N4/5

CHEMISTRY

UNIT 2

Nature's Chemistry

Learning Outcomes & Homework

Unit 2: Nature's Chemistry

TOPIC 1: FUELS

LEVEL N4 N5	After completing this topic, you should be able to:	NOTES	How well I have understood (✓)		
			☺	😐	☹
N4	*State that a fuel is a chemical which burns in oxygen giving out energy*				
N4	*State that combustion is a reaction of a substance with oxygen, giving out energy*				
N4	*State the tests for water, oxygen, hydrogen and carbon dioxide*				
N4	*State that the main components of air are 20% oxygen and 79% & nitrogen with traces of carbon dioxide, argon and other gases.*				
N4	*State that an exothermic reaction is one in which energy is released and an endothermic reaction is one which takes in energy from the environment*				
N4	*State what is meant by finite resource and peak oil in relation to the amount of coal, oil and natural gas in the Earth*				
N4	*Describe the formation of coal, oil and gas*				
N4	*State that crude oil is a mixture of hydrocarbons and define hydrocarbon as a compound which only contains hydrogen and carbon*				
N4	*State that a fraction is a group of hydrocarbons with boiling points within a given range and that fractional distillation is the process used to separate crude oil into fractions*				
N4	*Explain why fractions can be separated by fractional distillation in terms of the boiling points of fractions, and explain how boiling point changes with increasing hydrocarbon chain length*				
N4	*State what is meant by* • *Flammability* • *Viscosity* • *Evaporation* *And, describe how each changes with increasing molecular size*				
N4	*State that hydrocarbons burn completely to produce only carbon dioxide and water, but that carbon monoxide and carbon are produced in a supply of oxygen which is insufficient for complete combustion*				
N4	*State that the burning of some fuels releases sulphur dioxide, a poisonous gas to the atmosphere*				
N4	*State that nitrogen and oxygen from the air react inside a car engine to form nitrogen oxides (poisonous gases)*				
N4	*State that air pollution from the burning of hydrocarbons can be reduced by catalytic converters in exhaust systems containing the catalyst, platinum, or by increasing the air to fuel ratio*				

LEVEL N4 N5	After completing this topic, you should be able to:	NOTES	How well I have understood (✓)		
			☺	😐	☹
N4	*State that a biofuel is a fuel derived from crops*				
N4	*State that bioethanol is ethanol produced from the fermentation of carbohydrates from sugar cane*				
N4	*State that biodiesel is triglycerides produced from the trans-esterification of plant oils or animal fats*				
N4	*State that biomass is plant and tree derived material which is conventionally combusted to produce energy*				
N4	*Describe the advantages of biofuels compared to fuels produced from crude oil in terms of sustainability and the reduction in net carbon dioxide due to the emission of CO2 being partially balanced by the CO2 used by the growing crops in photosynthesis*				
N4	*Describe the disadvantages of biofuels in terms of reducing land, often in very poor countries, for the production of food.*				

Exercise 2.1

Fuels

1) Many substances can be used as fuels. Some are shown in the table below.

Fuel	Energy released on burning 1g of fuel/kJ
Hydrogen	143
Methane	56
Petrol	48
Ethanol	30
Carbon monoxide	10

   a) Present the information as a bar graph
   b) What is meant by the word "fuel"?
   c) Which of these fuels would produce no carbon dioxide on burning?
   d) Which fuel might be rejected for use because it is a highly poisonous gas?

2) The word equation for the incomplete combustion of the element carbon is given below:

   Carbon + oxygen → carbon monoxide

   a) Rewrite this as a balanced chemical equation
   b) What is formed if there is **enough** oxygen for complete combustion?

3) When the element hydrogen is burned only water is produced.
   a) write a word equation for this reaction
   b) rewrite this a balanced chemical equation
   c) Why are companies investing in hydrogen production and storage technologies?

4) Write a word equation for the burning of methane. Then rewrite as a balanced chemical equation.

5) Describe how crude oil and coal are formed. Try to get at least 4 main stages into each description.

6) Two hydrocarbon fuels which can be obtained from crude oil are:
   - Fuel oil, a liquid with a high viscosity, which is used to power ships and other heavy machinery.
   - Petrol, a liquid with a low viscosity, which can be used as a fuel for cars.

   a) How are fractions of crude oil separated?
   b) What is meant by the term "hydrocarbon"?
   c) Explain in terms of the size of their molecules why fuel oil is more viscous than petrol.

