Beatty Secondary School
Science Department (Chemistry Unit)
Chemistry 6092

Name: _____ ( ) Date: _____

Class: 4E1

TOPIC: ALKENES (WORKSHEET 1)

Learning Objectives:

(a) Describe the alkenes as an homologous series of unsaturated hydrocarbons with the general formula C_nH_{2n}.

(b) Draw the structures of unbranched alkenes, C2 to C4, and name the unbranched alkenes, ethene to butene.

(c) Describe the manufacture of alkenes and hydrogen by cracking hydrocarbons and recognise that cracking is essential to match the demand for fractions containing smaller molecules from the refinery process.

(d) Describe the difference between saturated and unsaturated hydrocarbons from their molecular structures and by using aqueous bromine.

(e) Describe the properties of alkenes (exemplified by ethene) in terms of combustion, polymerisation and the addition reactions with bromine, steam and hydrogen.

(f) State the meaning of polyunsaturated when applied to food products.

(g) Describe the manufacture of margarine by the addition of hydrogen to unsaturated vegetable oils to form a solid product.

Multiple-Choice Questions

1 What feature would show that a compound **must** be an alkene?

A if it only contains carbon and hydrogen
B if it reacts only with bromine
C if it is a hydrocarbon with a C=C bond
D if it burns in air with a smoky flame (**C**)

2 Which of the following would be a likely product on cracking the hydrocarbon octadecane, $C_{18}H_{38}$?

A C_9H_{18} **B** C_9H_{22}
C $C_{18}H_{40}$ **D** $C_{36}H_{74}$ (**A**)

3 The cracking of one mole of X produces two moles of ethene, two moles of propene and one mole of propane. How many carbon atoms does one molecule of X contain?

A 8 **B** 10
C 13 **D** 16 (**C**)

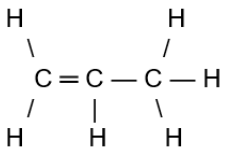
4 Which statements about the cracking of hydrocarbons are correct?

1 Cracking involves breaking down hydrocarbon molecules.
2 One of the products of cracking is always unsaturated.
3 Cracking is essential because of the demand for fractions containing smaller molecules.

A 1 and 2 only **B** 2 and 3 only
C 1 and 3 only **D** 1, 2 and 3 (**D**)

5 Which structural formula represents an unsaturated hydrocarbon?

A



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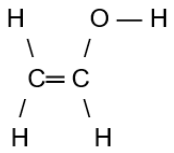

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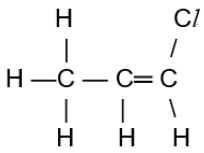

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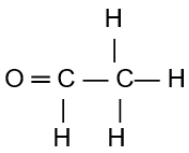


(**A**)

6 Compounds **X** and **Y** are two different alkenes. Which statement about **X** and **Y** is **not** correct?

A They both undergo addition reactions.
B They have the same empirical formula.
C They both contain carbon and hydrogen only.
D They have the same boiling point. (**D**)

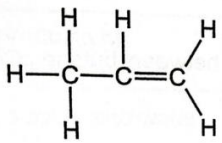
7 Which one of these equations does **not** show an addition reaction?

A $CH_3Cl + Cl_2 \rightarrow CH_2Cl_2 + HCl$
B $C_3H_6 + Br_2 \rightarrow C_3H_6Br_2$
C $C_4H_8 + H_2 \rightarrow C_4H_{10}$
D $nC_2H_4 \rightarrow -[CH_2\text{-}CH_2]-_n$

(**A**)

8 Compound Y has the empirical formula CH_2, has an M_r of 56 and forms two alcohols that have different structural formulae when reacted with steam. What is compound Y?

A



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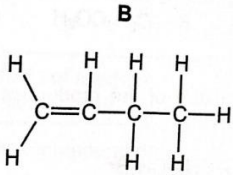

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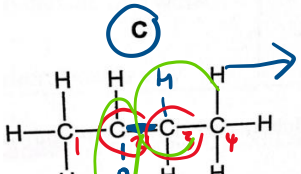

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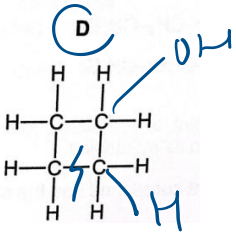
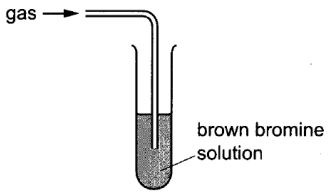


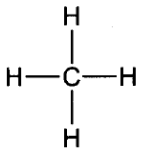
(**B**)

9 The diagram shows an apparatus used to test a gas.



The bromine solution becomes colourless. What is the structure of the gas?

