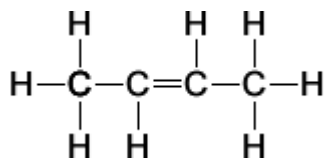


Q1.Compound **X** is shown below. It is a member of a homologous series of hydrocarbons.



- (a) (i) Deduce the general formula of the homologous series that contains **X**.

.....

(1)

- (ii) Name a process used to obtain a sample of **X** from a mixture containing other members of the same homologous series.

.....

(1)

- (b) There are several isomers of **X**.

- (i) Give the IUPAC name of the position isomer of **X**.

.....

(1)

- (ii) Draw the structure of a functional group isomer of **X**.

(1)

- (c) At high temperatures, one molecule of $\text{C}_{15}\text{H}_{32}$ can be converted into two molecules of **X** and one molecule of another compound.

- (i) Write an equation for this reaction.

.....

(1)

- (ii) State the name of the process used to obtain a high yield of **X** from $C_{15}H_{32}$.
Give **one** reason why this process is used in industry.

Name

Reason

.....

(2)

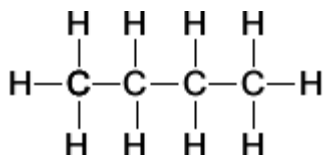
- (iii) State why high temperatures are needed for this process.

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(1)

- (d) Compound **X** can be converted into compound **Y**.
Compound **Y** is shown below.



- (i) Suggest the formula of a reagent that could be added to **X** in order to convert it into **Y**.

.....

(1)

- (ii) Give **one** use of **Y**.

.....

(1)

- (iii) Write an equation to show the reaction of **Y** in a limited supply of air to produce a solid and water only.

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(1)

- (iv) When a sample of **Y**, contaminated with CH_3SH , is burned completely in air, a toxic gas is formed.
Identify this toxic gas and suggest a compound that could be used to remove the toxic gas from the products of combustion.

Toxic gas

Compound used to remove toxic gas

.....

(2)

- (v) Suggest the name of the process that occurs when the toxic gas in part (d)(iv) is removed.

.....

(1)

- (e) Explain why the boiling points of **X** and **Y** are similar.

.....

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.....

(2)

(Total 16 marks)

Q2. Methanol (CH_3OH) is an important fuel that can be synthesised from carbon dioxide.

- (a) The table shows some standard enthalpies of formation.

$\text{CO}_2(\text{g})$	$\text{H}_2(\text{g})$	$\text{CH}_3\text{OH}(\text{g})$	$\text{H}_2\text{O}(\text{g})$
-------------------------	------------------------	----------------------------------	--------------------------------

$\Delta H_f^\ominus/\text{kJ mol}^{-1}$	- 394	0	- 201	- 242
---	-------	---	-------	-------

- (i) Use these standard enthalpies of formation to calculate a value for the standard enthalpy change of this synthesis.



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(Extra space)

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(3)

- (ii) State why the standard enthalpy of formation for hydrogen gas is zero.

.....

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(1)

- (b) State and explain what happens to the yield of methanol when the total pressure is increased in this synthesis.



Effect on yield

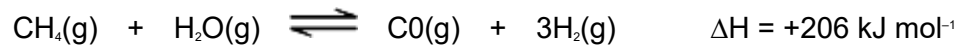
Explanation

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.....
(Extra space)
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(3)

(c) The hydrogen required for this synthesis is formed from methane and steam in a reversible reaction. The equation for this reaction is shown below.



State and explain what happens to the yield of hydrogen in this reaction when the temperature is increased.

Effect on yield

Explanation

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(Extra space)
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(3)

(d) The methanol produced by this synthesis has been described as a carbon-neutral fuel.

(i) State the meaning of the term *carbon-neutral*.

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(Extra space)
.....

(1)

(ii) Write an equation for the complete combustion of methanol.

.....

(1)

(iii) The equation for the synthesis of methanol is shown below.



Use this equation and your answer to part (d)(ii) to deduce an equation to represent the overall chemical change that occurs when methanol behaves as a carbon-neutral fuel.

Equation

(1)

(e) A student carried out an experiment to determine the enthalpy change when a sample of methanol was burned.

