BISCUIT NOTES

BISCUITNOTES ON CAROUSELL

BISCUITNOTES GROUP ON TELEGRAM

BISCUITNOTES ON TIKTOK

Chapter 18 - Fuels and Crude Oil

Sources of fuel:

- Fossil fuels in the form of crude oil, natural gas and coal (carbon)
- Biofuels

Fossil fuels are burned in oxygen to form CO_2 and H_2O. This exothermic reaction is combustion and the thermal energy generated from the combustion of fossil fuels can be converted to other forms of energy

Combustion: Fuel burns in the presence of excess/sufficient oxygen to produce CO_2 and H_2O
Incomplete combustion: Fuels burn in the presence of insufficient oxygen to produce CO and/or C(s) and H_2O

Characteristics of Natural gas

1. It is colourless
2. It is a mixture of light hydrocarbons, mainly consisting of methane
3. It can be easily liquefied (due to low boiling point) and stored in tanks. It can flow
4. It produces almost no pollutant
5. Combustion:

- Complete combustion

☐ CH_4 burns in excess oxygen to form CO_2 and H_2O to produce energy

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

- Incomplete combustion

☐ CH_4 burns in insufficient oxygen to form CO and/or C(s) and H_2O to produce energy

☐ $CH_4(g) + O_2(g) \rightarrow CO(g) + C(s) + H_2O(l)$

- Comparing complete and incomplete combustion, for 1 mole of CH_4, 2 moles of O_2 is required for complete combustion whereas only 1 mole of O_2 is required for incomplete combustion. Hence, when there is insufficient oxygen supply, complete combustion is more likely to occur as less mole of O_2 is required for the same mole of CH_4
- However, for methane, most of the times, complete combustion occurs 99% of the time, as in most cases, there will be sufficient oxygen supplied for complete combustion to the its low percentage mass of carbon (it has only 1 carbon atom in each molecule)
- Low percentage mass of carbon: $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ - [1]
- Higher percentage of carbon: $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ - [2]

Which equation [1] or [2] will give out sootier products/have more incomplete combustion?

- For the same mole of CH_4 and C_3H_8, C_3H_8 requires more oxygen than CH_4 for complete combustion. Hence, this means that C_3H_8 will undergo more incomplete combustion as compared to CH_4, hence producing more soot.
- Rule of thumb: For the same mole of fuel, the fuel that requires the greater number of moles of oxygen for complete combustion will undergo more incomplete combustion and hence more soot/CO will be produced

Characteristics of crude oil

1. It is a dark brown liquid
2. It is a mixture of hydrocarbons (compounds with hydrogen and carbon only)
3. It can be stored and transported easily by tankers. It can flow through a pipe easily.
4. It is moderately polluting as some soot is produced due to incomplete combustion (due to slightly higher percentage mass of carbon compared to natural gas)
5. It also undergoes combustion in the forms of complete and incomplete combustion.

Characteristics of coal:

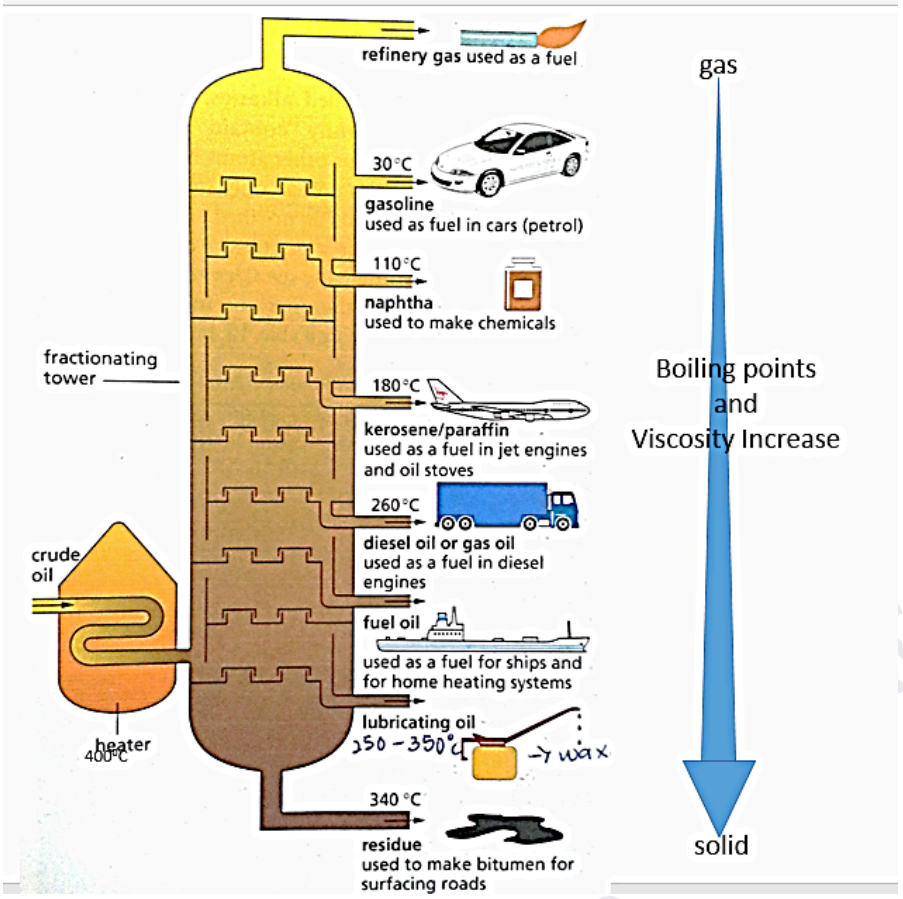
1. It is a black solid
2. It is mainly just carbon
3. It is not easily stored and transported.
4. It is extremely polluting as large amount of soot is produced due to incomplete combustion (due to 100% percentage mass of carbo)
5. It undergoes combustion in the forms of complete and incomplete combustion.

