1.3 Describe an example of a chemical reaction such as combustion, where reactants form different products under different conditions and thus would need monitoring –

- **Combustion is a chemical reaction that forms different products under different conditions**
- **A variety of products (CO_2, CO & $C_{(s)}$) can form under different conditions (varying amounts of available oxygen gas as a reactant)**

Complete Combustion (Abundant Oxygen Supply): $2C_8H_{18\,(l)} + 25O_{2\,(g)} \rightarrow 8CO_{2\,(g)} + 9H_2O_{\,(g)}$

Incomplete Combustion (Insufficient Oxygen Supply): $2C_8H_{18\,(l)} + 17O_{2\,(g)} \rightarrow 16CO_{\,(g)} + 18H_2O_{\,(l)}$

Problems with Incomplete Combustion:

- **CO is a poisonous gas thus affects human health as it competes for haemoglobin in blood thereby affecting cellular respiration and can thus cause death**
- **Carbon soot is carcinogenic to humans and thus can irritate the lungs & cause cancer**
- **Incomplete combustion reduces fuel efficiency and maximum yield thus increasing costs**
- **If the air: fuel ratio is too high (excess oxygen), the excess oxygen can react with nitrogen present in the air to yield 2NO, which can lead to acid rain**

Benefits of Chemists Monitoring Combustion Reactions:

- **Monitoring O_2 levels ensure that air-to-fuel ratio is sufficient for complete combustion, thereby minimising pollution & maximising energy output and yield of desired products**
- **Monitoring products also detects any pollutants that may form so necessary safety precautions can be immediately taken**
- **Ensuring the reaction goes to completion avoids an unfavourable equilibrium to set-up**

5.3 Describe and assess the effectiveness of methods used to purify and sanitise mass water supplies –

1. **CATCHMENT MONITORING:**

- Ensuring good quality water starts by protecting the catchment area by keeping it clean
- Involves preventing land-clearing, mining, deforesting and industry in entire catchment area → ensures the water that flows into the dam is free of sediments and animal wastes

2. **SCREENING & AERATION:**

- Screening → water from catchment is passed through large metal screens that sieve out (acts as sieves) large debris (sticks, leaves, trash) and even fish and plants (physical)
- Aeration → water is sprayed into air to increase DO. Fe and Mn salts are also oxidised, removing their undesirable colour and odour (physical and chemical)

3. **FLOCCULATION:**

- Flocculation is a series of processes that removes turbidity and suspended particles in water → making water clear and colourless
- Coagulants such as $Al_2(SO_4)_3$ and $FeCl_3$ are added to cause suspended particles to form a larger, gelatinous precipitate of $Al(OH)_3$, which attracts suspended solids (by adsorption), precipitated iron and some pathogens
- The finely dissolved particles of aluminium hydroxide coagulate (clump together) into heavier particles (flocs) in a process called Flocculation
- Flocs are easier to filter due to their greater size and weight (chemical)

4. **SEDIMENTATION:**

- The flocculated water is passed through into large settling tanks and allowed to stand so the flocs and other particles settle to the bottom to form a sludge, which can be periodically removed and reused as compost
- About 95% of the suspended impurities are removed by sedimentation (physical)

5. **FILTRATION:**

- The water from the settling tanks is transferred to filtration tanks where layers of sand, gravel and anthracite coal filter the water of any remaining suspended materials
- Charcoal filters may also be used to remove coloured ions and coloured inorganic solutes
- By the end of this stage, the turbidity of the water is less than 0.5NTU

6. **pH ADJUSTMENT:**

- Water must be within the pH range of 6.5-8.5
- Na_2CO_3 is added for acidic water (corrodes pipes etc) and HCl is added for alkaline waters

7. **CHLORINATION & FLUORIDATION:**

- Water is sanitised/disinfected by adding gaseous chlorine, forming hypochlorite ions (ClO^-) to destroy pathogens e.g. bacteria (E. Coli), microbes and prevent the growth of algae
- Fluoride (in compounds like NaF, CaF_2) is added to the water in very small amounts (1ppm) to reduce tooth decay by strengthening tooth enamel