7) Even unleaded petrol engines can produce polluting gases from their exhausts and catalysts are now used to try to prevent this.
   a) Name one of the gases from car exhausts which causes air pollution and explain how it is formed,
   b) What type of metal is used to make these catalysts?
   c) Explain how a "lean burn" engine reduces pollutants in exhaust systems.

8) Crude oil fractions such as butane can be burned to provide heat.

A hydrogen	B methane	C ethene
D water	E butene	F carbon dioxide

Identify the product(s) of the burning of butane

A	B	C
D	E	F

9) When a fuel such as coal burns, oxygen reacts with the coal in an exothermic reaction.
   (a) What is meant by the term “exothermic”?
   (b) What are the products of combustion of coal?
   (c) How does burning coal and other hydrocarbons cause “global warming” and how can “carbon capture” help mitigate this? (Hint: Google “*carbon capture*”)
   (d) Coal also contains trace amounts of sulphur. How does the sulphur contribute to environmental pollution?

10) You have to carry out an experiment to prove that the combustion of butane produces water vapour and carbon dioxide. Draw a labelled diagram of the apparatus you would use to show how this experiment would be carried out.

11) Calculate the mass of oxygen needed to burn 2 g of methane. The balanced equation is:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

12) Sulphur is a common impurity in coal and reacts with oxygen when the coal is burned to form SO_2. The SO_2 is soluble in rain water where it forms acidic rain. A sample of coal was analysed for the content of Sulphur and 1 tonne of coal was found to contain 20 g of sulphur. Calculate how much SO_2 would be formed on the combustion of 100 tonnes of coal. The balanced equation is:

$$S + O_2 \rightarrow SO_2$$

Unit 2: Nature's Chemistry

TOPIC 2: HYDROCARBONS

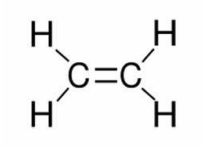
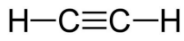
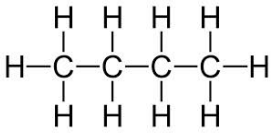
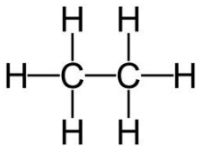
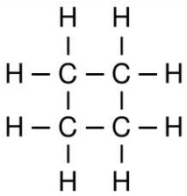
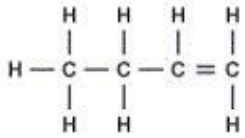
LEVEL N4 N5	After completing this topic, you should be able to:	NOTES (Web 3)	How well I have understood (✓)		
			☺	😐	☹
N4	*State that alkanes are a sub-set of hydrocarbons which form a homologous series with general formula: C_nH_{2n+2}*				
N4	*Name the first 8 members of the alkane series*				
N4	*Molecular formulae can be written and shortened and full structural formulae can be drawn, given the names of straight-chain alkanes (only C1 to C8)*				
N5	*Name branched-chain alkanes from shortened and full structural formulae (only C4 to C8).* *Draw the Molecular formulae and shortened and full structural formulae, given the systematic names of branched-chain alkanes (only C4 to C8)*				
N4	*State that alkenes area subset of the set of hydrocarbons which forma homologous series with general formula for the alkenes is C_nH_{2n}*				
N4	*Name straight-chain alkenes from shortened and full structural formulae (only C2 to C8).*				
N5	*Name branched-chain alkenes, incorporating the position of the double bond, from shortened and full structural formulae (only C2 to C8).*				
N4	*Draw the Molecular formulae and shortened and full structural formulae, given the names of straight chain alkenes (only C2 to C8).*				
N5	*Draw the Molecular formulae and shortened and full structural formulae, given the names of branched chain alkenes (only C2 to C8).*				
N5	*State that cycloalkanes are a subset of the set of hydrocarbons with the general formula C_nH_{2n}*				
N5	*Name Cycloalkanes from molecular formulae, shortened and full structural formulae.*				
N5	*Molecular formulae can be written and shortened and full structural formulae can be drawn, given the names of cycloalkanes (only C3 to C8).*				
N5	*State that a homologous series is a set of compounds with the same general formula, similar chemical properties, and graduated physical properties.*				
N5	*State that isomers are compounds with the same molecular formula but different structural formulae.*				

