

Homologous series

Model Answers 1

Level	IGCSE
Subject	Chemistry (0620/0971)
Exam Board	Cambridge International Examinations (CIE)
Topic	Organic chemistry
Sub-Topic	Homologous series
Booklet	Model Answers 1

Time Allowed: 33 minutes

Score: /27

Percentage: /100

Grade Boundaries:

9	8	7	6	5	4	3	2	1
>85%	75%	68%	60%	53%	48%	40%	33%	<25%

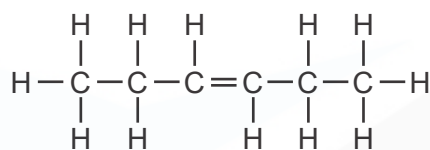
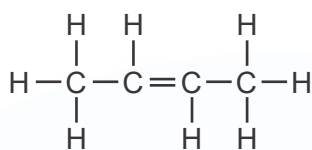
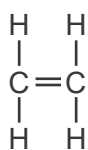
- 1 Butene and hexene belong to the same homologous series.

What is the same for butene and hexene?

- A boiling point
- B functional group**
- C number of hydrogen atoms per molecule
- D relative molecular mass

- ✓ A homologous series is a family of hydrocarbons with **similar** chemical properties that share the same general formula and which have the same **functional group**.
- ✓ Butene, C_4H_8 and hexene, C_6H_{12} , each have a carbon carbon double bond, which is the functional group of the **alkenes**.
- ✓ A, B and D are incorrect as these properties are different between members of a homologous series.

2 The structures of three compounds are shown.

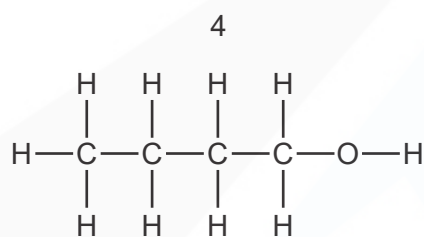
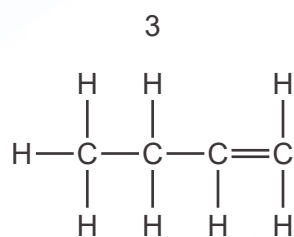
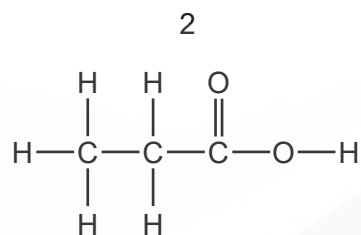
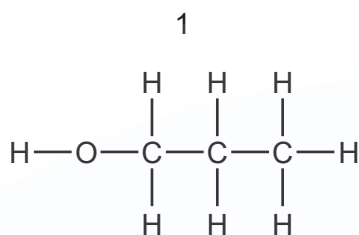


Why do these substances all belong to the same homologous series?

- A They all contain an even number of carbon atoms.
- B They all contain the same functional group.**
- C They are all hydrocarbons.
- D They are all saturated.

- ✓ A homologous series is a family of hydrocarbons with **similar** chemical properties that share the same general formula, and which have the same **functional group**.
- ✓ Ethene, C_2H_4 , butene, C_4H_8 and hexene, C_6H_{12} , each have a carbon carbon double bond, which is the **functional group** of the alkenes.
- ✓ Since each molecule contains this functional group, then they are part of the same homologous series, hence the correct answer is B.
- ✓ A is incorrect as each molecule contains a different number of carbon atoms.
- ✓ C is incorrect as even though they are all hydrocarbons, it is the carbon carbon double bond that provides the similarity in their chemistry.
- ✓ D is incorrect as all alkenes are unsaturated compounds.

3 Which structures show compounds that are members of the same homologous series?



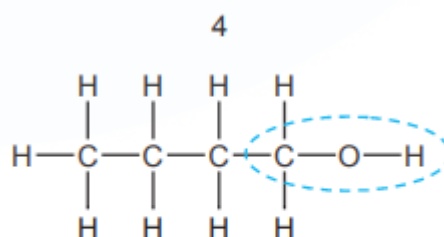
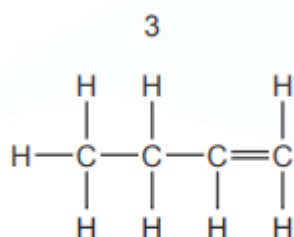
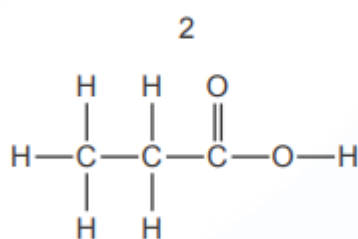
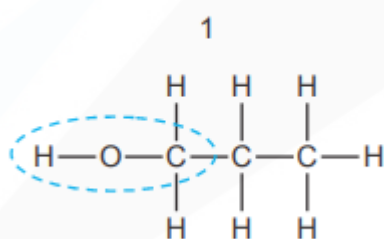
A 1 and 2

B 1 and 4

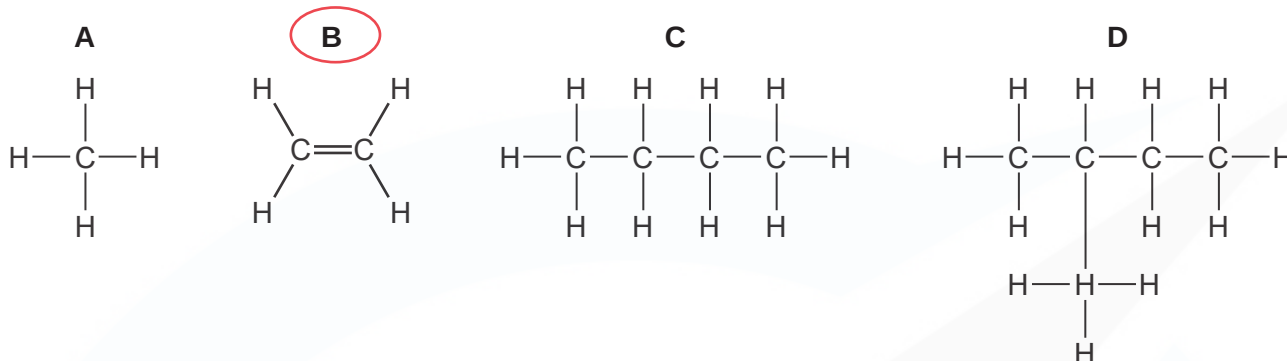
C 2 and 3

D 3 and 4

- ✓ Compounds 1 and 4 are **both alcohols** as they both contain the R-OH group, so B is the correct answer.
- ✓ Compound 2 is a **carboxylic acid** and compound is an **alkene** so disregard A, C and D.