A



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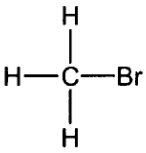

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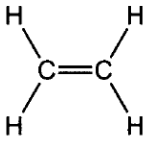

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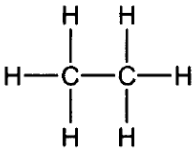


(**C**)

10 Which compound undergoes an addition reaction with bromine?

A C_2H_4 **B** C_2H_6
C C_2H_5OH **D** CH_3CO_2H (**A**)

11 What is the structure of the product of the reaction between butene, $CH_3–CH_2–CH=CH_2$, and bromine?

A $CH_2Br–CH_2–CH_2–CH_2Br$ **B** $CH_2Br–CH_2–CHBr–CH_3$
C $CH_3–CHBr–CH_2–CH_2Br$ **D** $CH_3–CH_2–CHBr–CH_2Br$ (**D**)

12 A student investigated the reaction of vegetable oils with hydrogen. 100 cm^3 of hydrogen was bubbled through 1 g samples of four different vegetable oils containing a suitable catalyst. The volume of hydrogen remaining after each experiment was recorded.

vegetable oil	volume of hydrogen remaining / cm^3
P	100
Q	87
R	63
S	0

saturated

unsaturated

Which vegetable oils are unsaturated?

A P, Q and R **B** Q and R only
C Q, R and S **D** S only (**C**)

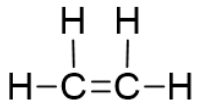
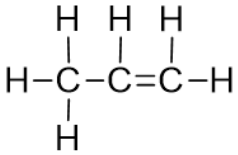
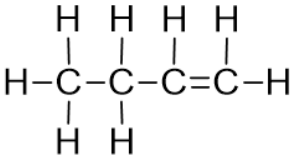
13 How can margarine be made from vegetable oils?

A by the addition of hydrogen to a saturated oil
B by the addition of hydrogen to an unsaturated oil
C by the addition of steam to a saturated oil
D by the addition of steam to an unsaturated oil (**B**)

Structured Questions

14 The hydrocarbon ethene (C_2H_4) is the first member of the alkenes homologous series.

(a) **Name** and **draw** the structural formulae of the first three members of the alkene series.

 ethene	 propene	 butene

(b) (i) What substance would you expect to be produced when ethene is burned in a plentiful supply of air, other than water vapour?

Carbon dioxide

(ii) How would you show the presence of the gaseous product other than water vapour?

Bubble the gas into limewater. If gas produced forms a white precipitate in limewater, carbon dioxide is present.

15 Alkenes burn in air like alkanes but they produce more soot than alkanes.

(a) Write an equation for the complete combustion of butene.

$C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$

(b) Suggest why alkenes produce more soot than alkanes upon combustion.

Alkenes have a higher percentage of carbon than corresponding alkanes. This leads to a higher proportion of incomplete combustion as carbon particles (soot) may be produced.

16 Write the balanced chemical equation when propene undergoes each of the following reactions.

(a) addition of bromine,

$C_3H_6 + Br_2 \rightarrow C_3H_6Br_2$

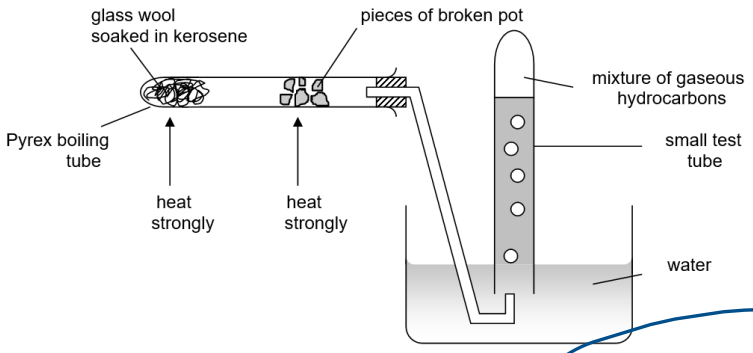
(b) addition of hydrogen,

$C_3H_6 + H_2 \rightarrow C_3H_8$

(c) addition of steam.

