}\text{H}_{27}\text{COOH}$

5.

Which of the following is an isomer of ethyl propanoate?

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

6.

Which of the following is most likely to be used as a flavouring?

- A $\text{CH}_3\text{CH}_2\text{CHO}$
- B $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$
- C $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$
- D $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_3$

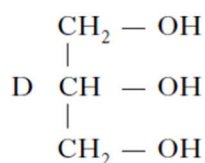
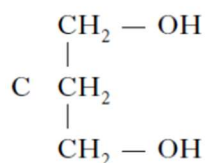
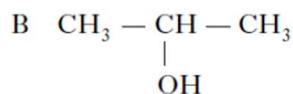
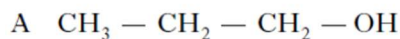
7.

Fats have higher melting points than oils because comparing fats and oils

- A fats have more hydrogen bonds
- B fat molecules are more saturated
- C fat molecules are more loosely packed
- D fats have more cross-links between molecules.

8.

Which of the following alcohols is likely to be obtained on hydrolysis of butter?



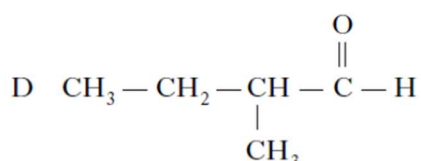
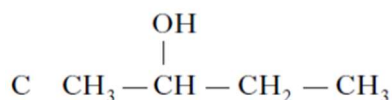
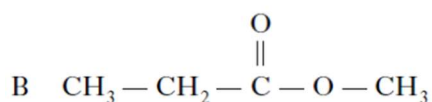
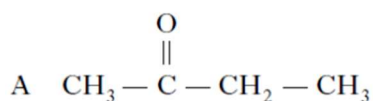
9.

Which of the following consumer products is **least** likely to contain esters?

- A Solvents
- B Perfumes
- C Toothpastes
- D Flavourings

10.

Which of the following compounds is hydrolysed when warmed with sodium hydroxide solution?



11.

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

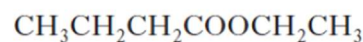
The iodine number of an oil is the mass of iodine in grams that will react with 100 g of oil.

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

	Oil	Iodine number
A	corn	123
B	linseed	179
C	olive	81
D	soya	130

12.

An ester has the following structural formula



The name of this ester is

- A propyl propanoate
- B ethyl butanoate
- C butyl ethanoate
- D ethyl propanoate.

13.

Esters are formed by the reaction between which **two** functional groups?

- A A hydroxyl group and a carboxyl group
- B A hydroxyl group and a carbonyl group
- C A hydroxide group and a carboxyl group
- D A hydroxide group and a carbonyl group

14.

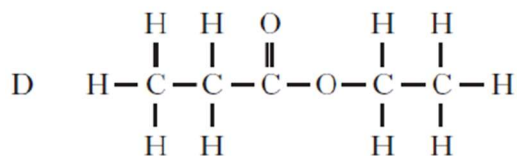
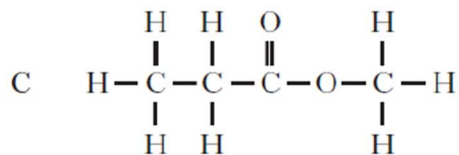
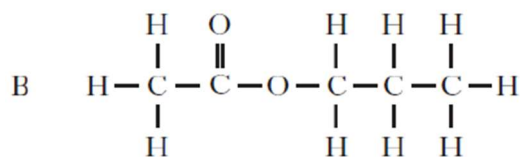
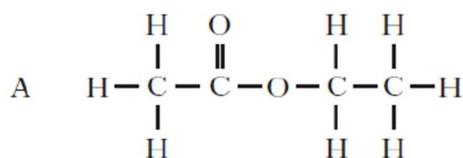
Oils are generally

- A solid at room temperature and contain a high proportion of unsaturated molecules
- B solid at room temperature and contain a high proportion of saturated molecules
- C liquid at room temperature and contain a high proportion of unsaturated molecules
- D liquid at room temperature and contain a high proportion of saturated molecules.

15.

Hydrolysis of an ester gave an alcohol and a carboxylic acid both of which had the same molecular mass of 60.

The structure of the ester was



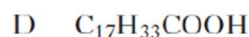
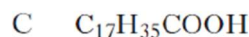
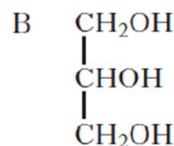
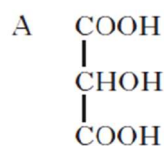
16.

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

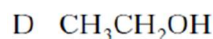
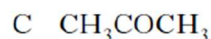
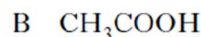
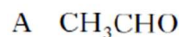
17.

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



18.

Which of the following compounds would react with sodium hydroxide solution to form a salt?



19.

The conversion of linoleic acid, $\text{C}_{18}\text{H}_{32}\text{O}_2$, into stearic acid, $\text{C}_{18}\text{H}_{36}\text{O}_2$, is likely to be achieved by

A hydrogenation

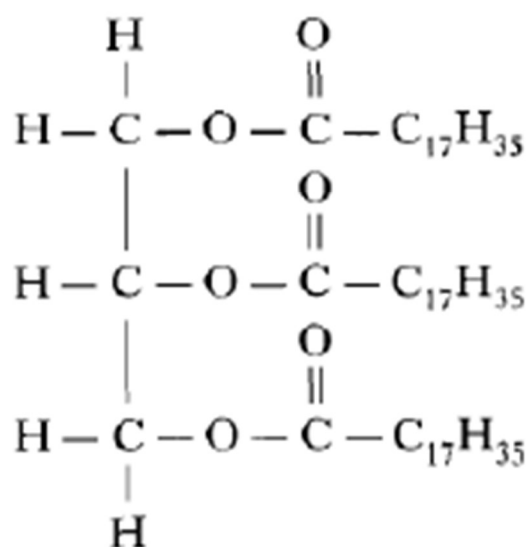
B hydrolysis

C hydration

D dehydrogenation.

20.

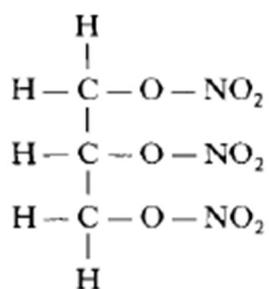
The structure of a fat molecule is shown below.



- (a) When the fat is hydrolysed, a fatty acid is obtained.
Name the other product obtained in this reaction.
- (b) Oils are liquid at room temperature; fats are solid.
Why do oils have lower melting points than fats?

21.

Glycerol trinitrate is an explosive with the structure shown.



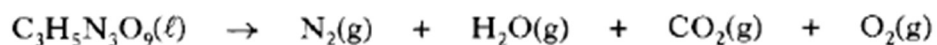
(a) Glycerol trinitrate is produced from glycerol.

(i) Draw a structural formula for glycerol.

(ii) Name a group of naturally occurring esters that can be hydrolysed to obtain glycerol.

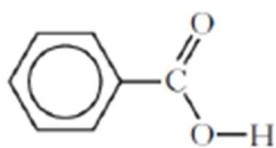
(b) When exploded, glycerol trinitrate decomposes to give nitrogen, water, carbon dioxide and oxygen.

Balance the equation for this reaction.



23.

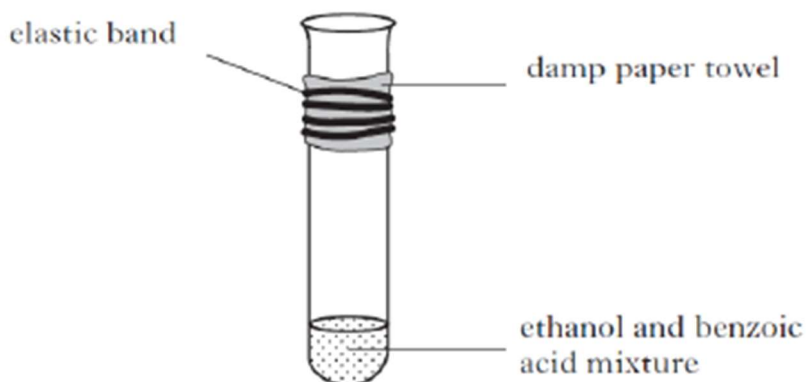
Benzoic acid, C_6H_5COOH , is an important feedstock in the manufacture of chemicals used in the food industry.



benzoic acid

The ester ethyl benzoate is used as a food flavouring.

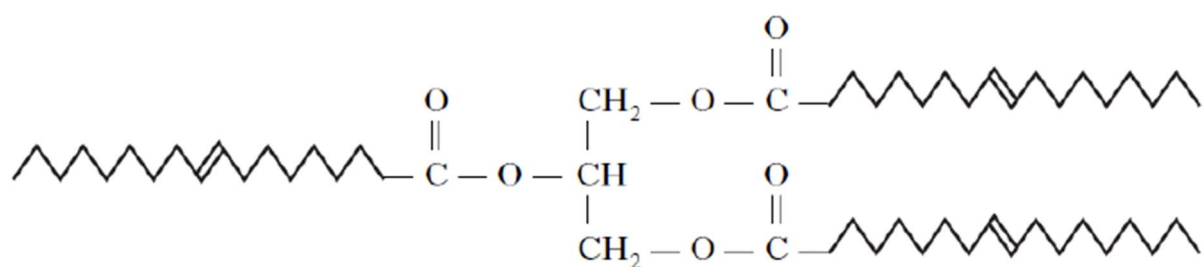
Ethyl benzoate can be prepared in the laboratory by an esterification reaction. A mixture of ethanol and benzoic acid is heated, with a few drops of concentrated sulfuric acid to catalyse the reaction.



- Suggest a suitable method for heating the reaction mixture
- During esterification the reactant molecules join by eliminating a small molecule. What name is given to this type of reaction?
- Draw a structural formula for ethyl benzoate.

24.

A typical triglyceride found in olive oil is shown below.



- (a) To which family of organic compounds do triglycerides belong?
- (b) Olive oil can be hardened for use in margarines.
What happens to the triglyceride molecules during the hardening of olive oil?
- (c) Give **one** reason why oils can be a useful part of a balanced diet.

25.

When vegetable oils are hydrolysed, mixtures of fatty acids are obtained. The fatty acids can be classified by their degree of unsaturation.

