SNS COLLEGE OF TECHNOLOGY

Vazhiamyampalayam,Coimbatore-35

(An Autonomous institution)

Accredited by **NBA-AICTE** and Re-Accredited by **NAAC-UGC with A+ Grade**

Approved by **AICTE,** New Delhi & Affiliated to **Anna University**, Chennai

DEPARTMENT OF CHEMISTRY

COURSE NAME : 23CHT102- CHEMISTRY OF ENGINNERING MATERIALS

I YEAR / II SEMESTER

UNIT : 3. FUELS AND COMBUSTION

TOPIC : 7. COMBUSTION - ORSAT

BRAINSTORMING WITH RECAP

COMBUSTION

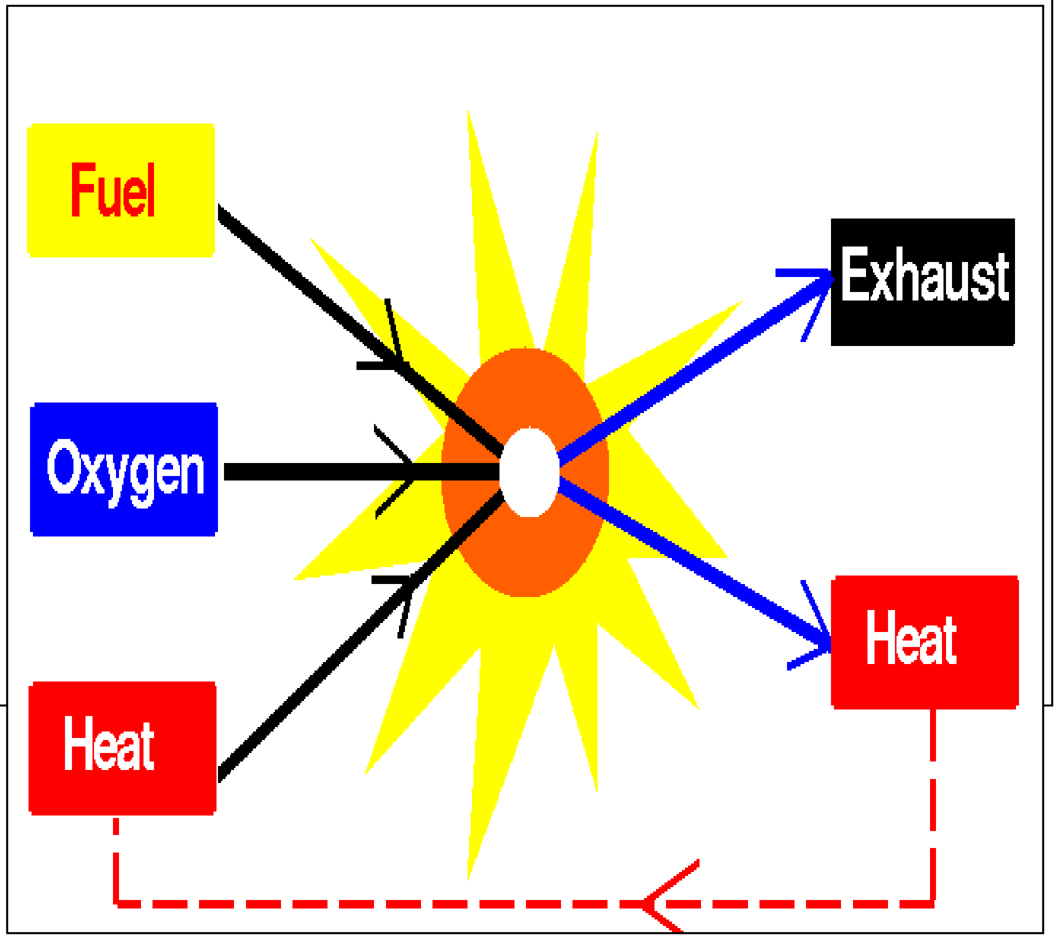
Combustion of a fuel

Combustion is a process of rapid exothermic reaction in which a fuel burns in the presence of oxygen with the liberation of heat.

