34 Synergy Education

HSC Chemistry

Production of Materials

Lesson 1: Ethylene

Name: _____

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Summary of Key Words

Account
Account for: state reasons for, report on. Give an account of: narrate a series of events or transactions

Analyse
Identify components and the relationship between them; draw out and relate implications

Apply
Use, utilise, employ in a particular situation

Assess
Make a judgement of value, quality, outcomes, results or size

Calculate
Ascertain/determine from given facts, figures or information

Clarify
Make clear or plain

Classify
Arrange or include in classes/categories

Compare
Show how things are similar or different

Construct
Make; build; put together items or arguments

Contrast
Show how things are different or opposite

Deduce
Draw conclusions

Define
State meaning and identify essential qualities

Demonstrate
Show by example

Describe
Provide characteristics and features

Discuss
Identify issues and provide points for and/or against

Distinguish
Recognise or note/indicate as being distinct or different from; to note differences between

Evaluate
Make a judgement based on criteria; determine the value of

Examine
Inquire into

Explain
Relate cause and effect; make the relationships between things evident; provide why and/or how

Extract
Choose relevant and/or appropriate details

Extrapolate
Infer from what is known

Identify
Recognise and name

Interpret
Draw meaning from

Investigate
Plan, inquire into and draw conclusions about

Justify
Support an argument or conclusion

Outline
Sketch in general terms; indicate the main features of

Predict
Suggest what may happen based on available information

Propose
Put forward (for example a point of view, idea, argument, suggestion) for consideration or action

Recall
Present remembered ideas, facts or experiences

Recommend
Provide reasons in favour

Lesson Dotpoints

By the end of the lesson, you should understand the following concepts:

Producing Ethylene

- Identify the industrial sources of ethylene from the cracking of some of the fraction from the refining of petroleum

Ethylene

- Identify that ethylene, because of the high reactivity of its double bond, is readily transformed into many useful products

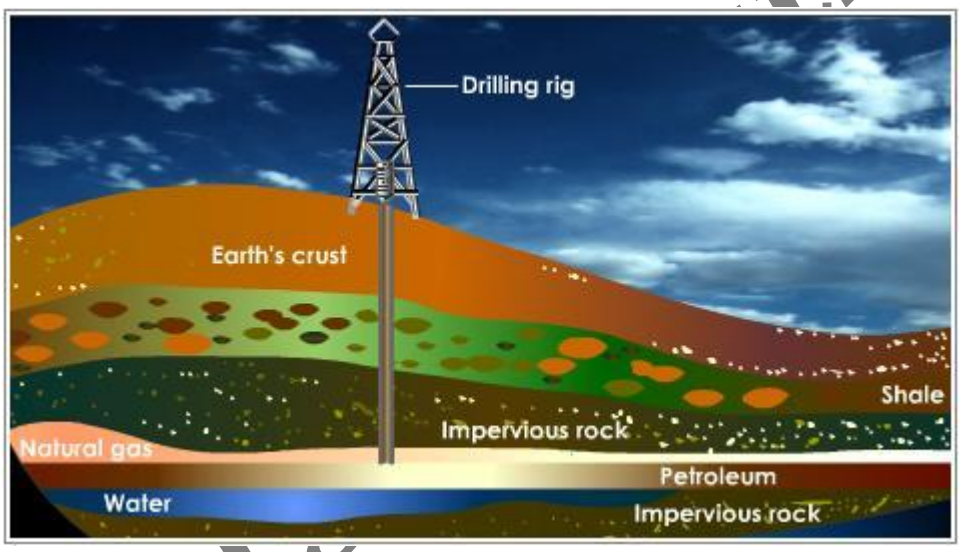
1. Producing Ethylene

CHECKPOINT:

- Identify the industrial sources of ethylene from the cracking of some of the fraction from the refining of petroleum

⚙ Introduction to Petroleum

- Petroleum is a **naturally occurring**, yellow to black liquid found below Earth's surface

