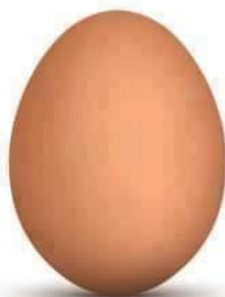


# Firrhill High School

## CfE Higher Chemistry

### INGREDIENTS OF AN ALL-NATURAL EGG



**INGREDIENTS:** AQUA (75.8%), **AMINO ACIDS (12.6%)** (GLUTAMIC ACID (14%), ASPARTIC ACID (11%), VALINE (9%), ARGININE (8%), LEUCINE (8%), LYSINE (7%), SERINE (7%), PHENYLALANINE (6%), ALANINE (5%), ISOLEUCINE (5%), PROLINE (4%), TYROSINE (3%), THREONINE (3%), GLYCINE (3%), HISTIDINE (2%), METHIONINE (3%), CYSTINE (2%), TRYPTOPHAN (1%)); **FATTY ACIDS (9.9%)** (OCTADECENOIC ACID (45%), HEXADECANOIC ACID (32%), OCTADECANOIC ACID (12%), EICOSATETRAENOIC ACID (3%), EICOSANOIC ACID (2%), DOCOSANOIC ACID (1%), TETRACOSANOIC ACID (1%), OCTANOIC ACID (<1%), DECANOIC ACID (<1%), DODECANOIC ACID (<1%), TETRADECANOIC ACID (<1%), PENTADECANOIC ACID (<1%), HEPTADECANOIC ACID (<1%), TETRADECENOIC ACID (<1%), HEXADECENOIC ACID (<1%), EICOSENOIC ACID (<1%), DOCOSENOIC ACID (<1%), OMEGA-6 FATTY ACID: OCTADECADIENOIC ACID (12%), OMEGA-3 FATTY ACID: OCTADECATRIENOIC ACID (<1%), EICOSAPENTAENOIC ACID (EPA) (<1%), OMEGA-3 FATTY ACID: DOCOSAHEXAENOIC ACID (DHA) (<1%)); **SUGARS (0.8%)** (GLUCOSE (30%), SUCROSE (15%), FRUCTOSE (15%), LACTOSE (15%), MALTOSE (15%), GALACTOSE (15%)); **COLOUR** (E160c, E160a), E306, E101; **FLAVOURS** (PHENYLACETALDEHYDE, DODECA-2-ENAL, HEPTA-2-ENAL, HEXADECANAL, OCTADECANAL, PENTAN-2-ONE, BUTAN-2-ONE, ACETALDEHYDE, FORMALDEHYDE, ACETONE); SHELL (E170), ALSO CONTAINS BENZENE & BENZENE DERIVATIVES, ESTERS, FURANS, SULFUR-CONTAINING COMPOUNDS AND TERPENES.

## Unit 2 Homework

### Natures Chemistry

## Alcohols, Carboxylic Acids and Esters

1. Write the general formula for the alkanols.
2. Draw the structural formulae for each of the following alcohols and state whether the alcohol is a primary, secondary or tertiary alcohol.

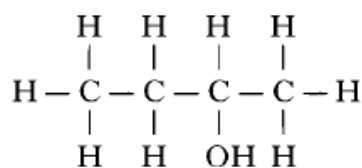
a) Pentan-3-ol.

b) 2-methylbutan-1-ol

c) 3-ethylpentan-3-ol.

3. What is meant by a **hydroxyl group**?

4. Compound X is a secondary alcohol.



compound **X**

- (a) Name compound X.
  - (b) Draw a structural formula for the tertiary alcohol that is an isomer of compound X.
5. The dehydration of butan-2-ol can form two different isomers of butene.
    - a) Draw a diagram of the apparatus you could use in the laboratory to bring about the dehydration of butan-2-ol. Name any chemicals used.
    - b) What is meant by the term 'dehydration'?
    - c) Draw and name the structures of the two butene isomers formed.
    - d) An isomer of butan-2-ol gives only one product on dehydration. Name this isomer.

6. Write the general formula for the alkanolic acids.

7. Name and draw the functional group found in all carboxylic acids.

8. Draw the structural formulae for the following carboxylic acids:

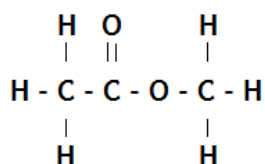
a) Pentanoic acid

b) 2-methylpropanoic acid

c) Benzoic acid

9. Which two types of chemicals react together to produce an ester?

10. Copy the chemical structure shown below and circle the ester link.



11. Name and draw the structural formula of the ester formed when each of the following chemicals reacts together.

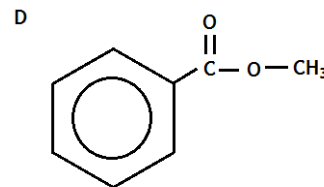
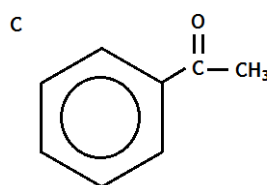
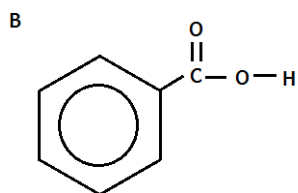
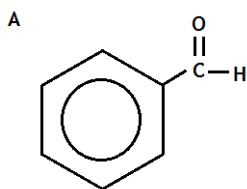
- a) ethanol and methanoic acid  
c) butanoic acid and pentanol

