

INDIAN INSTITUTE OF TECHNOLOGY

DATE 07/1/19

Exp 10(a) :- Determination of water content
in an oil by Dean & Stark Apparatus.

SHEET NO. 2

OBJECTIVE :- To measure the moisture content of the given liquid fuel sample by Dean and Stark Apparatus

THEORY :- The solubility of water in oil is quite low (0.005 - 0.05)

under ordinary conditions. It may however be present in the dispersed state upto 1%. There are two methods

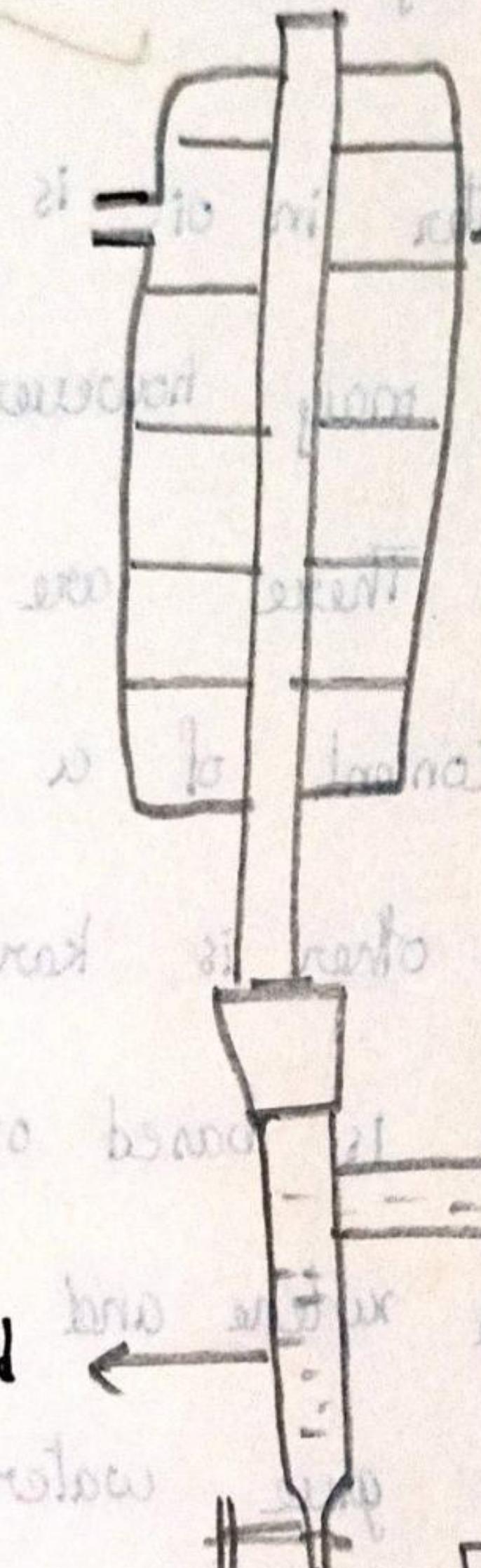
to determine the moisture content of a liquid fuel, one is Dean and Stark method and the other is Karl Fischer method

Dean and Stark method is based on the azeotrope.

Forming property of water with xylene and benzene. The distilled vapour on condensing give water as separate layer and can be measured

Apparatus Required :-

- (1) Dean and Stark Apparatus
- (2) Pipette
- (3) Measuring cylinder



Condenser

Received
Water

solution

heater

Procedure: (i) 50ml toluene and 5ml water were taken in a round bottomed flask and heated for 45min. The amount of water in distillate was read from the graduated stem of the apparatus and efficiency of the apparatus was determined.

(ii) A mixture of 50ml test sample (kerosene oil), 50ml toluene and 5ml water was taken into the same round bottom flask and heated for 45min. The amount of water collected is taken note. ✓

OBSERVATION:

- (i) Volume of water collected = 4.5ml
(ii) Volume of water collected in distillate = 4.8ml

Calculation:-

5ml of water was used initially.

$$\text{efficiency of the apparatus} = \frac{4.5}{5} \times 100 = 90\%.$$

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 4

In 2nd step amount of water = 4.8 ml

$$\text{Water recovered from kerosine} = \frac{4.8 - 4.5}{0.9}$$

$$= 0.33 \text{ ml}$$

Result: Amount of water in kerosine is 0.33 ml / 50 ml of kerosine

Dissussions:

(i) In first step, a mixture of 5 ml of water and 50 ml of Xylene is taken in Dean and Stark apparatus. After the process only 4.5 ml of water was received. This leads to the conclusion that the efficiency of the Dean and Stark apparatus is 90% (not 100%).

(ii) The deviation from the 100% efficiency of the apparatus might have occurred due to the following reasons.

- > The system was open to the surroundings. Thus, some amount of vapour might have escaped from the system during the experiment

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 5

(a) Water wets the tube along the walls during the heating process. Therefore some of the water in the form of droplets may cling to the wall.