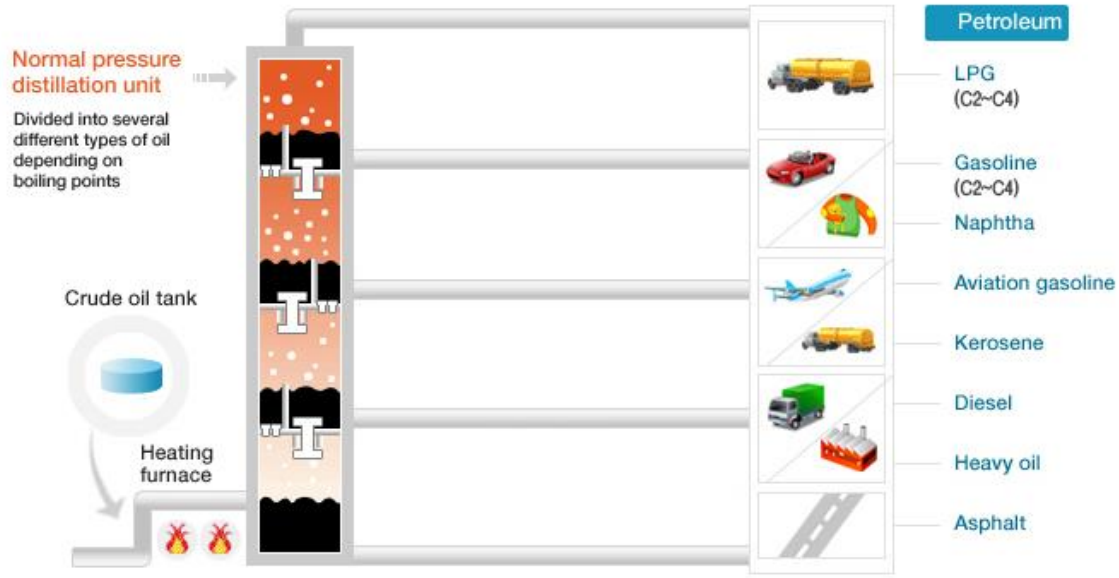


- It consists of _____ of various molecule weights and many other organic compounds
- The name petroleum cover naturally occurring unprocessed _____ and petroleum products that are made up of refined crude oil
- Petroleum is a _____ of a very large number of different hydrocarbons; the most commonly found molecules are alkanes, cycloalkanes and aromatic hydrocarbons
- Each petroleum variety has a unique mix of molecules, which define its **physical** and **chemical** properties, like color and viscosity.

⚙ Refining of Petroleum

- Since crude oil have is a mixture with a range of hydrocarbons they need to be separated
- The main separation process is **fractional distillation**
- What physical property do you think allows petroleum to be separated? Explain your answer.

- Below shows the refinery process for petroleum:



- **Label** with an arrow hydrocarbons with the highest to lowest boiling point
- **Explain** how fractional distillation works in terms of refining crude oil.

Uses of Petroleum

- The uses of petroleum are based on its molecular weight as well
- Hydrocarbons with **small amounts of carbon in its chain** tend to be gases at room temperature
- Hydrocarbons with **large amounts of carbon in its chain t**end to be liquids or solids at room temperature
- Fill in the following table.

Number of carbons	**Boiling range** (°C)	**Name of Fraction**	**Uses**
1 – 4	Below 30	Gas	
5 – 8	30 – 125	Petrol	
7 – 13	90 – 220	Petrol	
11 – 16	175 – 275	Kerosene	
16 – 20	300 – 370	Lubricating oil	
20 – 40	Above 350	Paraffin waxes	
Above 40	Above 400	Asphalt/Tar	

What is Ethylene?

- Ethylene is a product that can be derived from petroleum
- It is one of the most important chemicals produced in the petrochemical industry. Explain why.

- Ethylene also called _____ is commonly derived from steam cracking or catalytic cracking of larger alkanes
- List some chemicals derived from ethylene.

- Draw an ethylene molecule.

How is Ethylene Produced?

Method A: Thermal Cracking of Alkanes

- Thermal cracking involves heating alkanes to high temperatures in the absence of air.
  - This causes them to 'crack' into smaller molecules.
  - Why is the absence of air required?