- b) methanol and propanoic acid  
d) ethanoic acid and propanol

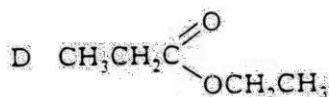
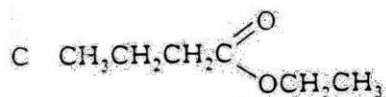
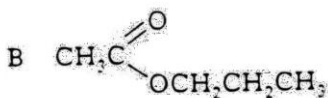
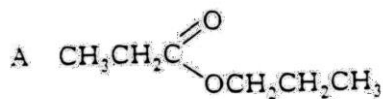
12. Which of the following consumer products is **least** likely to contain esters?

- A flavourings  
B perfumes  
C solvents  
D toothpastes

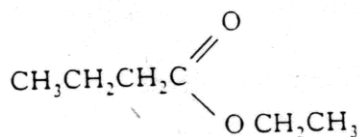
13. Which of the following is an ester?



14. When propanoic acid is reacted with ethanol, one of the products is,



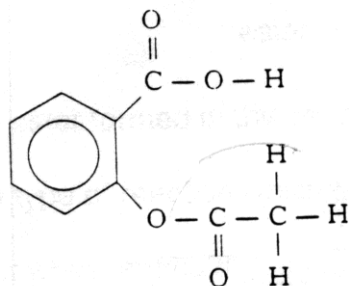
15. Rum flavouring is based on a compound with the formula shown,



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

16. Aspirin is one of the most widely used pain relievers in the world. It has the structure,



Which two functional groups are present in an aspirin molecule?

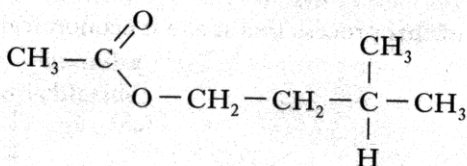
- A hydroxyl and carbonyl
- B aldehyde and ketone
- C carboxyl and ester
- D ester and aldehyde

17. Give three uses of esters.

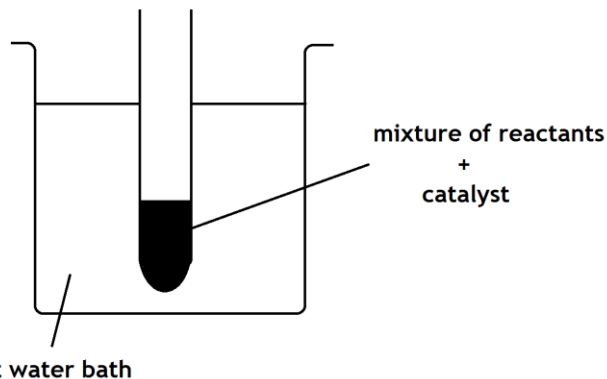
18. A pupil made the ester ethyl propanoate in a test tube and poured the reaction mixture into a beaker containing sodium hydrogen-carbonate solution.

- a) Name the acid and alcohol used to make the ester.
- b) What two things would the pupil observe when the ester is poured into the sodium hydrogen- carbonate solution?
- c) The pupil heated the reaction mixture using a hot water bath. Why was the reaction mixture not heated directly with a Bunsen flame?

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

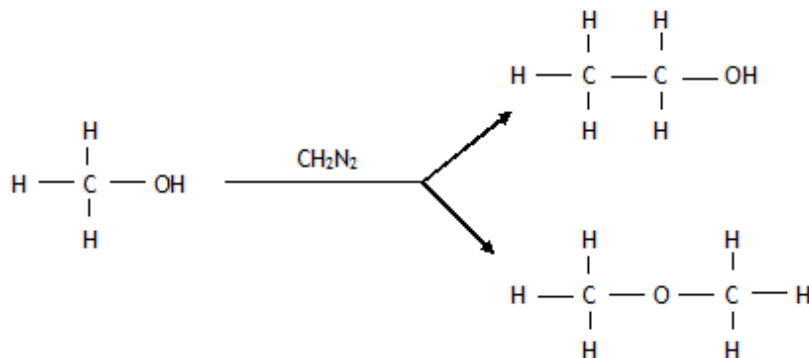


This ester can be produced by the reaction of an alcohol with an alkanolic acid.



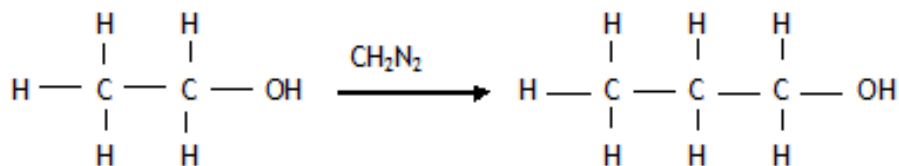
- (a) Name this acid.  
 (b) The ester can be prepared in the lab by heating a mixture of the reactants with a catalyst.  
 (i) Name the catalyst used in the reaction.  
 (ii) What improvement could be made to the experimental setup shown in the above diagram?