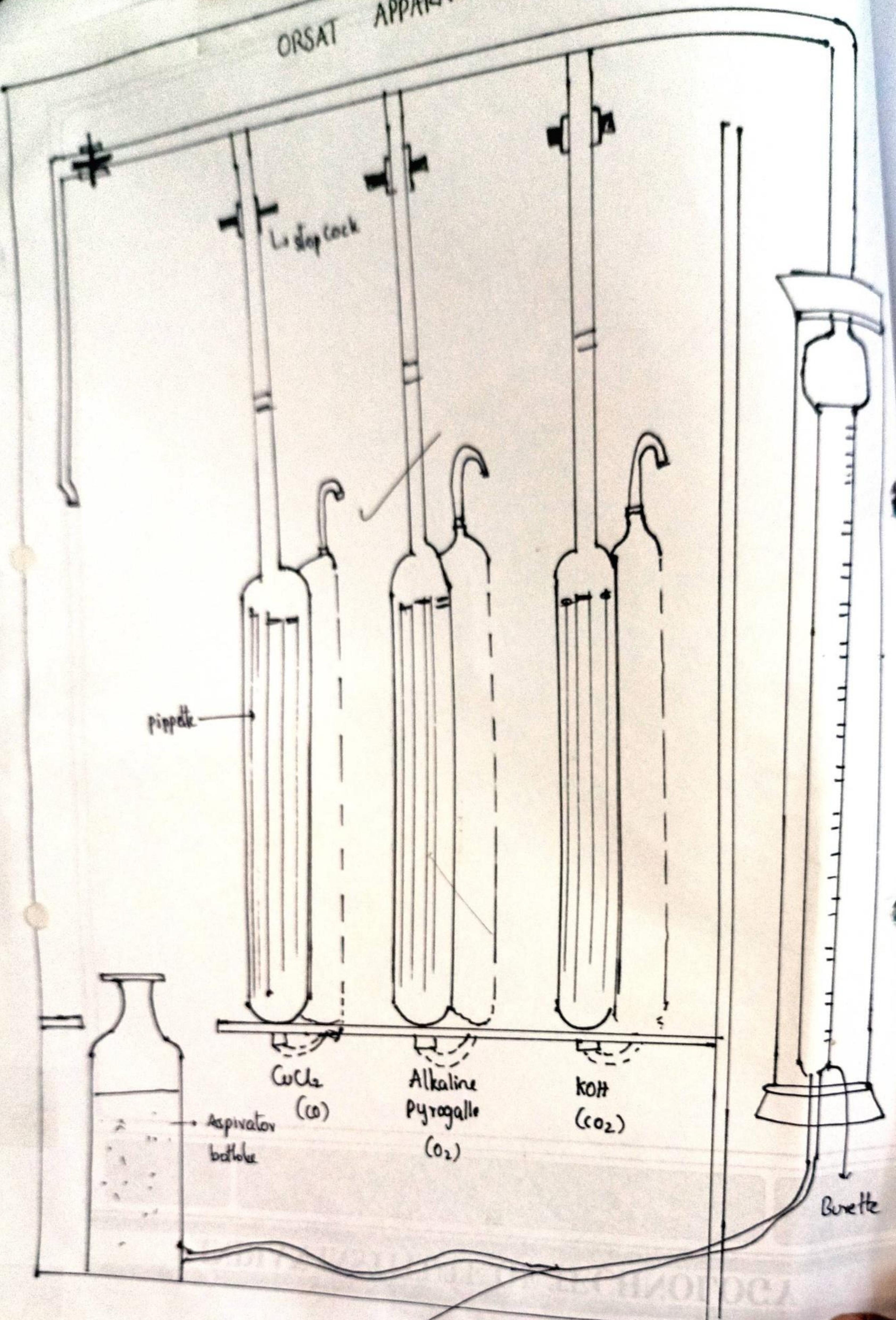
(b) In the 2nd part of the experiment, 50ml of kerosine as well as a mixture of 50ml of Xylene and 5ml of water in Dean and Stark apparatus.

This is done to reduce the error. Kerosine contains relatively very less amount of water. Thus if only kerosine was subjected to distillation there may be a greater amount of water that have escaped from system.

But we have taken both kerosine and the xylene & water the error was reduced and % error is less now.

✓
Shubham
14/1/19

ORSAT APPARATUS



INDIAN INSTITUTE OF TECHNOLOGY

DATE 7/1/19

Experiment 106) Orsat Analysis of fuel gas.

SHEET NO. 6

Objectives + To analyse air and fuel gas with the help of orsat apparatus.

Theory + The composition of fuel gas is determined by analysis in a standard apparatus known as the orsat apparatus.

The orsat analysis normally reports the percentage quantities of carbon dioxide, carbon monoxide and nitrogen. provisions can also be made for using the apparatus for more complex analysis, namely, ascertaining the quantities of hydrogen, methane and unsaturated hydrocarbons.

The analysis is made on the volumetric measurement of the gas at constant pressure. This method consists of the removal of the components of the mixture successively by selective absorption from a known volume of original gas and noting its volume after removal of each component.

P.R.E.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 7

APPARATUS & ORSAT APPARATUS

The apparatus consists of a burette graduated from the bottom upwards into 100 divisions, an aspirator bottle, a series of pipettes having necessary fittings and a three-way stop cock connecting the top of the burette to the gas stream. Each pipette contains an absorbent for removing one gas. The absorbents used are KOH soln., alkaline pyragollol and ammonical CuCl_2 for removal of $\text{CO}_2, \text{O}_2, \text{CO}$.