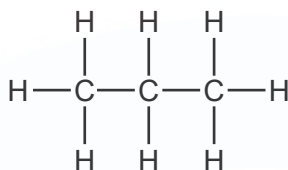
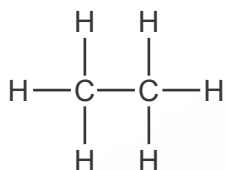
4 Which structure shows a compound that belongs to a **different** homologous series to propane?



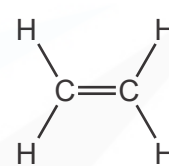
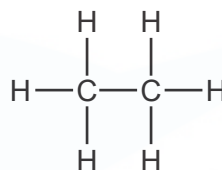
- ✓ A homologous series is a family of hydrocarbons with **similar** chemical properties that share the same general formula and which have the **same** functional group.
- ✓ Propane belongs to the family of hydrocarbons called **alkanes**.
- ✓ Alkanes are **saturated** hydrocarbons which means these compounds contain only **single** bonds between the **carbon** atoms in the chain and have the general formula C_nH_{2n+2} .
- ✓ Molecule A, C and D are **all alkanes** as they are all saturated hydrocarbons and contain carbon and hydrogen only.
- ✓ Molecule B is not in the same series as propane as it is an **alkene**.
- ✓ These are **unsaturated** compounds that contain a carbon carbon **double** bond.

5 Which pair of compounds are members of the same homologous series?

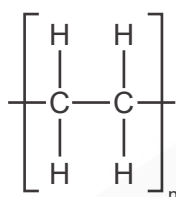
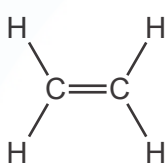
A



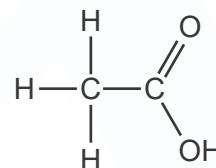
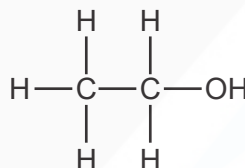
B



C



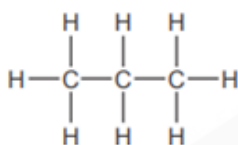
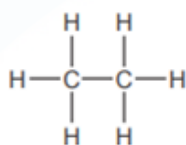
D



- ✓ In organic chemistry compounds are grouped into families of compounds called **homologous series**.
- ✓ The functional group is a group or structure on a compound which infers specific characteristics on the compound and which is **common** to all members of a homologous series.

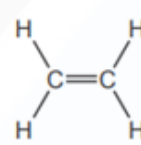
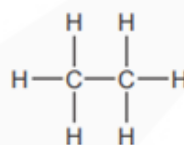
Both of these molecules are **alkanes** so they are members of the **same** homologous series.

A

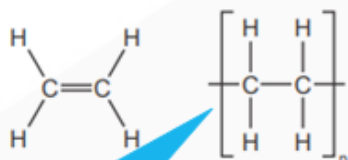


These are an **alkane** and an **alkene** so are not from the same series.

B

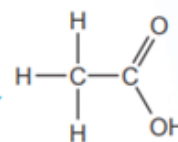
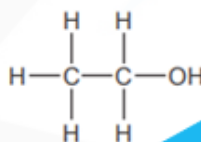


C



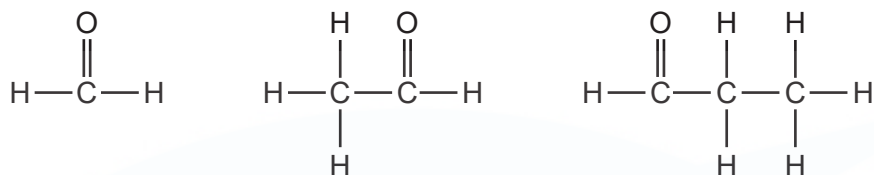
These are an **alkane monomer** and an **alkene** so are not from the same series.

D



These are an **alcohol** and a **carboxylic acid** so are not from the same series.

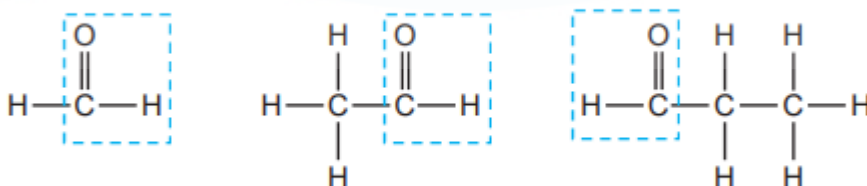
6 The diagram shows the structures of three compounds.



Why do these three compounds belong to the same homologous series?

- A They all contain carbon, hydrogen and oxygen.
- B They all contain the same functional group.**
- C They are all carbon based molecules.
- D They are all flammable liquids.

- ✓ A homologous series is a family of hydrocarbons with **similar** chemical properties that share the same general formula and which have the **same** functional group.
- ✓ Looking at the molecules in the question it's clear that each one has an oxygen atom and as highlighted below, each oxygen atom has formed a **double bond** with a carbon atom which then has a single bond to a hydrogen atom.
- ✓ This is a particular functional group called **aldehydes** (this is not on the syllabus but it is important that you recognize it as a functional group).
- ✓ Each molecule has the **same functional group** present, hence B is the correct answer.
- ✓ A is incorrect as even though each molecule does contain these C, H and O, the key point is the **bonding arrangement** which forms the functional groups.
- ✓ C is incorrect as all organic molecules are carbon based but it is the functional groups that decide to which homologous series a molecule belongs.
- ✓ D is incorrect as the physical properties are not used to categorise molecules into homologous groups.



