

Beatty Secondary School Science Department (Chemistry Unit) Chemistry 6092

Name:

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Date: \_\_\_\_\_

Class: 4E1

# **TOPIC: ALKANES (WORKSHEET 1)**

### Learning Objectives:

- (a) Describe an homologous series as a group of compounds with a general formula, similar chemical properties and showing a gradation in physical properties as a result of increase in the size and mass of the molecules, e.g. melting and boiling points; viscosity; flammability.
- (b) Describe the alkanes as an homologous series of saturated hydrocarbons with the general formula  $C_nH_{2n+2}$ .
- (c) Draw the structures of branched and unbranched alkanes, C1 to C4, and name the unbranched alkanes, methane to butane.
- (d) Describe the properties of alkanes (exemplified by methane) as being generally unreactive except in terms of burning and substitution by chlorine.

## **Multiple-Choice Questions**

- 1 Decane is an alkane containing ten carbon atoms per molecule. What is its molecular formula?
- 2 The structure of compound J is shown. Which row describes J?

	saturated	hydrocarbon
Α	no	no
В	no	yes
С	yes	no
D	yes	yes

H H I I H - C - C - O - H I I H H

( **C** )

**3** Methane is the first member of the alkane homologous series. Which row describes the changes in flammability and the size of the molecules in the alkane homologous series from methane to propane?

	flammability	size of molecules
Α	decreases	decreases
В	decreases	increases
С	increases	decreases
D	increases	increases

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В

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- 4 Which of these properties of alkanes **decreases** with increasing relative molecular mass of the alkane?
  - Α melting point В flammability С density 🔶 D boiling point B ) Which statement about a homologous series is correct? Α The boiling point increases with decreasing relative molecular mass. The members have the same empirical formula (formula showing the number В of atoms in the simplest ratio). С The members have similar chemical properties.
    - **D** The relative molecular masses of consecutive members differ by 12. (**C**)
- 6 Nonane is an alkane present in petrol. What are the products formed when nonane is **completely** burnt in air?
  - A carbon dioxide and hydrogen
  - B carbon monoxide and water
  - **C** carbon dioxide and water

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D carbon dioxide, carbon monoxide and water

**C**)

- 7 What are the main products when chlorine reacts with methane?
  - A chloromethane and hydrogen
  - **B** chloromethane and hydrogen chloride
  - **C** dichloromethane and hydrogen
  - **D** trichloromethane and carbon chloride
- 8 The diagrams show the structures of three compounds.



Which compounds can be products of substitution reactions of ethane with chlorine?

Α 1 only В 2 only С 1 and 3 only D 1, 2 and 3 ( D ) 100 cm<sup>3</sup> of methane is burned in (150 cm<sup>3</sup> of oxygen. When cooled to room 9 temperature, what could be the resulting mixture of gases?  $CH_4$ , CO,  $CO_2$  $CH_4$ , CO,  $H_2O$ В X  $CH_4$ ,  $CO_2$ ,  $M_4$ D ) 2

# Structured Questions

- 10 Briefly explain what is meant by the following terms:
  - (a) a saturated hydrocarbon,

A saturated hydrocarbon contains carbon and hydrogen atoms only, with only carbon-carbon single bonds in the compound.

(b) a homologous series,

A homologous series is a family of organic compounds which has the same functional group, each successive member differing in composition by a  $-CH_2$  - group.

(c) a functional group.

A functional group is an atom or group of atoms responsible for the chemical properties of an organic compound.

11 (a) Name the compound with the formula  $C_3H_8$ .

#### propane

(b) Write a balanced chemical equation for the complete combustion of  $C_3H_8$  in air.

 $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ 

(c) Name two products of the combustion, other than water if the supply of oxygen is restricted.

carbon monoxide (incomplete combustion) / carbon dioxide (Complete combustion) / carbon (from incomplete combustion)

- 12 The alkanes are an homologous series of saturated hydrocarbons.
  - (a) State the general formula of alkanes.

## $C_nH_{2n+2}$

(b) One property of a homologous series is that its members have the same gene

Each successive member differs by a -CH<sub>2</sub>- group. All the members have the same functional group. Members of a homologous series have similar chemical properties but different physical properties. 3 Chemical properties

(c) Name the type of reaction that occurs when an alkane reacts with chlorine.

substitution

(d) Write a balanced equation for the reaction between methane and chlorine.

 $\underline{\mathsf{CH}_4 + \mathsf{C}l_2} \to \underline{\mathsf{CH}_3}\underline{\mathsf{C}l} + \underline{\mathsf{HC}l}$ 

13 Alkanes are saturated compounds which do not react with most chemicals.

However they do undergo substitution reactions with chlorine in the presence of sunlight to form a mixture of chloroalkanes.

(a) Complete the following chemical equations involving methane. Draw the structural formula of the chloroalkane formed at each stage. The one for methane is given.

(i)	CH <sub>4</sub>	+	$Cl_2$	 heat + light	<b>→</b>	<u>CH₃C<i>l</i></u>	+	<u>HC/</u>
(ii)	CH₃C <i>l</i>	+	$Cl_2$	 heat + light	<b>→</b>	<u>CH2Cl2</u>	+	<u>HC/</u>
(iii)	CH <sub>2</sub> Cl <sub>2</sub>	+	$Cl_2$	 heat + light	<b>→</b>	<u>CHC/</u> ₃	+	<u>HC/</u>
(iv)	CHCl <sub>3</sub>	+	$Cl_2$	 heat + light	<b>→</b>	<u>CC/4</u>	+	<u>HC/</u>

methane	(i) monochloromethane	(ii) dichloromethane
H H—C—H	H H-Ċ-CI	

(iii) trichloromethane	(iv) tetrachloromethane
CI	CI

- (,H)
- (b) Using one **example** from the above, **explain** what is meant by a *substitution* reaction.