The student found that the temperature of 140 g of water increased by 7.5 °C when 0.011 mol of methanol was burned in air and the heat produced was used to warm the water.

Use the student's results to calculate a value, in kJ mol⁻¹, for the enthalpy change when one mole of methanol was burned.
(The specific heat capacity of water is 4.18 J K⁻¹ g⁻¹).

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(Extra space)
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(3)
(Total 16 marks)

Q3. (a) There is a risk of gas explosions in coal mines. This risk is mainly due to the presence of methane. If the percentage of coal-mine methane (CMM) in the air in the mine is greater than 15%, the explosion risk is much lower. CMM slowly escapes from the mine into the atmosphere.

Write an equation to show the complete combustion of methane.

Suggest **one** reason why there is a much lower risk of an explosion if the percentage of CMM is greater than 15%.

State why it is beneficial to the environment to collect the CMM rather than allowing it to escape into the atmosphere.

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(Extra space)
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(3)

- (b) Methane can be obtained from crude oil. Some of this crude oil contains an impurity called methanethiol (CH_3SH). This impurity causes environmental problems when burned.

Write an equation to show the complete combustion of methanethiol.

State why calcium oxide can be used to remove the sulfur-containing product of this combustion reaction.

State **one** pollution problem that is caused by the release of this sulfur-containing product into the atmosphere.

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(Extra space).....
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(3)
(Total 6 marks)

Q4. Pentane is a member of the alkane homologous series.

- (a) Give the general formula for the homologous series of alkanes.

.....

(1)

- (b) One of the structural isomers of pentane is 2,2-dimethylpropane.

Draw the displayed formula of 2,2-dimethylpropane.

State the type of structural isomerism shown.

.....

(2)

- (c) A molecule of hydrocarbon **Y** can be thermally cracked to form one molecule of pentane and two molecules of ethene only.

Deduce the molecular formula of **Y**.

State why high temperatures are necessary for cracking reactions to occur.

Give **one** reason why thermal cracking reactions are carried out in industry.

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(Extra space)
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(3)

- (d) Write an equation for the incomplete combustion of pentane to form a solid pollutant.

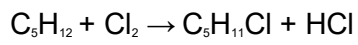
Suggest why this solid pollutant is an environmental problem.

.....

 (Extra space)

(2)

(e) Pentane can react with chlorine as shown in the following equation.



Calculate the percentage atom economy for the formation of $C_5H_{11}Cl$

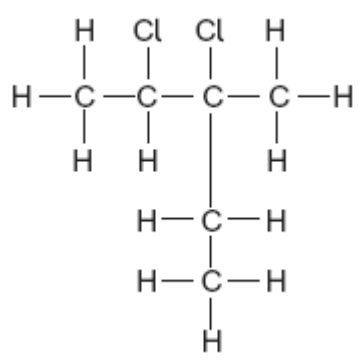
Deduce how many straight-chain isomers of $C_5H_{11}Cl$ could be formed.

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 (Extra space).....

(3)

(f) Consider the following compound.



Name this compound.

Deduce the empirical formula of this compound.

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(2)
(Total 13 marks)

Q5. Alkanes are used as fuels. A student burned some octane (C_8H_{18}) in air and found that the combustion was incomplete.

- (a) (i) Write an equation for the incomplete combustion of octane to produce carbon monoxide as the only carbon-containing product.

.....

(1)

- (ii) Suggest **one** reason why the combustion was incomplete.

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(1)

- (b) Catalytic converters are used to remove the toxic gases NO and CO that are produced when alkane fuels are burned in petrol engines.

- (i) Write an equation for a reaction between these two toxic gases that occurs in a catalytic converter when these gases are removed.

.....

(1)

- (ii) Identify a metal used as a catalyst in a catalytic converter.

Suggest **one** reason, other than cost, why the catalyst is coated on a ceramic honeycomb.

Metal

Reason

.....

(2)

(c) If a sample of fuel for a power station is contaminated with an organic sulfur compound, a toxic gas is formed by complete combustion of this sulfur compound.

(i) State **one** environmental problem that can be caused by the release of this gas.

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.....

(1)

(ii) Identify **one** substance that could be used to remove this gas. Suggest **one** reason, other than cost, why this substance is used.

Substance

Reason why used

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(2)

(Total 8 marks)