LEVEL N4 N5	After completing this topic, you should be able to:	NOTES (Web 3)	How well I have understood (✓)		
			☺	😐	☹
	Saturated and Unsaturated Hydrocarbons				
N4	*State that the alkanes and the cycloalkanes are saturated hydrocarbons. Saturated hydrocarbons contain only carbon to carbon single covalent bonds.*				
N4	*State that the alkenes are unsaturated hydrocarbons. Unsaturated hydrocarbons contain at least one carbon to carbon double covalent bond.*				
N4	*State that it is possible to distinguish an unsaturated hydrocarbon from a saturated hydrocarbon using bromine solution and be able to write the chemical equation for the reaction.*				
	Reactions of Hydrocarbons				
N5	*State that an alkene reacts with hydrogen to form the corresponding alkane and be able to write the chemical equation for the reaction.*				
N5	*State that the reactions of an alkene with bromine, hydrogen and water are addition reactions and be able to write the chemical equation for these reactions.*				
N4	*State that fractional distillation of crude oil yields more long-chain hydrocarbons than are useful for present-day industrial purposes.*				
N4	*State that cracking is an industrial method for producing a mixture of smaller, more useful molecules, some of which are unsaturated.*				
N4	*State that the catalyst used for cracking allows the reaction to take place at a lower (more economical) temperature, and cracking can be carried out in the laboratory using an aluminium oxide or silicate catalyst.*				

Exercise 2.2

Hydrocarbons

1) Full structural formula for some hydrocarbons are given in the grid below:

A. 	B. 	C. 
D 	E. 	F. 

a) Which two hydrocarbons belong to a series with the general formula C_nH_{2n+2}?

b) Which hydrocarbon is the simplest alkene?

c) Which two hydrocarbons are isomers?

d) Draw the product formed by the reaction of molecule F with bromine

2)

a) Draw the full structural formula for propane?

b) Draw the shortened structural formula for pentene

c) What is the molecular formula for the alkane with 21 carbon atoms in each molecule?

d) Give the general formula for all alkenes.

3) Look at the following reaction

C_2H_4 + Br_2 → X

a) Draw the full structural formula for substance X?

b) What name is given to this type of reaction?

c) Name the product(s) of the reaction C_2H_4 with H_2

4) As part of an investigation into hydrocarbons Kirsten was given samples of 2 liquids in bottles labelled as follows:

"heptane – a saturated hydrocarbon"

"heptene – an unsaturated hydrocarbon"

(a) Explain which is meant by the word "saturated" used in this context.

(b) Which bond is present in molecules of heptene but not those of heptane?

(c) If the bottles had NOT been labelled, what chemical test could Kirsten have carried out in order to decide which bottle contained heptane and which contained heptene?

5) The boiling points of some alkanes are given in the table below.

Alkane	**Boiling point / K**
Methane	109
Ethane	185
Propane	231
Butane	273
Hexane	342

a) Draw a bar graph to show this information.

b) Use your graph to estimate the boiling point of pentane.

c) You now have information about six alkanes, including pentane.

Name the alkanes which are liquids at 250K

6) The following questions are about the cycloalkanes

(a) Are cycloalkanes saturated or unsaturated?

(b) What is the formula for the cycloalkane with 12 carbon atoms per molecule?

(c) Draw the full structural formula for each of the following molecules:

(i) Cyclobutane

(ii) Cyclohexane

7) Explain what is meant by the term “isomers”. Illustrate your answer by drawing isomers of butane

8) Draw the full structural formula and name each of the following:
   (a) Three isomers of pentane.
   (b) Four isomers of C_4H_8.
   (c) Three isomers of cyclobutane.