The table below shows the composition of each of the mixtures of fatty acids obtained when palm oil and olive oil were hydrolysed.

	Palm oil	Olive oil
Saturated fatty acids	51%	16%
Monounsaturated fatty acids	39%	75%
Polyunsaturated fatty acids	10%	9%

(a) Why does palm oil have a higher melting point than olive oil?

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

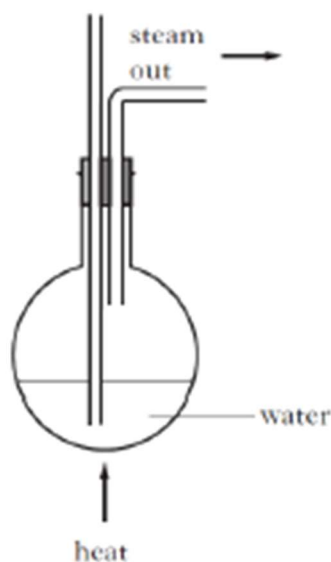
To which class (saturated, monounsaturated or polyunsaturated) does this fatty acid belong?

26.

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

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

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

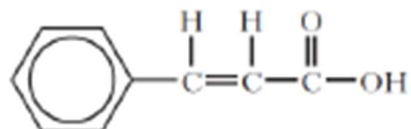


- (ii) The essential oil extracted is a mixture of compounds.

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

- (b) Methyl cinnamate can be made from cinnamic acid and methanol.

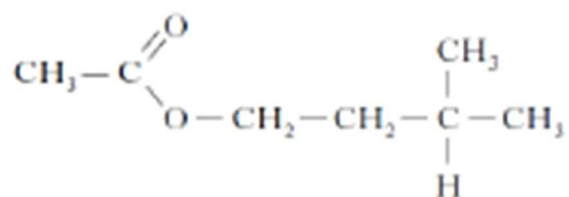
A structural formula for cinnamic acid is shown.



Draw a structural formula for the ester methyl cinnamate.

27.

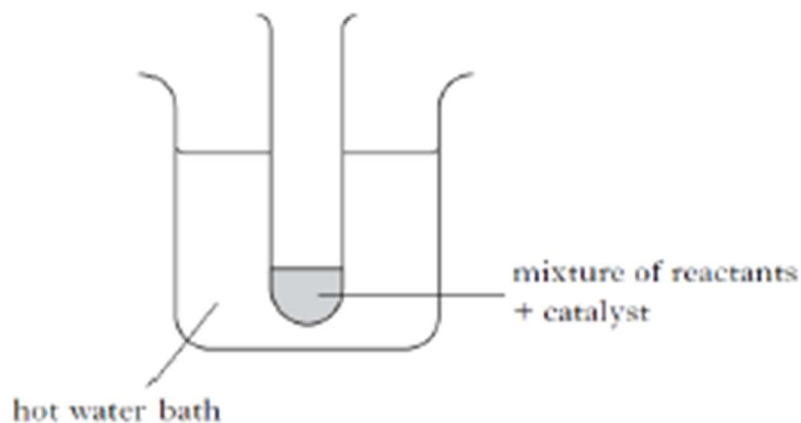
One of the chemicals released in a bee sting is an ester that has the structure shown.



This ester can be produced by the reaction of an alcohol with an alkanoic acid.

(a) Name this acid.

(b) The ester can be prepared in the lab by heating a mixture of the reactants with a catalyst.

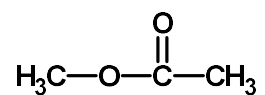


(i) Name the catalyst used in the reaction.

(ii) What improvement could be made to the experimental set-up shown in the diagram?

28.

(a) Name the following substance



(b) Propan-1-ol and propanoic acid react to form an ester. The mixture of excess reactants and ester product is poured onto sodium hydrogencarbonate solution.

- (i) What evidence would show that an ester is formed?
- (ii) Draw a structural formula for this ester.

(d) Soaps, detergents and emulsions

1.

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

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

2.

The compound $\text{CH}_3\text{CH}_2\text{COO}^-\text{Na}^+$ is formed by reaction between sodium hydroxide and

- A propanoic acid
- B propan-1-ol
- C propene
- D propanal.

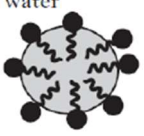
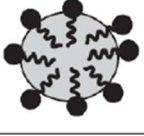
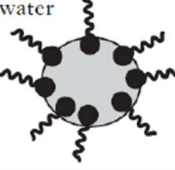
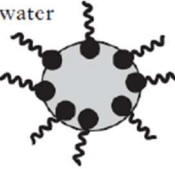
3.

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

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

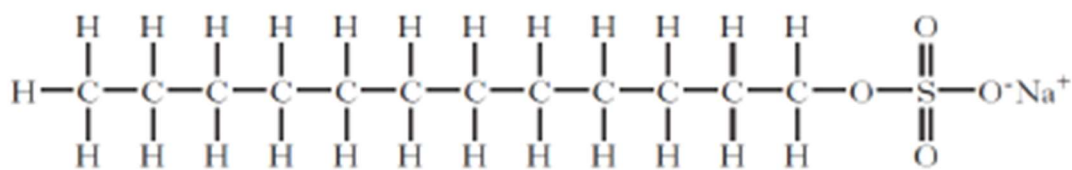
4.

Which of the following diagrams and explanations best describes a step in the cleansing action of soap?

	Diagram	Explanation
A	 <p>water</p>	<p>Hydrophobic head dissolves in water.</p> <p>Hydrophilic tail dissolves in oil droplet.</p>
B	 <p>water</p>	<p>Hydrophilic head dissolves in water.</p> <p>Hydrophobic tail dissolves in oil droplet.</p>
C	 <p>water</p>	<p>Hydrophobic head dissolves in oil droplet.</p> <p>Hydrophilic tail dissolves in water.</p>
D	 <p>water</p>	<p>Hydrophilic head dissolves in oil droplet.</p> <p>Hydrophobic tail dissolves in water.</p>

7.

Sodium lauryl sulfate, $\text{CH}_3(\text{CH}_2)_{11}\text{OSO}_3\text{Na}$, is a compound found in handwash. It has a similar cleaning action to soap.

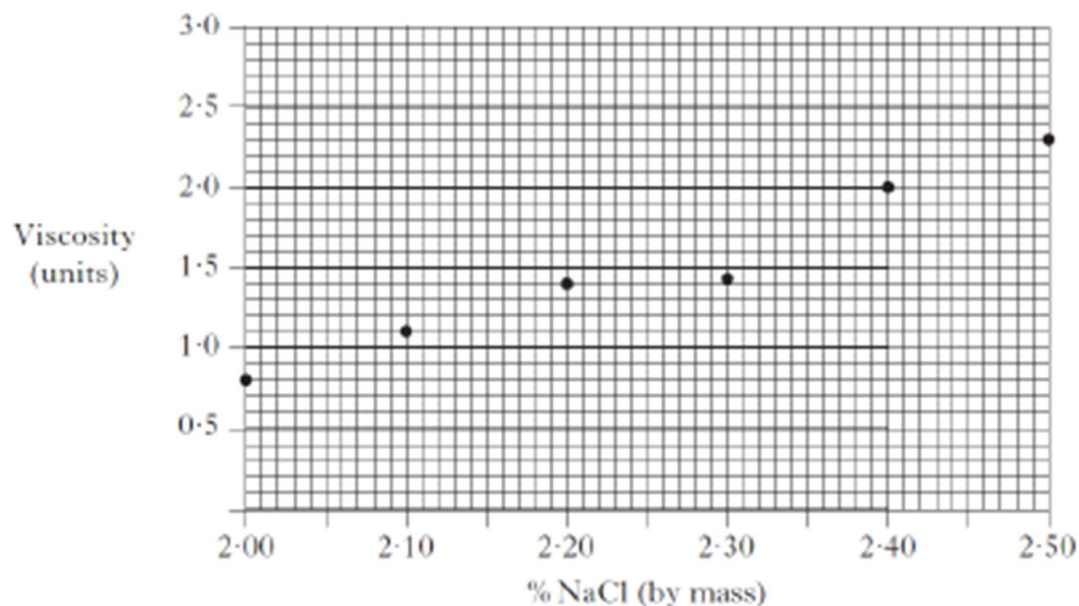


sodium lauryl sulfate

(a) **Explain fully** the cleaning action of sodium lauryl sulfate. (You may wish to use diagrams to illustrate your answer.)

(b) Sodium chloride is added during manufacture to increase the viscosity of handwashes.

In an investigation to measure the effect of sodium chloride on the viscosity of handwash, the following results were obtained.

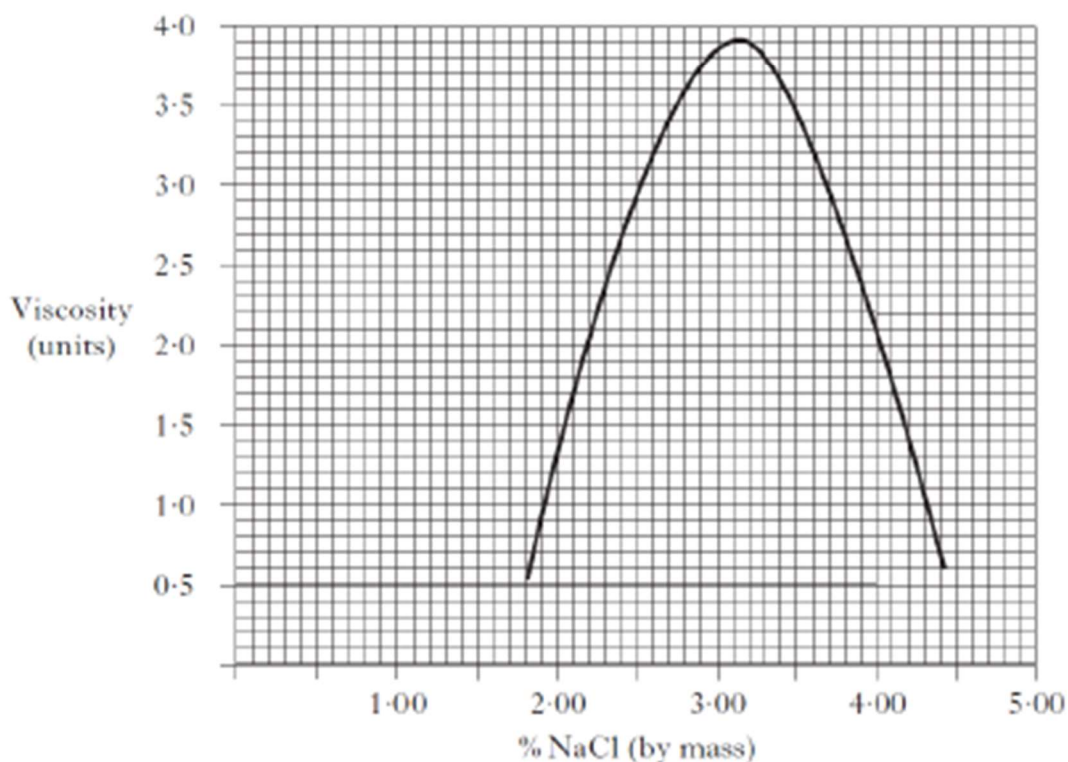


7. (cont)

- (i) Use the graph to calculate the mass of sodium chloride, in grams, that should be added to 1 litre of handwash to give a viscosity of 1.5 viscosity units.