PROCEDURE The aspirator bottle is first raised so as to fill the burette completely with a solution containing NaCl & $\text{K}_2\text{Cr}_2\text{O}_7$. The three way stop cock is turned to draw the gas into the burette through smoke filter by lowering the aspirator bottle. The operation is repeated two or three times to purge the system.

P.R.E.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 3

Before closing the cock, the water of the burette is adjusted exactly to the zero mark where the level of liquid inside the burette and the aspirator bottle is the same. The measured gas sample is passed into the first pipette containing KOH solution by opening the stopcock and raising the aspirator bottle. By lowering the bottle again the gas is brought back into the burette. This operation is repeated until there is no further change in the level of water in the burette. The new level is now noted, the difference being the % volume of CO_2 present. The same procedure is followed for second and third pipette to know the % volume of O_2 and CO_2 respectively.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 9

Observation :-

Air collected = 100ml

Composition	Initial reading (ml)	Final Reading (ml)	difference Total volume (ml)	% of composition
CO ₂	0.0	0.2	0.2	0.2%
O ₂	0.0	20.1	20.1	20.1%
CO	20.1	20.2	0.1	0.1%

Composition of air :-

CO₂ - 0.2%

O₂ - 20.1%

CO - 0.1%



Composition	Initial (ml)	Final (ml)	Volume (ml)	% of composition
CO ₂	0.0	2.2	2.2	2.2%
O ₂	2.2	18.2	16	6%
CO	18.2	18.4	0.2	0.2%

P.R.E.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 10

Result:-

The fuel gas sample contains

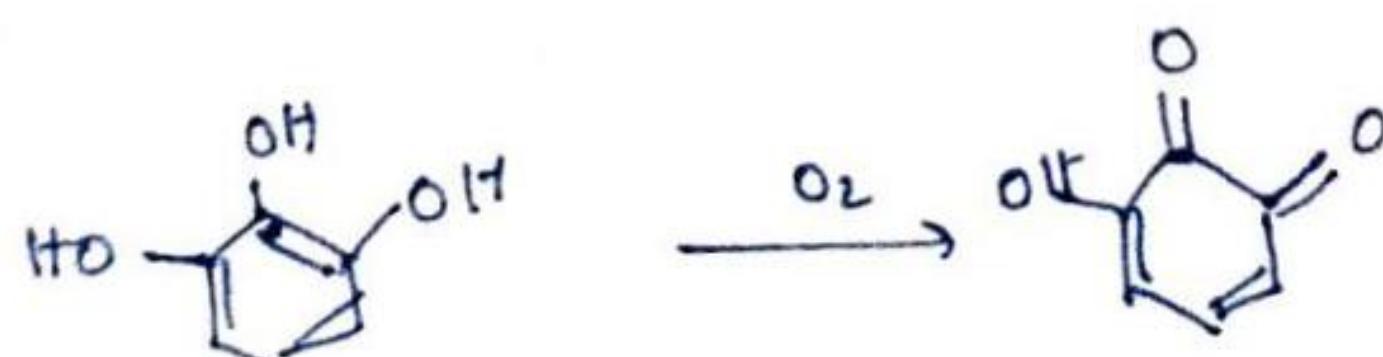
2.2% of CO_2 basis N_2 ??

16% of O_2

0.2% of CO

Discussion

The experiment is dependent on selective absorption of gases. In the experiment potassium hydroxide is used for absorption of carbon dioxide, alkaline pyrogallol for O_2 and ammonial cuprous chloride for carbon monoxide.



INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 11

(2) In first step, air sample is analysed. This is done to make sure that the apparatus is working properly or not. One conclusion can be drawn from the result, that the gases which are present in very small proportions e.g. CO_2 can not be eliminated using this method.

(3) The certain order of analysing is followed because the component gases may react unintentionally with other absorbents, leading to wrong result

(4) Some glass sticks are dipped inside the absorbent solution to ensure more surface area for absorption.
Shubham
14/1/19

INDIAN INSTITUTE OF TECHNOLOGY

DATE 14-1-19

Experiment 1: Determination of ASTM distillation characteristic of gasoline

SHEET NO. 12

OBJECTIVE:- Determination of distillation characteristics (boiling, volatility) of petroleum product using ASTM methods (D-86). The boiling range gives information on the composition the properties and the behavior of fuel storage and use.

Theory: (Terminology) :-

- charge volume : n - the volume of the specimen , 100ml, changed to the distillation flask at specified temperature
- Decomposition : n. of a hydrocarbon , the pyrolysis or cracking of a molecule yielding smaller molecules with lower boiling points than the original molecule.
- Decomposition Point : n - the corrected thermometer reading that coincides with the first indication of thermal decomposition of the liquid in the flask.
- Dry Point : n - the corrected thermometer reading that is observed at the instant the last drop of liquid

P.R.E.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 13

evaporated from the lowest point in the distillation flask.

Dynamic Holdup: n- the amount of material present in the neck of the flask, in the side-arm of the flask, and in the condenser tube during the distillation.

Emergent Steam Effect: n- the offset in temperature reading caused by the use of total immersion mercury glass thermometer in the partial immersion made.

END POINT: n- the maximum corrected thermometer reading obtained during the test. This is also called the final boiling point.