$C_3H_6 + H_2O \rightarrow C_3H_7OH$

17 Kerosene is a mixture of alkanes. The diagram below shows how a mixture of propene and other hydrocarbons can be produced from kerosene in the laboratory.



(a) Name the type of reaction shown in the diagram.

energy change

Catalytic cracking

(b) What is the purpose of the pieces of broken pot?

Increase the surface area and catalyse the reaction to increase the speed of reaction

(c) Why must the end of the delivery tube be taken out of the water before the heating process is stopped?

This is to prevent 'suck-back' from occurring due to the difference in pressure, where water flows back into the delivery tube to the boiling tube, causing it to crack.

(d) (i) A typical alkane found in kerosene has the formula $C_{14}H_{30}$. Construct the equation for one reaction that takes place in the apparatus producing propane from $C_{14}H_{30}$.

$C_{14}H_{30} \rightarrow C_3H_8 + C_{11}H_{22}$

(ii) Describe a chemical test to show that the other product formed is unsaturated.

bromination

test **addition of aqueous bromine**

observation

reddish-brown bromine turns colourless / decolourises

18 Catalytic cracking is used to break big hydrocarbon molecules into smaller ones.

(a) State and explain one advantage to vehicles of catalytic cracking of hydrocarbons.

Cracking involves breaking down of larger alkanes, which are less useful and lower in demand, into shorter alkane fractions which are higher in demand to be used as fuels but lower in supply.

(b) State the conditions for cracking.

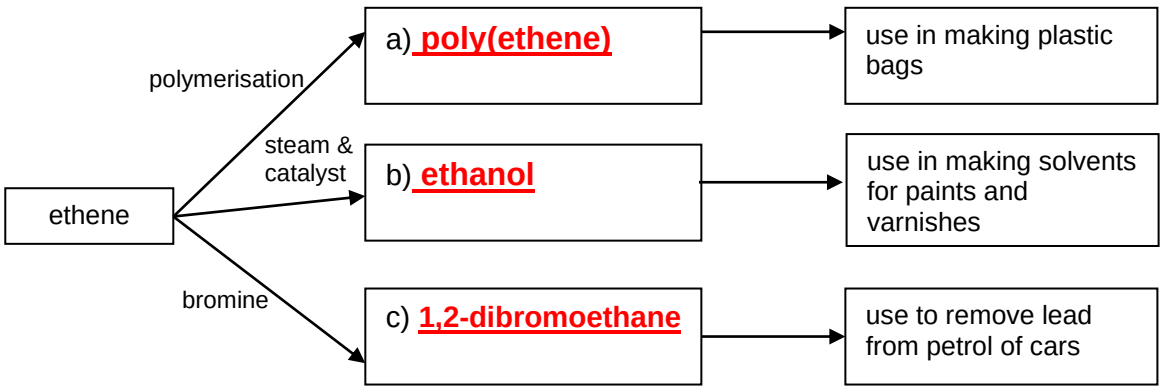
porous pot / zeolite with finely divided catalyst: aluminium oxide or silicon(IV) oxide and high temperature of 600 °C

19 Explain the meanings of *substitution* and *addition* reactions.

A substitution reaction is a reaction in which an atom or a group of atoms is replaced by atoms of other elements.

An addition reaction is a reaction in which an unsaturated organic compound reacts with another element or compound to form a single new compound.

20 Complete the following boxes with the name of the compounds formed from ethene.



Ethene has a wide range of uses. It is used to make organic compounds, solvents and plastics.

(a) Briefly describe how ethene can be converted to ethane.

Addition of hydrogen to ethene at 200 °C using a nickel catalyst.

(b) This type of reaction is known as hydrogenation. Name one industrial use of hydrogenation.

Manufacturing of margarine

(c) Calculate the volume of hydrogen (measured at r.t.p) needed to convert 5.6 g of ethene to ethane.

Volume = 4.80 dm^3

21 A student collects some data about the fat content of some margarines. The margarines tested are all mixtures of saturated fat, A, unsaturated fat, B, and water. He also does an experiment to count how many drops of bromine water react with 10g of each type of margarine. The table shows his results.

margarine	% by mass of saturated fat	% by mass of unsaturated fat	number of drops of bromine water per 10 g
1	10	80	12
2	20	70	11
3	40	20	3

(a) (i) What colour change happens when bromine reacts with a margarine?

