Bonding workshop

Covalent bonding and hydrocarbons

Download the teacher notes, student workbook and technician notes that accompany this resource at rsc.li/3ASiknU.

ROYAL SOCIETY OF CHEMISTRY

Learning objectives

By the end of this session, you will be able to:

- Explain how a covalent bond is formed between two atoms.
- Construct models for at least three hydrocarbons.
- Draw the displayed structures for three alkanes and three alkenes.
- Work out the structures for at least two additional functional groups and draw their displayed formulas.

Hydrocarbons

Hydrocarbons are compounds made up of only:

1	1.0079
H	
Hydrogen	

6	12.011
C	
Carbon	

Activity 1

Hydrocarbons

See student workbook

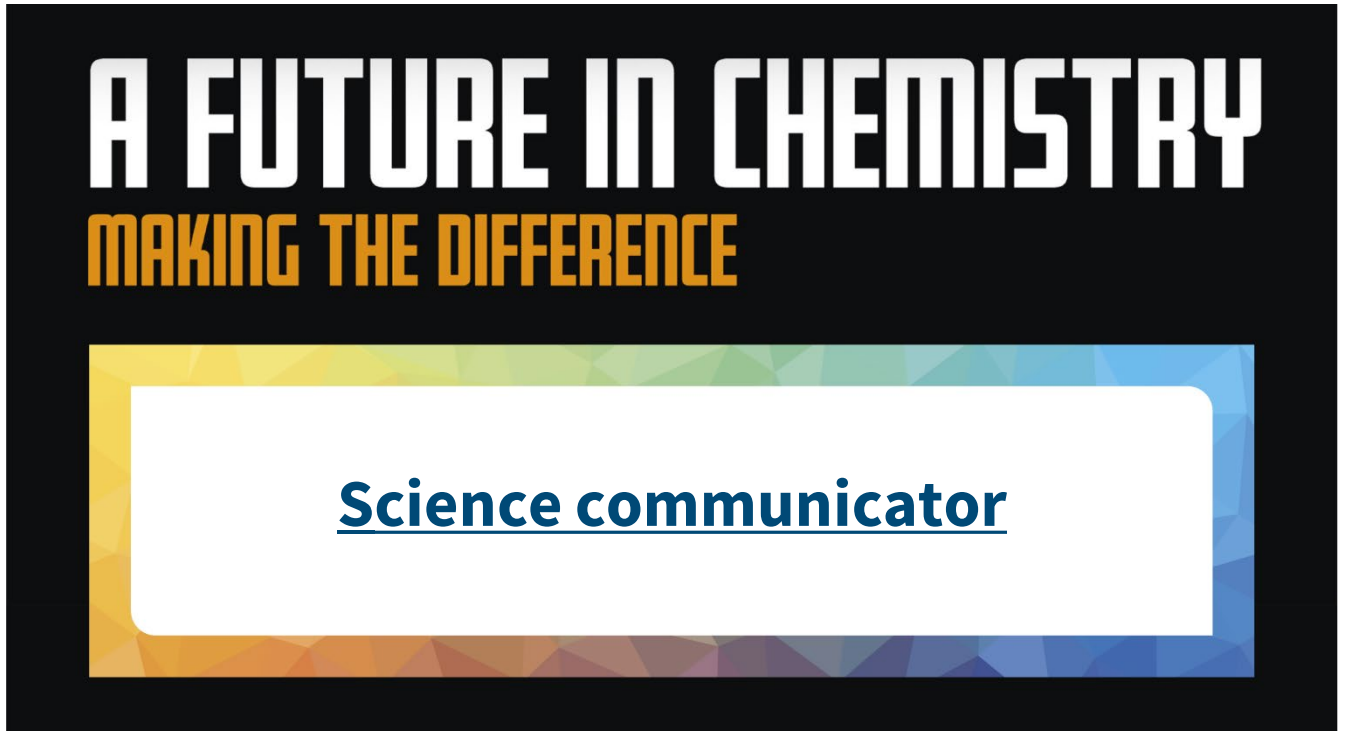
Answers

Elements	the simplest substances that cannot be broken down using chemical methods
Compound	a substance formed when two or more chemical elements are chemically bonded together
Hydrocarbon	a compound containing hydrogen and carbon atoms only
Saturated hydrocarbon	a hydrocarbon containing only single bonds between the carbon atoms
Unsaturated hydrocarbon	a hydrocarbon containing one or more double or triple bonds between the carbon atoms

Career link

Science communicator

Meet Fernando, a science communicator, who uses his scientific knowledge to uncover and translate complicated science for the public.



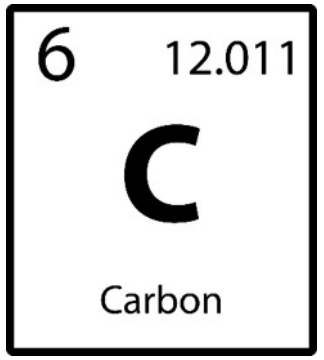
Activity 2

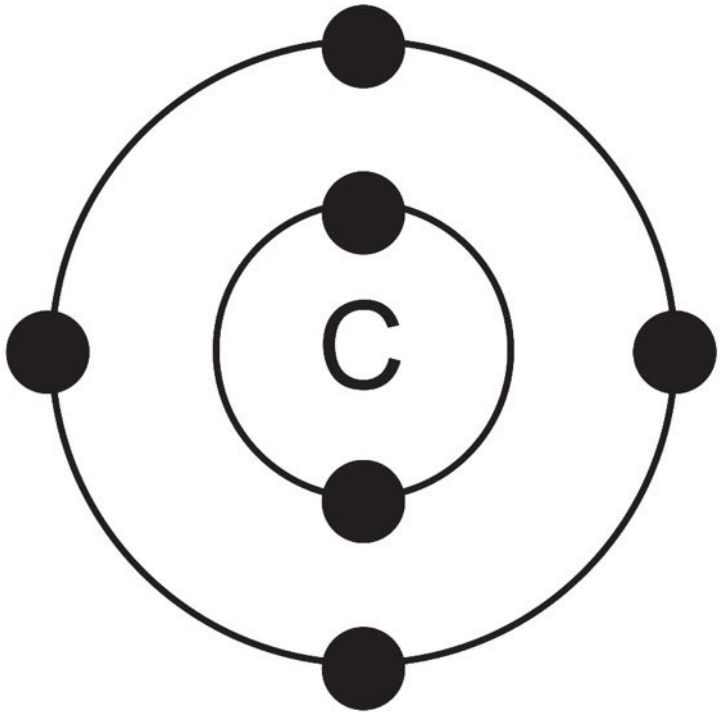
Structure of hydrocarbons

See student workbook

Structure of a carbon atom

1. (a)



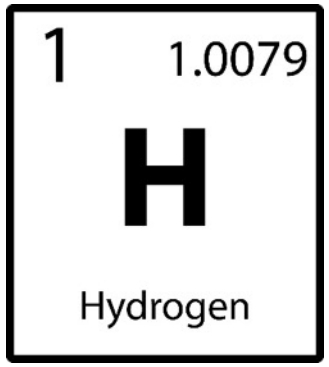


This means that carbon has

- 6 protons
- 6 neutrons
- 6 electrons

Structure of a hydrogen atom

1. (b)

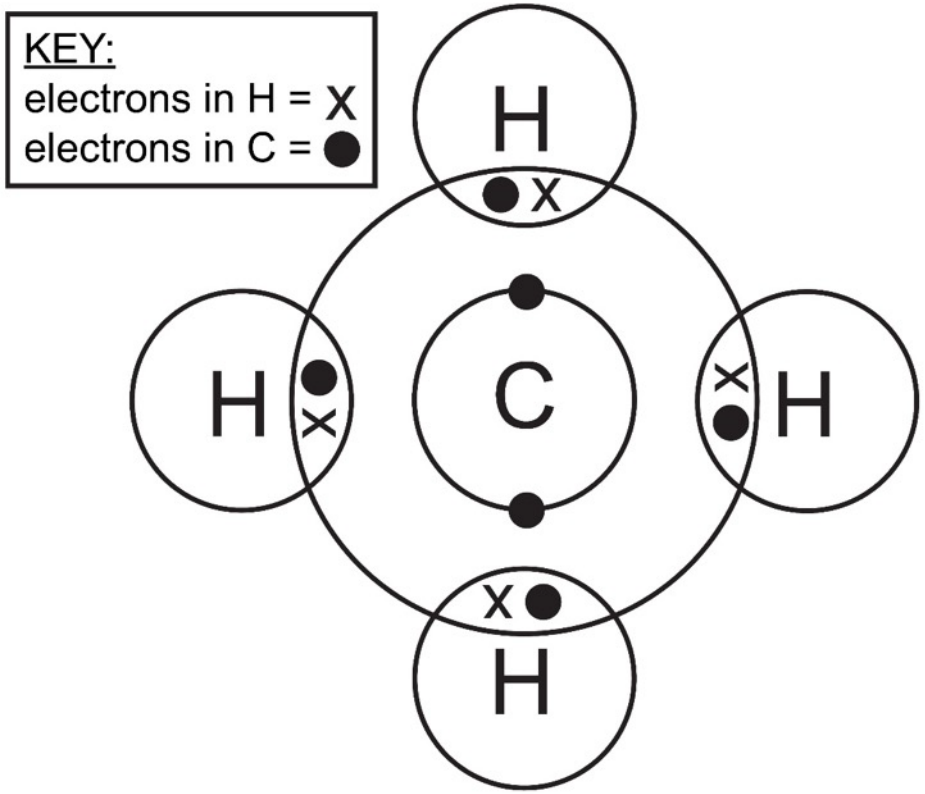


This means that hydrogen has

- 1 proton
- 0 neutrons
- 1 electron

Covalent bonding

2.