20. The compound diazomethane undergoes an unusual reaction called insertion. Under certain conditions, the CH<sub>2</sub> group produced can insert itself into any bond, which includes an atom of hydrogen.



Nitrogen is produced in every reaction.

One of the products for the reaction of diazomethane with ethanol is shown below.

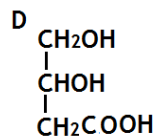
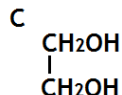
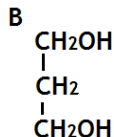
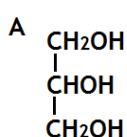


- (a) Name the product shown.  
 (b) Draw the full structural formula for the other **two** organic products which could be formed in this reaction.

## Fats, Oils and Soaps

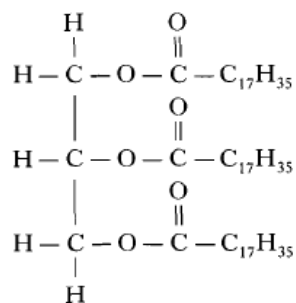
1. Fats and oils can be classified as
  - A soaps
  - B fatty acids
  - C esters
  - D polyesters
2. Which of the following decolourises bromine water least successfully?
  - A palm oil
  - B hex-1-ene
  - C cod liver oil
  - D mutton fat
3. In the formation of “hardened” fats from vegetable oils, the hydrogen
  - A causes cross-linking between the chains
  - B causes hydrolysis to occur
  - C increases the carbon chain length
  - D reduces the number of carbon to carbon double bonds.

4. The structural formula for glycerol is



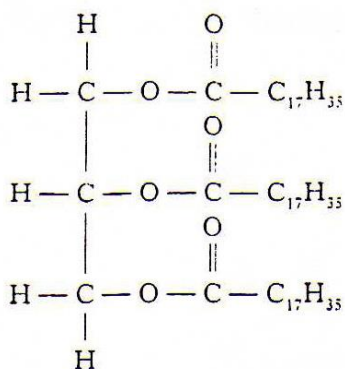
5. The production of fatty acids and glycerol from fats in foods is an example of
  - A hydrolysis
  - B hydrogenation
  - C dehydration
  - D dehydrogenation
6. Explain, in terms of structure, why fats are solids and oils are liquids at room temperature.
7. Foodstuffs have labels that list ingredients and provide nutritional information. The label on a tub of margarine lists **hydrogenated vegetable oils** as one of the ingredients. Why have some of the vegetable oils in this product been hydrogenated?
8.
  - a) Draw the extended structural formula for a molecule of glycerol.
  - b) What is the systematic name for a molecule of glycerol.
  - c) Explain why fats are sometimes referred to as triglycerides
  - d) What do you understand by the term ‘fatty acid’?

9. 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?

10. Mutton fat contains a compound called as tristearin.



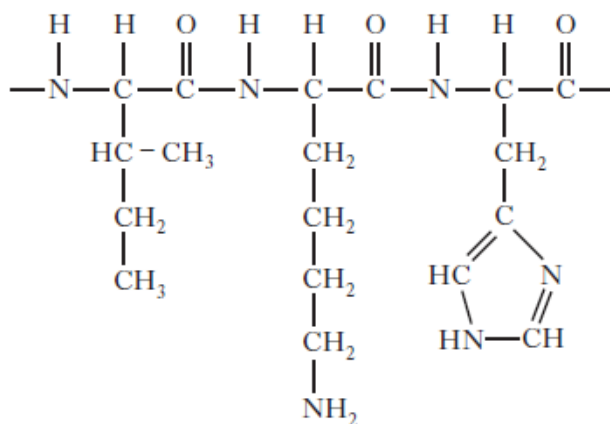
Tristearin is hydrolysed in the body during digestion by an enzyme known as lipase.

- (a) Give **one** reason why fats can be a useful part of a balanced diet.
- (b) To which set of compounds do enzymes belong?
- (c) The hydrolysis of tristearin produces a fatty acid.  
Name the other product of the reaction.

11. Chemists have developed cheeses specifically for use in cheeseburgers.

- (a) When ordinary cheddar cheese is grilled the shapes of the protein molecules change and the proteins and fats separate leaving a chewy solid and an oily liquid.  
What name is given to the change in protein structure which occurs when ordinary cheddar is grilled?
- (b) To make cheese for burgers, grated cheddar cheese, soluble milk proteins and some water are mixed and heated to no more than 82 °C. As the cheese begins to melt an emulsifying agent is added and the mixture is stirred.
- (i) Why would a water bath be used to heat the mixture?

(ii) A section of the structure of a soluble milk protein is shown below.



Draw a structural formula for any one of the amino acids formed when this section of protein is hydrolysed.

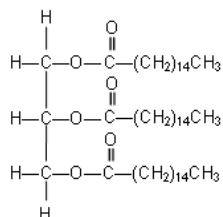
(iii) The emulsifier used is trisodium citrate, a salt formed when citric acid is neutralised using sodium hydroxide.

Copy and complete the equation below showing a structural formula for the trisodium citrate formed.