7 A hydrocarbon X is cracked to make Y and hydrogen.

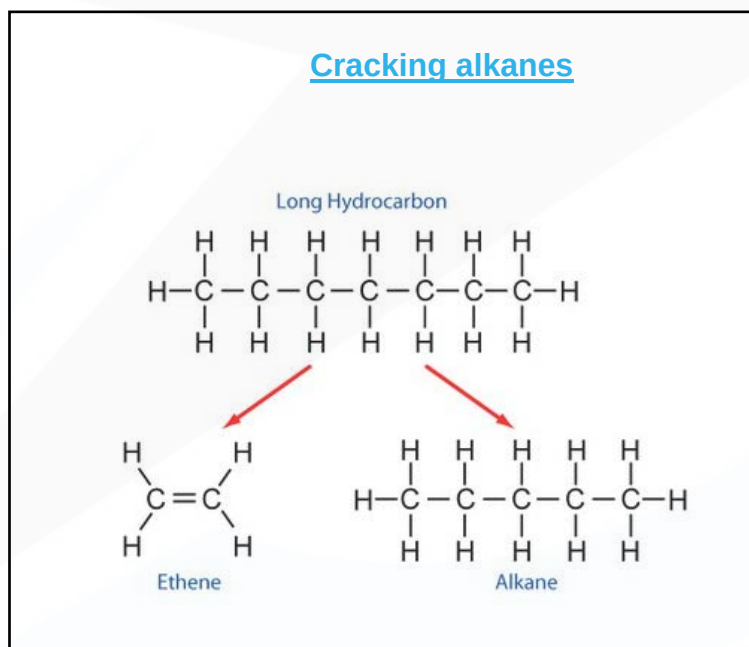
Compound Z is formed by the addition polymerisation of Y.

To which homologous series do X, Y and Z belong?

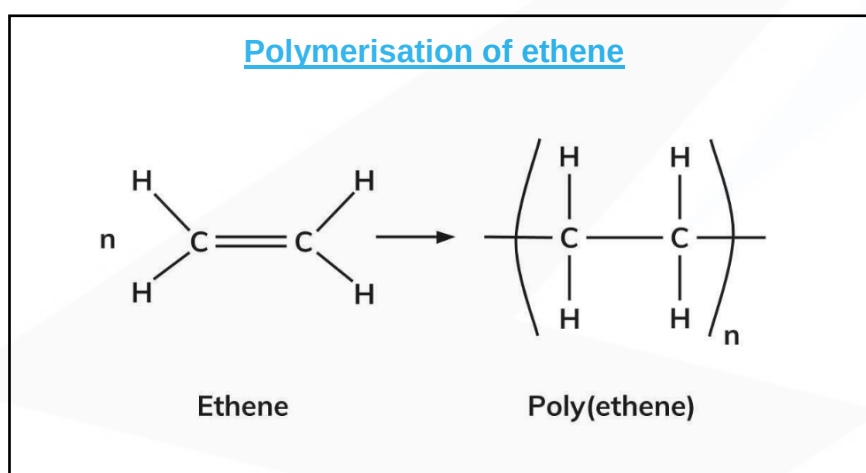
	alkane	alkene
A	X, Y and Z	–
B	X and Y	Z
C	X and Z	Y
D	Y and Z	X

✓ X is an alkane as **cracking** alkanes can produce either:

- A shorter **alkane** and a short chain **alkene**.
- 2 or more **alkenes** and **hydrogen**.



- ✓ Z is an alkane as it can be produced by the **addition polymerisation** of alkenes.
- ✓ In ethene for example, the carbon carbon double bond allows many ethene molecules to join together making a large molecule or **polymer** called **poly(ethene)** (polythene).



- ✓ Y must therefore be an alkene as it polymerises to form the alkane Z.
- ✓ X and Z are alkanes, Y is an alkene.
- ✓ A, B and D are therefore incorrect.

8 Which group of compounds is part of a homologous series?

- A CH_4 , C_2H_4 , C_3H_8
- B C_3H_6 , C_3H_8 , $\text{C}_3\text{H}_7\text{OH}$
- C CH_3OH , $\text{C}_2\text{H}_5\text{OH}$, $\text{C}_3\text{H}_7\text{OH}$**
- D $\text{CH}_3\text{CO}_2\text{H}$, $\text{CH}_3\text{CH}_2\text{OH}$, HCO_2H

- ✓ A is **incorrect** as this group of compounds contain **alkanes** and **alkenes**.
- ✓ B is **incorrect** as this group of compounds contain **alkenes**, **alkanes** and **alcohols**.
- ✓ C is **correct** as this group contains **alcohols only**.
- ✓ D is **incorrect** as this group contains **carboxylic acids** and **alcohols**.

Functional groups

Alcohol	Alkane	Alkene	Carboxylic acid
$\begin{array}{c} \text{R}-\text{O} \\ \\ \text{H} \end{array}$	$\begin{array}{c} \diagup \quad \diagdown \\ \text{C} - \text{C} \\ \diagdown \quad \diagup \end{array}$	$\begin{array}{c} \diagup \quad \diagdown \\ \text{C} = \text{C} \\ \diagdown \quad \diagup \end{array}$	$\begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{OH} \end{array}$

9 A hydrocarbon A is cracked to make B and hydrogen.

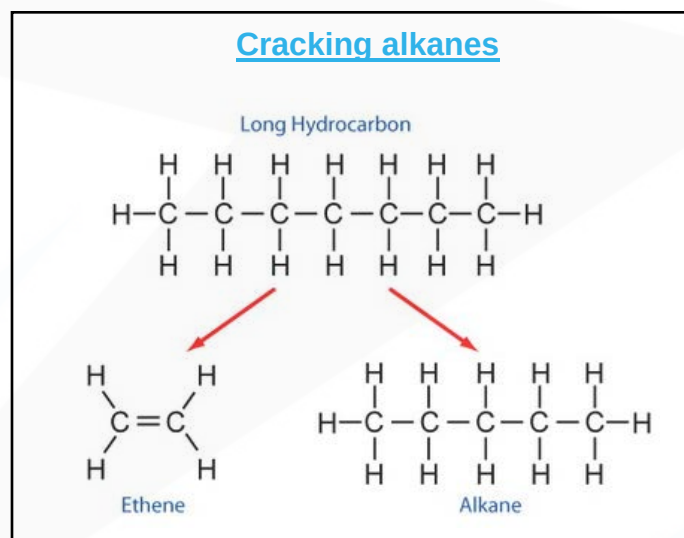
Compound C is formed by the addition polymerisation of B.