Activity 3

Simple molecules

See student workbook

Activity 3

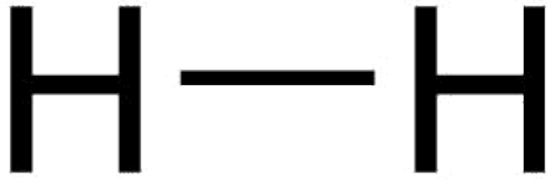
Simple molecules

Colour of ball	Atom name	Chemical symbol	Number of bonds
	hydrogen	H	1
	carbon	C	4
	oxygen	O	2
	nitrogen	N	3
	sulfur	S	2
	chlorine	Cl	1
	iodine	I	1
	aluminium	Al	4

Hydrogen: H_2

Model

Displayed formula



Chlorine: Cl_2

Model

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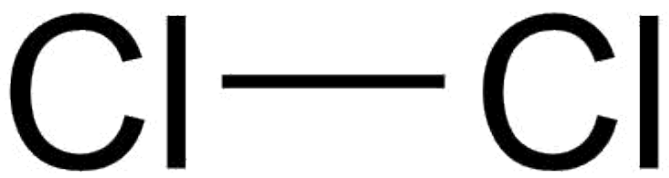

Hydrogen chloride: HCl

Model

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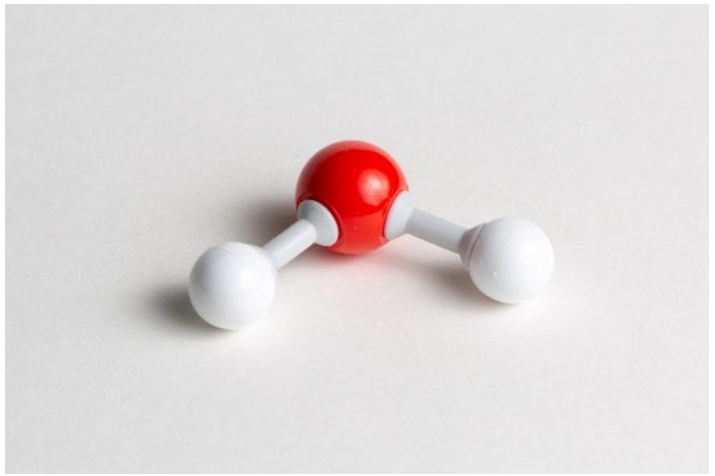
Water: H_2O

Model



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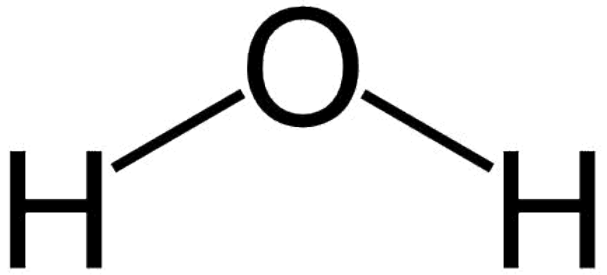
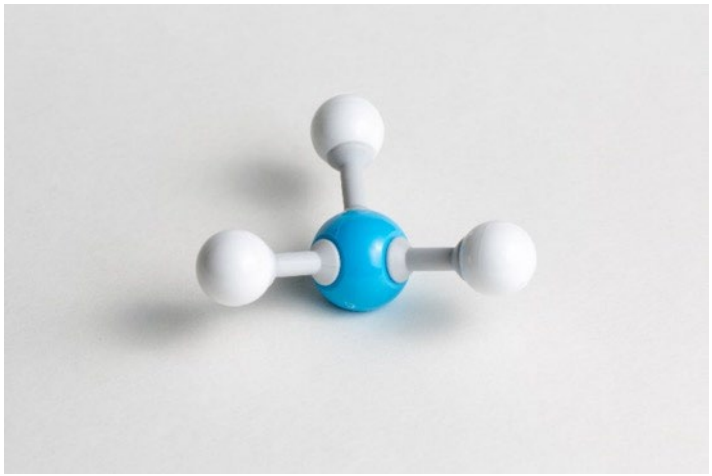


Activity 3

Ammonia: NH_3

Model



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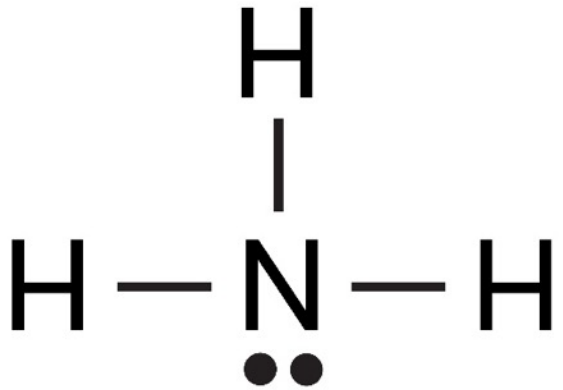
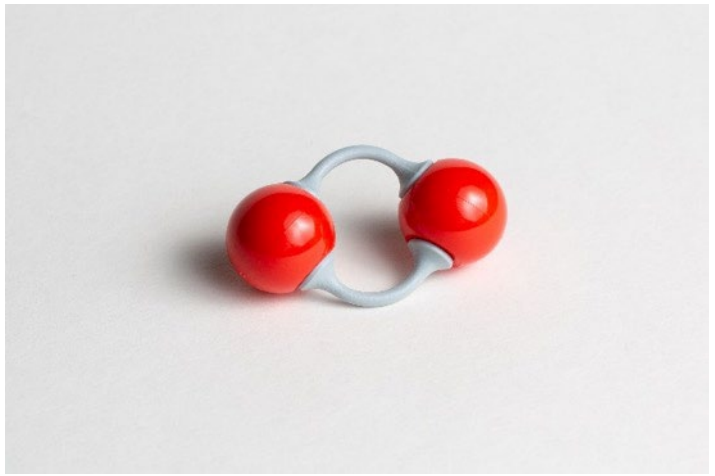


Oxygen: O_2

Model



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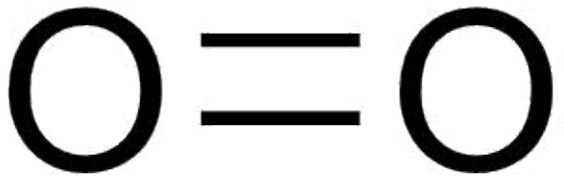
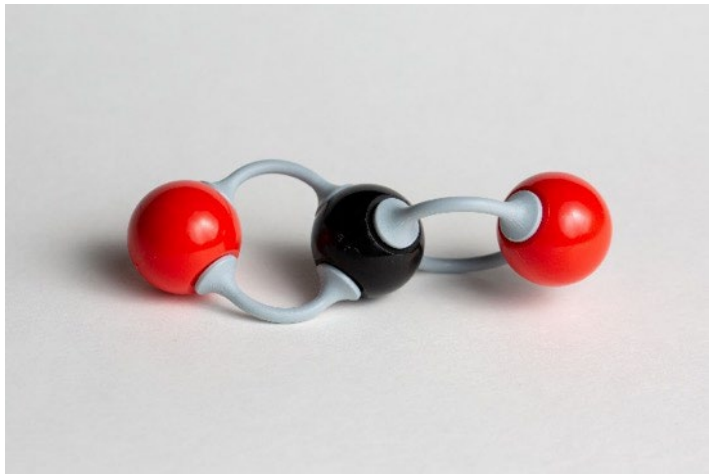


Carbon dioxide: CO_2

Model



Displayed formula

Activity 4

Alkanes

See student workbook

Career link

Alkanes

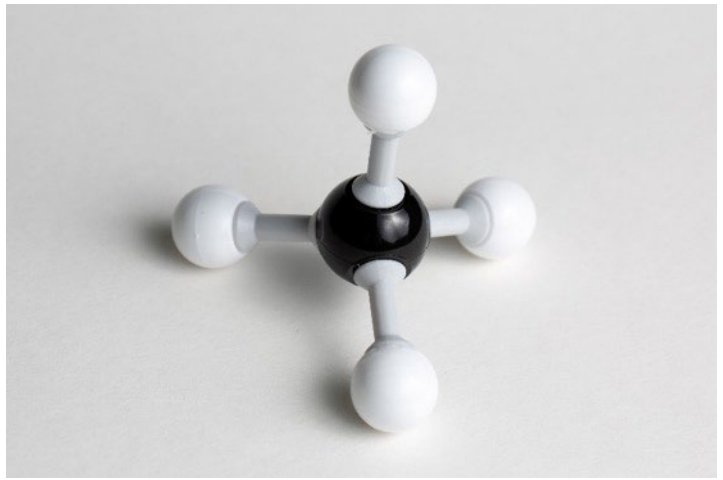
Alkanes are saturated hydrocarbons that are obtained from crude oil.

Meet Stuart, a project leader of enhanced experimentation in oil and gas at Shell, who uses robots, computer modelling and data to research and develop new ways to use crude oil and gas.

You are now going to build models of the first four alkanes and look for patterns in their formulas.

