• identify the industrial source of ethylene from the cracking of some of the fractions from the refining of petroleum

**Industrial Source of Ethylene**

- Ethylene is obtained industrially in 3 main steps:
  1) Mining of Petroleum
  2) Refining of Petroleum
  3) Cracking of Fractions

**Mining of Petroleum**

- What is petroleum?
  - Because it is a liquid underground, petroleum is retrieved by drilling into the earth and then pumping it out.
Refining of Petroleum

- After mining, the petroleum is then refined by a separation process called fractional distillation.

- This is conducted in a fractioning tower as shown in the diagram below:

- Describe what happens to the petroleum in the refinery process.

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Cracking of Fractions

- Petroleum contains many long-chain hydrocarbons that are less useful than shorter-chain hydrocarbons.

- As a result, longer-chain fractions undergo an additional step called cracking which effectively breaks down the molecules into shorter, more useful molecules.

- There are 2 main types of cracking processes:
  1) Thermal Cracking
  2) Catalytic Cracking

- Thermal cracking involves heating the alkanes to high temperatures of about 700°C in the absence of air, causing them to ‘crack’ or ‘split’ into smaller molecules.

- The preferred method today is catalytic cracking.

CATALYTIC CRACKING

- Catalytic cracking is the process of ‘cracking’ alkanes into smaller molecules upon heating using hot steam at temperatures of about 500°C, with the addition of a catalyst.

- The catalyst used in the industrial catalytic cracking of petroleum is a group of inorganic materials called zeolites (composed of aluminium, silicon and oxygen).

  - Write a chemical equation showing the production of ethylene by catalytic cracking.

  - Why do you think catalytic cracking is used over thermal cracking?
Concept Check 1.3:

Catalytic cracking is a process used in the petrochemical industry.

(a) What important carbon compound is produced in the process of catalytic cracking?

(b) A catalyst is used in this process. Explain the role of the catalyst.

(c) Explain the process of catalytic cracking.

(d) Discuss the importance of the discovery of cracking to the petrochemical industry.
• identify data, plan and perform a first-hand investigation to compare the reactivities of appropriate alkenes with the corresponding alkanes in bromine water

First-Hand Investigation: Bromine Water Test

Aim: To test for the presence of saturation or unsaturation using bromine water and hence, compare the reactivities of appropriate alkenes with the corresponding alkanes.

Materials:
- 2 Test tubes
- Bromine water
- Different alkanes and their corresponding alkenes (hexane, hexene, cyclohexane, cyclohexene)

Safety:
Bromine and hydrocarbons such as cyclohexane and cyclohexene are volatile and poisonous. The experiment therefore should be conducted in a fume cupboard or in a well ventilated laboratory.

All materials should be discarded into labelled waste containers and NOT into the sink.

Method:
1) Place equal drops (5ml) of an alkane with its corresponding alkene in each test tube.

2) Add the same volume of bromine water (2ml) to each of the test tubes.

3) Shake gently to mix.

4) Observe changes in colour of solutions, avoiding UV exposure.

5) Thoroughly clean out test tubes and repeat experiment with different set of hydrocarbons.
**Results:**

On addition of the bromine water, the following observations were made:

- The test tube which contained the alkane remained deep red in colour.
- The test tube which contained the alkene decolourised.

**Conclusion:**

Addition reaction of cyclohexene and bromine

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\begin{align*}
\text{H}_2\text{C} &= \text{C} &= \text{CH} \\
\text{H}_2\text{C} &= \text{C} &= \text{CH}_2 \\
+ \quad \text{Br}_2 \quad \longrightarrow \\
\text{H}_2\text{C} &= \text{C} &= \text{CBrH} \\
\text{H}_2\text{C} &= \text{C} &= \text{CH}_2
\end{align*}
\]

Addition reaction of cyclohexene and bromine
Discussion:

- Why was it necessary to avoid UV exposure?

- To ensure the validity of the experiment, what variables did you control?

- Was the experiment reliable?

- How could we improve reliability?
Concept Check 1.4: [HSC 2002 Q16]

You have carried out a first-hand investigation to compare the reactivity of an alkene with its corresponding alkane.

(a) State the name of the alkene.

(b) Outline a procedure to compare the reactivity of this alkene with its corresponding alkane.

(c) Describe the results obtained from this first-hand investigation and include relevant chemical equations.