(Take the mass of 1 cm^3 of handwash to be 1.1 g)

- (ii) The graph below shows how the mass of sodium chloride added, affects the viscosity of a particular handwash.



Manufacturers want to produce handwashes with high viscosity.

During the manufacturing process the mass of sodium chloride added is monitored. Suggest why this needs to be done.

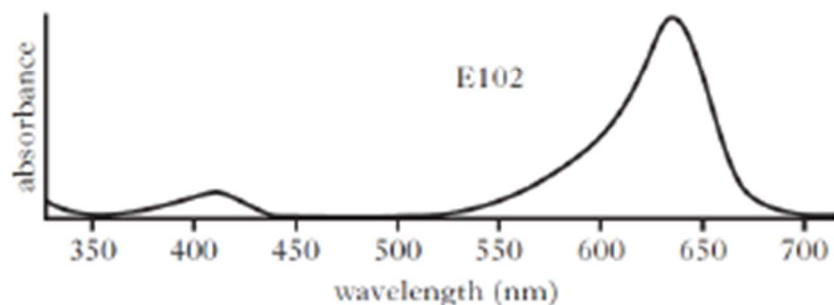
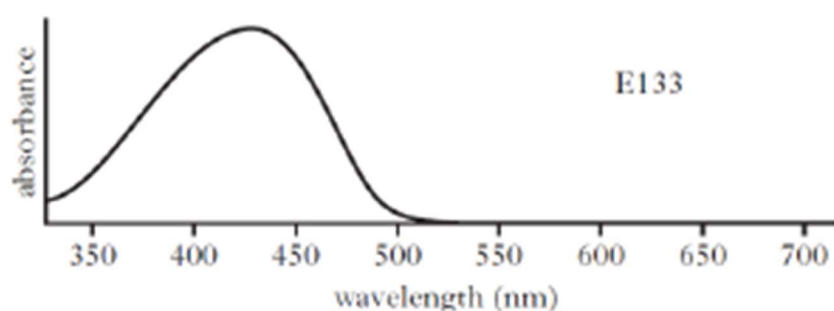
7. (cont)

- (c) The colour of a handwash is due to the wavelengths of light that pass through the handwash, ie, are not absorbed.

A handwash contains two dyes, E133 and E102, which absorb light of particular wavelengths. The typical wavelengths associated with some colours are shown in the table.

Colour	Wavelength (nm)
Red	650
Orange	590
Yellow	570
Green	510
Blue	475
Indigo	450
Violet	400

The peaks in the following spectra show the wavelengths of light absorbed by each of the two dyes.



State the colour of the handwash.

8.

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.

9.

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

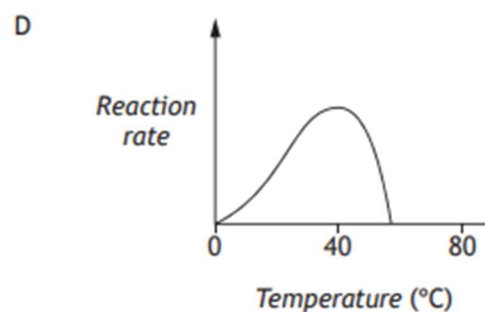
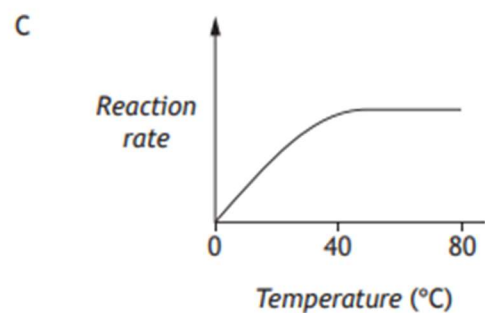
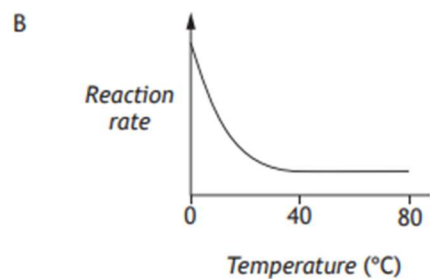
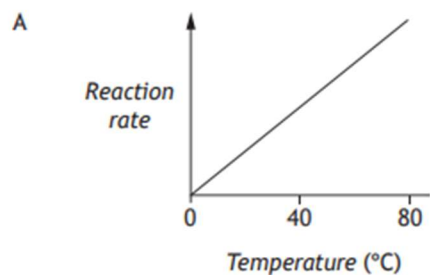
Using your knowledge of chemistry, describe the relationships between fats, oils, detergents, soaps and emulsifiers.

3

(e) Proteins

1.

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



2.

Which type of bond is broken when a protein is denatured?

- A Ionic
- B Polar covalent
- C Hydrogen
- D Non-polar covalent

3.

When a protein is denatured

- A its overall shape is distorted
- B its amide links are hydrolysed
- C it is broken into separate peptide fragments
- D it decomposes into amino acids.

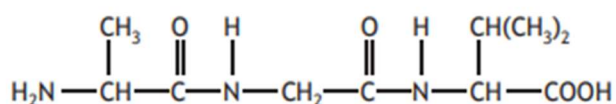
4.

Essential amino acids are defined as the amino acids which

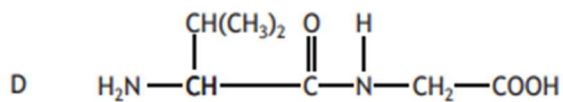
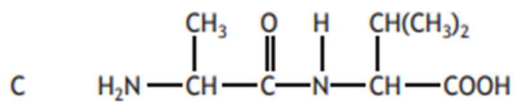
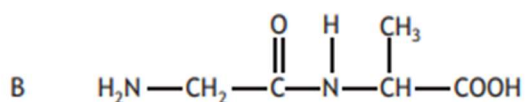
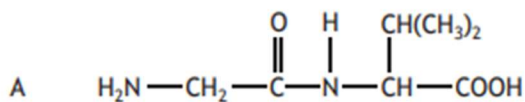
- A are necessary for building proteins
- B humans must acquire through their diet
- C plants cannot synthesise for themselves
- D are produced when any protein is hydrolysed.

5.

Molecule X has the structure



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



6.

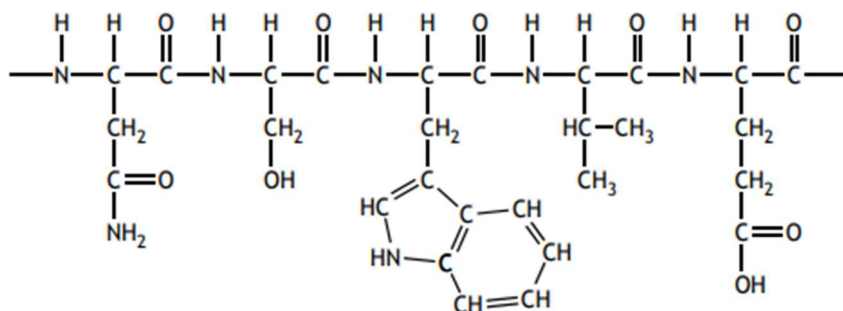
Uncooked egg white is mainly composed of dissolved proteins. During cooking processes, the proteins become denatured as the protein chains unwind, and the egg white solidifies.

(a) Explain why the protein chains unwind.

1

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

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



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

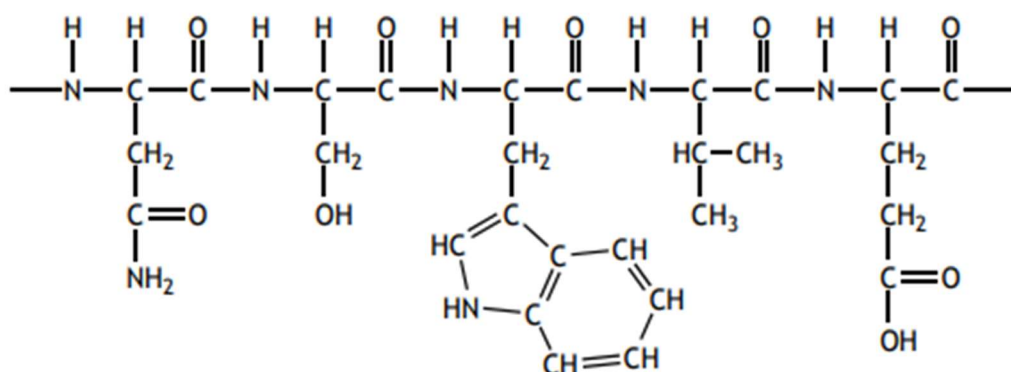
1

(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

(f) Oxidation of Food

1.

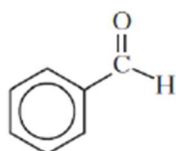
Compound **X** reacted with hot copper(II) oxide and the organic product did not give a colour change when heated with Fehling's solution.

Compound **X** could be

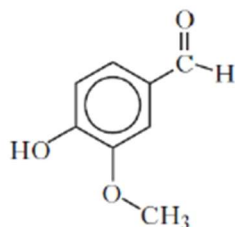
- A butan-1-ol
- B butan-2-ol
- C butanone
- D butanoic acid.

2.