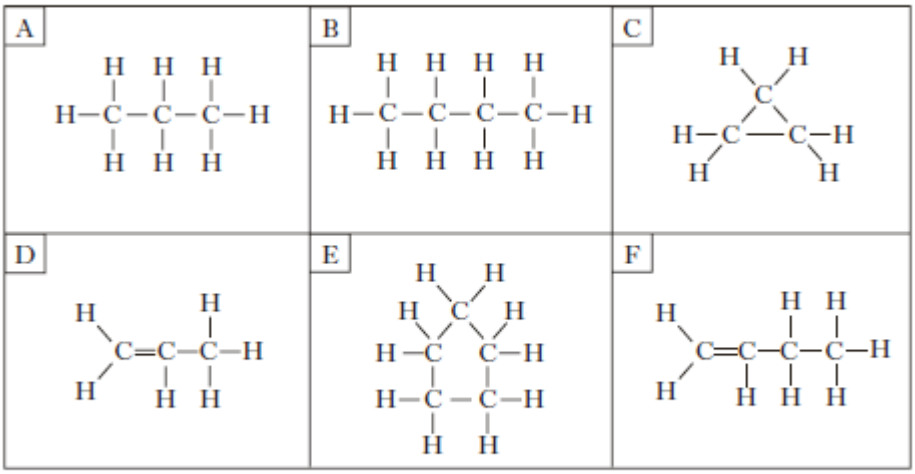
9) Compound X is both a feedstock for the petrochemicals industry and a fuel which is widely used in rural areas. The cracking of X produced only propene and hydrogen.
   (a) Name the compound X and give an equation for the cracking reaction using molecular formulae.
   (b) Why is a catalyst used?

10) $C_8H_{18} \xrightarrow{\text{Process X}}$ Ethene + Compound Y

Which line in the table correctly identifies Process X and Compound Y?

	Process X	**Compound Y**
A	cracking	hexane
B	cracking	hexene
C	distillation	hexane
D	distillation	hexene

11) The grid shows the structural formulae of some hydrocarbons.



(*a*) Identify the hydrocarbon which reacts with hydrogen to form butane.

A	B	C
D	E	F

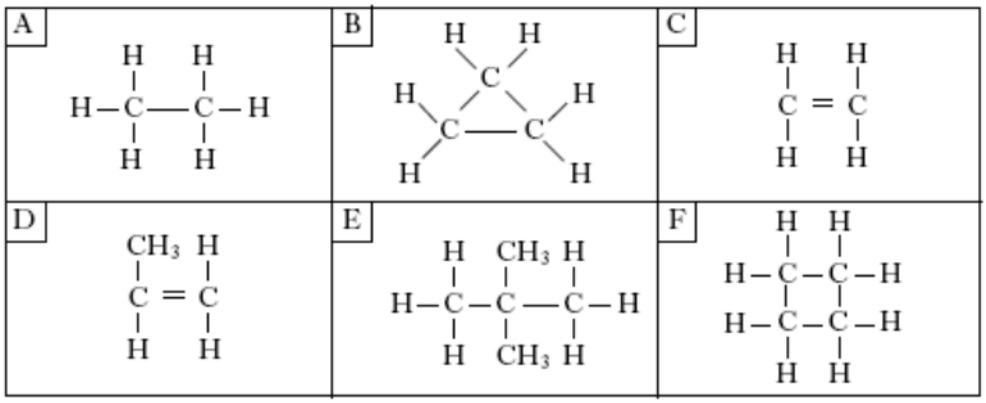
(*b*) Identify the **two** isomers.

A	B	C
D	E	F

(*c*) Identify the structural formula which represents propene.

A	B	C
D	E	F

12) The grid shows the structural formulae of some hydrocarbons.



(*b*) Identify the **two** hydrocarbons with the general formula C_nH_{2n} which do **not** decolourise bromine solution quickly.