12. The hydrolysis of a fat produces glycerol and fatty acids.

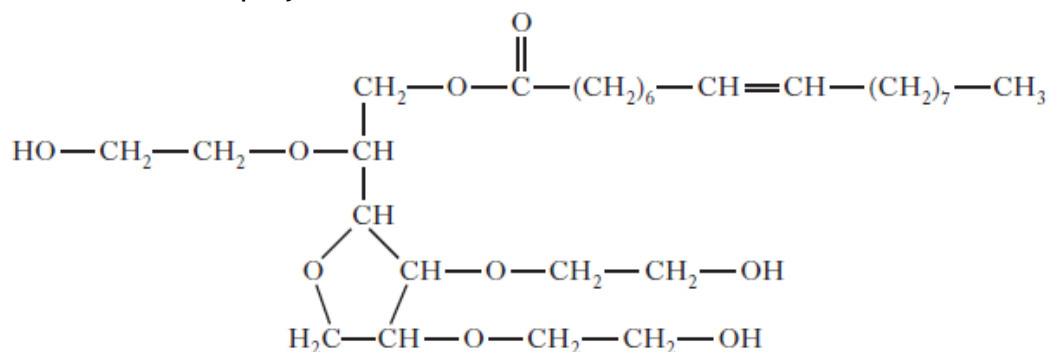
- What does the term hydrolysis mean?
- State the ratio of glycerol molecules to fatty acid molecules.
- A triglyceride produces only glycerol and palmitic acid,  $\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$ , on hydrolysis.
  - Draw the structural formula for the triglyceride.



ii) Explain whether the triglyceride is likely to be a fat or an oil.



13. Explain why edible oils are sometimes used as lubricants for farm machinery.
14. Explain what is meant by the terms a) hydrophilic b) hydrophobic.
15. Describe how soap can clean a fat stain from clothing. You should use the following words in your answer:  
*ionic head covalent tail hydrophobic hydrophilic polar non-polar*
16. Soap can be produced by the reaction of fats and oils with sodium hydroxide solution.
- Name the kind of reaction that is taking place.
  - Describe the structure of soap
17. Small children can find it difficult to swallow tablets or pills so ibuprofen is supplied as an “infant formula” emulsion.  
 The emulsifier used is polysorbate 80. Its structure is shown below.



Explain why this molecule acts as an emulsifier.

## Proteins

1. Describe two reasons why we need protein in our diet.
2. What four elements are present in proteins?
3. Copy and complete the table giving details of proteins found in the human body.

Name of protein	Where found	Function
Keratin		Structural support
Insulin		Controls blood glucose
Haemoglobin	Red blood cells	
Amylase	Saliva and pancreas	
Collagen		Structural support
Myosin	Muscles	
Immunoglobins	Blood, tears, saliva, skin	

4. What is meant by the term *essential amino acids*?
5. When amino acids join together to form a protein molecule, what other chemical is produced?
6. On complete hydrolysis, a peptide produced 5 amino acids represented by the letters P, Q, R, S and T. The following fragments were produced on partial hydrolysis.



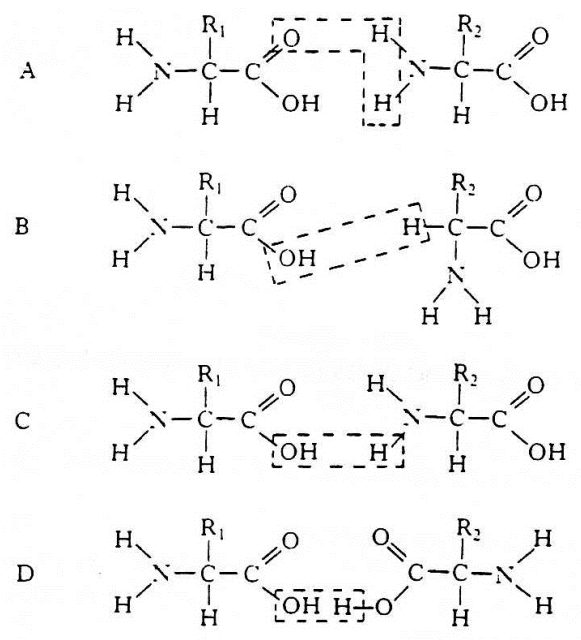
Which one of the sequences below could be the correct one for the arrangement of amino acids in the peptide?

- A P-T-S-Q-R
  - B R-T-S-P-Q
  - C Q-P-T-S-R
  - D R-T-S-Q-P
7. Which of the following must contain nitrogen?
    - A an enzyme
    - B an oil
    - C a polyester
    - D a carbohydrate

8. Proteins can be denatured under acid conditions. During this denaturing, the protein molecule

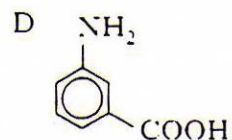
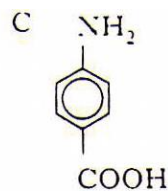
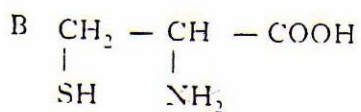
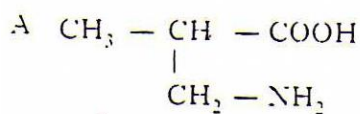
- A changes shape
- B is dehydrated
- C is neutralised
- D is polymerised

9. When two amino acids condense together, water is eliminated and a peptide link is formed. Which of the following represents this process?