Example: Combustion of carbon.

Factors : The rate of combustion depends on

- The nature of the fuel used
- The concentration of oxygen
- The surface area of the fuel
- Temperature
- Catalysts



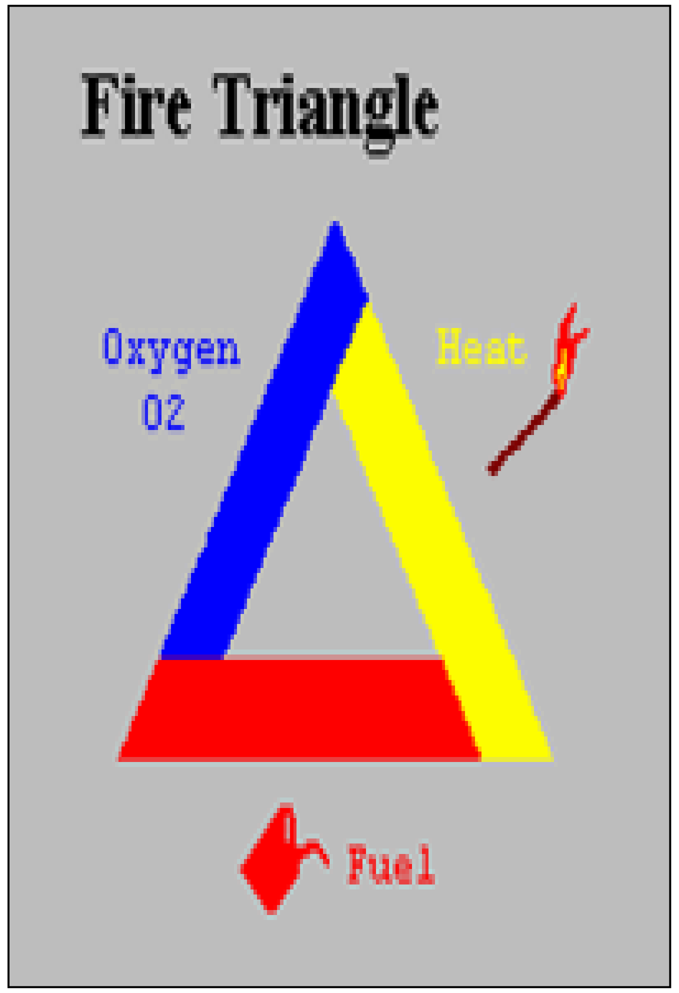
Catalyst.

- Increase the Temperature. ...
- Concentrate of the Reactants. ...
- Increase the Surface Area of the Reactants.

CALORIFIC VALUE

Definition

- The efficiency of a fuel is determined by its calorific value.
- The calorific value of a fuel is defined as "the total amount of heat liberated by the complete combustion of an unit mass of fuel".



Units of Calorific value

The quantity of heat can be expressed by the following units:

- **Calorie**: the amount of heat req. to raise the temp of 1g of water through 1^{o}C (25 – 26 ^{o}C).
- **Kilocalorie**: The amount of heat req. to raise the temp of 1kg of water through 1 ^{o}C.
- **British Thermal Unit (BTU)** :The amount of heat req to raise the temp of 1 pound of water through 1^{o}F (70 – 71 ^{o}F).
- **Centigrade Heat Unit (CHU)** : The amount of heat req to raise the temp of 1 pound of water through 1 ^{o}C.

The CV **solid and liq. fuels** are expressed in **cal./g or kcal./kg**. The CV of **gaseous fuels** are expressed in **kcal. /m^3.**

