

Chapter – 3 and 4: Coal, Petroleum and Combustion of Fuels

- People light – candles and diyas – wax and oil – burn
- Wax and oil – cannot be recovered back – non-reversible chemical reaction
- Many other materials – burn – heat and light

Combustion

- Substance – burns in air – heat and light produced
- Conditions for combustion –
 - Combustible substance –
 - Substance – catch fire easily – **fuels**
 - Primary condition
 - All fuels – petrol, kerosene, LPG, CNG
 - Can be solid, liquid or gas
 - Substance – does not burn – **non-combustible**
 - Supporter of combustion –
 - Substance – helps in combustion
 - Combustion not possible without supporter
 - Most cases – oxygen
 - Ignition temperature –
 - Minimum temperature – substance starts burning
 - Nothing catches fire below ignition temperature
 - Piece of wood – low ignition than – log of wood
- Light a candle – cover it with glass – candle goes off after some time – oxygen used – air supply cut-off
- Light a cone of paper – burn easily – fill it with water and then light it – does not burn easily – water increases ignition temperature

Inflammable substances

- Some substance – catch fire easily and rapidly
- Low ignition temperature – slightest spark can ignite temperature – store carefully

Types of combustion

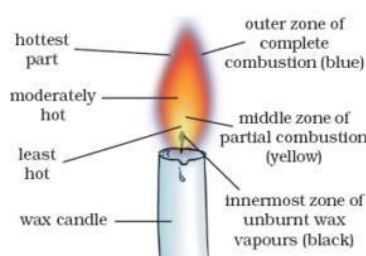
- Depending on rate of combustion
 - Slow combustion –
 - Moderate speed
 - Burning of coal, wood, candle
 - Fuel – does not burn completely – produce smoke
 - Digestion – slow combustion – 37⁰ C
 - Rapid combustion –
 - Burns – short span of time – almost complete combustion – lots of heat and light
 - LPG in gas stove, oxyhydrogen flame in welding
 - Spontaneous combustion –
 - Catches fire – as soon as – ignition temperature reached

- White phosphorus – burns at 35⁰ C and above – without heat source
- Explosion –
 - Takes place suddenly – evolution of heat, light, sound
 - Large amount of gas – evolved
 - Fire crackers
- Depending on supporters of combustion
 - Complete combustion –
 - Sufficient oxygen – substance burns completely
 - Produce – carbon dioxide, water (vapour), heat and light – blue flame
 - Incomplete combustion –
 - Insufficient oxygen – substance do not burn completely
 - Produce – yellow flame – carbon monoxide, soot (residue – left over) – pollute environment

Flame

- Different materials – burn with different colour flames
- Candle – yellow flame with smoke – LPG (liquefied petroleum gas) – blue flame
- Fuel – ignited – catches fire – region – it burns – **flame**
- Colour – depend on chemical substance burning or gases released
- All substance – do not burn with flame
- Substance – vapourise – produce flame
- Matchstick – wood gas released – yellow flame
- Light a candle – wax melts – vapour rises upwards through wick (thread) – yellow flame
- Charcoal – so not vapourise – no flame – only glow

Parts of a candle flame



- Non-luminous zone
 - Outermost part
 - Complete combustion of carbon
 - Carbon dioxide and water vapour produced
 - Carbon dioxide – no light added to flame
 - Hottest part – very little light
 - Flame colour – blue
- Luminous zone
 - Middle part
 - This zone – yellow colour of the flame
 - Partial or incomplete combustion – limited supply of oxygen

- Unburnt carbon particles – produce smoke (soot)
 - Not very hot
- Dark zone
 - Close to the wick
 - Unburnt carbon particles – present here
 - Coldest part – presence of wax vapour
 - Innermost part
 - No oxygen – wax does not burn
- Blue zone
 - Base of the flame
 - Burning of carbon monoxide