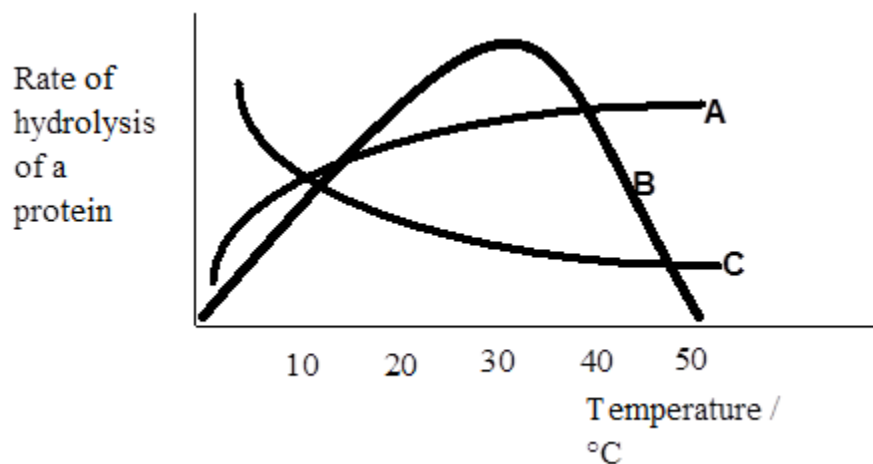
10. Some amino acids are called  $\alpha$ (alpha) amino acids because the amino is on the carbon atom next to the acid group.

Which of the following is an  $\alpha$ (alpha) amino acid?



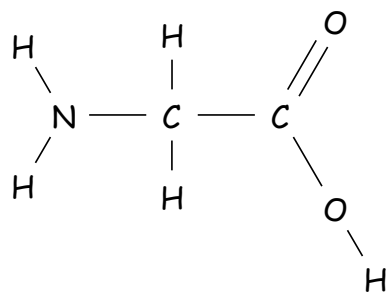


13. Examine the graphs below.



- Which graph is likely to represent the results from a series of reactions using an enzyme? Explain your answer
- To which family of compounds do enzymes belong?
- Name the four elements which must be present in all enzyme molecules.

14. Glycine is an amino acid with the following structure.

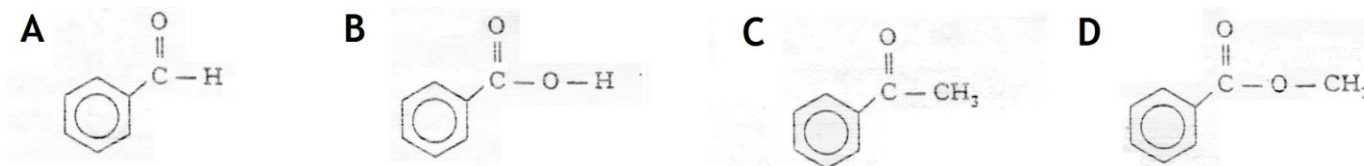


- Draw the structure of part of the polymer chain that would be formed when three glycine molecules polymerise.
- What type of polymerisation process is taking place?

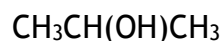
## The Chemistry of Cooking and Oxidation of Food

1. What is the general formula for aldehydes and ketones?
2. What is the name of the functional group found in aldehydes and ketones?

3. Which of the following is an aldehyde?

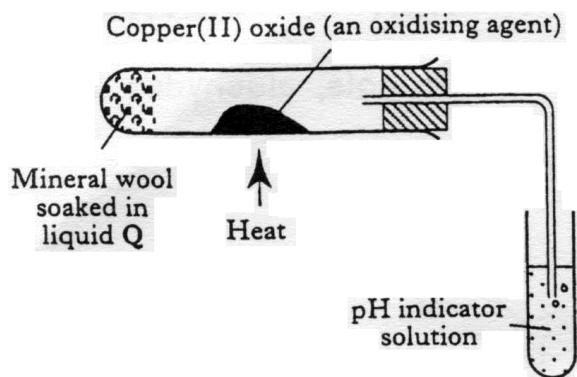


4. Which is true of a compound with the following formula?



- A It is a primary alcohol
  - B It can be oxidised to an aldehyde
  - C It is a tertiary alcohol
  - D It can be oxidised to a ketone.
5. Which process is used to convert methanol to methanal?
    - A oxidation
    - B condensation
    - C hydration
    - D hydrogenation
  6. Which of the following alcohols can be oxidised to give a ketone?
    - A 2-methylbutan-1-ol
    - B 2,3-dimethylpentan-1-ol
    - C 3-methylbutan-2-ol
    - D 2-methylbutan-2-ol
  7. Ethanol vapour is passed over hot aluminium oxide. What kind of reaction occurs?
    - A Hydrogenation
    - B Dehydration
    - C Hydrolysis
    - D Dehydrogenation

8. After heating for several minutes as shown in the diagram, the pH indicator solution turned red. Liquid Q could be



- A propanone
- B paraffin
- C butan-1-ol
- D butan-2-ol

9. What compound is formed by the oxidation of propan-2-ol?

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

10. During oxidation, what happens to the ratio of O:H atoms in a hydrocarbon?

11. Two compounds A and B, both have the formula  $\text{C}_4\text{H}_8\text{O}$ . They were both mixed separately with Fehling's solution and the mixtures warmed in a water bath. Only compound B gave an orange-red precipitate.