Benzaldehyde and vanillin are examples of flavour molecules.



benzaldehyde



vanillin

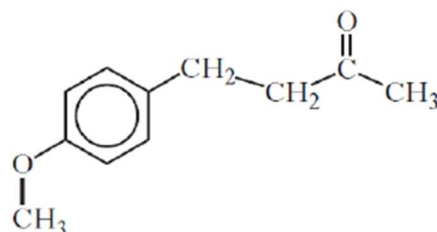
Vanillin is soluble in water and is fairly volatile.

Which line in the table correctly compares benzaldehyde to vanillin?

	Solubility in water	Relative volatility
A	greater than vanillin	greater than vanillin
B	greater than vanillin	less than vanillin
C	less than vanillin	less than vanillin
D	less than vanillin	greater than vanillin

3.

A compound with the following structure is used in perfumes to help provide a sweet, fruity fragrance.

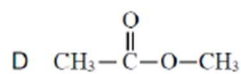
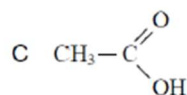
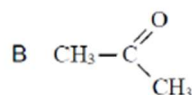
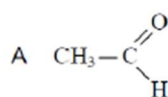


This compound could be classified as

- A an aldehyde
- B a carboxylic acid
- C an ester
- D a ketone.

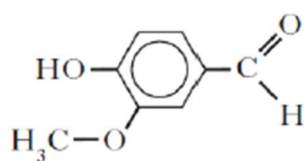
4.

Which of the following compounds is an aldehyde?

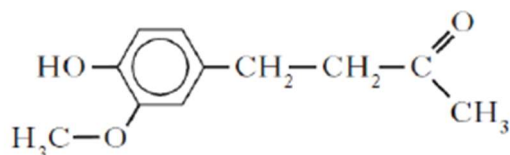


5.

Vanillin and zingerone are flavour molecules.



vanillin



zingerone

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

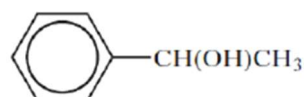
	More soluble in water	More volatile
A	vanillin	vanillin
B	vanillin	zingerone
C	zingerone	vanillin
D	zingerone	zingerone

6.

Propanoic acid can be made from propanal by

- A oxidation
- B reduction
- C hydrolysis
- D condensation.

7.



Which of the following statements about the above compound is correct?

- A It reacts readily with bromine solution.
- B It can be oxidised to an aldehyde.
- C It can be oxidised to a ketone.
- D It can be polymerised to form poly(phenylethene).

8.

Which line in the table shows correct functional groups for aldehydes and ketones and fats and oils?

	Aldehydes and ketones	Fats and oils
A	carbonyl	hydroxyl
B	carboxyl	hydroxyl
C	carboxyl	ester link
D	carbonyl	ester link

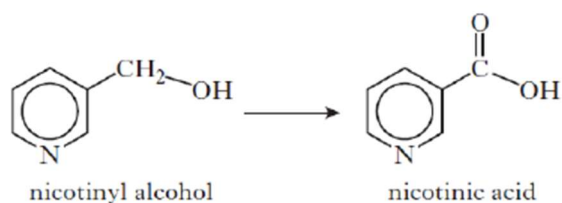
9.

Methanol is converted into methanal by

- A neutralisation
- B condensation
- C dehydration
- D oxidation.

10.

A step in the synthesis of nicotinic acid (vitamin B₃) is shown.



The type of reaction taking place in this step is

- A hydration
- B oxidation
- C reduction
- D condensation.

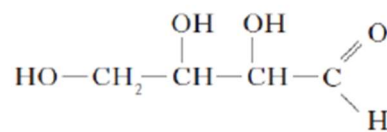
11.

Which of the following reactions can be classified as reduction?

- A $\text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{CH}_3\text{COOH}$
- B $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3 \rightarrow \text{CH}_3\text{COCH}_3$
- C $\text{CH}_3\text{CH}_2\text{COCH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$
- D $\text{CH}_3\text{CH}_2\text{CHO} \rightarrow \text{CH}_3\text{CH}_2\text{COOH}$

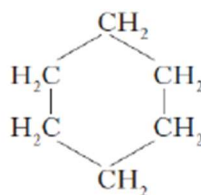
12.

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

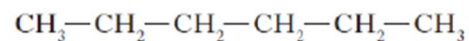


Which of the following compounds will be the **best** solvent for erythrose?

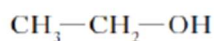
A



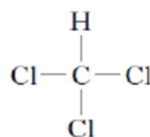
B



C

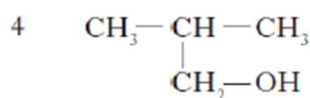
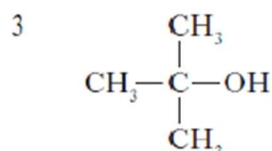
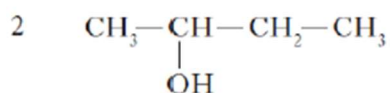
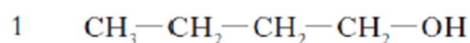


D



13.

Which **two** isomers would each produce an acid when warmed with acidified potassium dichromate solution?



- A 1 and 2
 B 2 and 3
 C 1 and 4
 D 3 and 4

14.

Which of the following organic compounds is an isomer of hexanal?

- A 2-Methylbutanal
 B 3-Methylpentan-2-one
 C 2,2-Dimethylbutan-1-ol
 D 3-Ethylpentanal

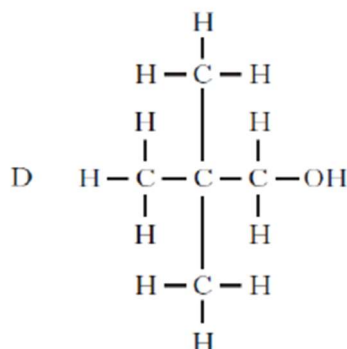
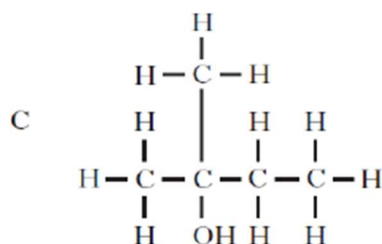
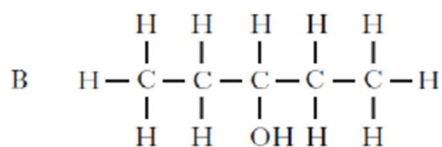
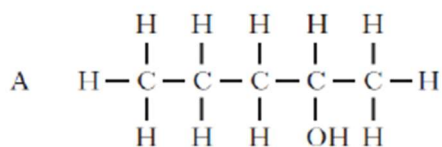
16.

Which of the following types of alcohols will not react with copper(II) oxide?

- A Straight chain primary alcohols
 B Branched chain primary alcohols
 C Secondary alcohols
 D Tertiary alcohols

15.

Which alcohol could be oxidised to a carboxylic acid?

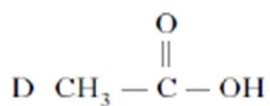
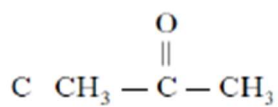
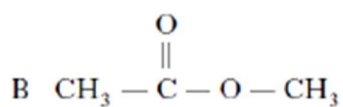
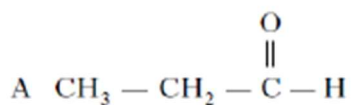


17.

- (a) Lycopene, $C_{40}H_{56}$, is an antioxidant found in tomatoes. To prevent the loss of this antioxidant, explain whether tomatoes should be cooked in oil or water?
- (b) Suggest a reason why asparagus should be cooked in oil rather than in water to retain the best flavour.

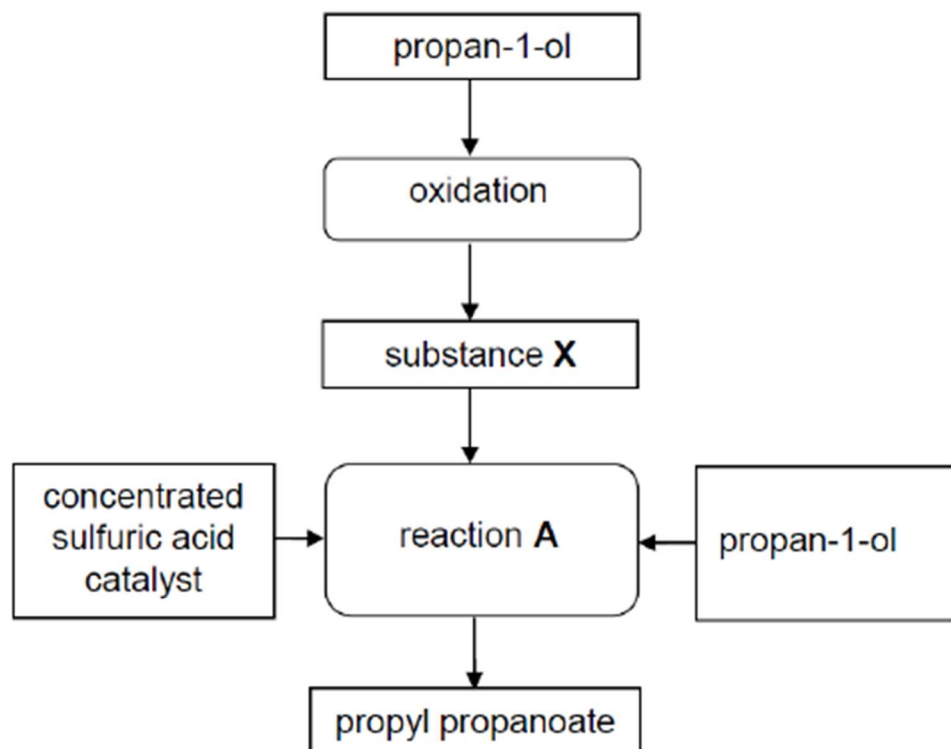
18.

Which of the following compounds is an alkanone?



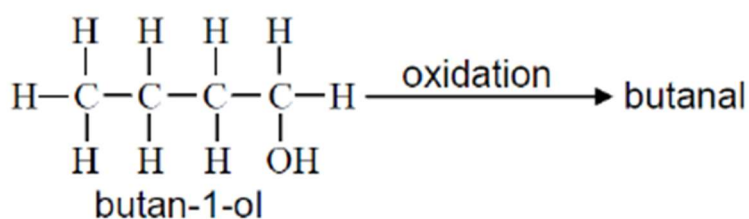
19.