Methane: CH_4

Model



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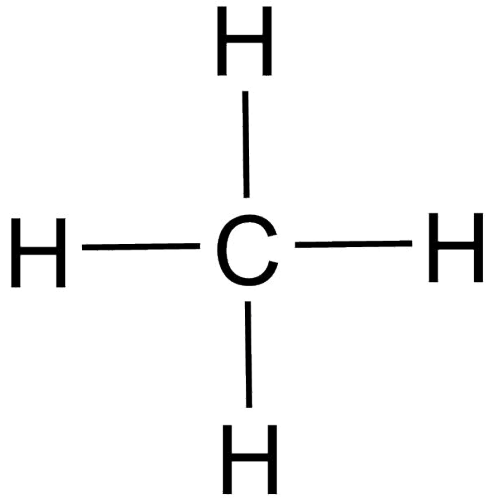
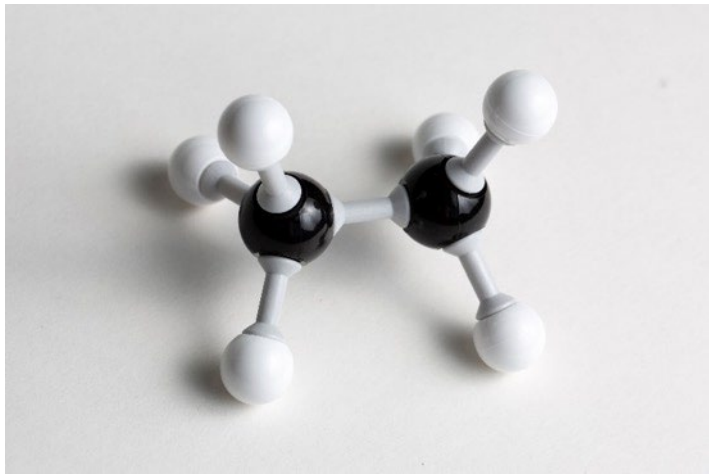


Ethane: C_2H_6

Model



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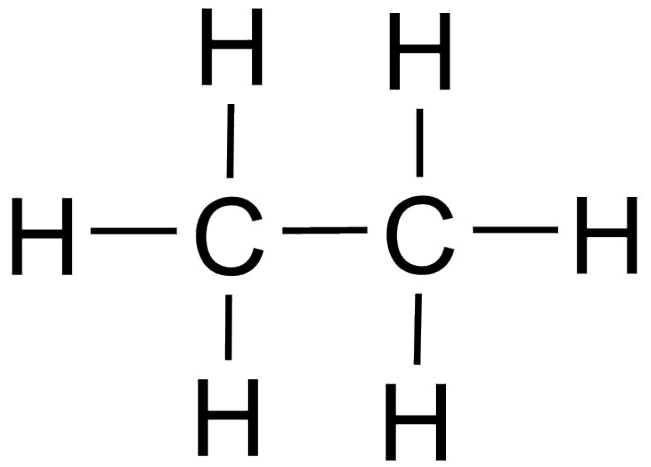
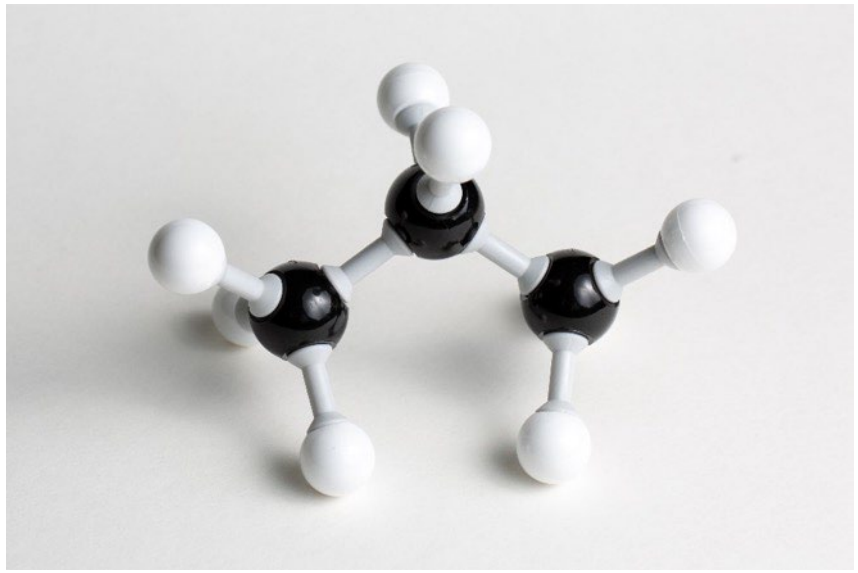


Propane: C_3H_8

Model



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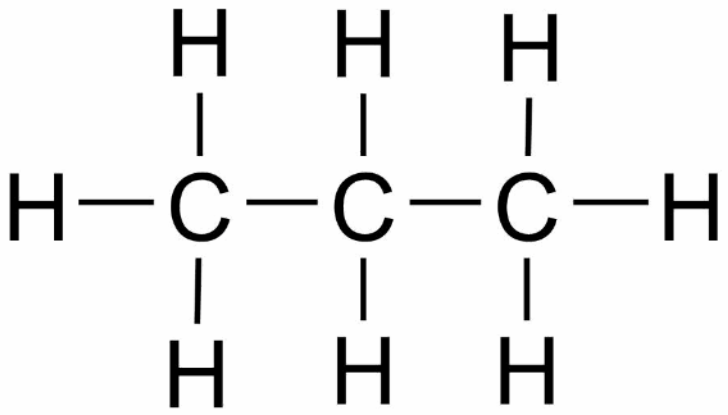
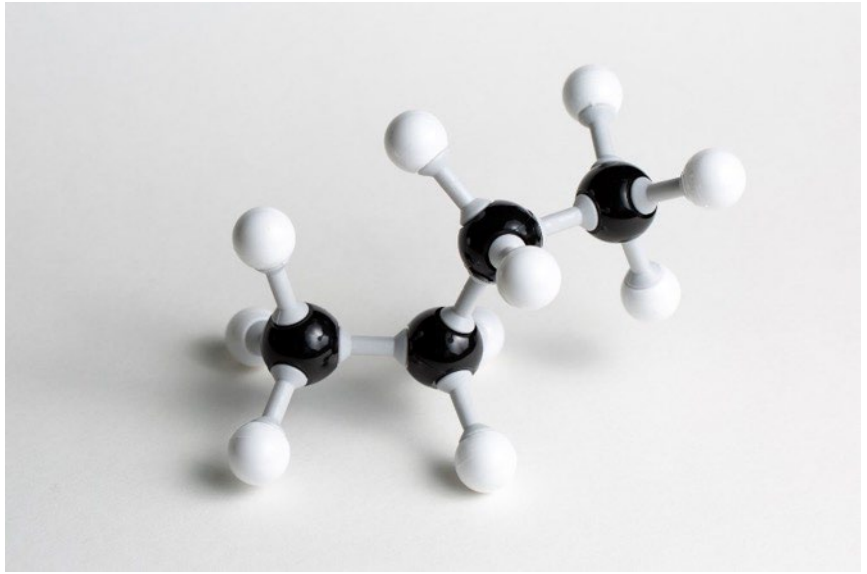


Butane: C_4H_{10}

Model



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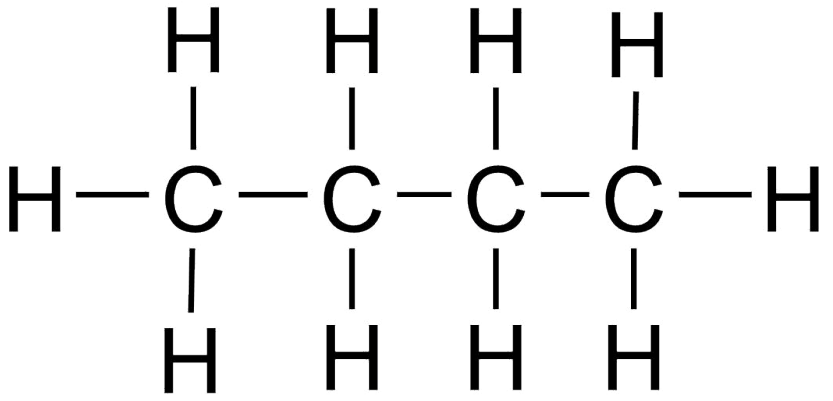