A	B	C
D	E	F

Unit 1: Nature's Chemistry

TOPIC 3: EVERYDAY CONSUMER CHEMISTRY

LEVEL N4 N5	After completing this topic, you should be able to:	NOTES (Web 3)	How well I have understood (✓)		
			☺	😐	☹
	Carbohydrates				
N4	*State that Photosynthesis is the process by which plants make carbohydrates from carbon dioxide and water using light energy in the presence of chlorophyll; oxygen is released in the process*				
N4	*State that carbohydrates supply the body with energy. Respiration is the process by which the body obtains a Supply of energy by breaking down carbohydrates (using oxygen) to give carbon dioxide and water.*				
N4	*State that carbohydrates are compounds which contain carbon, hydrogen and oxygen with the hydrogen and oxygen in the ratio of two to one.*				
N4	*State that carbohydrates can be divided into sugars and starches. Examples of sugars include glucose, fructose, maltose and sucrose (table sugar).*				
N4	*State that most sugars can be detected by the Benedict's test; sucrose is an exception. Starch can be distinguished from other carbohydrates by the iodine test.*				
N4	*State that sugars are carbohydrates with small molecules. Starch is a natural condensation polymer made of many glucose molecules linked together. Plants convert the glucose into starch for storing energy and animals break down the starch into glucose during digestion.*				
	Alcohols (Alkanols) - Ethanol				
N4	*State that fermentation is the breakdown of glucose to form ethanol and carbon dioxide*				
N4	*State that an enzyme in yeast acts as a biological catalyst for the reaction. Ethanol, for alcoholic drinks, can be made by fermentation of glucose derived from any fruit or vegetable.*				
N4	*State there is a limit to the ethanol concentration of fermentation products because once the alcohol concentration reaches 14%, it kills the yeast.*				
N4	*State that distillation is a method of increasing the ethanol concentration of fermentation products in the manufacture of 'spirit' drinks.*				
N4	*State that to meet market demand ethanol is made by means other than fermentation. Industrial ethanol is manufactured by the catalytic hydration of ethene*				
N5	*State that Ethanol can be converted to ethene by dehydration and be able to write the chemical equation for the reaction.*				

LEVEL N4 N5	After completing this topic, you should be able to:	NOTES (Web 3)	How well I have understood (✓)		
			☺	😐	☹
	Alcohols (Alkanols) and Carboxylic Acids (Alkanoic Acids)				
N4	*Identify a molecule as an alkanol from the hydroxyl group and the '-ol' name ending*				
N5	*Name straight-chain and branched chain alkanols, incorporating the position of the hydroxyl group, from shortened and full structural formulae (only C1 to C8)*				
N5	*Write the molecular formulae and draw the shortened and full structural formulae, given the names of straight-chain and branched-chain alkanols (only C1 to C8)*				
N5	*Identify an alkanoic acid from the carboxyl (COOH) group and the '-oic' name ending.*				
N5	*Name straight-chain alkanoic acids from shortened and full structural formulae (only C1to C8).*				
N5	*Write the molecular formulae and draw the shortened and full structural formulae, given the name of straight-chain alkanoic acids (only C1 to C8).*				
	Esters				
N5	*Identify an ester from the ester group and the '-oate' ending*				
N5	*Name an given the names of the parent alkanol and alkanoic acid or from shortened and full structural formulae.*				
N5	*Draw the shortened and full structural formulae for esters, given the names of the parent alkanol and alkanoic acid or the names of esters.*				
N5	*Name the products of the breakdown of an ester, and draw the shortened and full structural formulae, given the name of the ester or from the shortened or full structural formulae of the ester.*				
N5	*State that esters are formed by the condensation reaction between a carboxylic acid and an alcohol where the hydroxyl group of the alcohol reacts with the carboxylic group of the acid giving out a molecule of water*				
N5	*State that the parent carboxylic acid and the parent alcohol can be obtained by hydrolysis of an ester.*				
N5	*State that the formation and hydrolysis of an ester is a reversible reaction*				

Exercise 2.3

Carbohydrates

1) The equations represent chemical reactions involving carbohydrates.

A carbon dioxide + water → glucose + oxygen

B glucose → starch + water

C starch + water → glucose

D glucose → ethanol + carbon dioxide

E glucose + oxygen → carbon dioxide + water

(a) Identify the reaction which is catalysed by enzymes in yeast.

(b) Identify the hydrolysis reaction.

(c) Identify the reaction which takes place in animals during respiration.

2) Various reagents can be used to identify substances

A Benedict's solution

B bromine solution

C ferroxyl indicator

D iodine solution

E lime water

a) Identify the reagent used to test for starch.

b) Identify the reagent used to test for glucose

3) Glucose, sucrose and starch are carbohydrates.

Identify the **two** correct statements.

A Glucose molecules join together with a loss of water.

B Starch is a polymer made from sucrose molecules.

C Sucrose turns warm Benedict's solution orange.

D Glucose is an isomer of sucrose.

E Starch dissolves easily in water.

F Sucrose can be hydrolysed.

4) The equation shows the reaction in which glucose is converted into ethanol (alcohol).

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

(a) What name is given to this process?

(b) Calculate the mass of ethanol that is obtained when 60 kg of glucose is totally converted into alcohol.