The following reaction sequence is used to convert propan-1-ol into propyl propanoate.



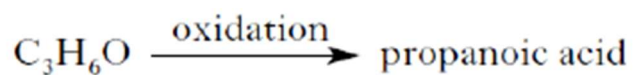
- (a) Name substance **X**.
- (b) What type of reaction is reaction **A**?

20.



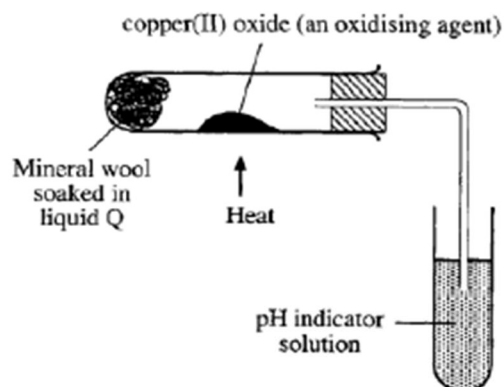
- (a) Draw a structural formula for butanal
- (b) To which group of compounds does butanal belong?
- (c) What would be observed when heating the butanal with Tollens' reagent?

21.



Draw a structural formula for $\text{C}_3\text{H}_6\text{O}$.

22.



After heating the copper(II) oxide for several minutes as shown in the diagram, the pH indicator solution turned red.

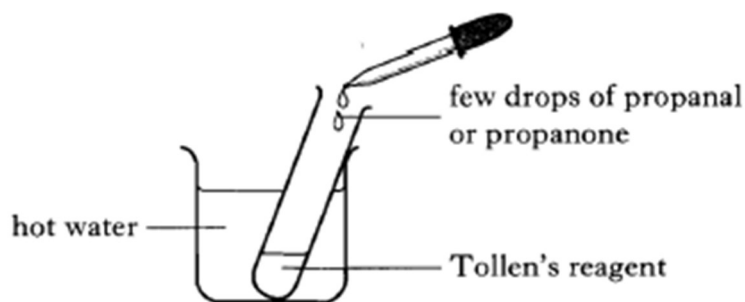
Liquid **Q** could be

- A propan-2-ol
- B propanone
- C propanal
- D paraffin.

23. Propanone and propanal both contain the same functional group.

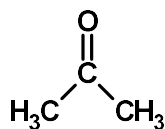
(a) Name this functional group.

(b) The diagram shows how to distinguish between propanone and propanal.



Explain what is observed in the reaction between propanal and Tollen's reagent.

24. Name the following substance



25.

A student read that some whiskies contain aldehydes.

To test this, a sample of whisky was reacted with acidified dichromate.

A colour change was observed.

(a) What was the colour change observed?

(b) Reacting a whisky with acidified dichromate does not show conclusively that the whisky contains an aldehyde. What other substance, present in whisky, would also give a colour change with acidified dichromate?

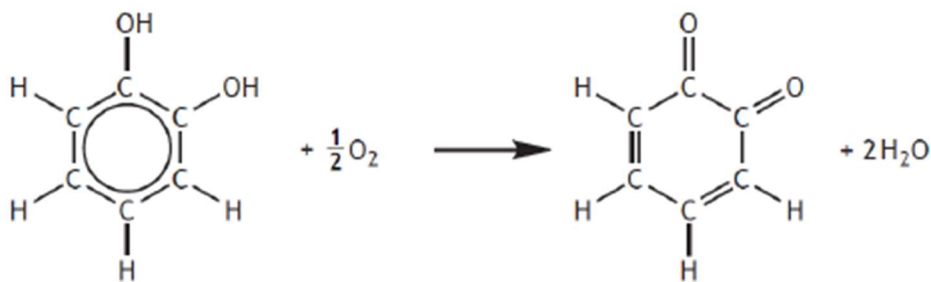
(c) Name another reagent which can be used to test for the presence of aldehydes.

(d) What type of compounds are formed when aldehydes are oxidised?

26.

Enzymes are involved in the browning of cut fruit.

One reaction taking place is:



Which of the following correctly describes the above reaction?

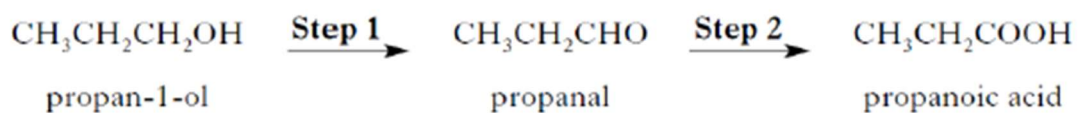
- A Oxidation
- B Reduction
- C Hydrolysis
- D Condensation

27.

Which of the following statements is correct for ketones?

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

31. Alkanols can be oxidised to alkanolic acids

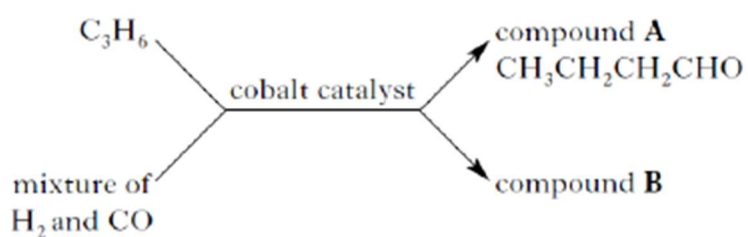


- (a) Why can Step 1 be described as an oxidation reaction
- (b) Acidified potassium dichromate solution can be used to oxidise propanal in Step 2.
What colour change would be observed in this reaction?

32. Using a cobalt catalyst, alkenes react with a mixture of hydrogen and carbon monoxide.

The products are two isomeric aldehydes.

Propene reacts with the mixture as shown.

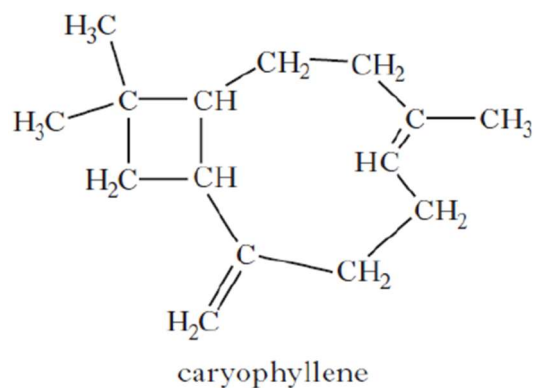


- (a) Draw a structural formula for compound B
- (b) What would be observed if compound A was gently heated with Tollens' reagent.
- (c) How would the reaction mixture be heated?
- (d) Aldehydes can also be formed by the reaction of some alcohols with copper(II) oxide
Name the type of alcohol that would react with copper(II) oxide to form an aldehyde.

(g) Fragrances

1.

Caryophyllene is a natural product which can be extracted from clove oil using a solvent.

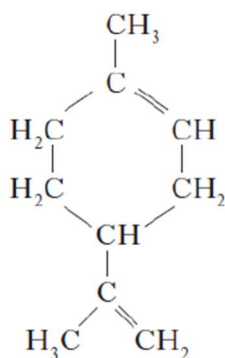


Which of the following would be the best solvent for extracting caryophyllene?

- A Hexane
- B Hexanal
- C Hexan-2-ol
- D Hexan-3-one

2.

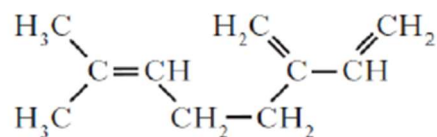
Limonene is one of the terpene molecules responsible for the flavour of lemons.



How many isoprene units are used in the production of one limonene molecule?

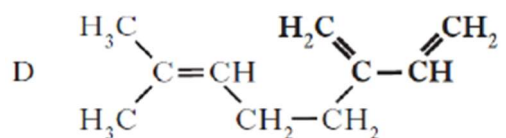
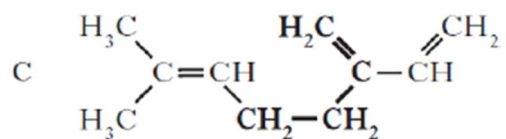
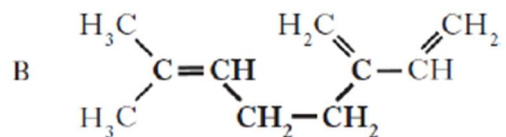
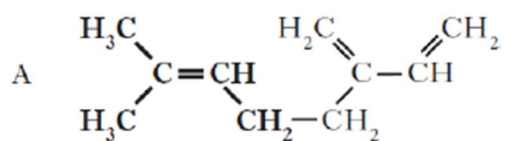
- A 1
- B 2
- C 3
- D 4

3.



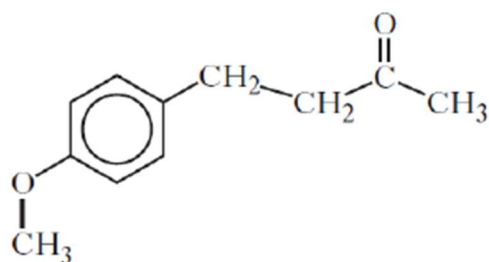
Terpenes contain at least one isoprene unit.

Which of the following shows a correctly highlighted isoprene unit?



4.

A compound with the following structure is used in perfumes to help provide a sweet, fruity fragrance.

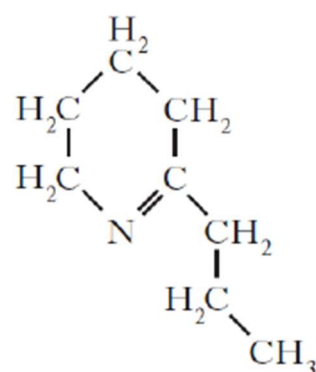


This compound could be classified as

- A an aldehyde
- B a carboxylic acid
- C an ester
- D a ketone.

5.

Coniceine is a deadly poison extracted from the plant hemlock.



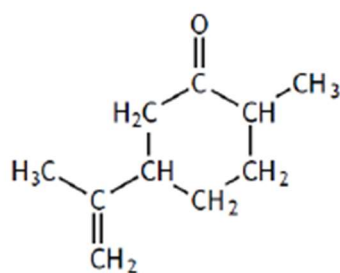
coniceine

Which of the following would be the best solvent for coniceine?