The reddish-brown bromine water turns colourless.

(ii) What is seen when the bromine is in excess?

The bromine water remains reddish-brown.

(b) The margarines are sold in 500 g packs. Which margarine contains most water per 500 g? Explain your reasoning.

Margarine 3. It contains 40% by mass of water compared to margarine 1 and margarine 2 which have 10% each.

(c) Another margarine contains 50 g of saturated fat A, and 20 g of unsaturated fat B, per 100 g. Estimate the number of drops of bromine water that react with 10 g of this margarine.

% by mass of unsaturated fat in this margarine = 20%. Thus, number of drops of bromine water required = 3

(d) Some cooking oils contain a mixture of water with molecules of saturated and unsaturated fats. Iodine and bromine both react in a similar way with fat molecules. The mass of iodine that reacts with three different types of oil are shown below.

oil	mass of iodine that reacts with 100 g of the oil / g
C	175
D	124
E	163

(i) A student says 'oil C contains a larger mass of fat than oil D'. Do you agree with the student? Explain your reasoning.

No, I do not agree with the student. Iodine only reacts with unsaturated fats and not saturated fats.
The mass of iodine that reacts can only compare the amount of unsaturated fats in each cooking oil. It does not compare the total amount of saturated and unsaturated fats.
It is correct to say that oil C contains a larger amount of unsaturated fats than oil D.

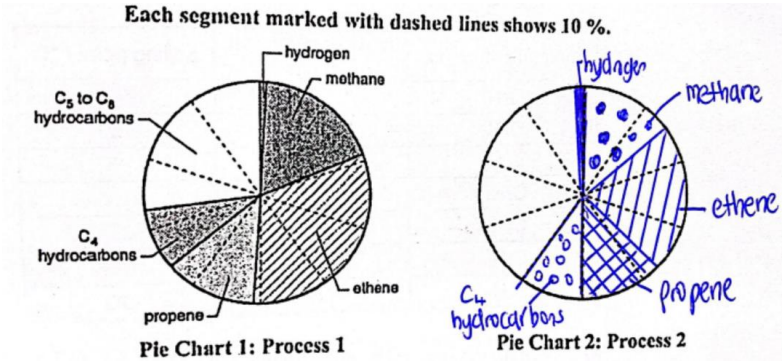
(ii) A pure fat has a molecular mass of 400. 100 g of the fat reacts with 127 g of iodine. How many double bonds are there in each molecule of the fat? Show your working.

No. of mol of iodine = [127 ÷ (2 × 127)] = 0.500 mol
No. of mol of fat = 100 ÷ 400 = 0.250 mol
Mole ratio of fat : iodine = 0.250 : 0.500
= 1 : 2
Thus, there are 2 double bonds in each molecule.

22 An oil refinery uses two different processes, Process 1 and Process 2, to crack naphtha. The table below shows some information about the percentage yields of products from each process.

	Process 1	Process 2
hydrogen	1	1
methane	18	14
ethene	32	20
propene	13	15
C_4 hydrocarbons	9	10
C_5 to C_8 hydrocarbons	27	40

(a) **Pie chart 1** shows the percentage yield of products for **Process 1**. Complete **Pie chart 2** to show the percentage yield of products for **Process 2**.



(b) The refinery sells ethene and C_5 to C_8 hydrocarbons. Ethene is used to make addition polymers and C_5 to C_8 hydrocarbons are added to petrol. Use the information given to explain why the refinery must use both processes to meet the high demand for both ethene and C_5 to C_8 hydrocarbons.

Process 1 produces more ethene than Process 2.
Process 2 produces more C_5 to C_8 hydrocarbons than Process 1. Hence, both processes are required to meet the high demands of ethene and C_5 to C_8 hydrocarbons.

(c) During cracking, molecules of nonane, C_9H_{20}, produce three different products: butane, ethene and **product X**.

(i) Complete the equation to show the formula of **product X**.

nonane $\xrightarrow{\text{crack}}$ butane + ethene + **product X**

$C_9H_{20} \longrightarrow C_4H_{10} + C_2H_4 + \ldots\ldots\underline{C_3H_6}\ldots\ldots$

(ii) Draw the **structural formulae** of **product X** in the box.