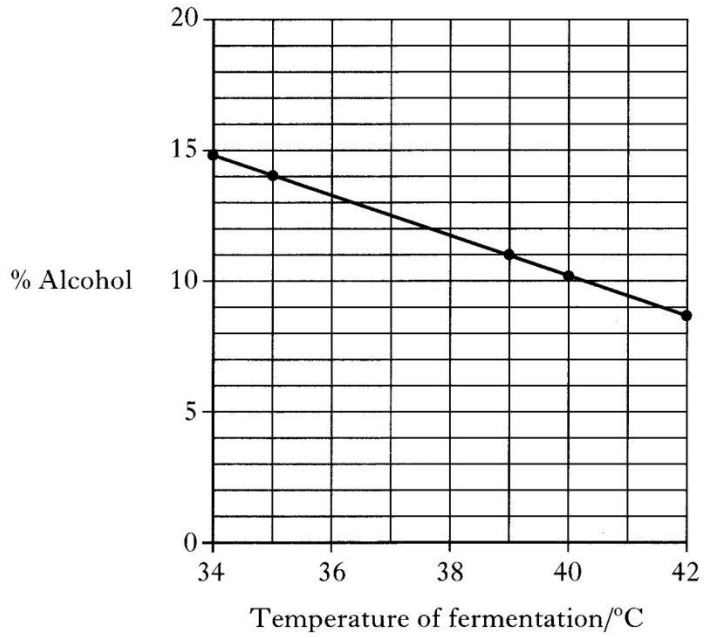
(c) What would happen to the rate of reaction if the temperature was increased to 50°C?

5) Starch and glucose are carbohydrates.

(a) Which chemical would you use to test for starch?

(b) What is the chemical name for the alcohol produced by the fermentation of glucose?

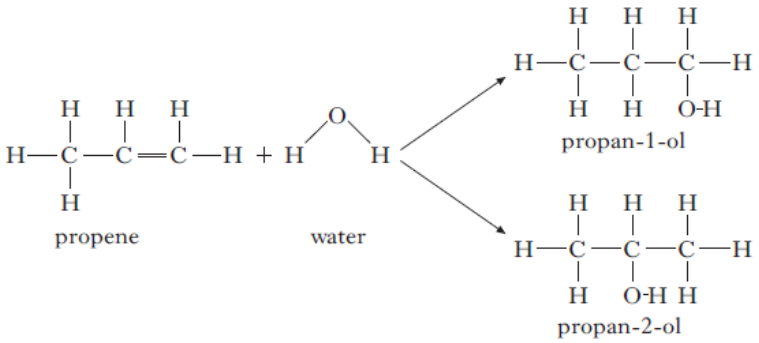
(c) The percentage of alcohol in wine depends on the temperature of the fermentation process. Some results are shown on the graph.



(i) Describe how the temperature of fermentation affects the % alcohol produced?

(ii) Use the graph to estimate the % alcohol when the temperature is 37°C

6) In industry, alcohols can be produced from alkenes as shown in the example below.

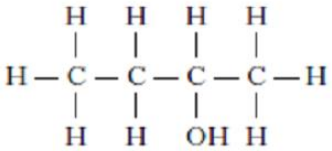


(i) Name the type of chemical reaction taking place.

(ii) What **term** is used to describe a pair of alcohols like propan-1-ol and propan-2-ol?

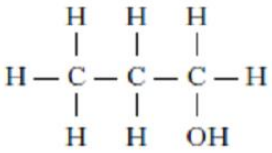
(iii) Propan-1-ol and propan-2-ol have different boiling points. Name the process which could be used to separate a mixture of these alcohols.

7)



Which of the following compounds is an isomer of the one above?

A



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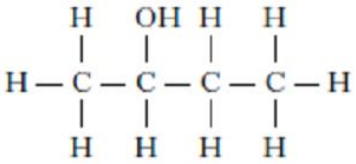
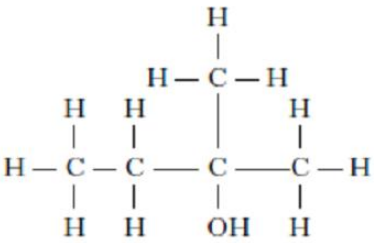


B



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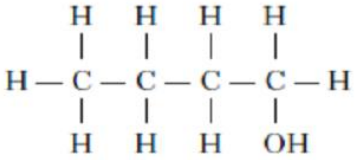
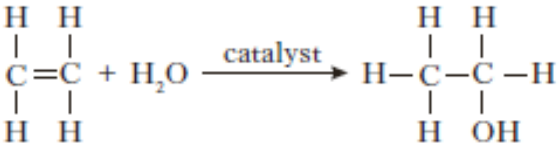


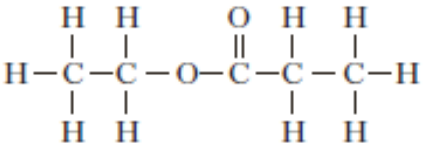
8) Ethanol is a member of the alkanol family of compounds.