- Heavier fractions produced by fractional distillation of petroleum are less useful than the lighter fractions.
- If these long chain alkanes are heated to high temperatures, the molecules split and form more useful shorter-chain molecules
  - Identify the temperatures used in thermal cracking of alkanes.
  - Using chemical equations, provide an example of thermal cracking.
  - Explain why thermal cracking is rarely used in industry.

- **Ethene** can also be produced by cracking **ethane** which has the formula _____
  - Draw a diagram of ethane.

- Ethane is cracked at around temperatures of 850°C
- The products in this thermal cracking method is ethene and hydrogen
  - Provide a chemical equation to show the thermal cracking of ethane.

  - Do you think the reaction is endothermic or exothermic? Explain your answer.

- Once this reaction is completed, the mixture is rapidly cooled to prevent the reaction from reversing
- Identify any safety concerns in the thermal cracking process.

Method B: Catalytic 'Cracking' of Alkanes

- Today ethylene is obtained from the **catalytic cracking** of petroleum
- Catalytic cracking is a **by-product** in producing other alkanes
- Define catalytic cracking.

- What is the purpose of a catalyst?

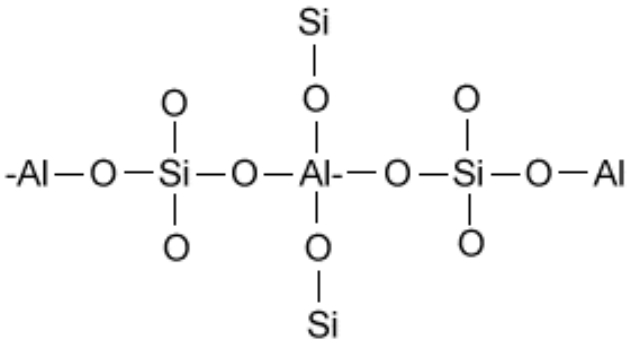
- What are the benefits of using catalytic cracking over thermal cracking?

  - Identify the temperatures used in catalytic cracking.

- It is common that alkanes with _____ carbon atoms are cracked into two smaller molecules
  - Write a chemical equation for the cracking of pentadecane into pentene and another product.

- Pentene is then further cracked into ethylene and propene. Write a chemical equation.

- The catalysts involved in catalytic cracking are called **zeolites** which are a group of silicate materials
  - Zeolites are crystalline substances composed of aluminum, silicon and oxygen
  - Below is an example of a basic zeolite structure.



- In catalytic cracking alkanes and alkenes are formed. Alkanes can be used in gasoline. A type of alkene is ethylene.
- What is a benefit of catalytic cracking over thermal cracking?

Applications 1.1

Question 1

a) Identify two processes that allow the production of ethene. (1 mark)

b) Explain the importance of ethene to the petrochemical industry. (1 mark)

c) Explain the process of thermal cracking. (3 marks)

d) Explain the process of catalytic cracking. (3 marks)

Question 2

Justify the statement, "Catalytic cracking has many advantages over thermal cracking". (3 marks)

Question 3 (Exam Choice 2009 – Qu 16)

Compare the cracking reactions of $C_{14}H_{30}$ and C_3H_8 and include chemical equations to support your answer. (3 marks)

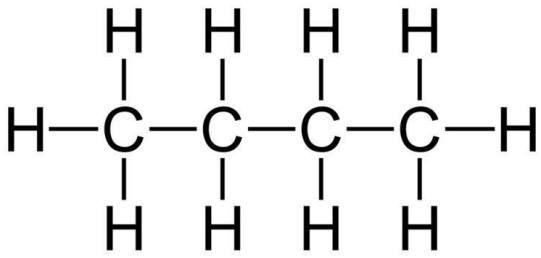
2. Ethylene

CHECKPOINT:

- Identify that ethylene, because of the high reactivity of its double bond, is readily transformed into many useful products

What are Alkanes?

- Alkanes are _____ molecules meaning they are _____ in water
- Alkanes have only a _____ bond between its carbons
- Butane is an example of an alkane as shown below:



- What types of substances are alkanes soluble in?