Fuel and its types

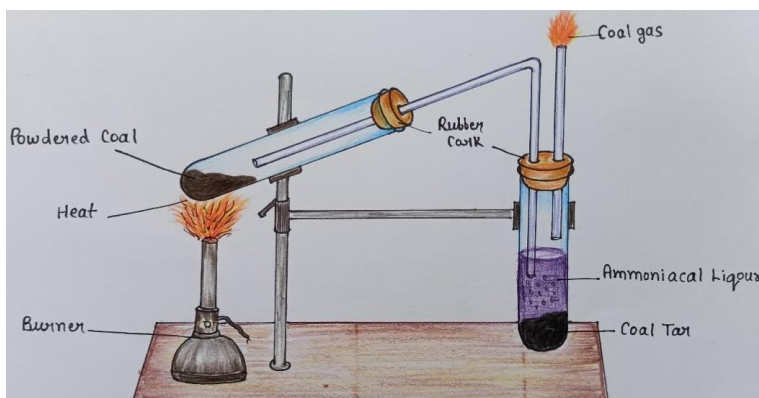
- Many substances – wood, coal, petrol, diesel, charcoal, kerosene – produce heat and light – **fuel**
- Contains carbon and hydrogen
- Sufficient supply of oxygen – lots of heat – complete combustion
- Efficiency – measured in **calorific value** – amount of heat energy produced on complete combustion of a unit mass of fuel
- Unit – kilojoules per kilogram (kJ/kg)
- Classification on the basis of source –
 - Natural fuels
 - Primary fuels
 - Occur in nature – used in same form
 - Coal, wood
 - Processed fuels
 - Secondary fuels
 - Some fuels – cannot be used in raw form – need to be processed – chemical methods
 - Petrol, diesel, kerosene
- Classification on the basis of physical state –
 - Solid fuels
 - Occur in solid state – room temperature
 - Coal, wood, coke, paraffin wax (solid wax)
 - Produce smoke – leave ash as residue
 - Liquid fuels
 - Occur in liquid state – room temperature
 - Kerosene, spirit, petrol, diesel
 - No residue
 - Lower ignition temperature
 - Gaseous fuels
 - Occur in gaseous state – room temperature
 - Compressed Natural Gas (CNG), coal gas, biogas
 - Very clean – no smoke or ash
- Advantages of liquid or gas over solid fuels
 - High **calorific value**

- Low **ignition temperature**
- **Burn completely** – no residue – little or no pollution
- **Convenient to store** – solid fuels require lots of space
- **Easy transportation** – pipelines – solid fuels are expensive to transport
- **Rate of combustion** – can be controlled

Fossil fuels

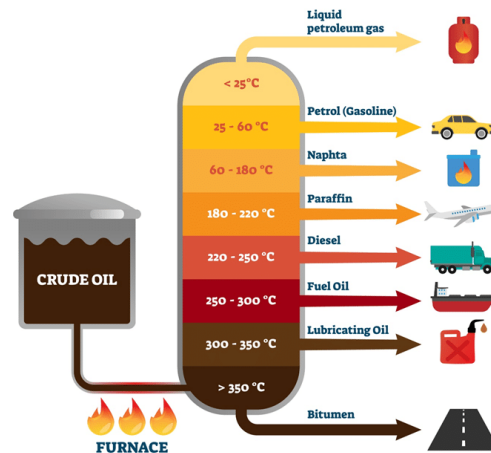
- Formed by decomposition of remains of organisms buried deep inside earth over millions of years
- 1000s of years – formation – exhaustible – limited quantity
- Imp. fossil fuels –
 - **Coal**
 - Made of carbon, hydrogen, oxygen
 - Found inside earth – form of deposits
 - High temperature and pressure
 - Plants, animals – die – gets buried inside earth – converted into coal over hundreds of thousands of years
 - **Formation of coal**
 - Started 300 million years ago
 - Plants, animals – forest – died and buried – due to cyclone, earthquake, other natural disasters
 - High temperature, high pressure, absence of air – organic matter decompose – oxygen, hydrogen removed – leaving carbon
 - High temperature, pressure – carbon – turned to stone-like residue – **coal**
 - This process – **carbonization**
 - Coal occurs in 3 forms
 - **Anthracite**
 - Highest calorific value
 - Cleanest form – 90 % carbon
 - Hard coal
 - Great depths – 6000 metres
 - **Bituminous coal**
 - 75 % carbon
 - Used for domestic purpose – soft coal
 - Depths – 3000-6000 metres
 - **Lignite**
 - 60-70 % carbon
 - Catches fire easily – brown colour
 - Causes pollution – contain Sulphur
 - Source – lots of other compounds and fuels
 - Obtained by **destructive distillation** – heated in absence of air at 1000⁰ C
 - Products of destructive distillation –
 - **Coal tar**
 - Black thick drops during distillation