(*a*) Ethanol can be manufactured from ethene as shown in the following addition reaction.



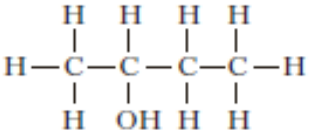
What other name can be given to this type of addition reaction?

(*b*) Ethanol can be used to make esters which can be used as flavourings for food. The following ester is used to give ice cream a rum flavour.



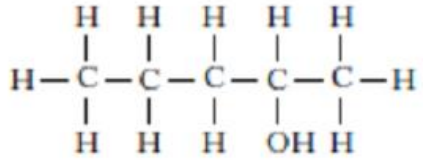
Name this ester.

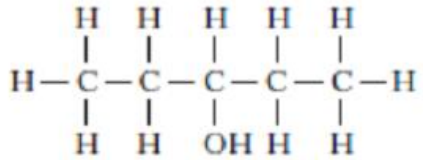
(*c*) Butan-2-ol is another member of the alkanol family.

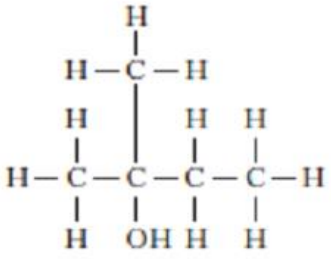


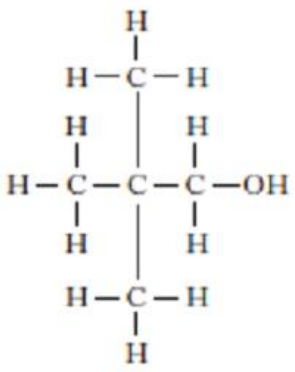
Draw the full structural formula for an isomer of butan-2-ol.

9) Which alcohol could be oxidised to a carboxylic acid?

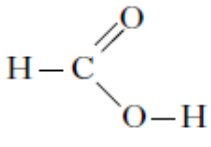
A 

B 

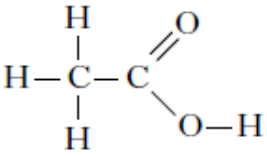
C 

D 

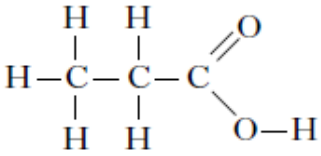
10) Alkanoic acids are a family of compounds which contain the group. The **full** structural formulae for the first three members are shown:



methanoic acid



ethanoic acid



propanoic acid

a) Draw the **full** structural formula for the alkanoic acid containing 4 carbon atoms.

b) The table gives information on some alkanoic acids.

Acid	*Boiling point/ °C*
methanoic acid	101
ethanoic acid	118
propanoic acid	141
butanoic acid	164

i) Using this information, make a general statement linking the boiling point to the number of carbon atoms.

ii) Predict the boiling point of pentanoic acid.

11) Name and draw the ester formed from

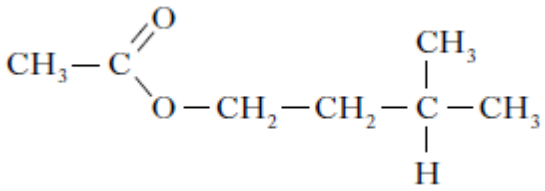
a) ethanol and propanoic acid

b) methanol and pentanoic acid

c) ethanoic acid and butan-1-ol

12) A food chemist carried out a titration of Tesco's own brand vinegar to establish the concentration of the ethanoic acid (CH_3COOH). She found that 20.33 cm^3 of vinegar neutralised 25 cm3 of sodium hydroxide of concentration 0.25 mol/l. What was the concentration of ethanoic acid in the vinegar?