Complete combustion:

- Coal burns in excess oxygen to form CO_2 to produce
- $C(s) + O_2(g) \rightarrow CO_2(g)$

Incomplete combustion:

- Coal burns in insufficient oxygen to form CO to produce energy
- $2C(s) + O_2(g) \rightarrow 2CO(g)$



Separation of crude oil: Fractional Distillation

- Petroleum/crude oil is heated in the furnace and vaporize into the fractionating column
- As the vapour rises up the fractionating column, it cools and condense at different boiling points.
- Fraction with lower boiling point condense at the top of the column (smaller hydrocerbons) and is distilled over first
- Fraction with higher boiling point condense at the bottom of the column (larger hydrocarbons)

Fractional distillation makes use of the fact that

- Hydrocarbons with more carbon atoms have a higher boiling point than one with fewer carbon atoms
- This is because hydrocarbons with more carbon atoms have a larger molecular size than hydrocarbons with fewer carbon atoms, and hence, there will be more intermolecular forces of attraction between hydrocarbons with more carbon atoms.
- Hence, more energy is required to overcome the intermolecular forces of attraction between hydrocarbons with more carbon atoms, thus resulting in a higher boiling point
- Hence, hydrocarbons with fewer carbon atoms will distill over first at the top of the fractionating column, leaving the hydrocarbons with more carbon atoms to distill over at the bottom

Hydrogen as a potential fuel

- It is a renewable energy resource
- It is obtained from : 1. Reaction of natural gas with steam

  $CH_4 + H_2O(g) \rightarrow CO + 3H_2$, $H_2O + CO \rightarrow CO_2 + H_2$

  2. Electrolysis of water

  $2H_2O(l) \rightarrow O_2(g) + 2H_2(g)$

  3. Cracking of hydrocarbons

  $C_2H_6(g) \rightarrow C_2H_4(g) + H_2(g)$

Advantages of using hydrogen :

- Hydrogen is renewable
- Hydrogen does not cause pollution as only water is formed when H_2 reacts with O_2 (fossil fuels form CO_2)
- When hydrogen is burnt, it releases more than twice the amount of energy compared to many other fuels (efficient power source)

Disadvantages of using hydrogen :

- Expensive. Obtaining H_2 from electrolysis is expensive / cracking of hydrocarbons
- Hydrogen is extremely flammable and explosive
- Hydrogen is a gas at rtp and requires large storage volumes compared to other fuels which are liquids at rtp (liquids require less storage volume)

Fuel cell (similar to a simple cell) : A fuel cell is a chemical cell in which reactants (fuel and oxygen) are continuously supplied to produce electricity directly (chemical energy → electrical energy)

Advantages of Fuel Cell:

- There are no pollutants formed as hydrogen reacts with oxygen to produce water
- It is more efficient as compared to coal/fossil fuels as it converts chemical energy directly to electrical energy

Disadvantages of Fuel Cell:

- It is expensive to source for hydrogen gas through electrolysis of water or cracking of hydrocarbons

How is electricity produced?

- Electrons are produced at the anode when hydrogen gas reacts with the electrolyte (OH^- ions)
- The electrons produced at the anodized will be transferred to the cathode where reduction occurs
- The flow of electrons from anode to cathode generates electricity