To which homologous series do A, B and C belong?

	alkene	alkane
A	A	B and C
B	B	A and C
C	C	A and B
D	–	A and C

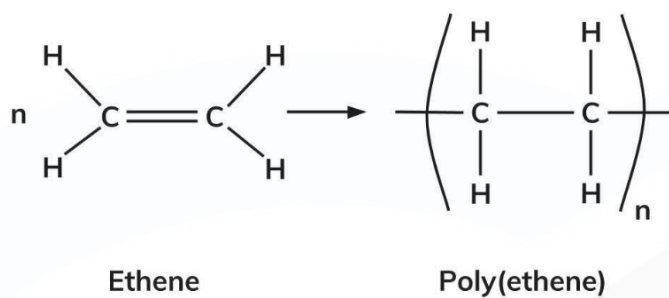
✓ A is an alkane as **cracking** alkanes can produce either:

- A shorter **alkane** and a short chain **alkene**.
- 2 or more **alkenes** and **hydrogen**.



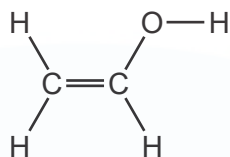
- ✓ C is an alkane as it can be produced by the **addition polymerisation** of alkenes.
- ✓ In ethene for example, the carbon carbon double bond allows many ethene molecules to join together making a large molecule or **polymer** called **poly(ethene)** (polythene).

Polymerisation of ethene



- ✓ B must therefore be an alkene as it polymerises to form the alkane C.
- ✓ A and C are alkanes, B is an alkene.
- ✓ A, C and D are therefore incorrect.

10 PVA is a polymer. The monomer has the structure shown.

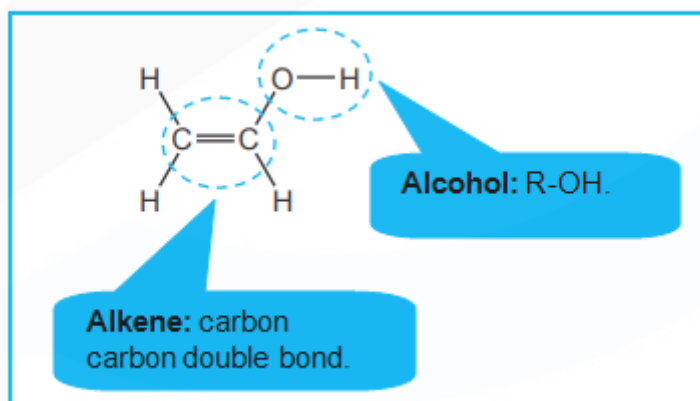


To which homologous series does this compound belong?

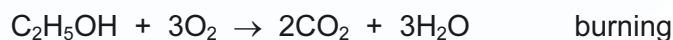
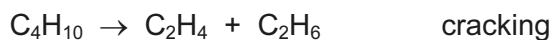
	alcohols	alkenes
A	✓	✓
B	✓	✗
C	✗	✓
D	✗	✗

- ✓ PVA contains both the **alcohol** and **alkene** functional groups and is thus a member of **both** homologous series.
- ✓ B, C and D are therefore incorrect.

Functional groups in PVA



11 Ethanol is a fuel used in cars. It can be made from petroleum.



Compounds of how many homologous series appear in these equations?

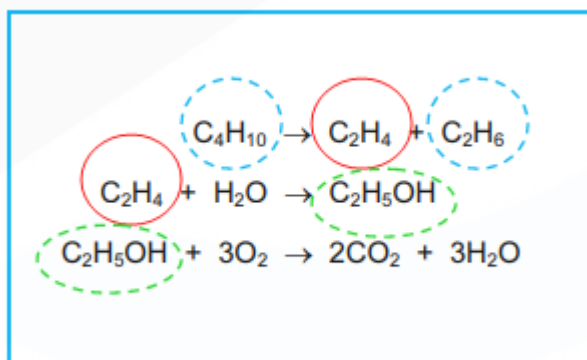
A 1

B 2

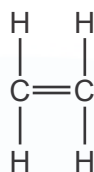
C 3

D 4

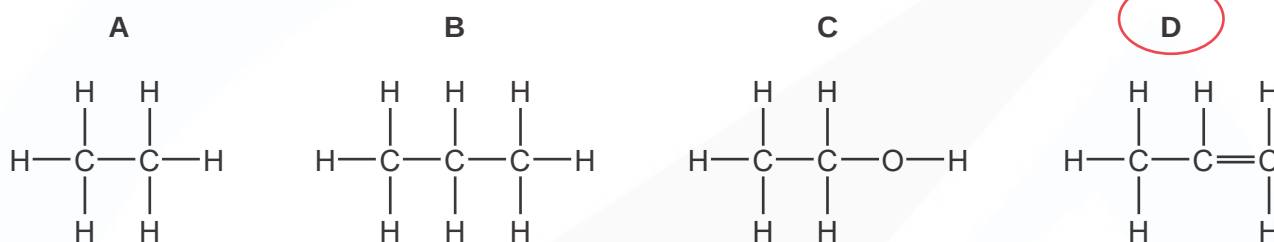
- ✓ There are **3** homologous series present in the compounds.
- ✓ These are:
 - Alkanes, which are shown on the diagram below in **dotted blue** circles.
 - Alkenes, which are shown in **solid red** circles.
 - Alcohols which are shown **dotted green** circles.
- ✓ A, B and D are incorrect as there are 3 functional groups present so therefore 3 homologous series.
- ✓ Remember: a homologous series is a family of organic compounds, based on carbon chains. Therefore, disregard H_2O , O_2 and CO_2