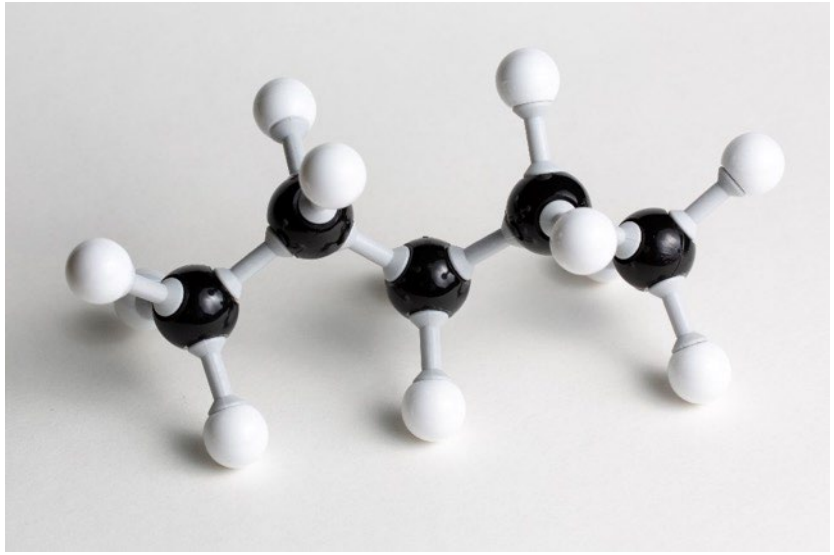
General formula for alkanes

2. The number of hydrogen atoms is determined by doubling the number of carbon atoms and adding two.

3. C_nH_{2n+2}

Pentane: C_5H_{12}

Model



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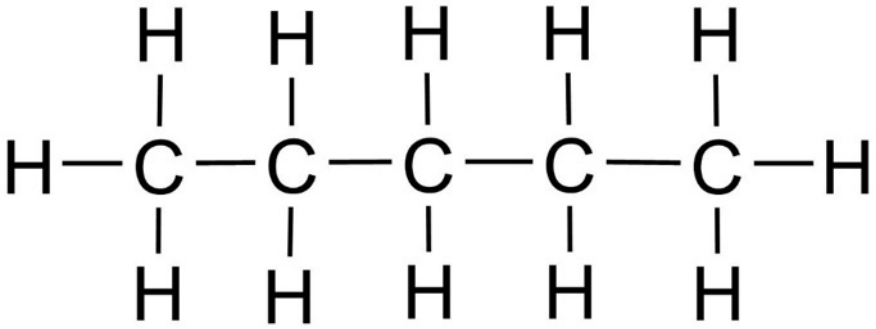
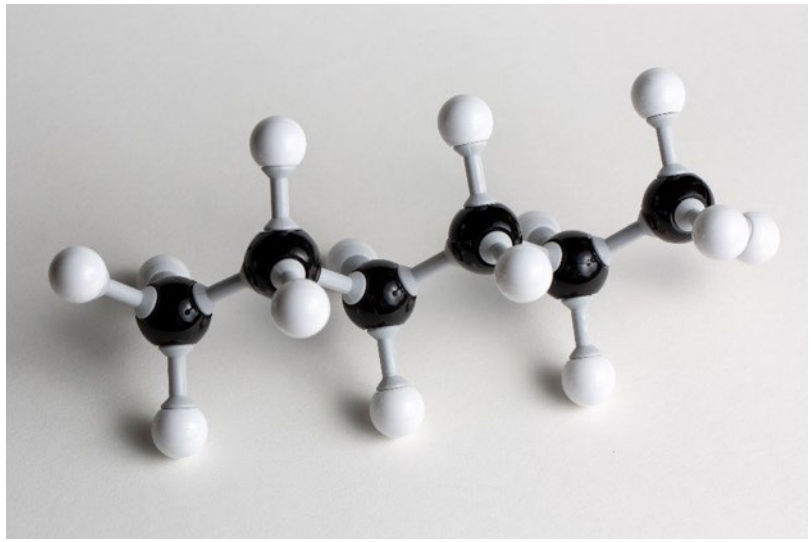


Hexane: C_6H_{14}

Model



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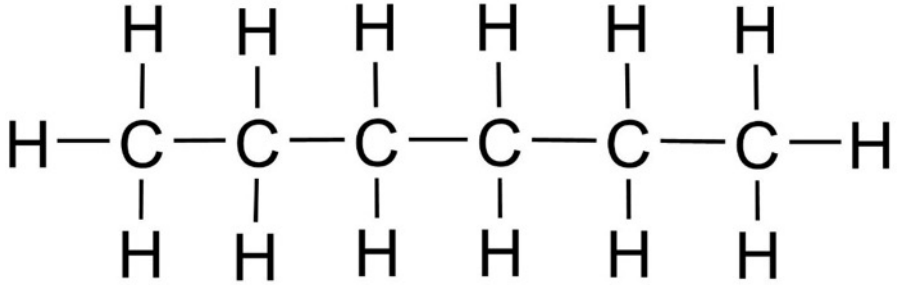
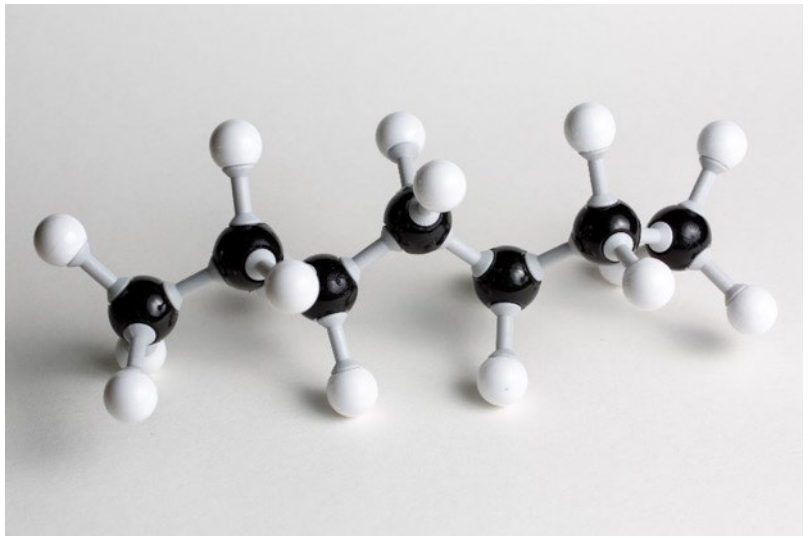


Heptane: C_7H_{16}

Model



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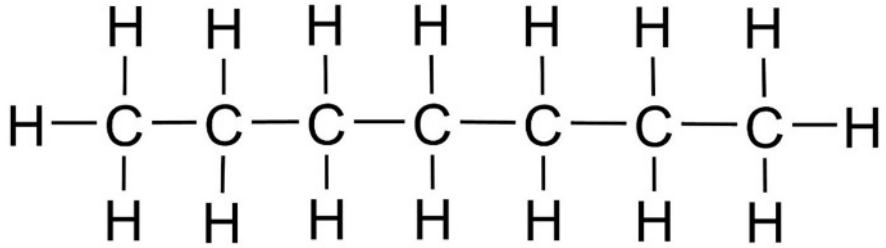
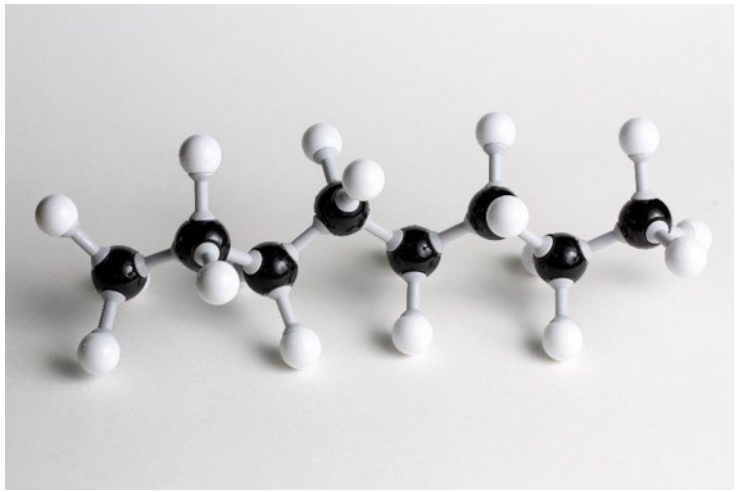


Octane: C_8H_{18}

Model



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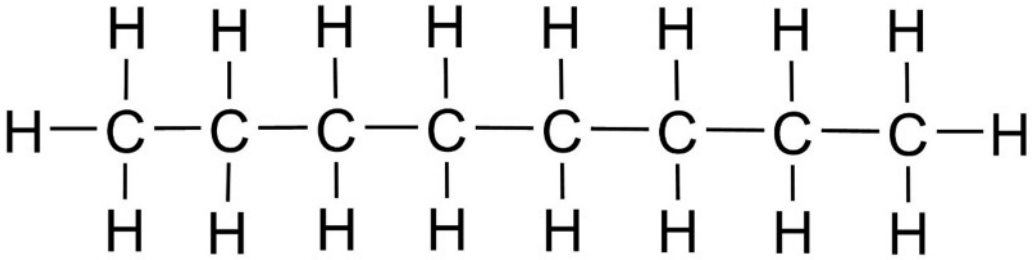


Challenge: intermolecular forces

Intermolecular forces are weak forces of attraction that act between molecules.

The strength of intermolecular forces is linked to the size of the molecules.

The larger the molecules are, the stronger the intermolecular forces between them. Therefore, more energy is needed to separate large molecules than smaller ones.

Challenge: answers

5. (a) Methane

(b) Any three from: pentane; hexane; heptane; octane; nonane; decane.

(c) As the molecular size increases, the melting point and boiling point increase.

(d) As the carbon chain gets longer, there are stronger intermolecular forces between the molecules. It takes more energy to overcome these forces, so the melting and boiling points increase.

Activity 5

Reactions of alkanes

See student workbook

Reactions of alkanes

Alkanes are commonly used as fuels as they readily undergo combustion reactions with oxygen to produce large amounts of energy.

There are two types of combustion reaction that may occur depending on the amount of oxygen present around the fuel.

Complete combustion occurs when there is a plentiful supply of oxygen:

alkane + oxygen → carbon dioxide + water

Incomplete combustion occurs when the supply of oxygen is limited:

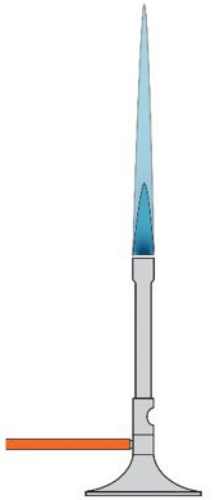
alkane + oxygen → carbon monoxide + carbon + water

Reactions of alkanes

In the **complete combustion** of methane:

methane + oxygen → carbon dioxide + water

$CH_4\,(g) + 2O_2\,(g) \rightarrow CO_2\,(g) + 2H_2O\,(g)$

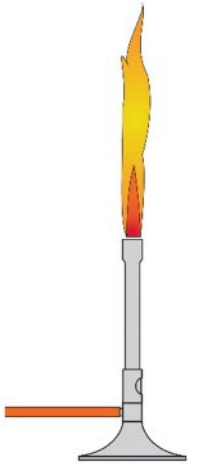


The Bunsen burner air hole is fully open and the flame is blue.