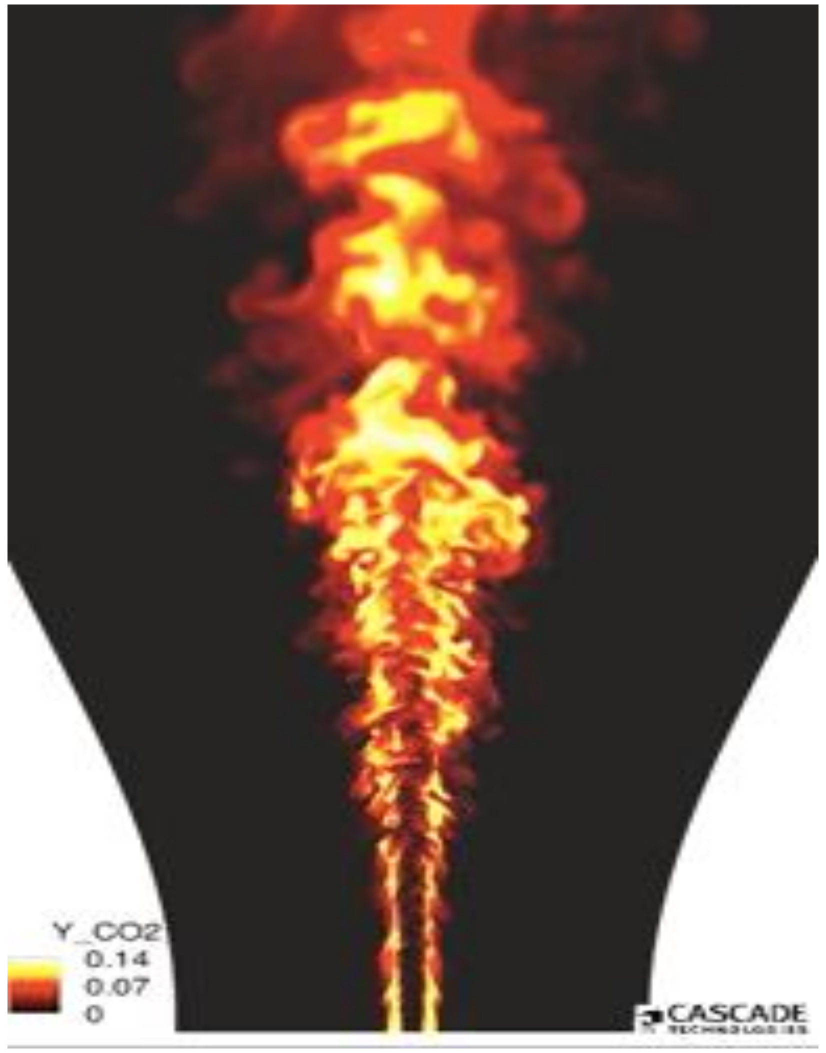
HCV (OR) GCV

Higher (or) Gross calorific value (HCV or GCV)

- When a fuel is burnt, the hydrogen is converted into steam.
- If the combustion products are cooled to room temperature, the steam gets condensed into water and latent heat is evolved.
- Thus, the latent heat of condensation of steam is also included in the calorific value determination which is called as higher calorific value or Gross Calorific value.

DEFINITION

- **GCV / HCV:** The total amount of heat produced, when a unit mass of the fuel is completely burnt and the products of combustion are cooled to room temperature.



Dulong's formula for calorific value from the chemical composition of fuel is:

HCV = 1/100 [8,080 C + 34,500 (H – O/8) + 2,240 S] kcal/kg

LCV OR NCV

- **Lower or Net Calorific value**
- In actual combustion practice, the products of combustion are not cooled to room temperature and are allowed to escape.
- As a result, only a lower amount of heat is available.
- The amount of heat so available is called lower or net calorific value
- The net calorific value is defined as the net heat produced, when a unit mass of the fuel is completely burnt and the products of combustion are allowed to escape.
- Net calorific value = HCV - Latent heat of condensation of water vapour produced
- **NCV = HCV - Mass of H per unit wt of the fuel burnt x 9 x Latent heat of condensation of water vapour**
- **LCV = [HCV - 9H/100 x 587] kcal/kg = [HCV - 0.09 H x 587] kcal/kg**

FLUE GAS ANALYSIS BY ORSAT APPARATUS

Flue gases.

- The mixture of gases such as CO_2, O_2, CO, etc., coming out from the combustion chamber.
- This analysis give an idea about the complete or incomplete combustion process.
- If the flue gases contain considerable amount of CO- incomplete combustion
- It contain a considerable amount of oxygen- complete combustion.
- The analysis of flue gas is carried out by using Orsat's apparatus.