- Alkanes are **normally unreactive** with many chemical reagents
- However alkanes are combustible in air
  - Provide a combustion reaction equation for propane reacting with air.

- Provide a combustion reaction equation for octane reacting with air.

- Alkanes also react with chlorine/bromine if it is exposed to UV light
  - Show how propane reacts with chlorine under UV light.

  - Show how hexane reacts with bromine under UV light.

  - These types of reactions are called _____ reactions as one atom in a molecule is replaced by another

What are Alkenes?

- Alkenes are also _____ molecules meaning they are also _____ in water like alkanes
- Alkenes have a double bond between its carbons allowing it to be **highly reactive**
- **The double bond is where the majority of reactions take place for alkanes**
- Name an alkene.

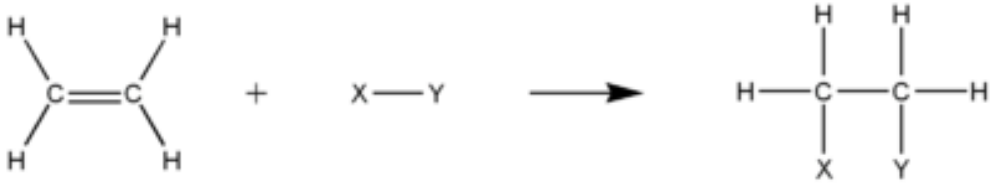
- Draw the structure of ethylene

- Like alkanes, alkenes are able to combust in air
  - Provide a combustion reaction equation for ethylene reacting with air.

- Are alkanes or alkenes more reactive? Explain your answer.

⚙ Alkenes and Addition Reactions

- Due to the double bond in alkenes, many substances are able to react with it
  - These types of reactions are called **addition reactions**
  - **Essentially, the double bond becomes two single bonds**
- The general formula for addition reactions is:

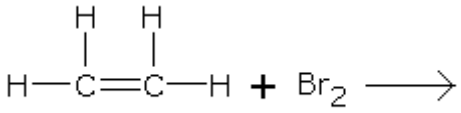


- Below are several examples of addition reactions:

Bromine and Chlorine

- This is one of the simplest types of addition reactions in which the reactions are called **bromination** and **chlorination**

- Complete the following addition reaction:



  - The product is called dibromoethane

- Write the structural formula for the addition reaction of chlorine and ethene.

Water (H_2O)

- Alkenes are able to reaction with water under the presence of a _____

  - This is a process called **hydration**

- The catalyst must be a _____. Examples of acid catalysts are:

  - Phosphoric acid
  - Sulfuric acid

- Draw the structural formula for the addition reaction of ethene and water.

Applications 2.1

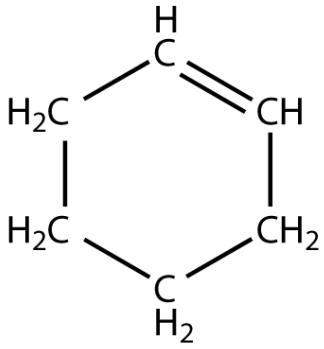
Question 1

a) Explain the concept of addition reactions. (1 mark)

b) Using ethane and ethene as examples, explain why alkanes are unable to undergo addition reactions. (4 marks)

Question 2

a) Draw the structural diagram of the reaction between cyclohexene and bromine.



b) Identify the product.