In the **incomplete combustion** of methane:

methane + oxygen → carbon monoxide + carbon + water

$3CH_4\,(g) + 4O_2\,(g) \rightarrow 2CO\,(g) + C\,(s) + 6H_2O\,(g)$



The Bunsen burner air hole is closed and the flame is yellow.

Demonstrations

1. Bunsen burner flame
2. Controlled explosion of methane
3. Methane bubbles

Activity 6

Alkenes

See student workbook

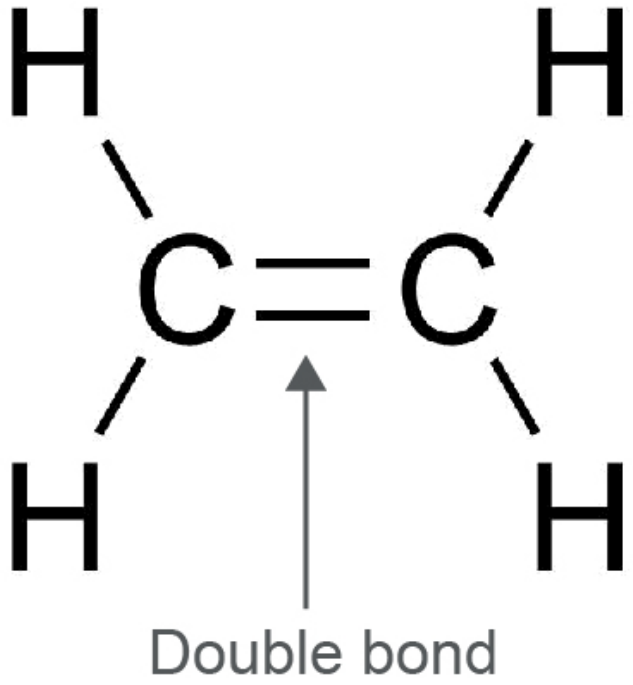
Alkenes

Alkenes are unsaturated hydrocarbons.

Alkenes are compounds that are made up of only hydrogen and carbon atoms and contain at least one double bond between two carbon atoms.

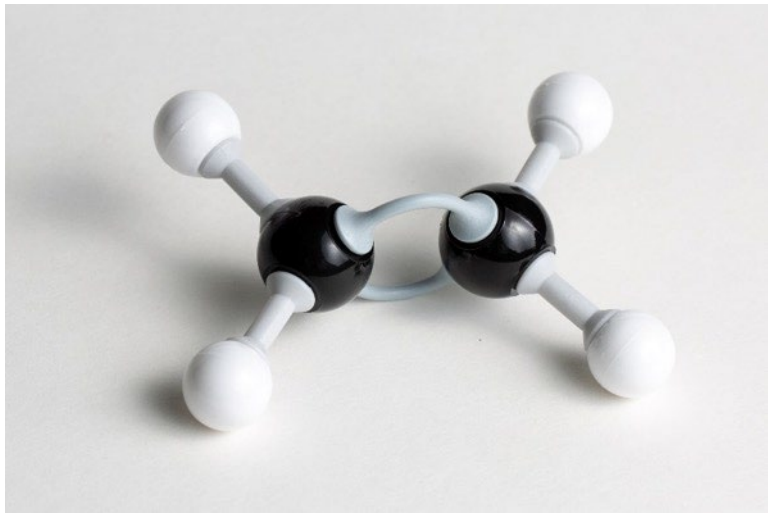
Double bond

1. (a)



Ethene C_2H_4

Model



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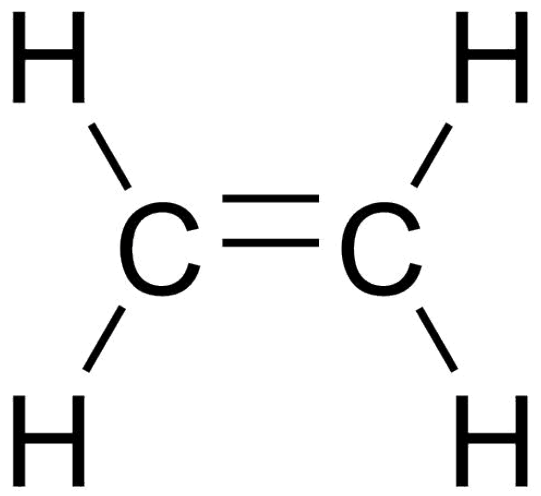
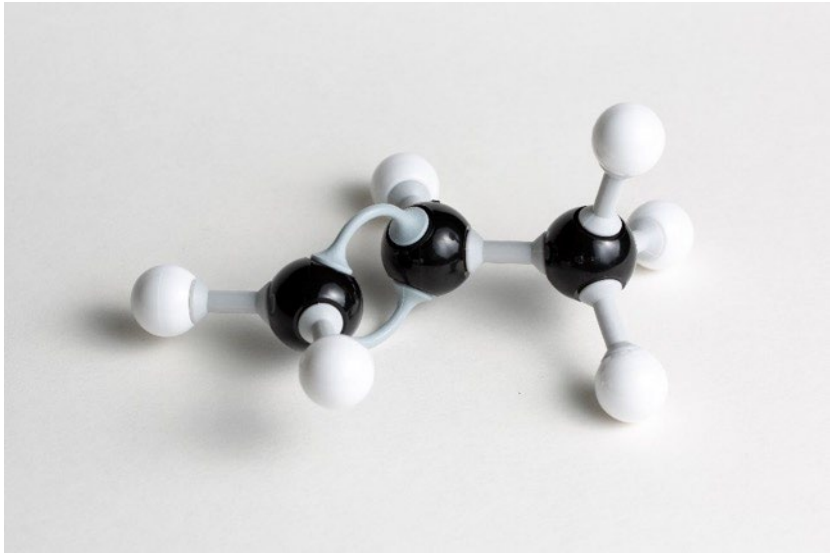


Propene: C_3H_6

Model



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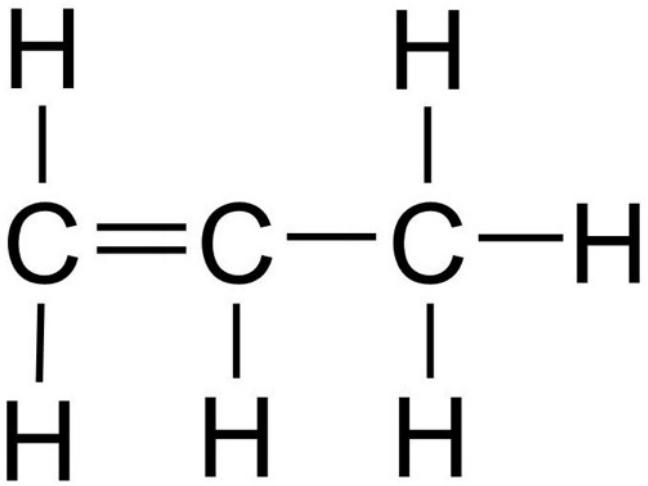
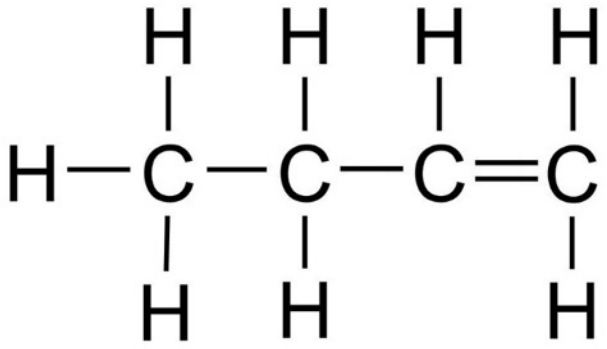
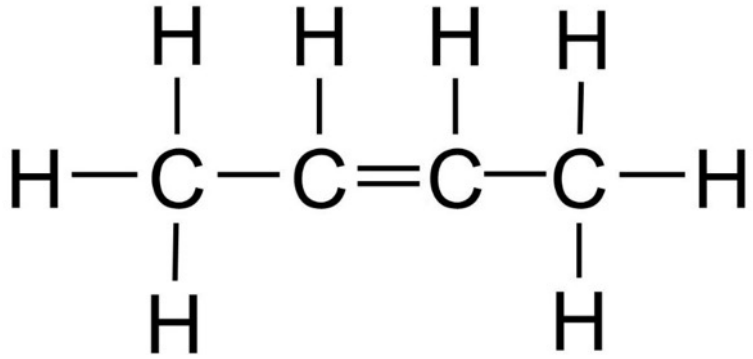