Activity

- How can two people fairly share a cake with a single knife cut?

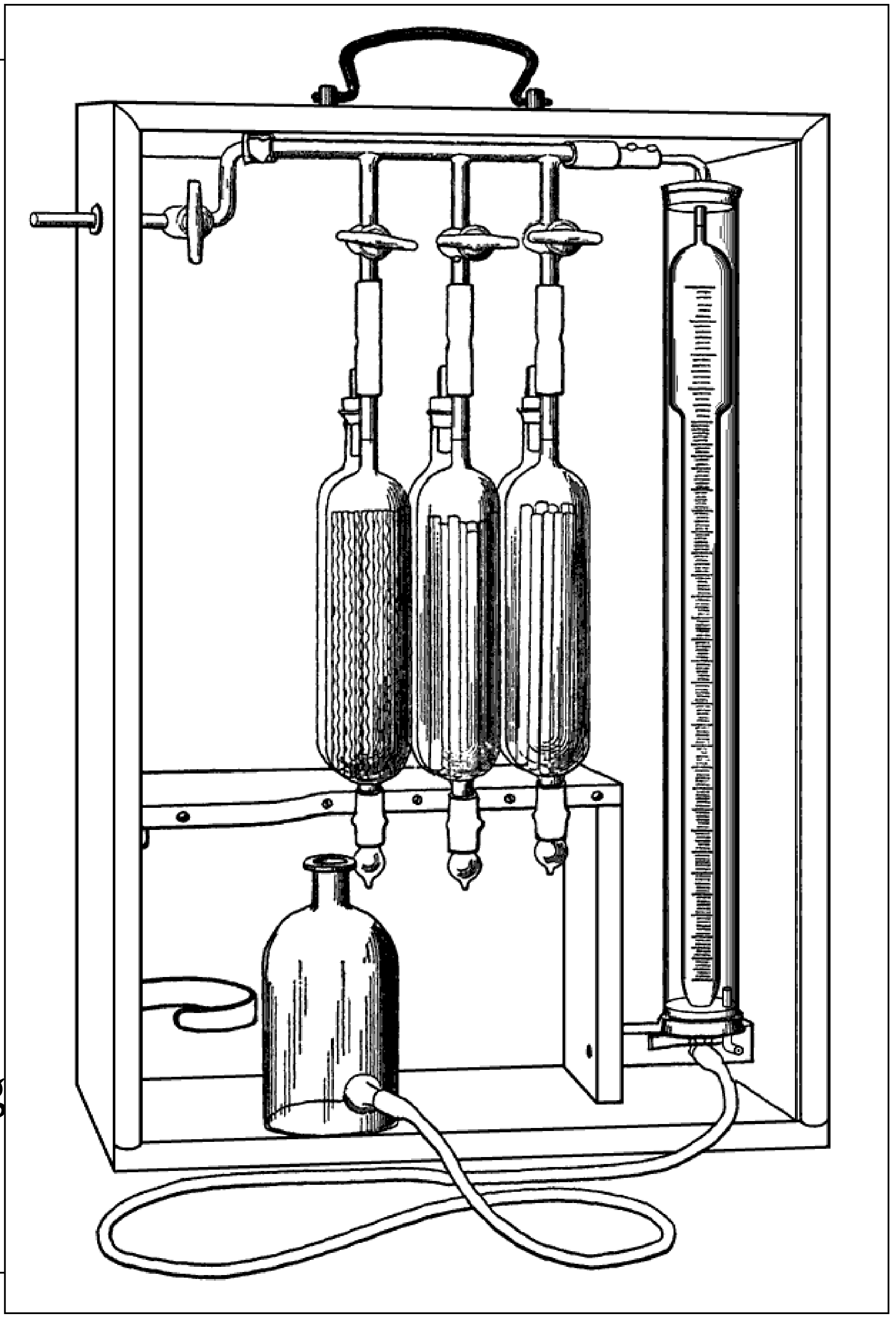
- What Can You Catch but Not Throw?