- A Propanoic acid
- B Propan-1-ol
- C Heptane
- D Water

6.

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



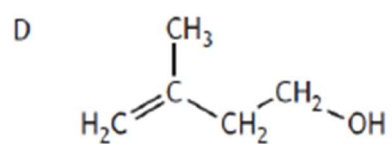
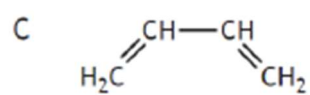
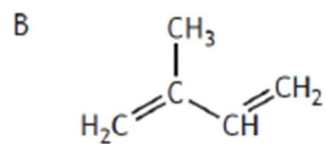
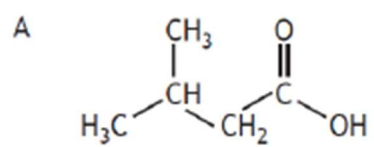
Carvone

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

	<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

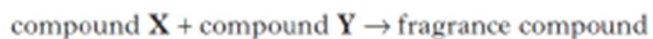
7.

The structure of isoprene is



8.

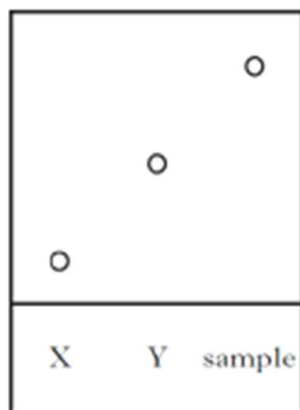
An organic chemist is attempting to synthesise a fragrance compound by the following chemical reaction.



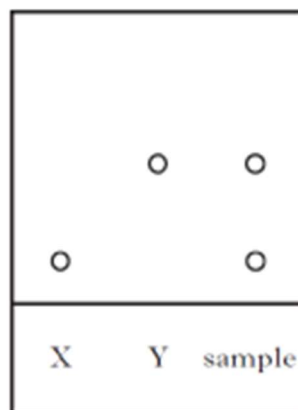
After one hour, a sample is removed and compared with pure samples of compounds **X** and **Y** using thin-layer chromatography.

Which of the following chromatograms shows that the reaction has produced a pure sample of the fragrance compound?

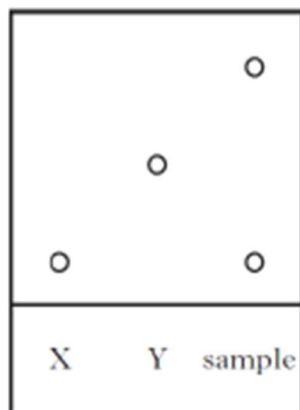
A



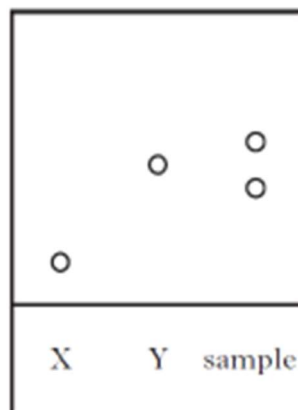
B



C

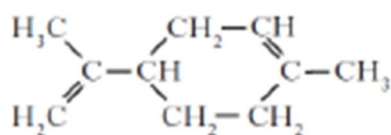


D

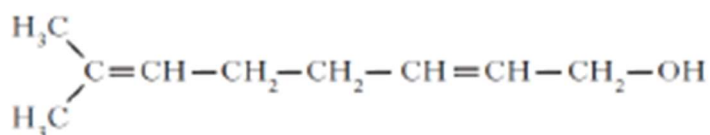


9.

Two typical compounds that are present in many perfumes are shown.

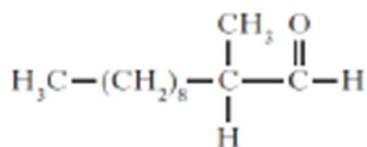


$\text{C}_{10}\text{H}_{16}$
limonene

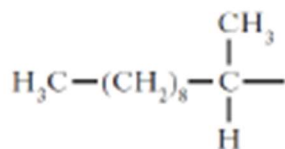


$\text{C}_9\text{H}_{16}\text{O}$
geraniol

- (a) Why does geraniol evaporate more slowly than limonene?
- (b) The structure of one of the first synthetic scents used in perfume is shown below.



- (i) Name the family of carbonyl compounds to which this synthetic scent belongs.
- (ii) Complete the structure below to show the product formed when this scent is oxidised.



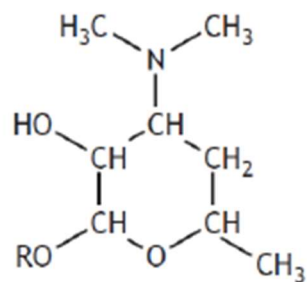
- (c) Traces of a liquid were discovered in a bottle believed to contain perfume belonging to Queen Hatshepsut, ruler of Egypt over 3500 years ago.

Perfumes were made by dissolving plant extracts containing pleasant smelling terpenes and esters in an edible oil. A little ethanol and water may also have been added.

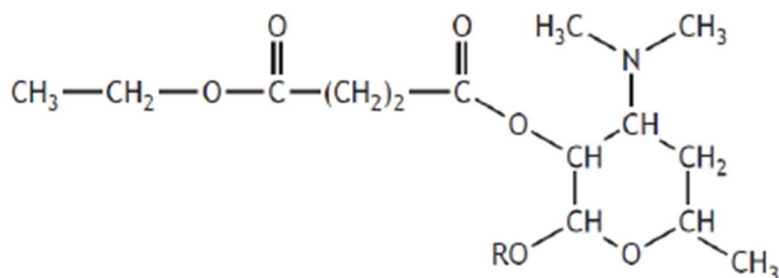
Using your knowledge of chemistry, comment on the possible smell(s) when such a bottle is opened after being stored for thousands of years.

10.

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?

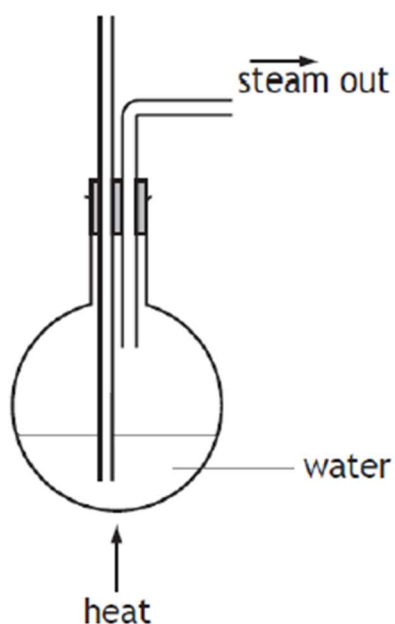
- A Alcohol
- B Aldehyde
- C Carboxylic acid
- D Ketone

11.

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

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

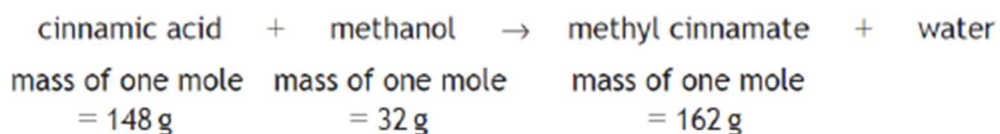
- (i) Complete the diagram to show an apparatus suitable for carrying out this extraction.



- (ii) The essential oil extracted is a mixture of compounds.
Suggest a technique that could be used to separate the mixture into pure compounds.

11. (cont)

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



6.5 g of cinnamic acid was reacted with 2.0 g of methanol.

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

- (ii) (A) The student obtained 3.7 g of methyl cinnamate from 6.5 g of cinnamic acid.

Calculate the percentage yield.

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

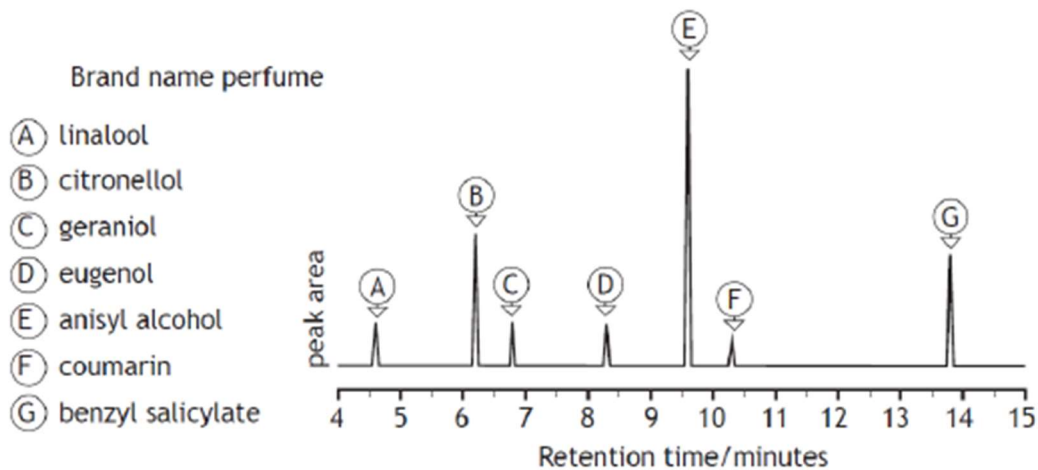
Cinnamic acid costs £35.00 per 250 g.

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

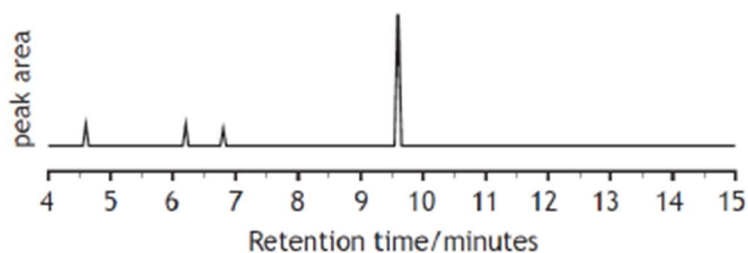
12.