12 The diagram represents ethene.

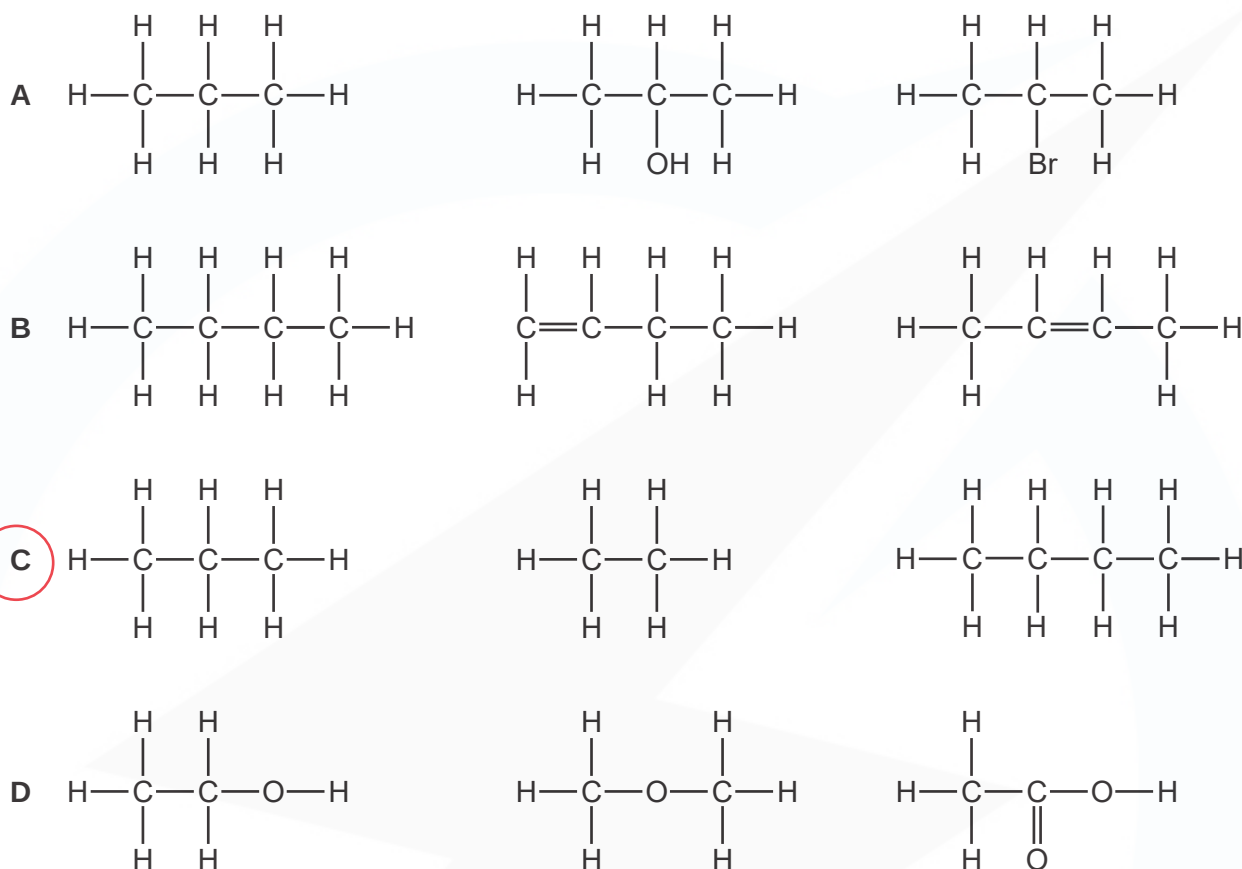


Which compound has chemical properties similar to those of ethene?



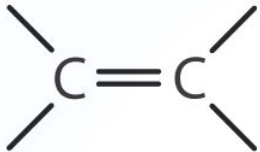
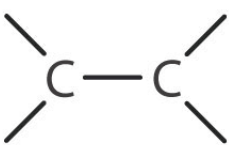
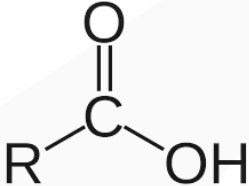
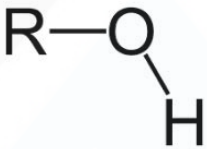
- ✓ In organic chemistry compounds are grouped into families of compounds called **homologous series**.
- ✓ The functional group is a group or structure on a compound which infers specific characteristics on the compound and which is **common** to all members of a homologous series.
- ✓ The functional group in ethene is the carbon carbon double bond which is the **alkene** family.
- ✓ The only compound of the options to have the **same** functional group is D, propene, which would have chemical properties to ethene.
- ✓ A and B are incorrect as these compounds are **alkanes**.
- ✓ C is incorrect as it is an **alcohol**.

13 Which row represents compounds in the same homologous series?

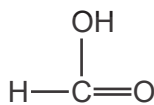


- ✓ In organic chemistry compounds are grouped into families of compounds called **homologous series**.
- ✓ The functional group is a group or structure on a compound which infers specific characteristics on the compound and which is **common** to all members of a homologous series.
- ✓ Row C is the only option which represents a homologous series, the alkanes.
- ✓ A is incorrect as it contains an **alkane**, an **alcohol** and a **haloalkane** (hydrocarbon molecule with a halogen atom attached).
- ✓ B is incorrect as it contains an **alkane** and 2 **alkenes**.
- ✓ D is incorrect as it contains an **alcohol**, an **ether** and a **carboxylic acid**.

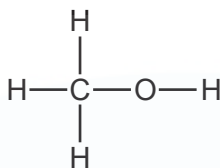
The functional groups of four common homologous series

Alkene	Alkane	Carboxylic acid	Alcohol
			

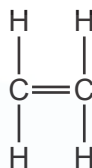
14 The structures of four molecules are shown.



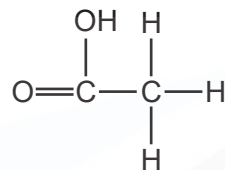
P



Q



R



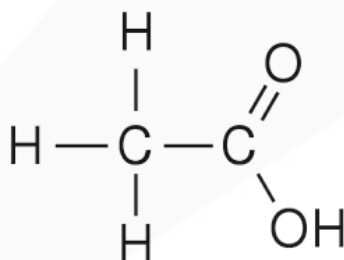
S

Which two molecules belong to the same homologous series?