Ans : The first person begins by dividing the cake into two pieces. Then the second person chooses which piece they will take. This means both sides will be satisfied

Ans : Cold!

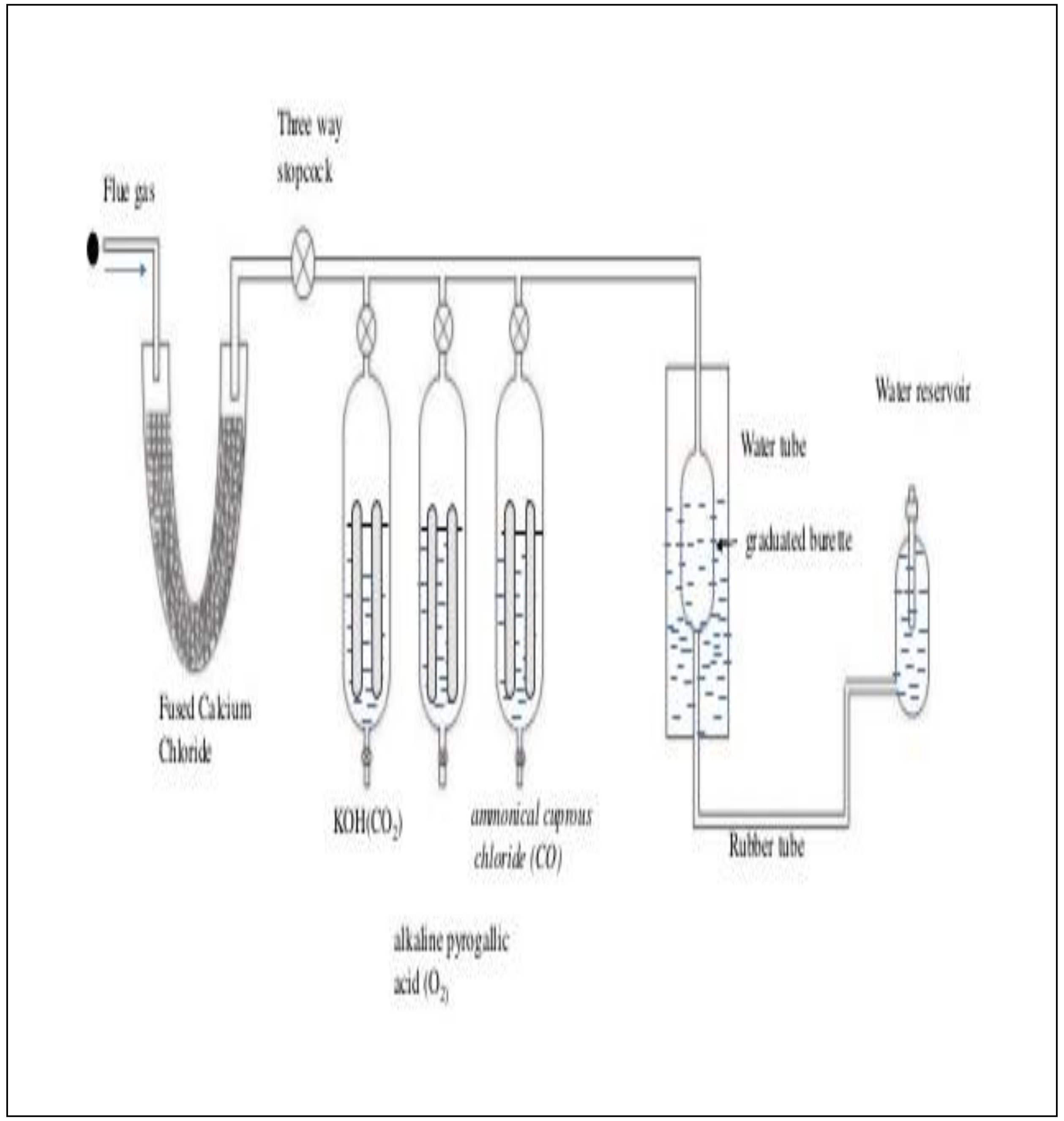
FLUE GAS ANALYSIS BY ORSAT APPARATUS

- It consists of a horizontal tube, having 3 way stopcock.
- At one end of this tube, U-tube containing fused $CaCl_2$ is connected.
- The other end of this tube is connected with a graduated burette.
- The burette is surrounded by a water-jacket to keep the temperature of gas constant.
- The lower end of the burette is connected to a water reservoir by means of a rubber tube.
- The level of water in the burette can be raised or lowered by raising or lowering the reservoir.
- The horizontal tube is also connected with 3 different absorption bulbs I, II & III for absorbing CO_2, O_2, CO.



FLUE GAS ANALYSIS BY ORSAT APPARATUS

- **Bulb- I:** KOH solution, & absorbs only CO_2
- **Bulb - II:** Alkaline pyrogallol' solution, & absorbs only CO_2 and O_2
- **Bulb: III:** Ammoniacal cuprous chloride' solution, &absorbs only CO_2, O_2 and CO.



Working

- The 3-way stopcock is opened to the atmosphere & the reservoir is raised, till the burette is completely filled with water & air is excluded from the burette.
- The 3-way stopcock is now connected to the flue gas supply, the flue gas is sucked into the burette & the volume of flue gas is adjusted to 100 cc by raising and lowering the reservoir.
- Then the 3-way stop cock is closed.

FLUE GAS ANALYSIS BY ORSAT APPARATUS

Absorption of CO_2 .

- The stopper of the bulb-1 containing KOH solution is opened and all the gas is passed into the bulb-1 by raising the level of water in the burette.
- The gas enters into the bulb-I, where CO_2 present in the flue gas is absorbed by KOH.
- The gas is again sent to the burette.
- This process is repeated several times to ensure complete absorption of CO_2.