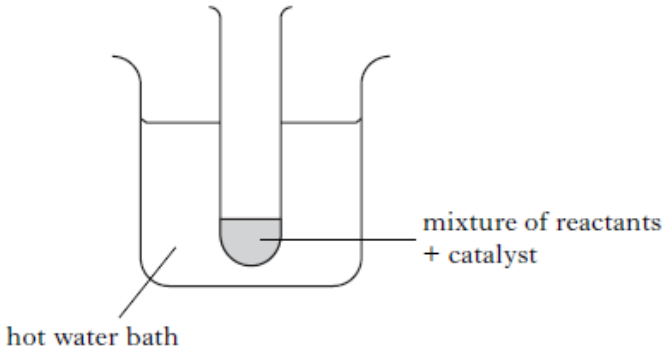
13) One of the chemicals released in a bee sting is an ester that has the structure shown.



a) Name this ester

b) Name the acid and alkali from which this ester was synthesised

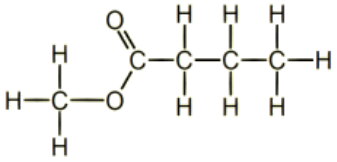
c) The ester can be prepared in the lab by heating a mixture of the reactants with a catalyst using the apparatus shown:

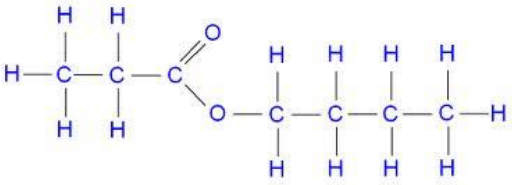


(i) Name the catalyst used in the reaction.

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

14) Name the following esters

a) 

b) 

15) Draw out the following esters and name them

a) CH_3COOCH_3

b) $CH_3CH_2CH_2COOCH_3$

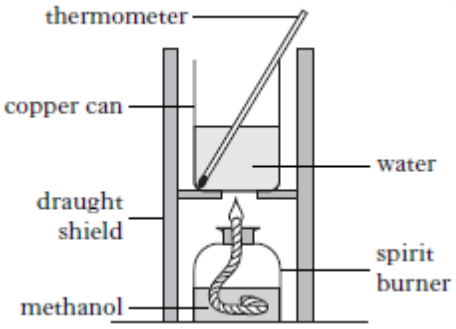
c) $CH_3(CH_2)_4OOCCH_2CH_2CH_3$

Unit 2: Nature's Chemistry

TOPIC 4: ENERGY CALCULATIONS

LEVEL N4 N5	After completing this topic, you should be able to:	NOTES (Web 4)	How well I have understood (✓)		
			☺	😐	☹
N5	*Define the terms in the equation E = cmΔT*				
N5	*Use the equation to calculate the energy released from the combustion of fuels and, using simple proportion, express the result in terms of kj/g of fuel*				
N5	*Rearrange the equation to calculate an unknown variable, given the other variables*				

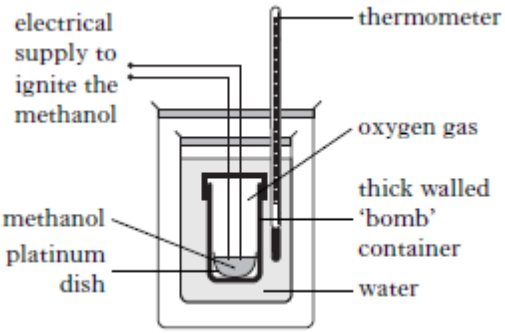
1) A student used the simple laboratory apparatus shown to determine the enthalpy of combustion of methanol.



(a) (i) What measurements are needed to calculate the energy released by the burning methanol?

(ii) The student found that burning 0.370 g of methanol produces 3.86 kJ of energy. Use this result to calculate the energy given out on kj / g for methanol.

(b) A more accurate value can be obtained using a bomb calorimeter.



One reason for the more accurate value is that less heat is lost to the surroundings than in the simply laboratory method. Give one other reason for the value being more accurate in the bomb calorimeter method.

2) The energy changes taking place during chemical reactions have many everyday uses.

Flameless heaters are used by mountain climbers to heat food and drinks. The chemical reaction in a flameless heater releases 45 kJ of energy.

If 200 g of water is heated using this heater, calculate the rise in temperature of the water, in °C.