- A** P and Q **B** P and S **C** Q and R **D** R and S

- ✓ Molecules P and S belong to the same homologous series called **carboxylic acids**.
- ✓ These molecules all contain the **carboxyl** functional group, -COOH.
- ✓ Q is an **alcohol** and R is an **alkene**.
- ✓ A, C and D are incorrect as only molecules P and S belong to the same homologous series.

Molecule S: acetic acid (vinegar)

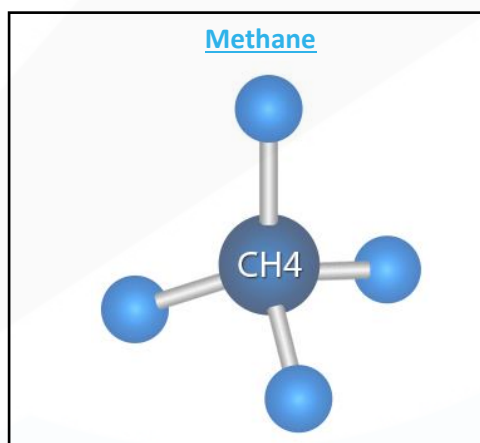


15 The main constituent of natural gas is hydrocarbon X.

To which homologous series does X belong and how many **atoms** are in one molecule of X?

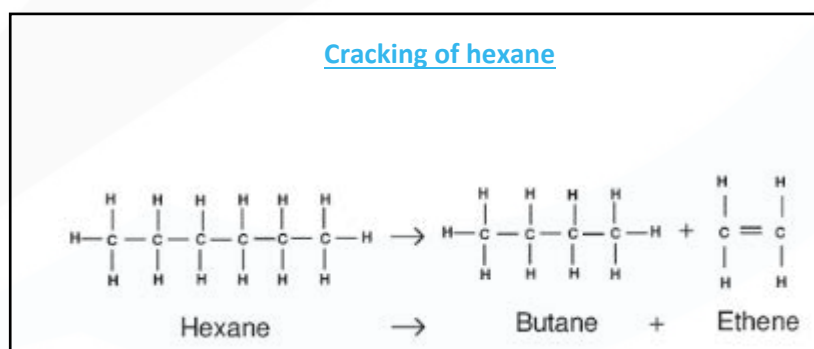
	homologous series	number of atoms in one molecule
A	alkane	1
B	alkane	5
C	alkene	1
D	alkene	5

- ✓ Natural gas is **methane**, CH₄.
- ✓ It is the first member of the **alkanes** and contains 1 carbon atoms bonded to 4 hydrogen atoms, making in total **5** atoms.
- ✓ A, C and D are incorrect as these options do **not** match the homologous series or number of atoms in methane.

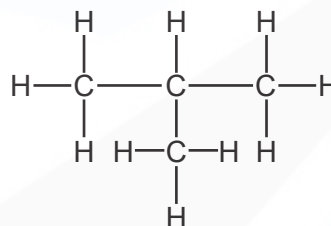
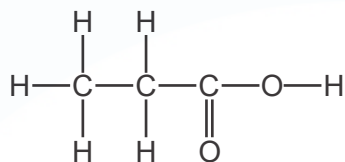
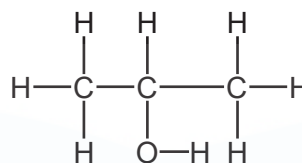
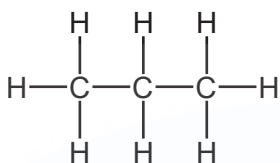


- 16 In which reaction could one of the products belong to the same homologous series as the organic reactant?
- A addition of steam to ethene
 - B combustion of an alkane
 - C cracking of an alkane**
 - D polymerisation of ethene

- ✓ **Cracking** alkanes can produce either:
 - A shorter **alkane** and a short chain **alkene**.
 - 2 or more **alkenes** and **hydrogen**.
- ✓ The **starting** molecule is an **alkane** and one of the products could also be an **alkane**.
- ✓ For the example given in the diagram below, **hexane** is the starting molecule and **butane** is one of the products.
- ✓ Hexane and butane are both saturated hydrocarbons and belong to the alkanes.
- ✓ A is incorrect as in this reaction the product is an **alcohol** and the reactant is an **alkene**.
- ✓ B is incorrect as combustion of alkanes produces **CO₂** and **water**.
- ✓ D is incorrect as polymerisation of ethene, an unsaturated compound, produces a **saturated** polymer.



17 Which homologous series is **not** represented in the compounds shown below?



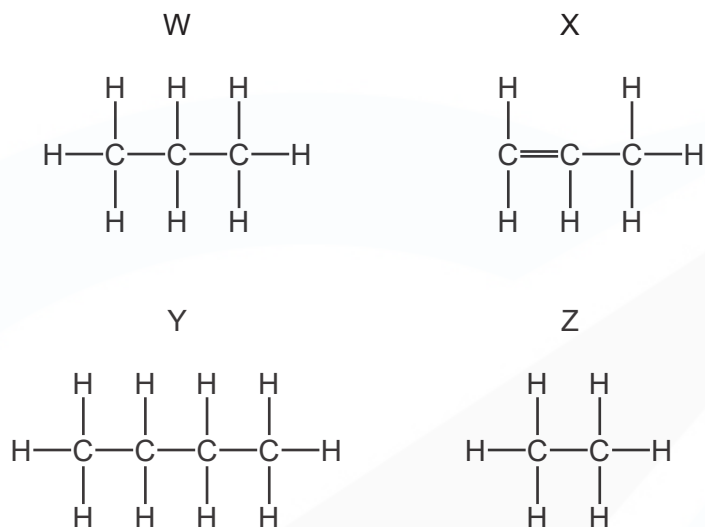
- A alcohols
- B alkanes
- C alkenes**
- D carboxylic acids

- ✓ Alkenes are **unsaturated** hydrocarbon compounds.
- ✓ They all contain a **carbon-carbon double bond**.
- ✓ Of the structures displayed in the question there is none which contains a carbon-carbon double bond.
- ✓ The homologous series of A, B and D are all represented in the structures.