- a) Name compounds A and B.
- b) Draw the extended structural formulae of A and B.
- c) Name another reagent which could also be used to show the difference between compound A and B and say what would happen when this reagent is reacted with A and B.

12.

A $\text{CH}_3\text{CH}_2\text{OH}$	B $\text{CH}_3\text{CHOHCH}_3$	C $\text{CH}_3\text{CH}_2\text{COOH}$
D $\text{CH}_3\text{COCH}_3$	E $\text{CH}_3\text{CH}_2\text{CHO}$	F $\text{CH}_3\text{COOH}$

Which box, or boxes, show(s) a substance which

- a) can be oxidised to an alkanal (aldehyde)?
- b) is an alkanone (ketone)?
- c) is an alkanonic (carboxylic) acid?
- d) is a primary alcohol?
- e) can be formed by the oxidation of B?

13. Propan-1-ol, can be oxidised by passing the alcohol vapour over hot copper(II) oxide.

- a) Draw a labelled diagram of the apparatus that would be used to carry out this experiment in the laboratory.

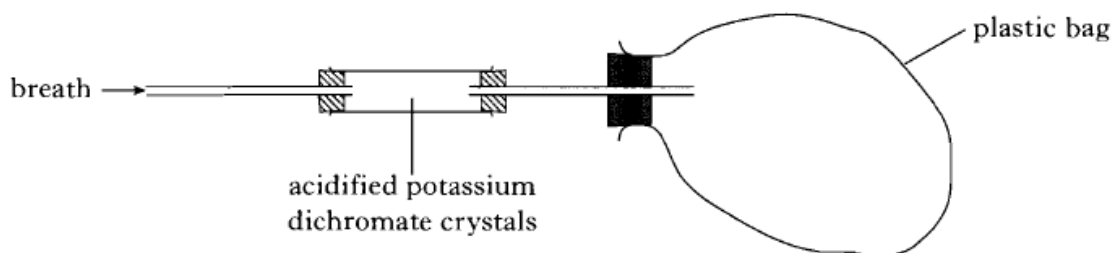
b) Oxidation of propan-1-ol yields a compound X, formula  $C_3H_6O$ , which can be further oxidised to compound Y, formula  $C_3H_6O_2$ .

- Name and draw the structure of compound X.
- Name and draw the structure of compound Y.

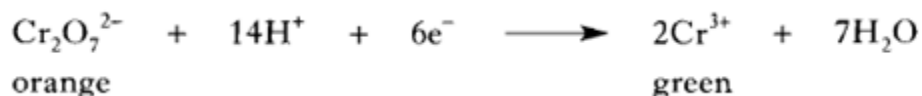
c) Name two other oxidising agents which could be used to carry out the oxidation.

d) If propan-2-ol was used in place of propan-1-ol there would be only one oxidation product. Name and draw the structure of this product.

14. "Self-test" kits can be used to check the quantity of alcohol present in a person's breath. The person blows through a glass tube until a plastic bag at the end is completely filled.



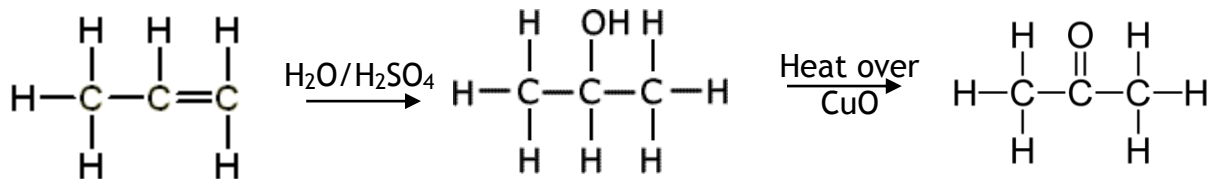
The tube contains orange acidified potassium dichromate crystals that turn green when they react with ethanol. The chemical reaction causing the colour change is:



The more ethanol present in the person's breath, the further along the tube the green colour travels.

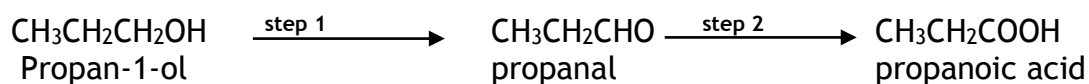
- What is the purpose of the plastic bag?
- Why are the potassium dichromate crystals acidified?
- Name a carbon compound formed by the reaction of ethanol with acidified potassium dichromate crystals.

15. Propanone is a widely used solvent. It can be made from propene. Using full structural formulae show the steps involved in this preparation and name the reagent used in each step.