- Source – imp. compounds – benzene, phenol, naphthalene
- Used in synthetic dyes, paints, explosives, plastic
- **Coal gas**
 - Contain hydrogen, methane, carbon monoxide, other gases
 - Used as a fuel – many industries near coal processing plants
- **Coke**
 - Residue from distillation
 - Non-polluting fuel
 - Used for production of gaseous fuels
 - $C + H_2O \rightarrow CO + H_2$ (water gas)
 - $2C + O_2 + 4N_2 \rightarrow 2CO + 4N_2$ (producer gas)
 - Almost purest form of carbon
 - Tough and porous
 - Used in manufacturing of steel and extraction of many metals
- **Ammonium compounds**
 - Mixture of compounds
 - Form ammoniacal liquor – dissolved in water – used in manufacture of fertilisers



- **Petroleum**
 - Petra – rock – oleum – oil
 - Found in rocks – mixture of solid, liquid, gaseous hydrocarbons
 - **Formation of petroleum**
 - Formed from remains of dead sea animals
 - Bodies – got covered in layers of sand
 - Over 1000s of years – bodies converted to liquid – **petroleum** – absence of air, high temperature, pressure
 - Dark, viscous, foul-smelling liquid – **crude oil**
 - Many useful compounds – obtained by **fractional distillation** – separation of substances – different boiling points
 - This process – **refining of petroleum**
 - Products –
 - **Petroleum gas**
 - Liquefied Petroleum Gas (LPG) – most common domestic fuel
 - Very less air pollution – compared to other fuels

- LPG – used to run vehicles
- **Gasoline**
 - Petrol obtained from it
 - Used as fuel in motors
 - Also used for dry cleaning clothes
- **Kerosene**
 - Commonly used as domestic fuel
 - Also used in jet engines
 - Lighting petromax (lantern) in villages – absence of electricity
- **Light oil**
 - Diesel obtained from it
 - Used as fuel in motors
 - Also used in generators – produce electricity
- **Heavy oil**
 - Used in production of various chemicals
 - Also used to heat boilers and furnaces
- **Residue**
 - Paraffin wax, lubricating oil, asphalt – derived from residue



- **Natural gas**
 - Fossil fuel – stored under high pressure as Compressed Natural Gas (CNG)
 - Contains mainly methane (95 %)
 - Occurs – deep under earth – alone or with oil
 - Sometimes – obtained as by-product – mining of petroleum
 - Advantages –
 - Higher calorific value than other fuels
 - No toxic gas, smoke on burning – better fuel for transport vehicles
 - $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
 - Burns readily to produce heat
 - Easy to transport – direct pipelines

Characteristics of an ideal fuel

- Choice of efficient fuel – depend on purpose – household, vehicles, industries
- Imp. properties – ideal fuel –

- High calorific value
- Moderate ignition temperature
- No pollution – neither harmful gases nor any residue
- Easily available and economical
- Easy to transport and store
- Burning rate – moderate
- Easy to handle

Pollution due to combustion of fuels

- All fuels – including fossil fuels – produce carbon dioxide and water vapour on combustion
- No fuel – 100 % pure – produce other gases – Sulphur dioxide, Nitrogen dioxide
- Insufficient supply of oxygen – incomplete combustion – produce Carbon monoxide – highly toxic (poisonous)
- Carbon monoxide – combines with haemoglobin – stopping supply of oxygen – poisoning – can cause death
- Carbon dioxide – released in atmosphere – absorb infrared radiation – raises temperature – global warming
- Harmful gases – combine with rain – form acid rain – soil and water pollution

Judicious use of fossil fuels

- Fossil fuels – limited – non-renewable – cannot be used again
- Millions of years – formation
- Advancement in technology – increasing consumption
- Everyone's duty and responsibility – use them wisely
- Non-conventional sources – also available
- Solar, wind, ocean energy
- Wise use can be done through –
 - Preventing wastage in kitchen
 - Stove – higher efficiency
 - Lighting only after all items ready – use pressure cooker – cover vessel while cooking
 - Clean stove regularly – improve functioning
 - Use public transport
 - Switch off electrical appliances when not in use