Functional groups

Alcohol functional group	Alkane	Alkenes	Carboxylic acid
$ \begin{array}{c} \\ -\text{C}-\text{O}-\text{H} \\ \end{array} $	$ \begin{array}{c} \text{H} & \text{H} \\ & \\ \text{H}-\text{C}-\text{C}-\text{H} \\ & \\ \text{H} & \text{H} \end{array} $	$ \begin{array}{c} \text{H} & & \text{H} \\ & \backslash & / \\ & \text{C}=\text{C} \\ & / & \backslash \\ \text{H} & & \text{H} \end{array} $	$ \begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{OH} \end{array} $

18 The structures of four compounds are shown.



Which are members of the same homologous series?

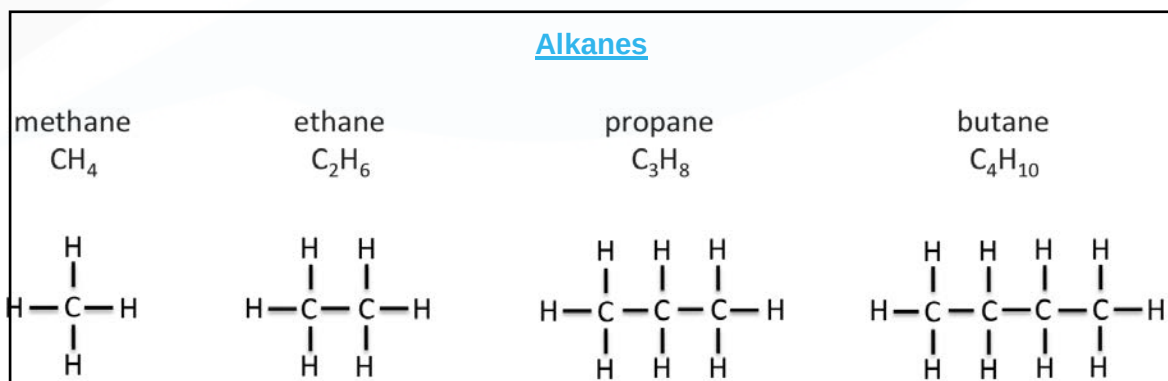
- A W, X, Y and Z
- B W and X only
- C W, Y and Z only**
- D X and Z only

✓ The compounds are:

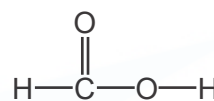
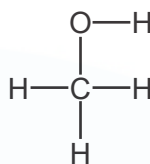
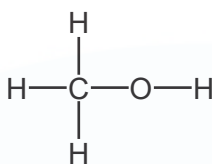
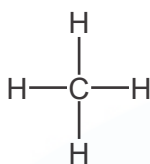
- W: propane
- X: propene
- Y: butane
- Z: ethane

✓ W, Y and Z are all **saturated hydrocarbons** and are in the same homologous series which is **alkanes**.

✓ X, propene, is an **unsaturated hydrocarbon** and is a member of the **alkenes**.



19 The structures of four different organic compounds are shown.



How many different homologous series are represented by these compounds?

A 1

B 2

C 3

D 4

✓ The 3 different homologous series shown are:

- **Alkane:** saturated molecule of **C** and **H** only.
- **Alcohol:** molecule containing the **R-OH** functional group.
- **Carboxylic acid:** molecule containing the **R-COOH** functional group.

✓ The structures show 1 alkane, 2 alcohols and 1 carboxylic acid.

✓ A, B and D are incorrect as they show the incorrect number of homologous series.

20 Ethene, propene and butene are all members of the same homologous series.

Which statement explains why ethene, propene and butene have similar chemical properties?

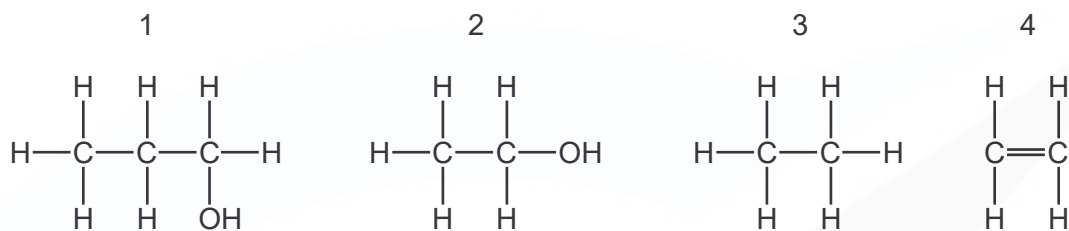
- A** They all have the same functional group.
- B** They are all gases at room temperature.
- C** They are all hydrocarbons.
- D** They are all organic.

- ✓ The **functional group** of organic compounds is what give them their **characteristic properties**.
- ✓ All members of a particular homologous series contain the **same** functional group.
- ✓ Carboxylic acids, for example, may have different lengths of hydrocarbon chains, but they all have the **-COOH** functional group.
- ✓ For this reason the carboxylic acids homologous series exhibit **similar properties**.
- ✓ B is incorrect physical state at room temperature is more determined by a compounds **molecular mass** and **intermolecular forces** than its functional group.
- ✓ C and D are incorrect as all **organic** molecules are **hydrocarbons** with their chemistry being determined by their functional groups.

The first three carboxylic acids

Methanoic acid	$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}-\text{C}-\text{OH} \end{array}$
Ethanoic acid	$\begin{array}{c} \text{H} \quad \text{O} \\ \quad \parallel \\ \text{H}-\text{C}-\text{C} \\ \quad \diagdown \\ \text{H} \quad \text{O}-\text{H} \end{array}$
Propanoic acid	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{O} \\ \quad \quad \parallel \\ \text{H}-\text{C}-\text{C}-\text{C} \\ \quad \quad \diagdown \\ \text{H} \quad \text{H} \quad \text{O}-\text{H} \end{array}$

21 The structures of four molecules are shown.



Which molecules belong to the same homologous series?

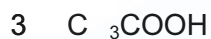
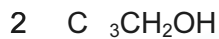
- A** 1 and 2 **B** 1 and 3 **C** 2 and 4 **D** 3 and 4

- ✓ Molecules that are hydrocarbons and contain the **same functional group** are members of a **homologous series**.
- ✓ They have the same **general formula** and similar **chemical** properties.
- ✓ One such homologous series are the alcohols which contain the functional group **-OH**.
- ✓ Molecule 1 is propanol and 2 is ethanol and both are alcohols, hence A is correct.
- ✓ Molecule 3 ethane which is an **alkane** and 4 is ethene which is an **alkene**.
- ✓ Only molecules 1 and 2 are from the same homologous series, hence B, C and D are incorrect.