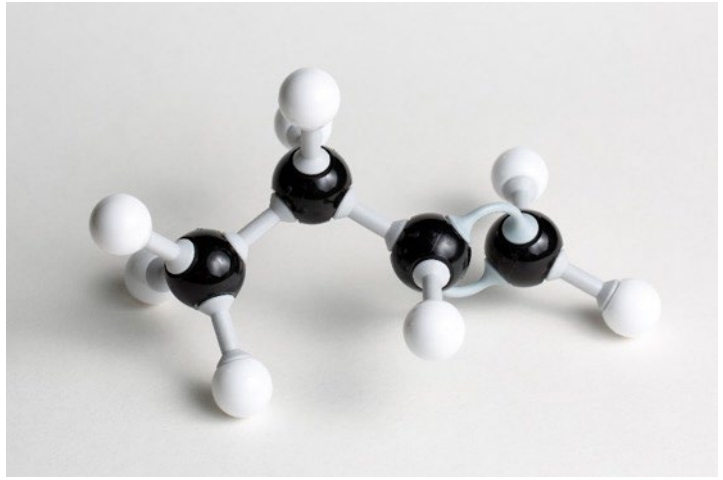
Butene: C_4H_8

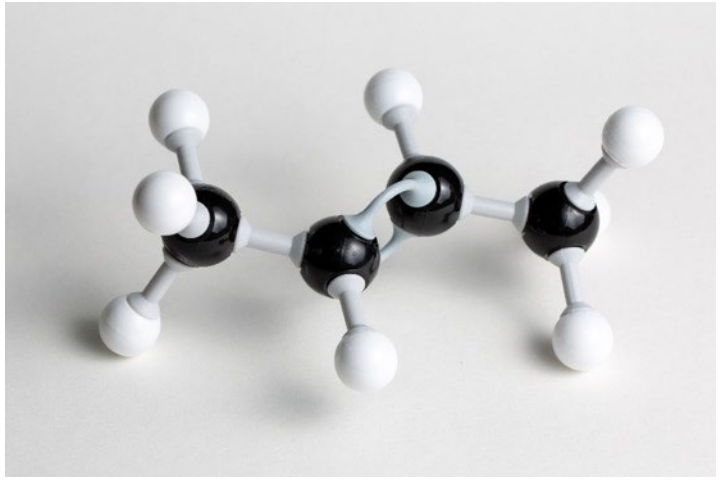
Displayed formulas





Models





Alkenes

2. Methene does not exist because alkenes have a double bond between two carbon atoms – methane would have only one carbon atom.

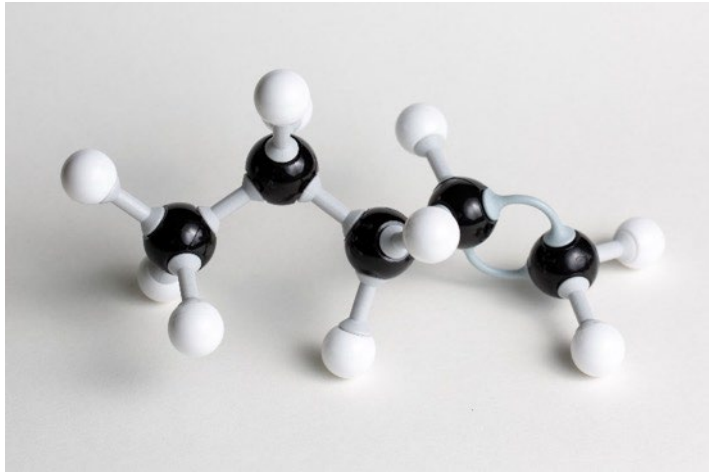
3. When one carbon atom is added to the chain, the number of hydrogen atoms increases by two. The number of hydrogen atoms is double the number of carbon atoms.

4. General formula of alkenes:

$$C_nH_{2n}$$

Pentene: C_5H_{10}

Model



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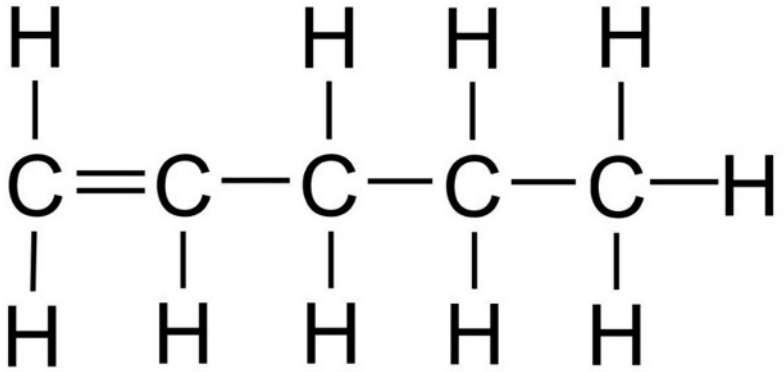
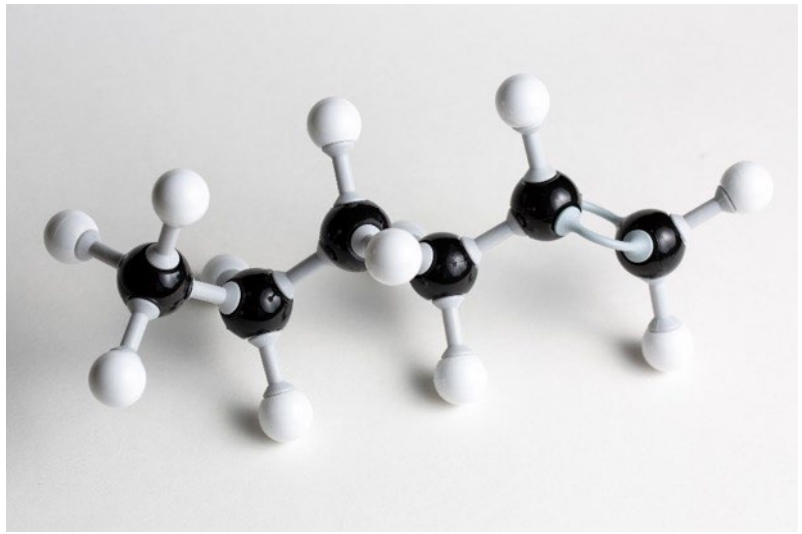


Hexene: C_6H_{12}

Model



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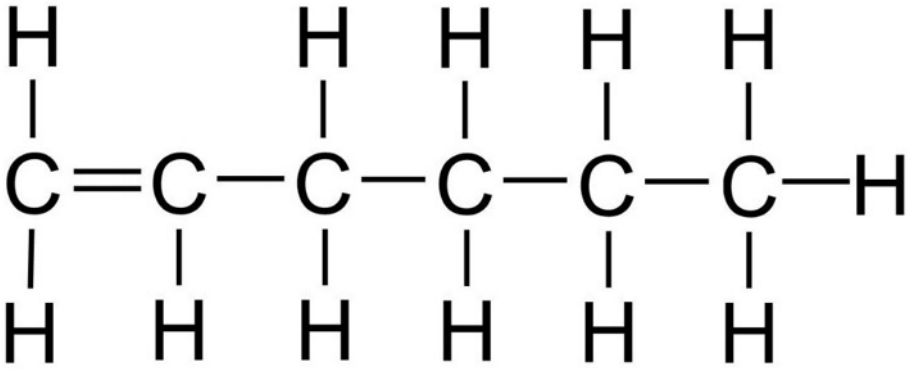
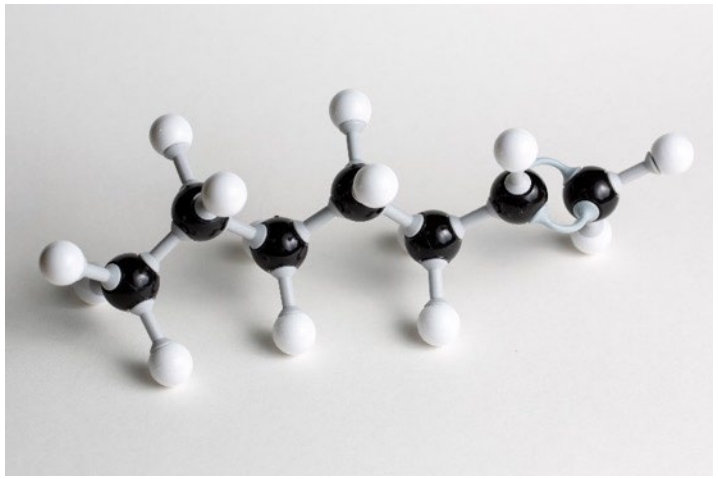


Heptene: C_7H_{14}

Model



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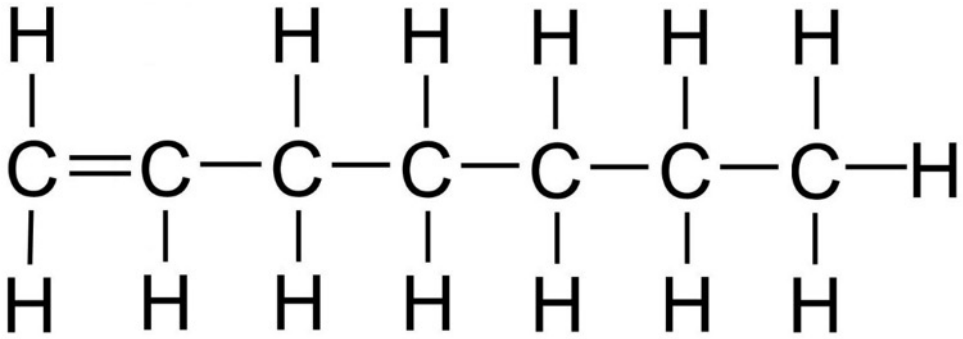
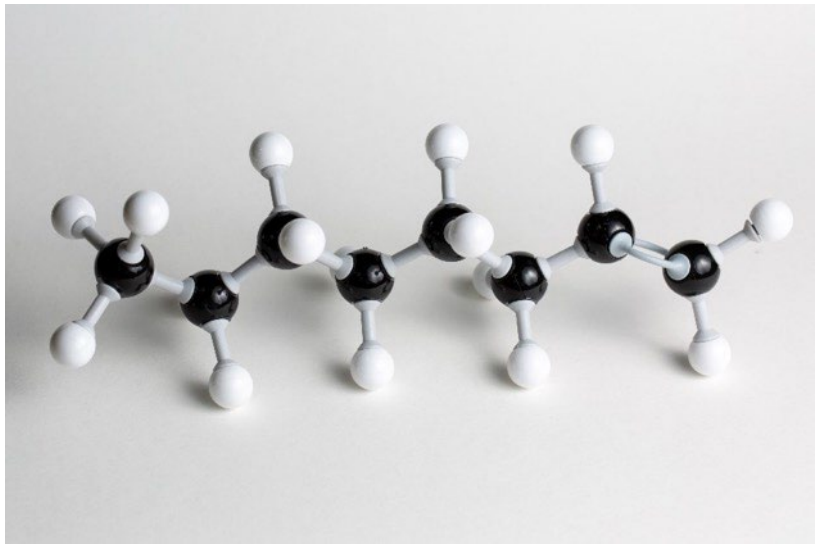