In the above reaction, a hydrogen atom from methane is substituted by a chlorine atom to form monochloromethane. A substitution reaction is a reaction in which an atom or a group of atoms is replaced by atoms of other elements. (c) Predict whether methane will react faster or slower with bromine. Explain your answer.

<u>Methane will react slower with bromine because bromine is less</u> reactive than chlorine.

14 The following apparatus is set up to study the products formed when methane is burnt. At the start of the experiment, the U-tube is empty and the liquid **Y** is present in the boiling tube.

The teacher lights a jet of methane and then turns on a suction pump to draw the combustion gases through the apparatus.



(a) Name liquid X.

#### <u>water</u>

(b) How can you prove that liquid X is pure?

Determine the boiling point of the liquid. If the liquid boils at a fixed temperature, the liquid is pure. If the liquid boils over a range of temperatures, the liquid is impure.

(c) Liquid Y is present in the tube to provide a test for carbon dioxide. Name liquid Y and describe how it would change during the investigation.

identity of liquid Y

limewater / calcium hydroxide

changes to liquid Y during the experiment

Colourless liquid Y turns to form a white precipitate.

(d) Write a chemical equation for the reaction in this experiment.

 $\underline{CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O}$ 

Ca(0X1)2 - XU - X (a(u)

**15** The table shows some information about the homologous series of a class of organic compounds called ether.

name	chemical formula	full structural formula
dimethyl ether	H₃COCH₃	
<u>diethyl ether</u>	<u>H₅C₂OC₂H₅</u>	
dipropyl ether	H7C3OC3H7	н н н н н н           н-с-с-с-с-с-с-с-н             н н н н н

- (a) Fill in the table to show the name, chemical formula and full structural formula of the ether that occurs between dimethyl ether and dipropyl ether in the homologous series.
- (b) Explain how you can tell that these molecules are from the same homologous series.

<u>These molecules have the same functional group -C-O-C-</u> same general formula of  $C_nH_{2n+2}O$  where n is an even number /  $C_nH_{2n+1}OC_nH_{2n+1}$ .

(c) Describe two differences in the physical properties between dimethyl ether and dipropyl ether.

Dimethyl ether has a lower boiling point than dipropyl ether. Dimethyl ether has a lower melting point than dipropyl ether. Dimethyl ether is less viscous than dipropyl ether. Dimethyl ether is more flammable than dipropyl ether.

(d) Dipropyl ether can undergo substitution with chlorine. State the conditions needed and the chemical formula of the product formed.

condition(s) ultraviolet (uv) light

chemical formula





C3DC3Cl7

**16** The table shows some information about two homologous series; the alkanes and the acid chlorides.

alkanes	acid chlorides			
formula	name formula			
$C_2H_6$	ethanoyl chloride	CH₃COC <i>l</i>		
C <sub>3</sub> H <sub>8</sub>		$C_2H_5COCl$		
C <sub>4</sub> H <sub>10</sub>	butanoyl chloride	C₃H7COC <i>l</i>		
C <sub>5</sub> H <sub>12</sub>	pentandyl chloride	C₄H <sub>9</sub> COC <i>l</i>		

Use the information in the table to answer the following questions.

(a) Name the acid chloride with the highest boiling point.

#### pentanoyl chloride

(b) Deduce the name of the acid chloride with the formula  $C_2H_5COCl$ .

propanoyl chloride

(c) The general formula for alkanes is  $C_{x}H_{(2x+2)}$ . Deduce the general formula for acid chlorides.

CnH2n+1COCl

- (d) Both alkanes and acid chlorides can undergo combustion.
  - (i) Name the products of the complete combustion of an alkane.

carbon dioxide and water / water vapour



Would you expect the products of complete combustion of the acid chlorides to be the same in (d)(i). Explain your reasoning.

<u>The products would be different. There is presence of a chlorine</u> atom in acid chlorides, which may yield hydrogen chloride gas as <u>a side product upon combustion.</u> **17** The table shows some information about an homologous series of carbon compounds called ethers.

name	number of carbon atoms	formula	boiling point / °C
methoxymethane	2	CH <sub>3</sub> OCH <sub>3</sub>	-24.8
methoxyethane	3	CH <sub>3</sub> OC <sub>2</sub> H <sub>5</sub>	7.0
methoxypropane	4	CH <sub>3</sub> OC <sub>3</sub> H <sub>7</sub>	
	5		70.3

(a) Deduce the name and formula of the ether that contains 5 carbon atoms.

name	methoxybutane	formula	<b>CH<sub>3</sub>OC</b>	4 <b>H</b> 9

(b) (i) Suggest a value for the boiling point of methoxypropane.

<u>39 °C</u>

(ii) Explain why the boiling points of this homologous series increase down the series.

The molecular size of ethers increases down the homologous series. Hence, the intermolecular forces of attraction between the molecules are stronger. As such, a larger amount of energy is required to overcome the forces of attraction, resulting in a higher boiling point down the homologous series.

(c) Put a tick ( $\checkmark$ ) in each of the correct boxes to show which of the following statements about ethers are true, and which are false.

	true	false
general formula for an ether is $C_nH_{(2n+2)}O$	$\checkmark$	
ethers are hydrocarbons		✓
ethers are all liquids at room temperature and pressure		✓
ethers are saturated compounds	$\checkmark$	

(d) One of the first anaesthetics used to stop pain during surgical operations was ethoxyethane,  $C_2H_5OC_2H_5$ . It is explosively flammable and so was very hazardous for doctors to use.

Write an equation for the complete combustion of ethoxyethane.

 $\underline{C_2H_5OC_2H_5+6O_2} \rightarrow \underline{4CO_2+5H_2O}$