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

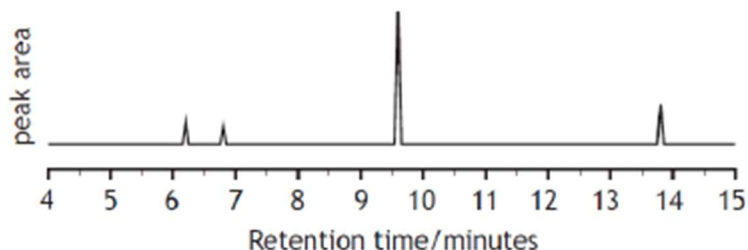
One way to identify if a perfume is counterfeit is to use gas chromatography. Shown below are gas chromatograms from a brand name perfume and two different counterfeit perfumes. Some of the peaks in the brand name perfume have been identified as belonging to particular compounds.



Counterfeit A



Counterfeit B

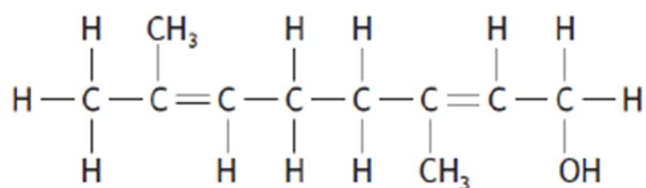


12. (cont)

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

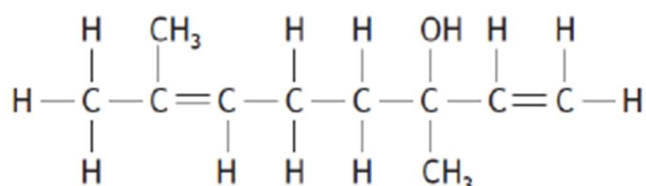
(i) State the name that is given to molecules consisting of joined isoprene units.

(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.

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

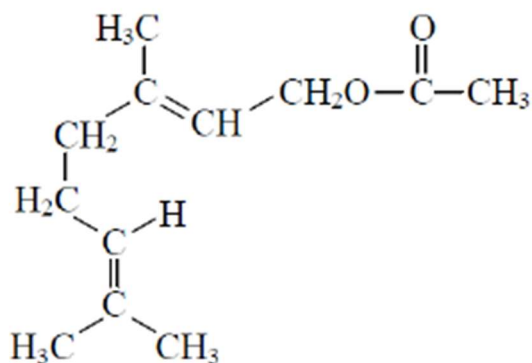
(e) Coumarin is another compound found in the brand name perfume. It is present in the spice cinnamon and can be harmful if eaten in large quantities.

The European Food Safety Authority gives a tolerable daily intake of coumarin at 0.10 mg per kilogram of body weight.

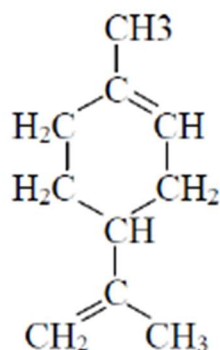
1.0 kg of cinnamon powder from a particular source contains 4.4 g of coumarin. Calculate the mass of cinnamon powder, in g, which would need to be consumed by an adult weighing 75 kg to reach the tolerable daily intake.

13.

Geranyl acetate is a pleasant smelling substance found in perfumes.



- (a) Why does geranyl acetate have a pleasant smell.
- (b) If geranyl acetate were to be made synthetically, which carboxylic acid would be used in its manufacture?
- (c) Limonene, a terpene found in oranges, consists of isoprene units.



- (i) Copy the structure of limonene onto your answer paper and circle the isoprene unit.
- (ii) Explain why limonene is unlikely to be soluble in water.
- (d) With reference to the structures of both geranyl acetate and limonene, why is geranyl acetate likely to be less volatile than limonene?

14.

Terpenes are present in many fruits. Terpenes can be classified by the number of isoprene units present in their structure.

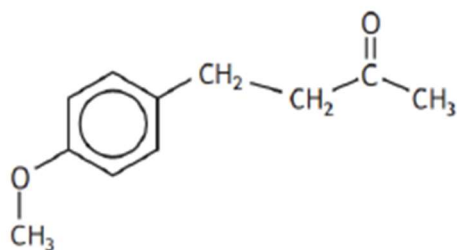
Type of terpene	Number of isoprene units	Molecular formula
Monoterpenes	2	$C_{10}H_{16}$
Sesquiterpenes	3	$C_{15}H_{24}$
Diterpenes	4	$C_{20}H_{32}$
Sesterterpenes	5	

(a) From the information in the table, predict the molecular formula of a sesterterpene.

(b) Why are terpenes an important component in fruits?

15.

A compound with the following structure is used in perfumes to help provide a sweet, fruity fragrance.

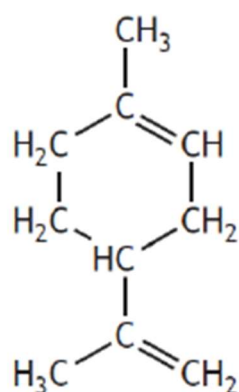


This compound could be classified as

- A an ester
- B a ketone
- C an aldehyde
- D a carboxylic acid.

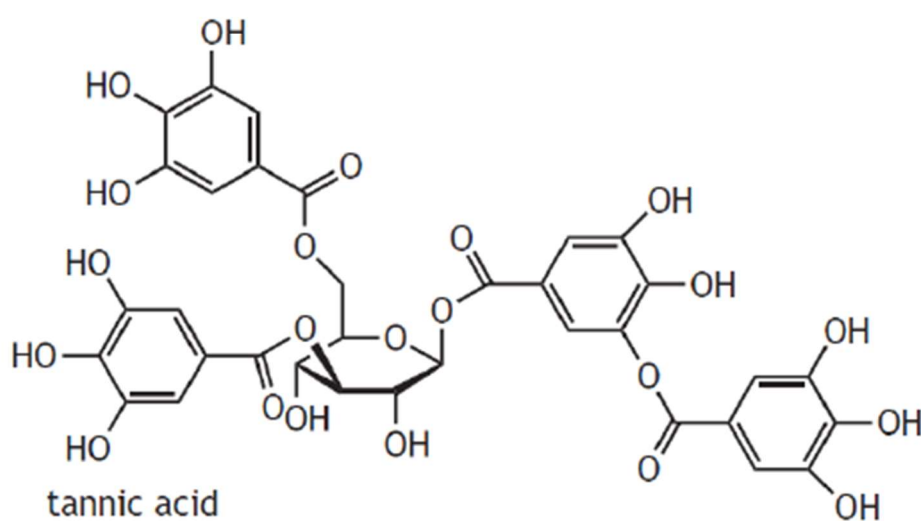
16.

(a) Limonene is a terpene found in many wines.



State why limonene can be classed as a terpene.

(b) Many wines also contain tannins such as tannic acid.



Explain why tannic acid will be a water-soluble compound.

(h) Skin Care

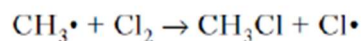
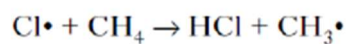
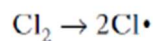
1.

Which of the following is a propagation step in the chlorination of methane?

- A $\text{Cl}_2 \rightarrow \text{Cl}\cdot + \text{Cl}\cdot$
- B $\text{CH}_3\cdot + \text{Cl}\cdot \rightarrow \text{CH}_3\text{Cl}$
- C $\text{CH}_3\cdot + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}\cdot$
- D $\text{CH}_4 + \text{Cl}\cdot \rightarrow \text{CH}_3\text{Cl} + \text{H}\cdot$

2.

Part of a possible chain reaction mechanism for chlorine reacting with methane is:



Which of the following will **not** be a termination step in this reaction?

- A $\text{H}\cdot + \text{Cl}\cdot \rightarrow \text{HCl}$
- B $\text{Cl}\cdot + \text{Cl}\cdot \rightarrow \text{Cl}_2$
- C $\text{CH}_3\cdot + \text{CH}_3\cdot \rightarrow \text{C}_2\text{H}_6$
- D $\text{CH}_3\cdot + \text{Cl}\cdot \rightarrow \text{CH}_3\text{Cl}$

3.

The reaction between chlorine and ethane to give chloroethane is an example of a chain reaction.

Which of the following is a propagation step in this reaction?

- A $\text{Cl}_2 \rightarrow \text{Cl}\cdot + \text{Cl}\cdot$
- B $\text{C}_2\text{H}_5\cdot + \text{Cl}\cdot \rightarrow \text{C}_2\text{H}_5\text{Cl}$
- C $\text{C}_2\text{H}_5\cdot + \text{C}_2\text{H}_5\cdot \rightarrow \text{C}_4\text{H}_{10}$
- D $\text{C}_2\text{H}_5\cdot + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{Cl}\cdot$

4.

Which of the following represents an initiation step in a chain reaction?

- A $\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$
- B $\text{CH}_3\cdot + \text{CH}_3\cdot \rightarrow \text{C}_2\text{H}_6$
- C $\text{CH}_4 + \text{Cl}\cdot \rightarrow \text{CH}_3\text{Cl} + \text{H}\cdot$
- D $\text{CH}_3\cdot + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}\cdot$

5.

Which of the following substances could **not** be a product in the chain reaction between ethane and chlorine?

- A HCl
- B $\text{C}_2\text{H}_3\text{Cl}$
- C $\text{C}_2\text{H}_5\text{Cl}$
- D C_4H_{10}

6.

Which of the following represents a propagation step in a chain reaction?

- A $\text{Cl}\cdot + \text{Cl}\cdot \rightarrow \text{Cl}_2$
- B $\text{Cl}\cdot + \text{CH}_4 \rightarrow \text{CH}_3\cdot + \text{HCl}$
- C $\text{CH}_3\cdot + \text{Cl}\cdot \rightarrow \text{CH}_3\text{Cl}$
- D $\text{Cl}_2 \rightarrow \text{Cl}\cdot + \text{Cl}\cdot$

7.

- (a) Carbon monoxide gas is produced as a result of the incomplete combustion of fuels.

The amount of carbon monoxide in the atmosphere is controlled by a series of free radical reactions.

(i) What is meant by the term *free radical*?

(ii) Why do free radicals form in the atmosphere?

- (iii) The equation shows one of the steps in the free radical chain reaction which controls the level of carbon monoxide.