Question 3

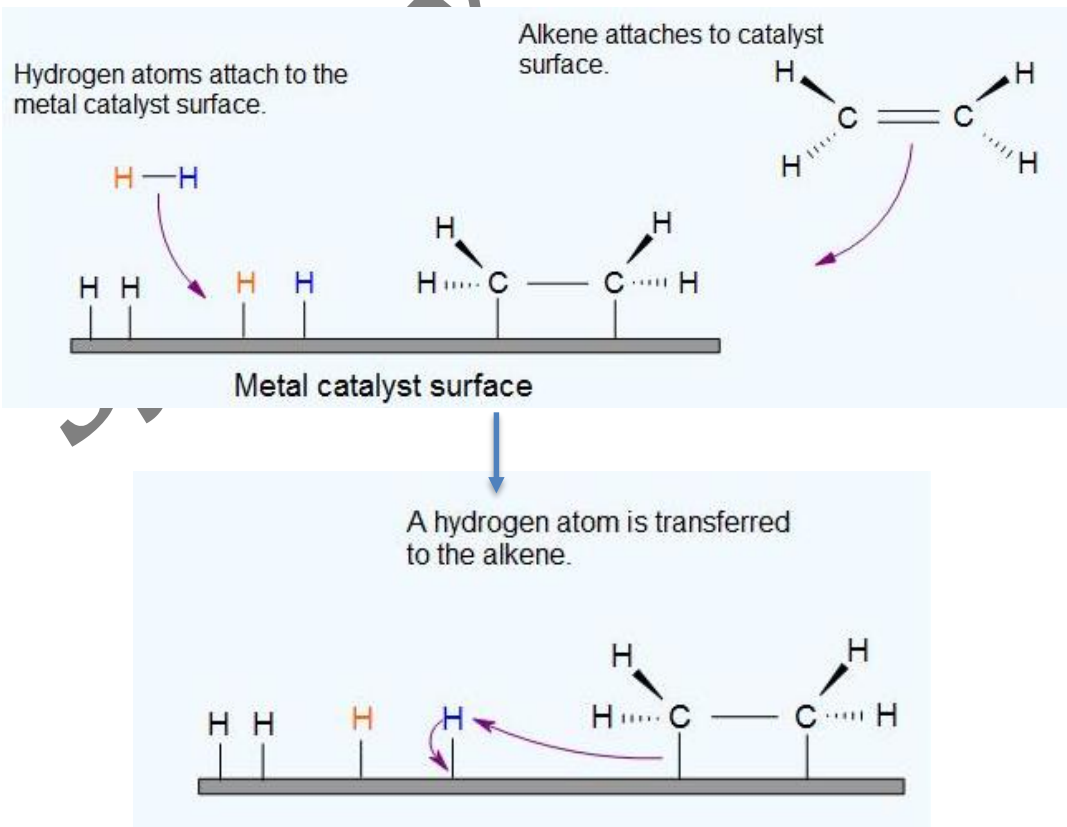
a) Draw the structural diagram of a propene hydration reaction.

b) Identify the product.

Hydrogen

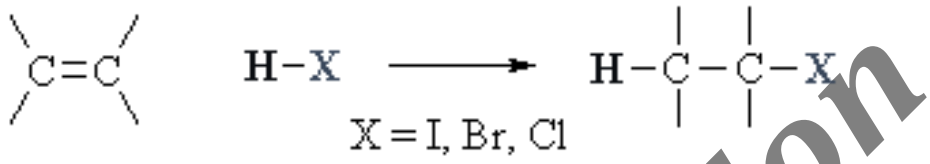
- The addition of hydrogen to an alkene allows it to be converted into an _____
- A metal catalyst is required for this reaction, which include:
  - Nickel
  - Rhodium
  - Platinium
- The purpose of the metal catalyst is it allow hydrogen to attach the metal surface which forms a:

- The metal catalyst also absorbs the alkene on its surface
- A hydrogen atom is then transferred to the alkene, forming a new C-H bond
- A second hydrogen atom is transferred forming another C-H bond
- Two hydrogens have added to the carbons across the double bond



Hydrohalogenation

- Hydrohalogenation involves a _____ such as HF, HCl, HBr, HI to form a **haloalkene**
- The general formula for hydrohalogentation is:



- Draw the structural equation for the hydrohalogentation of butene with HBr

Applications 2.2

Question 1 (HSC)

Ethene is a hydrocarbon that is insoluble in water.

a) Explain why ethene is insoluble in water. (2 marks)

b) Ethane and ethene both react with halogens.

i) Explain why ethene reacts more readily with halogens than does ethane. (2 marks)

ii) Write a balanced equation for a reaction between ethane and a halogen. (1 mark)

Question 2

Compare the reactivity of alkanes and alkanes and give a reason for the difference. (2 marks)