INITIAL BOILING POINT: n- the corrected thermometer reading that is observed at the instant the first drop of condensate falls from the lower end of the condenser tube.

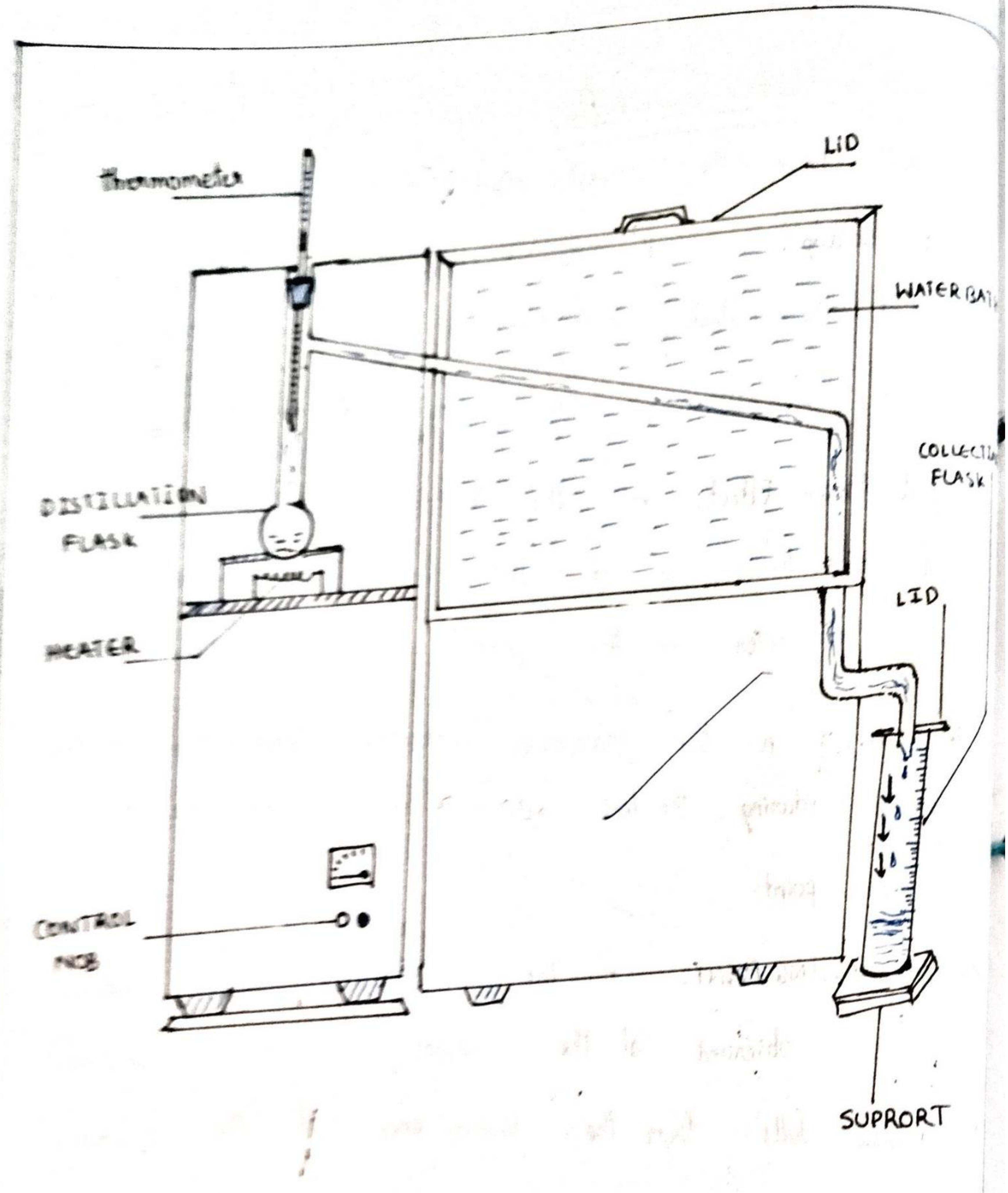


Fig 2 Experimental setup.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 14

APPARATUS :- (i) Distillation flask
(ii) Thermometer
(iii) Electric heater
(iv) Water bath
(v) Collection cylinder and measuring cylinder
(vi) Funnel.

PROCEDURE : A 100ml specimen of the sample () was distilled under the prescribed condition, systematic observations of temperature readings and volumes of condensate were made. The volume of the residue and the losses are also found. The temperature reading that was observed at the instant of the first drop of condensate falling from the lower end of the condenser tube was noted. This temperature is known as initial Boiling temperature (I.B.P). The volume of the condensate obtained in the receiving cylinder expressed as a percentage of the change in volume is

P.R.E.