What term describes this type of step in the free radical chain reaction

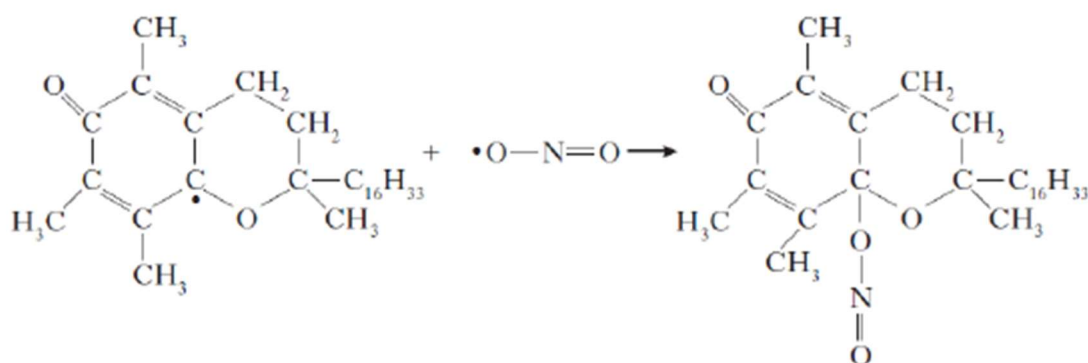
- (b) Carbon monoxide can be used to produce the gas tricarbon dioxide, C_3O_2 , a substance used to bind dyes to natural fur.

Draw a structural formula for tricarbon dioxide.

8.

Suncreams contain antioxidants.

- (a) The antioxidant, compound **A**, can prevent damage to skin by reacting with free radicals such as NO_2^\bullet .



Compound **A**

Why can compound **A** be described as a free radical scavenger in the reaction shown above?

- (b) Another antioxidant used in skin care products is vitamin C, $\text{C}_6\text{H}_8\text{O}_6$.

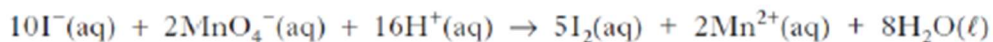
Complete the ion-electron equation for the oxidation of vitamin C.



9.

Fluorine is an extremely reactive element. Its compounds are found in a range of products.

- (a) Iodine can be extracted from iodide salts by reacting them with acidified permanganate solution.



Why can fluorine not be produced from fluoride salts using acidified permanganate?

- (b) Fluorine reacts with methane via a free radical chain reaction.

Some steps in the chain reaction are shown in the table below.

Reaction step	Name of step
$\text{F}_2 \rightarrow 2\text{F}\cdot$	
$\text{F}\cdot + \text{CH}_4 \rightarrow \text{HF} + \cdot\text{CH}_3$ $\cdot\text{CH}_3 + \text{F}_2 \rightarrow \text{CH}_3\text{F} + \text{F}\cdot$	propagation
$\cdot\text{CH}_3 + \text{F}\cdot \rightarrow \text{CH}_3\text{F}$	termination
	termination

Complete the table by:

- inserting the missing name for the first step;
- showing another possible termination reaction in the final row of the table.

10.

- (a) Lycopene, $C_{40}H_{56}$, is an antioxidant found in tomatoes. To prevent the loss of this antioxidant, explain whether tomatoes should be cooked in oil or water?
- (b) Suggest a reason why asparagus should be cooked in oil rather than in water to retain the best flavour.

11.

Which of the following is a termination step in a free radical chain reaction?

- A $Cl_2 \rightarrow Cl\cdot + Cl\cdot$
- B $CH_3\cdot + Cl\cdot \rightarrow CH_3Cl$
- C $CH_3\cdot + Cl_2 \rightarrow CH_3Cl + Cl\cdot$
- D $CH_4 + Cl\cdot \rightarrow CH_3\cdot + HCl$

12.

Which statement is **not** true about free-radical scavengers?

- A They remove grease and sweat from clothes.
- B They are present in many cosmetic products.
- C They are added to food products and plastics.
- D They react with free radicals to form stable molecules and prevent chain reactions.

13.

Which of the following is an initiation step in a free radical chain reaction?

- A $CH_3\cdot + Cl\cdot \rightarrow CH_3Cl$
- B $Cl_2 \rightarrow Cl\cdot + Cl\cdot$
- C $CH_4 + Cl\cdot \rightarrow CH_3\cdot + HCl$
- D $CH_3\cdot + Cl_2 \rightarrow CH_3Cl + Cl\cdot$

14.

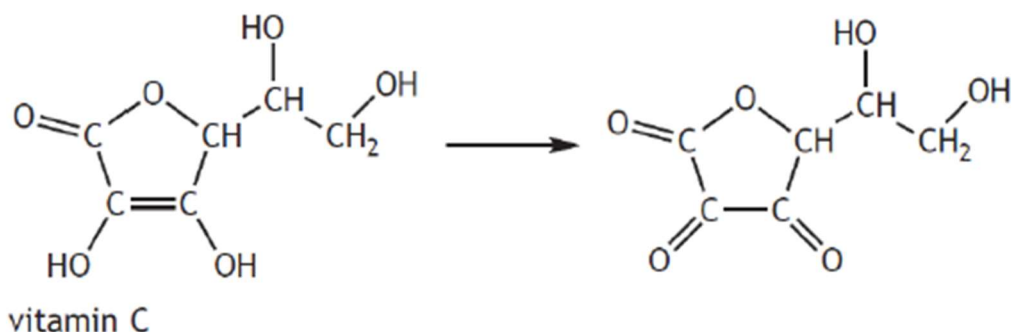
The manufacture of cosmetics is a major industry in the UK and worldwide.

- (a) What is the function of free radical scavengers in cosmetic products?
- (b) How do the chemicals present in sun-block prevent sunburn?

15.

Vitamin C and E are antioxidants that help prevent cellular damage and skin ageing.

- (a)
 - (i) Name the type of particles that antioxidants react with, preventing cellular damage and skin ageing.
 - (ii) The equation shows the change that takes place when vitamin C molecules are oxidised.



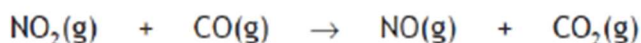
Explain why this process can be described as oxidation.

- (b) The recommended daily allowance (RDA) for vitamin E is 20 mg per day. Almonds are a good source of vitamin E and provide 26.2 mg per 100 g. Almonds are sold as 1 kg bags costing £13.99.

Calculate the cost of almonds that will provide the RDA of vitamin E.

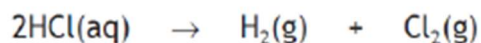
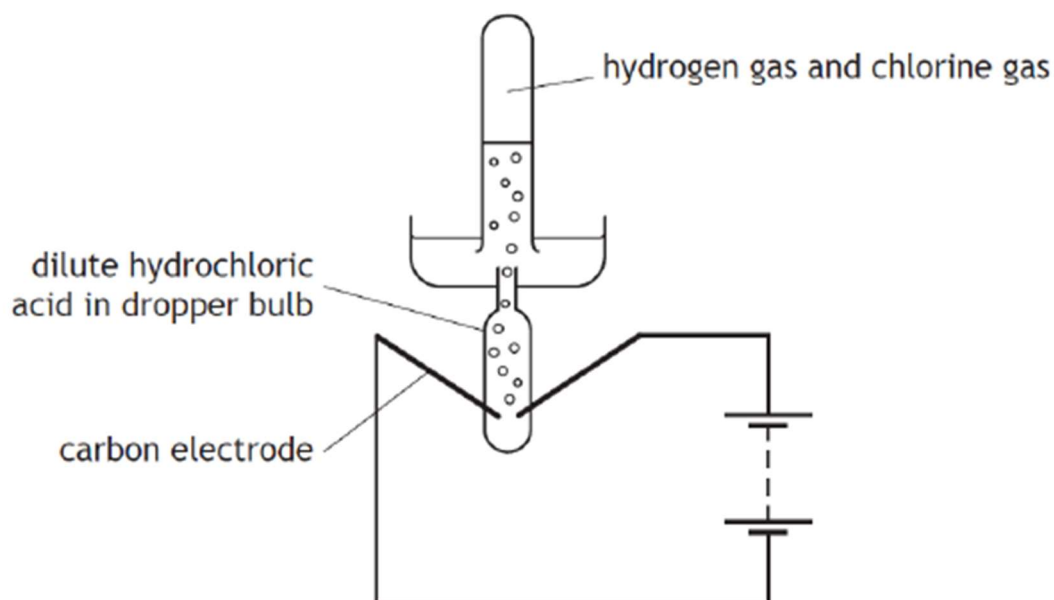
16.

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



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

- (b) Hydrogen gas and chlorine gas react explosively in a photochemical reaction. In a demonstration experiment, the reaction was used to fire a table tennis ball across a room.
- (i) A mixture of hydrogen gas and chlorine gas was generated by the electrolysis of hydrochloric acid.

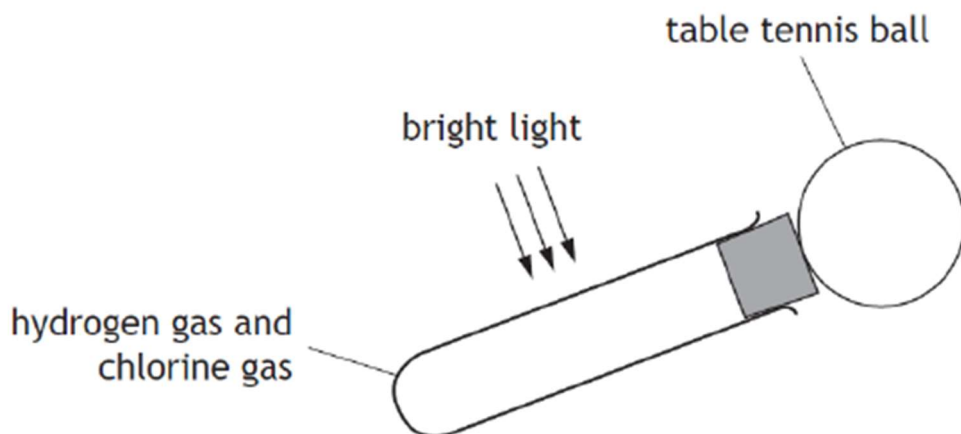


Calculate the number of moles of hydrochloric acid required to completely fill a 10 cm^3 test tube with the hydrogen gas and chlorine gas mixture.

(Take the molar volume of a gas to be $24 \text{ litres mol}^{-1}$)

16. (cont)

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



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

<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;
B showing a possible termination step.

p