Functional groups

Alcohol	Alkane	Alkene	Carboxylic acid
$ \begin{array}{c} \text{R}-\text{O} \\ \\ \text{H} \end{array} $	$ \begin{array}{c} \diagup \quad \diagdown \\ \text{C} - \text{C} \\ \diagdown \quad \diagup \end{array} $	$ \begin{array}{c} \diagup \quad \diagdown \\ \text{C} = \text{C} \\ \diagdown \quad \diagup \end{array} $	$ \begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{OH} \end{array} $

22 Which of the compounds shown are in the same homologous series?



A 1, 2

B 1, 2 and 4

C 1, 3 and 4

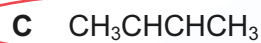
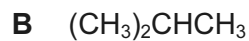
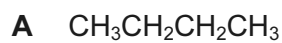
D 2, 3 and 4

- Molecules that are hydrocarbons and contain the **same functional group** are members of a **homologous series**.
- They have the same **general formula** and similar **chemical properties**.
- Compounds 1, 2 and 4 are all **alcohols**.
- They have the **-OH functional group**.
- Compound 3 is a **carboxylic acid**, ethanoic acid.
- Carboxylic acids are compounds that contain the **-COOH functional group**.

Displayed formula of an alcohol and a carboxylic acid

Alcohol (ethanol)	Carboxylic acid (Ethanoic acid)
$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$	$\begin{array}{c} \text{H} \quad \text{O} \\ \quad // \\ \text{H}-\text{C}-\text{C} \\ \quad \backslash \\ \text{H} \quad \text{O}-\text{H} \end{array}$

23 Which compound is **not** an alkane, C_nH_{2n+2} ?



- ✓ Molecules that are hydrocarbons and contain the **same functional** group are members of a **homologous** series.
- ✓ They have the same **general formula** and similar **chemical** properties.
- ✓ One such homologous series are the alkanes.
- ✓ They have the general formula C_nH_{2n+2}
- ✓ Only **option C** has the same formula.

The first three alkanes

Methane	Ethane	Propane
<pre> H H - C - H H</pre>	<pre> H H H - C - C - H H H</pre>	<pre> H H H H - C - C - C - H H H H</pre>

24 Which compound does **not** belong to the same homologous series as the other three compounds?

A CH_3OH

B $\text{C}_2\text{H}_5\text{COOH}$

C $\text{C}_2\text{H}_5\text{OH}$

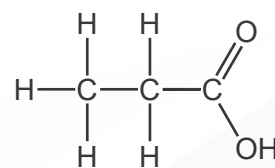
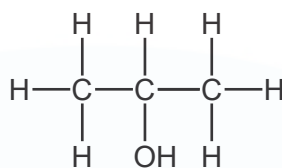
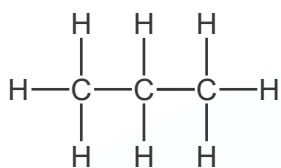
D $\text{C}_7\text{H}_{15}\text{OH}$

- ✓ Molecules that are hydrocarbons and contain the **same functional group** are members of a **homologous series**.
- ✓ They have the same **general formula** and similar **chemical properties**.
- ✓ Compounds 1, 2 and 4 are all **alcohols**.
- ✓ They have the **-OH functional group**.
- ✓ Compound 3 is a **carboxylic acid** called ethanoic acid.
- ✓ Carboxylic acids are compounds that contain the **-COOH functional group**.
- ✓ Hence A, C and D are incorrect.

Displayed formula of an alcohol and a carboxylic acid

Alcohol (ethanol)	Carboxylic acid (Ethanoic acid)
$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array} $	$ \begin{array}{c} \text{H} \quad \text{O} \\ \quad // \\ \text{H}-\text{C}-\text{C} \\ \quad \backslash \\ \text{H} \quad \text{O}-\text{H} \end{array} $

25 The structures of three molecules are shown.



Which homologous series is **not** represented?

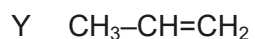
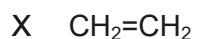
- A alcohols
- B alkanes
- C alkenes**
- D carboxylic acids

- ✓ Alkanes, alcohols and carboxylic acids are presented, but alkenes are not.
- ✓ Therefore A, B and D are incorrect.

Functional groups of the homologous series

Alcohol	Alkane	Alkene	Carboxylic acid
$ \begin{array}{c} \text{R}-\text{O} \\ \\ \text{H} \end{array} $	$ \begin{array}{c} \diagup \quad \diagdown \\ \text{C} - \text{C} \\ \diagdown \quad \diagup \end{array} $	$ \begin{array}{c} \diagup \quad \diagdown \\ \text{C} = \text{C} \\ \diagdown \quad \diagup \end{array} $	$ \begin{array}{c} \text{O} \\ \\ \text{R}-\text{C}-\text{OH} \end{array} $

26 X, Y and Z are three hydrocarbons.



What do compounds X, Y and Z have in common?

- 1 They are all alkenes.
- 2 They are all part of the same homologous series.
- 3 They all have the same boiling point.

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

- ✓ All three molecules contain a **carbon carbon double bond**, hence they are all **alkenes** so statement 1 is correct.
- ✓ Statement 2 is also correct as there are no other functional groups present, hence all molecules are members of the **alkenes**.
- ✓ Statement 3 is incorrect as their boiling points would be different as they have **different molecular masses**.
- ✓ Statements 1 and 2 are correct, statement 3 is incorrect hence options A, C and D can be disregarded.

27 Which statement about homologous series is **not** correct?

- A** Alkenes have the same general formula, C_nH_{2n+2} .
- B** Each member of the homologous series of alkanes differs from the next by CH_2 .
- C** The members of a homologous series all have similar chemical properties.
- D** The members of a homologous series all have the same functional group.

- ✓ The general formula given is for **alkanes**.
- ✓ The general formula for alkenes is **C_nH_{2n}** .
- ✓ Statements B, C and D are **correct**.