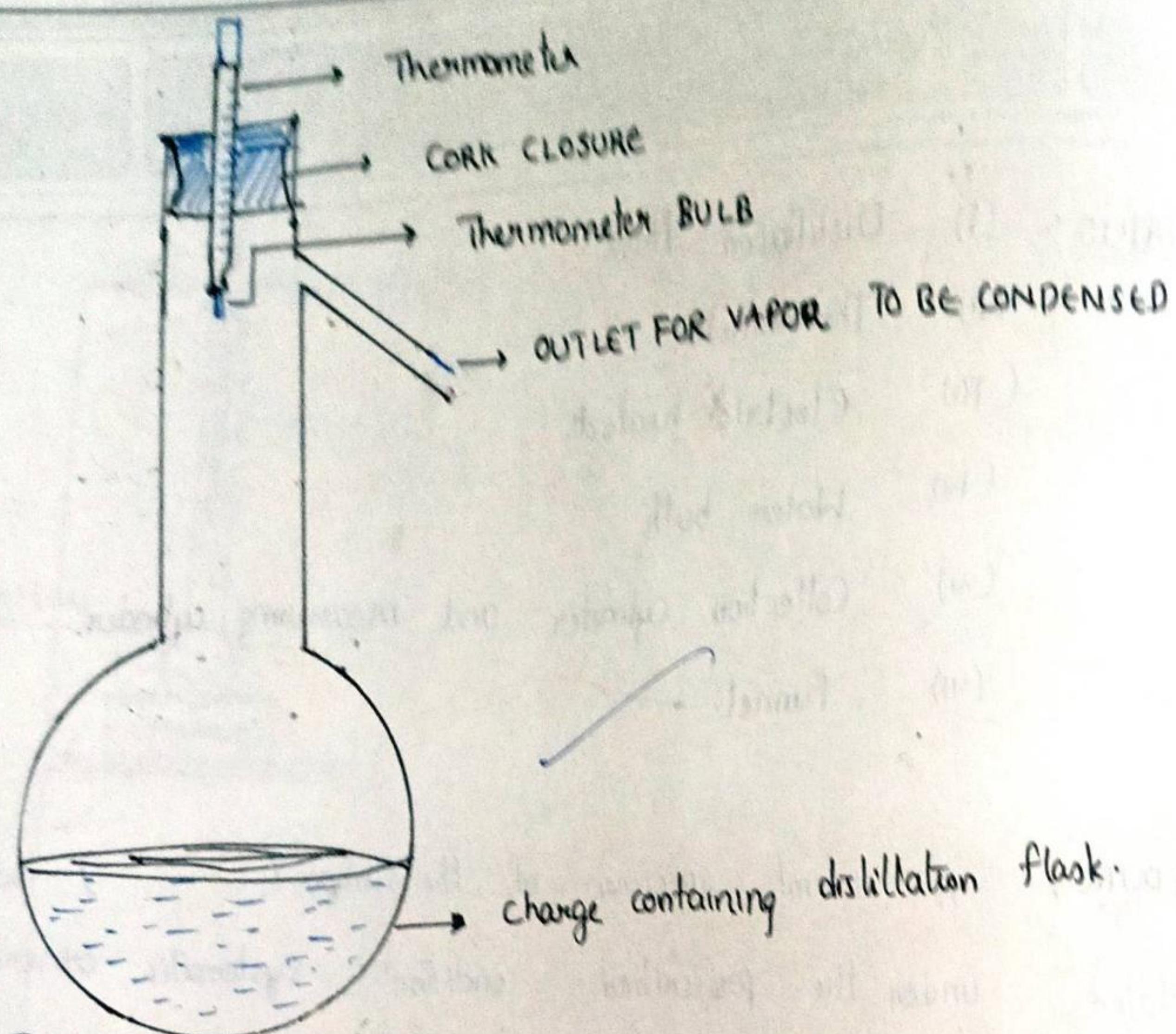


Fig. 2

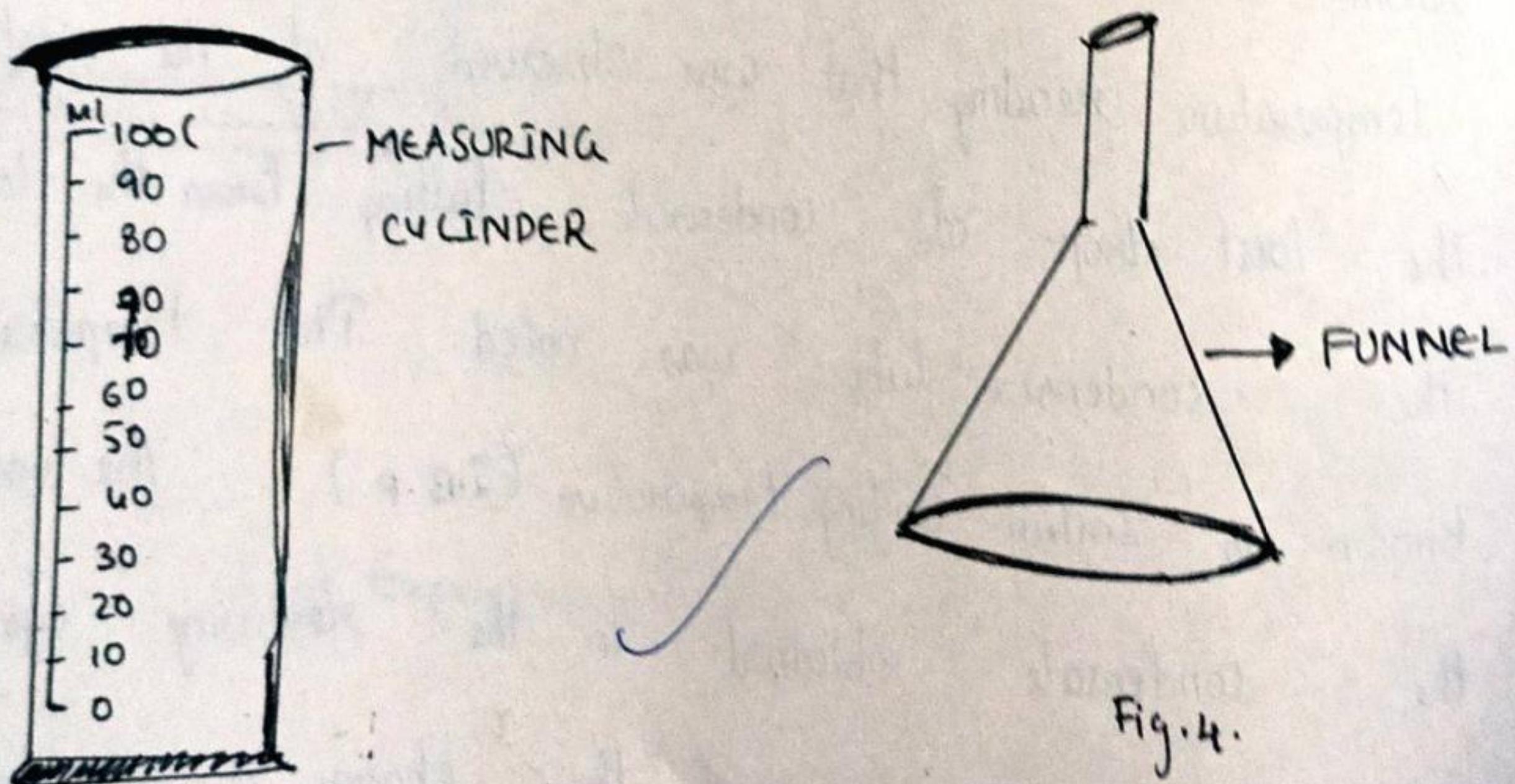


Fig. 3

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 15

called "percent recovered distillate". The maximum thermometer reading obtained during the test is called "final Boiling point"
(F.B.P)