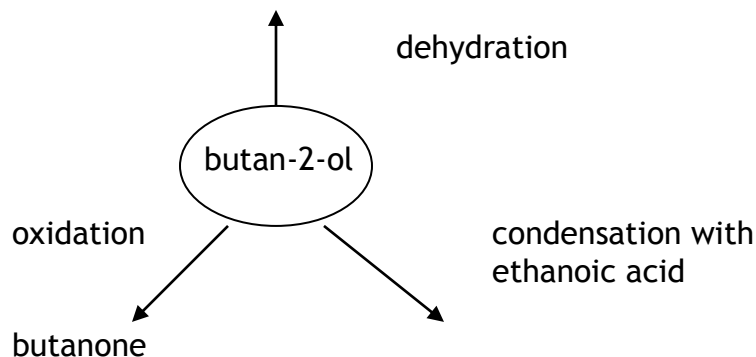


16. Alkanols can be oxidised to alkanoic acids.



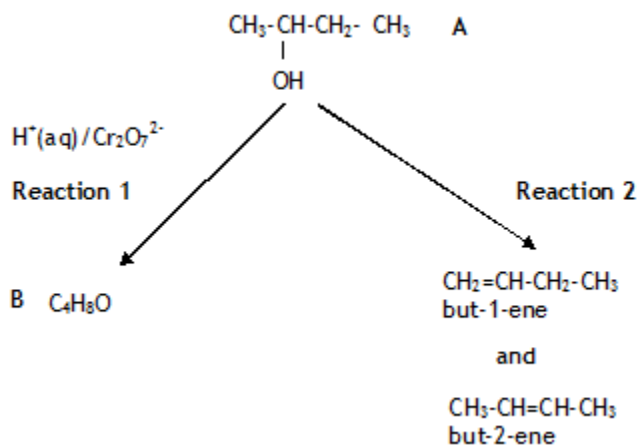
- (a) Why can **step 1** be described as an oxidation reaction?  
 (b) Acidified potassium dichromate solution can be used to oxidise propanal in **step 2**. What colour change would be observed in this reaction?

17. Butan - 2-ol reacts in different ways



- (a) Name the two products formed by the dehydration of butan-2-ol.  
 (b) Name a reagent which could be used to oxidise butan-2-ol to butanone.

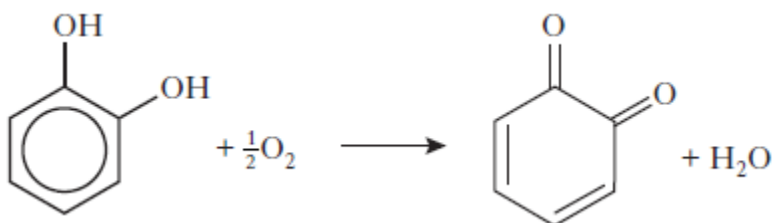
18. Two reactions involving a carbon compound, A, are shown.



- (a) Name compound A.  
 (b) Draw a structural formula for compound B.  
 (c) Name a substance used to convert compound A into but-2-ene and but-1-ene.

19. Give 3 ways that fatty foods are affected when they react with oxygen.

20. Why are antioxidants added to foods?
21. What is meant by a free radical?
22. Give the names of 3 natural antioxidants and state which foods they are found in.
23. Describe how orange juice can stop apples from going brown after they have been cut.
24. Apples and bananas turn brown when cut or bruised. The first step of the reaction causing the browning is shown below.

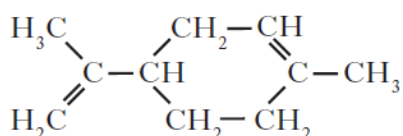


What type of reaction is this?

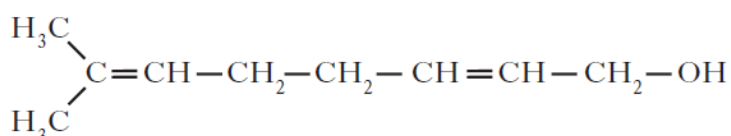
25. A student closed his eyes and held his nose. Another pupil gave him a teaspoon of strawberry jam to eat. Explain why the student could tell that the food was sweet, but not what the actual flavor was.
26. Explain why broccoli should be cooked in water but asparagus should be cooked in oil.

## Fragrances

1. Which unit makes up every terpene?
2. How many carbons there are in an isoprene unit?
3. What is the systematic name for isoprene?
4. What is an oxidised terpene known as?
5. Give 3 uses of essential oils.
6. Two typical compounds that are present in many perfumes are shown.

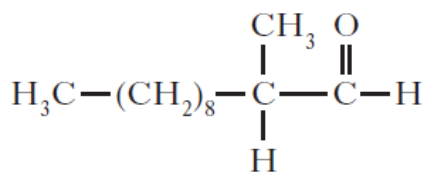


$\text{C}_{10}\text{H}_{16}$   
limonene

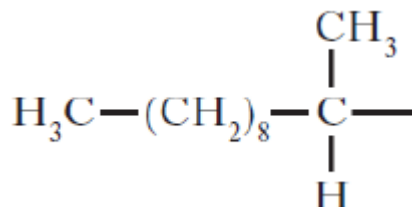


$\text{C}_9\text{H}_{16}\text{O}$   
geraniol

- (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) Copy and complete the structure below to show the product formed when this scent is oxidised.