Octene: C_8H_{16}

Model



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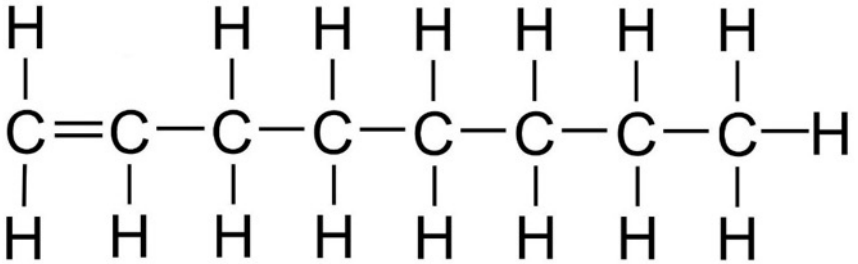


Career link

Alkenes

6. Yes, the position of the double bond does matter.

   This is because alkenes with four or more carbon atoms can have double bonds in various positions of the molecule (forming isomers). This affects the shape and often the properties of the molecule.

Meet Sandrine, a school science technician, who uses her knowledge and skills to design, prepare and test practical activities such as these demonstrations.

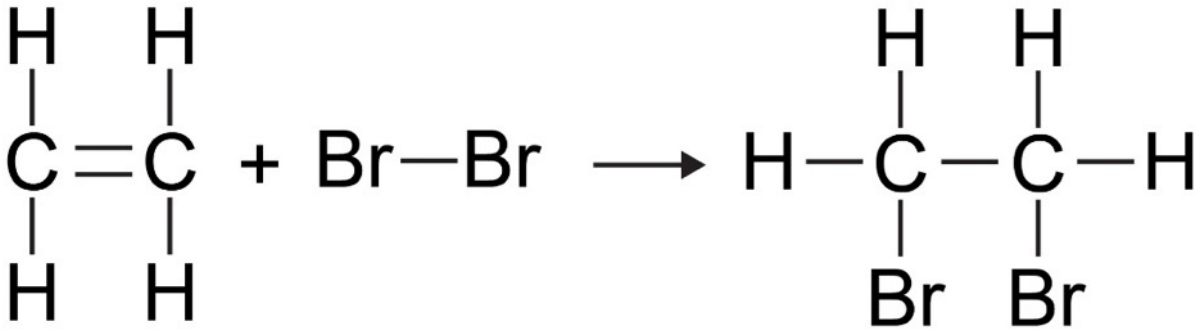
Activity 7

Reactions of alkenes

See student workbook

Reactions of alkenes

ethene + bromine ⟶ 1,2-dibromoethane



Reactions of alkenes

1. Bromine reacts with the carbon–carbon double bond, causing a colour change from orange to colourless. Alkanes do not contain this reactive bond so do not decolourise bromine water.

Alkane or Alkene	Appearance of bromine water (Br_2 (aq)) before adding the alkane/alkene	Appearance of bromine water (Br_2 (aq)) after adding the alkane/alkene
Hexane	orange	orange
Hexene	orange	colourless

Alkane Alkene

Activity 8

Functional groups

See student workbook

Career link

Functional group

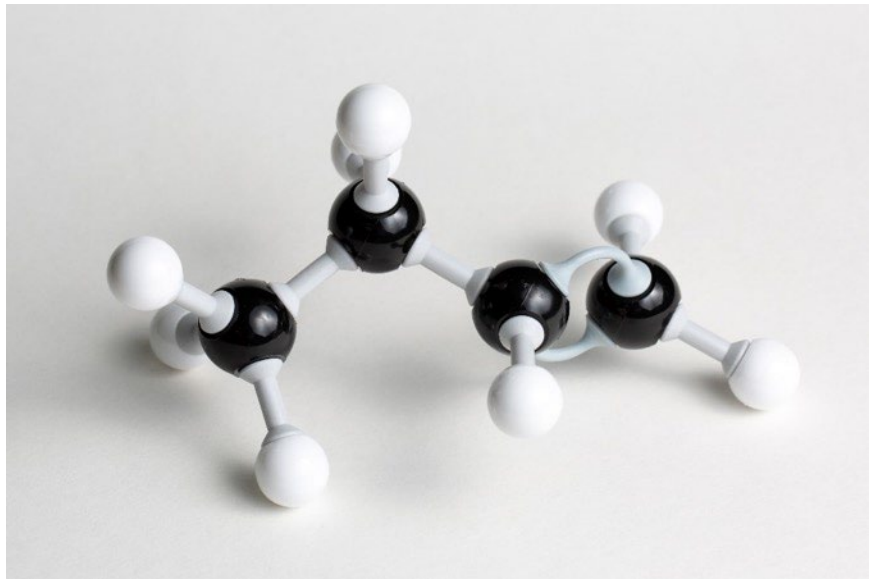
A **functional group** is an atom or a group of atoms that determines the chemical properties of the compound it is part of.

Compounds that contain the same functional group will share similarities in their chemical properties.

Meet Mike, a teaching technical specialist in the Department of Chemistry at Manchester University, who uses his knowledge of functional groups and chemical properties to support chemistry undergraduates and postgraduates. He makes sure they have all the equipment, materials and chemicals they need to conduct experiments and investigations in a safe manner.

Alkene: butene C_4H_8

Model



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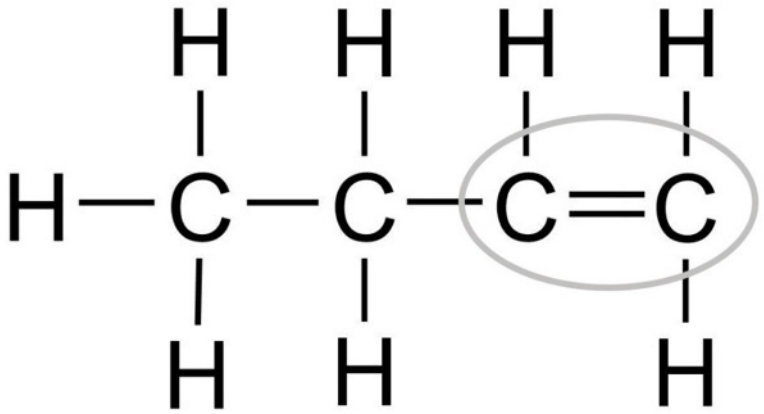
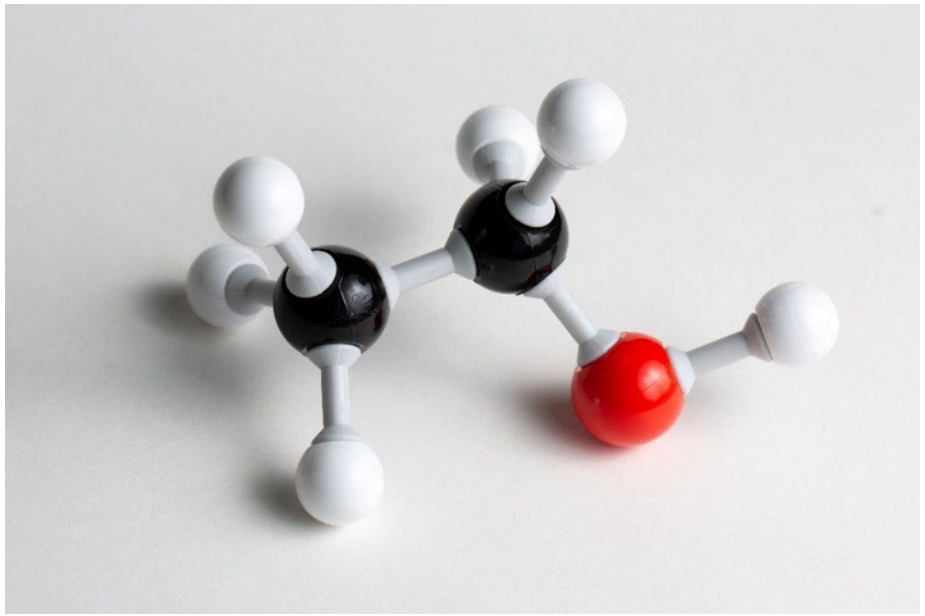