OBSERVATION:-

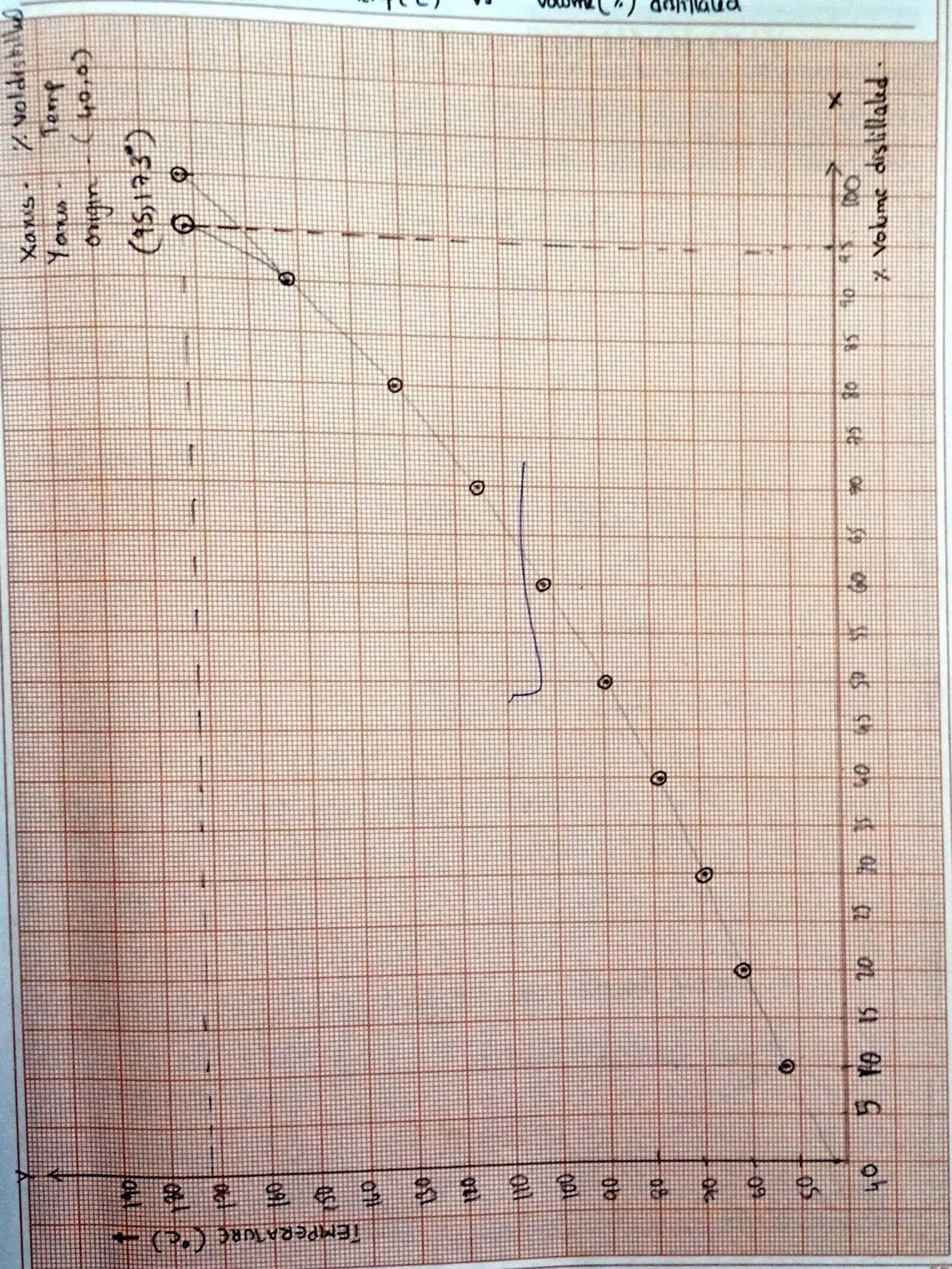
Initial Boiling Point :- 41°C

Table:-

VOLUME (%)	TEMP ($^{\circ}\text{C}$)
0	41°
10%.	53°
20%.	61°
30%.	68°
40%.	77°
50%.	89°
60%.	102°
70%.	116°
80%.	132°
90%.	153°
95%.	173°

P.R.E.

PLOT of Temp($^{\circ}\text{C}$) vs Volume(%) distilled



INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 16

Final B.pt = 173°C , Dry Point = 71°C

Volume of Recovered distillate - 95ml

Volume of Residue left - 1.2 ml

CALCULATIONS

$$\% \text{ of distillate recovered} = \frac{95 \text{ ml}}{100 \text{ ml}} \times 100 = 95\%$$

$$\begin{aligned} \text{Loss during the distillation} &= 100 - (95 + 1.2) \\ &= 3.8 \text{ ml} \end{aligned}$$

$$\% \text{ of loss} = \frac{3.8 \text{ ml}}{100 \text{ ml}} \times 100 = \underline{\underline{3.8\%}}$$

RESULTS Initial Boiling Point - 41°C

Final Boiling Point - 173°C

$$\% \text{ loss} = 3.8\%$$

The test results are plotted on percent recovered vs corresponding temperature graphically (distillation curve).

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 17

DISCUSSION :

- ① The distillation (volatility) characteristics of hydrocarbons have an important effect on their safety and performance, especially in the case of fuels and solvents.
- ② The boiling range gives information on the composition, the properties, and the behaviour of the fuel during storage. In the industries like HPCL, ONAC and various petrochemical industries.
- ③ Volatility as it effects rate of evaporation, is an important factor in the application of many solvents, particularly those used in paints.
- ④ Distillation limits are often included in petroleum product specifications, in commercial contract agreements, process refinery / control applications and for compliance to regulatory rules.
- ⑤ Characteristic indications of thermal decomposition are evolution of fumes and erratic temperature readings.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 18

- that usually decrease after any attempt is made to adjust the heat.
- In the course of experiment, we ignored the fact that ambient pressure is not exactly equal to (atm &r) 101.3 kPa. But the standard condition mentioned in D-86 method of ASIM incorporates the pressure to be 101.3 kPa as standard. Thus there should be some corrections to be considered in results.
- ASTM D standards originally known as the American Society for Testing and Materials is an international standards organization that develops and publishes voluntary consensus technical standards for a wide range of materials, products, systems and services.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

2

Exp. 2(a): Determination of REID Vapor pressure
of gasoline sample.

SHEET NO. 19

OBJECTIVE :- This method is intended to determine vapor pressure vapor of volatile, non-viscous petroleum product except liquified petroleum gases, for which it gives low results. A modification to the method permits its application to blends containing alcohols or others water-soluble materials. In this case gasoline is used for test.

THEORY :- ASTM D323 test method covers procedures for the determination of vapour pressure of gasoline, volatile crude oil and other volatile petroleum products. The procedure is not applicable to liquefied petroleum gases or fuels containing oxygenated compounds other than methyl t-butyl ether (MTBE). Because the external atmospheric pressure is counteracted by the atmospheric pressure initially present in the vapor chamber, the Reid vapor pressure is an absolute pressure at 37.8°C in kilo pascals (psi).