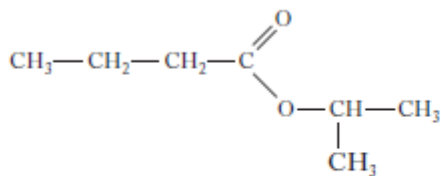


7. A team of chemists are developing a fragrance for use in a shower gel for men.

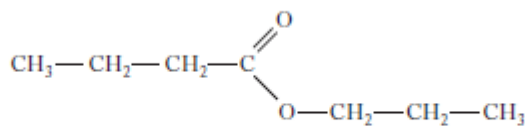
- (a) To give the gel a fruity smell the chemists are considering adding an ester. They synthesise six isomeric esters. Volunteers smell each ester and give it a rating out of one hundred depending on how fruity the smell is.

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

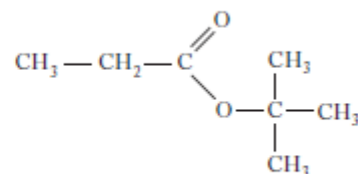
- (i) Name the ester with the fruit-smell rating of 92.  
(ii) Shown below are the structures of three more isomers.



Ester A



Ester B

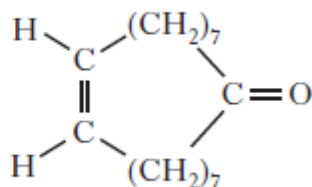


Ester C

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

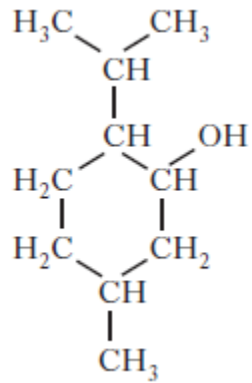
- (b) To create a fragrance for men, the compound civetone is added. Draw a structural formula for the alcohol that can be oxidised to form civetone.

civetone



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

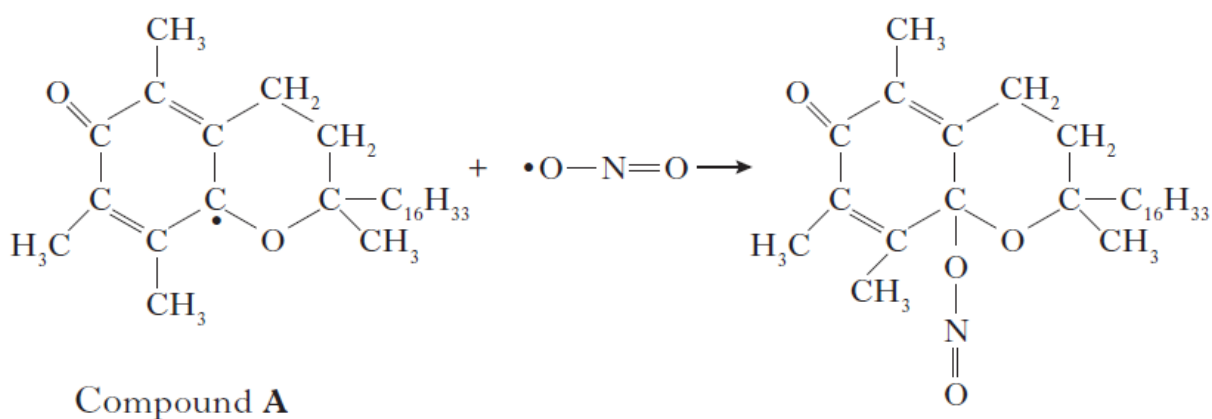
Like terpenes, menthol is formed from isoprene (2-methylbuta-1,3-diene).  
Copy the diagram of the structure of menthol below and circle an isoprene unit.



## Skin Care

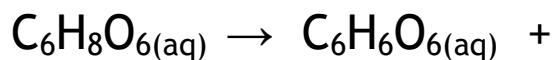
1. What are the three steps for the reaction between alkanes and halogens?
2. Write out each of the three steps for the reaction between fluorine gas and ethane under the action of UV light.
3. What is meant by a free-radical scavenger?
4. Suncreams contain antioxidants.

(a) The antioxidant, compound A, can prevent damage to skin by reacting with free radicals such as  $\text{NO}_2\cdot$ .



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,  $\text{C}_6\text{H}_8\text{O}_6$ .



Copy and complete the ion-electron equation for the oxidation of vitamin C.

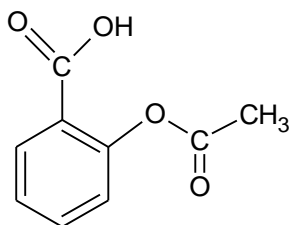
## Open Ended Questions

1. A student makes the following statement:

*'Sugar can be used to produce alcohol, a carboxylic acid and the ester ethyl ethanoate'*

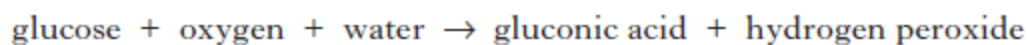
Using your knowledge of chemistry, comment on the accuracy of the student's statement.

2. Aspirin is a widely used medicine. It is advised that it is stored in dry, cool conditions.



Using your knowledge of chemistry, comment on the reasons why aspirin should be stored under these conditions.

3. To improve the shelf-life of foods, food manufacturers use several methods to remove oxygen from inside the food packaging. In one method, an enzyme is added which catalyses a reaction between oxygen and glucose present in the foods.



Using your knowledge of Chemistry, comment on why this method may not be suitable to improve the shelf-life for all foods.