Alcohol: ethanol CH_3CH_2OH

Model



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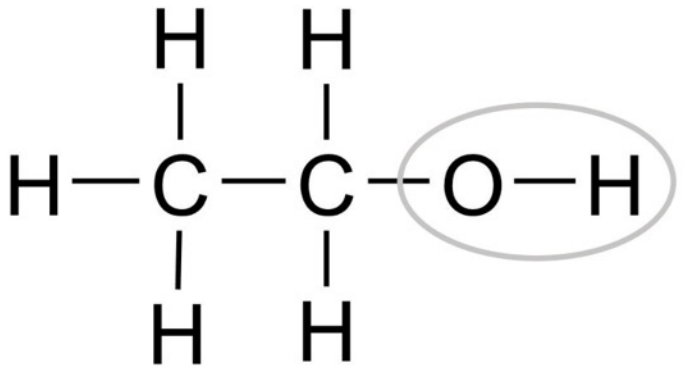
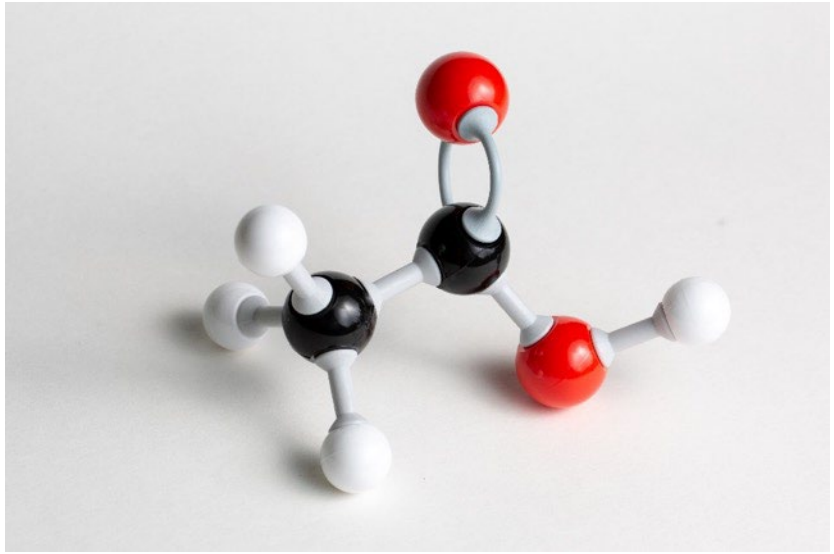


Carboxylic acid: ethanoic acid CH_3COOH

Model



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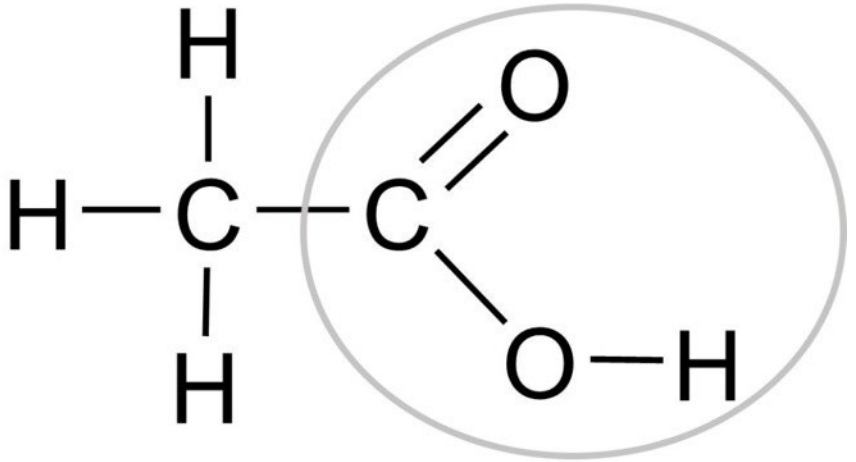
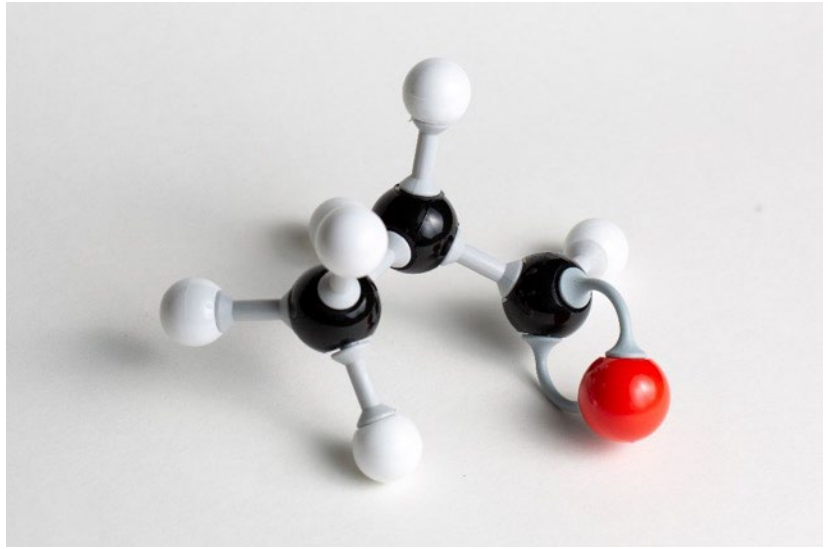


Aldehyde: propanal CH_3CH_2CHO

Model



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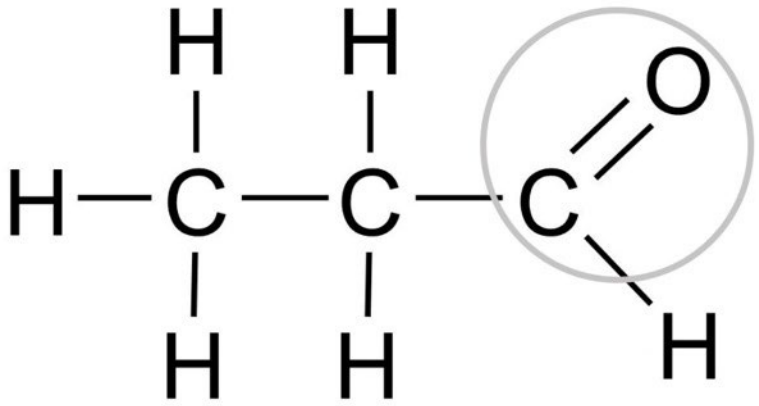
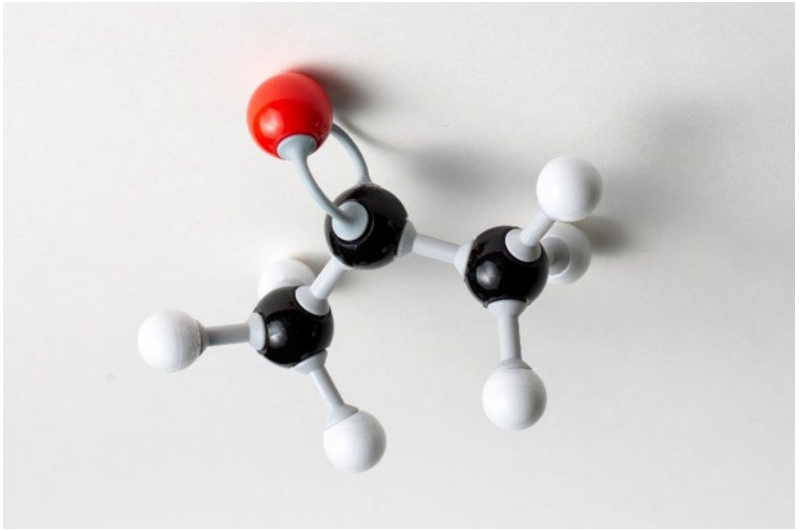


Ketone: propanone CH_3COCH_3

Model



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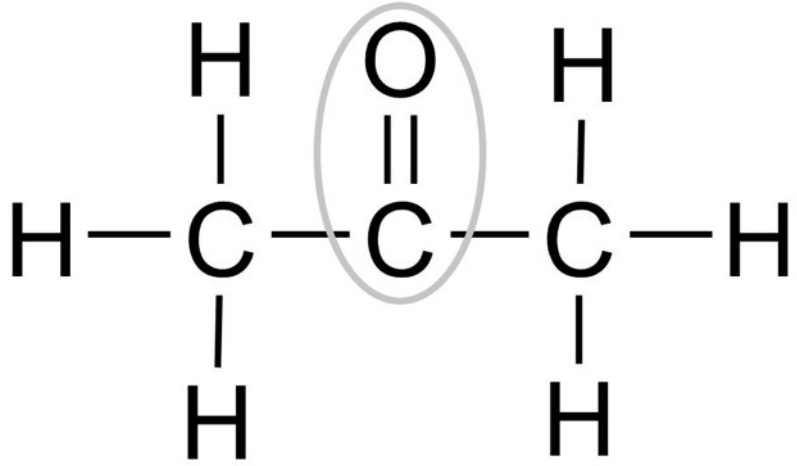


Quick quiz

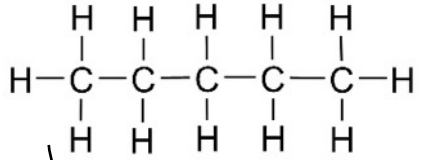
1. What happens in **covalent bonding?**

2. What's the name of this **hydrocarbon**?

C_5H_{12}

3. What's the difference between **alkanes** and **alkenes**?

4. Is this **displayed formula** correct?



Answers to the quick quiz

1. In covalent bonding two atoms share their outer shell electrons to achieve a full outer shell.

2. Pentane

3. Alkanes contain only single carbon to carbon bonds, whereas alkenes contain at least one double carbon to carbon bond.

4. Yes – that is the correct displayed formula of pentane.

Acknowledgements

This resource was originally developed by Liverpool John Moores University to support outreach work delivered as part of the Chemistry for All project.

To find out more about the project, and get more resources to help widen participation, visit our Outreach resources hub: rsc.li/3CJX7M3.