- The decrease in volume of the flue gas in the burette indicates the volume of CO_2 in 100 cc of the flue gas.

FLUE GAS ANALYSIS BY ORSAT APPARATUS

Absorption of O_2

- Stopcock of bulb-I is closed and stopcock of bulb-II is opened.
- The gas is again sent into the absorption bulb-II,
- Where O_2 present in the flue gas is absorbed by alkaline pyrogallol (925 g of pyrogallol + 200g of KOH in 500 ml distilled water).
- The decrease in volume of the flue gas in the burette indicates the volume of O_2.

FLUE GAS ANALYSIS BY ORSAT APPARATUS

Absorption of CO

- Now stopcock of bulb-II is closed and stopcock of bulb-Ill is opened.
- The remaining gas is sent into the absorption bulb-III,
- Where CO present in the flue gas is absorbed by ammoniacal cuprous chloride (100 g $CuCl_2$ + 125 mL liquor ammonia + 375 mL distilled water).
- The decrease in volume of the flue gas in the burette indicates the volume of CO.
- The remaining gas in the burette after the absorption of CO_2, O_2 and CO is taken as nitrogen.

FLUE GAS ANALYSIS BY ORSAT APPARATUS

Importance and Significance of Flue gas analysis

- Flue gas analysis gives an idea about the complete or incomplete combustion process of a fuel.
- If there is a presence of CO in flue gas, it indicates that incomplete combustion of fuel.
- It reveals the short supply of O_2.
- If there is a presence of oxygen in flue gas which ensures the complete combustion of fuel and excess supply of O_2.

ASSESSMENT

1. **Draw the ORSAT apparatus with complete parts**

2. Draw the Dulong's formula for HCV & LCV.

SUMMARY

REFERENCES

1. O.G. Palanna, “Engineering Chemistry ”Tata McGraw-Hill Pub. Co. Ltd, New Delhi.2017.
2. Wiley, “Engineering Chemistry”, John Wiley & Sons. InC, USA.
3. P.C.Jain & Monicka Jain, “Engineering Chemistry” , Dhanapat Rai Publising Company Pvt. Ltd. 2017.
4. R. Sivakumar and N Sivakumar, “Engineering Chemistry” Tata McGraw-Hill.Pub.Co.Ltd. New Delhi.2009.

THANK YOU