FIG. VAPOR PRESSURE TEST APPARATUS

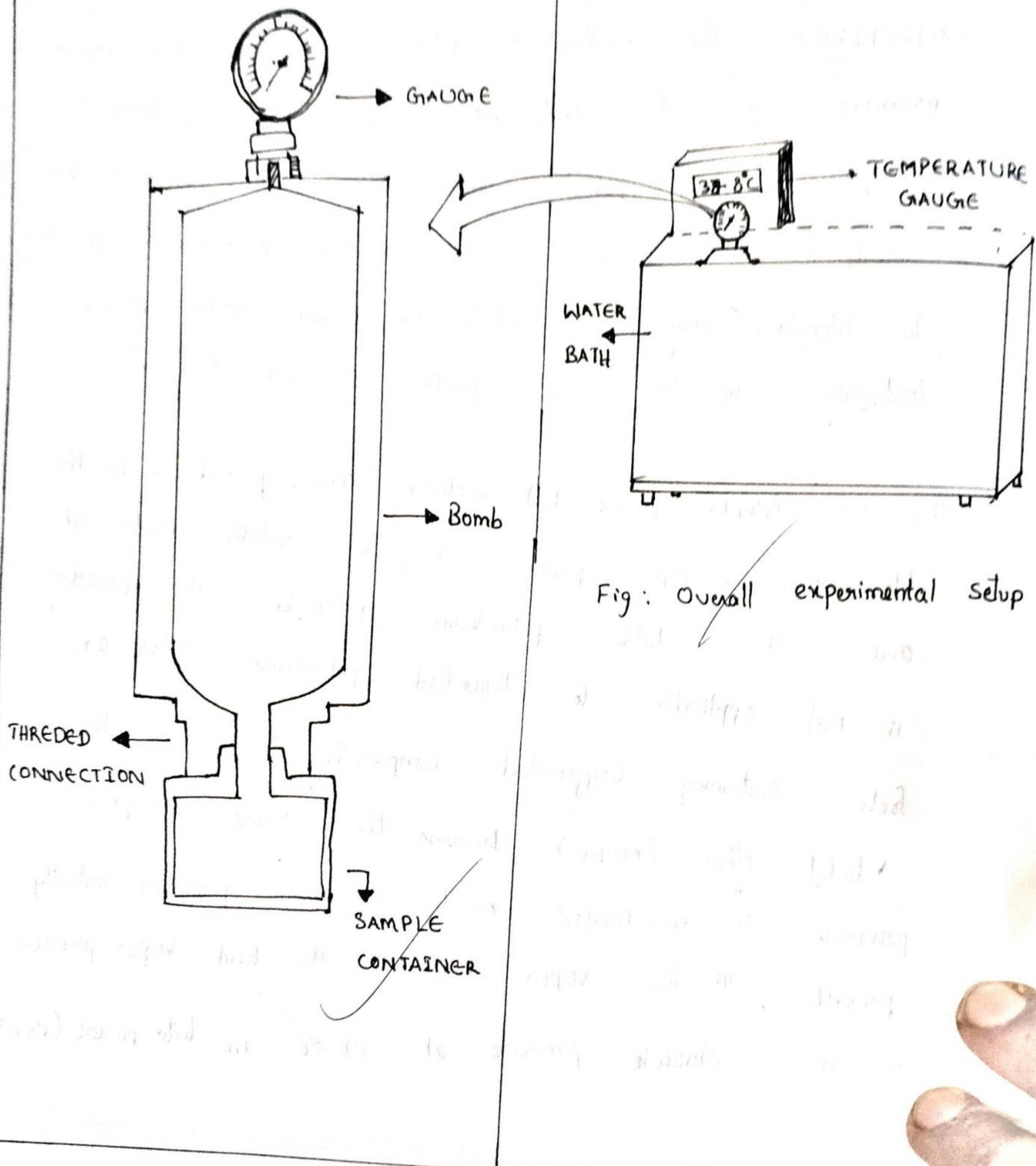


Fig: Overall experimental setup

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 20

APPARATUS:

- (i) Gasoline - chamber (vapor - pressure bomb)
- (ii) Air chamber (The upper part of the vapor pressure bomb, a cylindrical vessel)
- (iii) A Bourdon - type of spring gauge
- (iv) Water bath (maintained at $38.0^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$)

PROCEDURE:

- (i) The liquid sample container was cleaned thoroughly and gasoline sample was filled up to brim
 - (ii) The water bath is heated and maintained at $\sim 38^{\circ}\text{C}$
 - (iii) Both the Reid vapor pressure apparatus are shaken well to get rid of liquid bubbles.
- Temp = 38°C (100°)

Vapour pressure (Psi)

2.5

3

3.5

6

7

7

OBSERVATION:

Time (min)

5

8

11

14

17

20

P.R.E.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 21

Reid Vap. Pressure = 7 Psi

RESULT :

Observed Reid Vapor pressure for the given gasoline sample is 31.0264 kPa (4.5 Psi).

DISCUSSION :

Reid Vapor pressure (RVP) - is the absolute vapor pressure of a volatile fuel at 37.8°C (100°F) as evaluated using ASTM method D 323A. For oxygenate blends use ASTM method D 4953.

The term dry vapor pressure equivalent (DVPE) is often used interchangeably. DVPE and RVP values for a fuel sample are close but not identical. ISO 3007-1999 is the RVP test procedure used in Europe.

RVP is the most commonly used metric in discussing gasoline vapor pressure and its regulation.

P.R.E.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 2

- High RVP compounds are needed for vehicle starting and warm up of spark ignition engines.
- RVP is controlled to reduce vapor lack concerns for fuel systems where they still exist.
- Most of the RVP is provided by isomers of propane, butane and pentane. Butane is blended in various proportions to adjust RVP.
- However, most of liquid gasoline itself is comprised of heavier molecular weight compounds such as larger chain alkanes and aromatics.
- Vapor pressure for a given batch of gasoline is finished by adding the needed amount of butane.
 - n butane 52 psi RVP
 - iso butane 71 psi RVP

✓ Vapor source
precaution used
- RVP control reduces upstream and mid stream gasoline vapor emission (distribution, storage) and vehicle emissions.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

Experiment: ab: Determination of flash point
of an oil by Pensky Martens apparatus

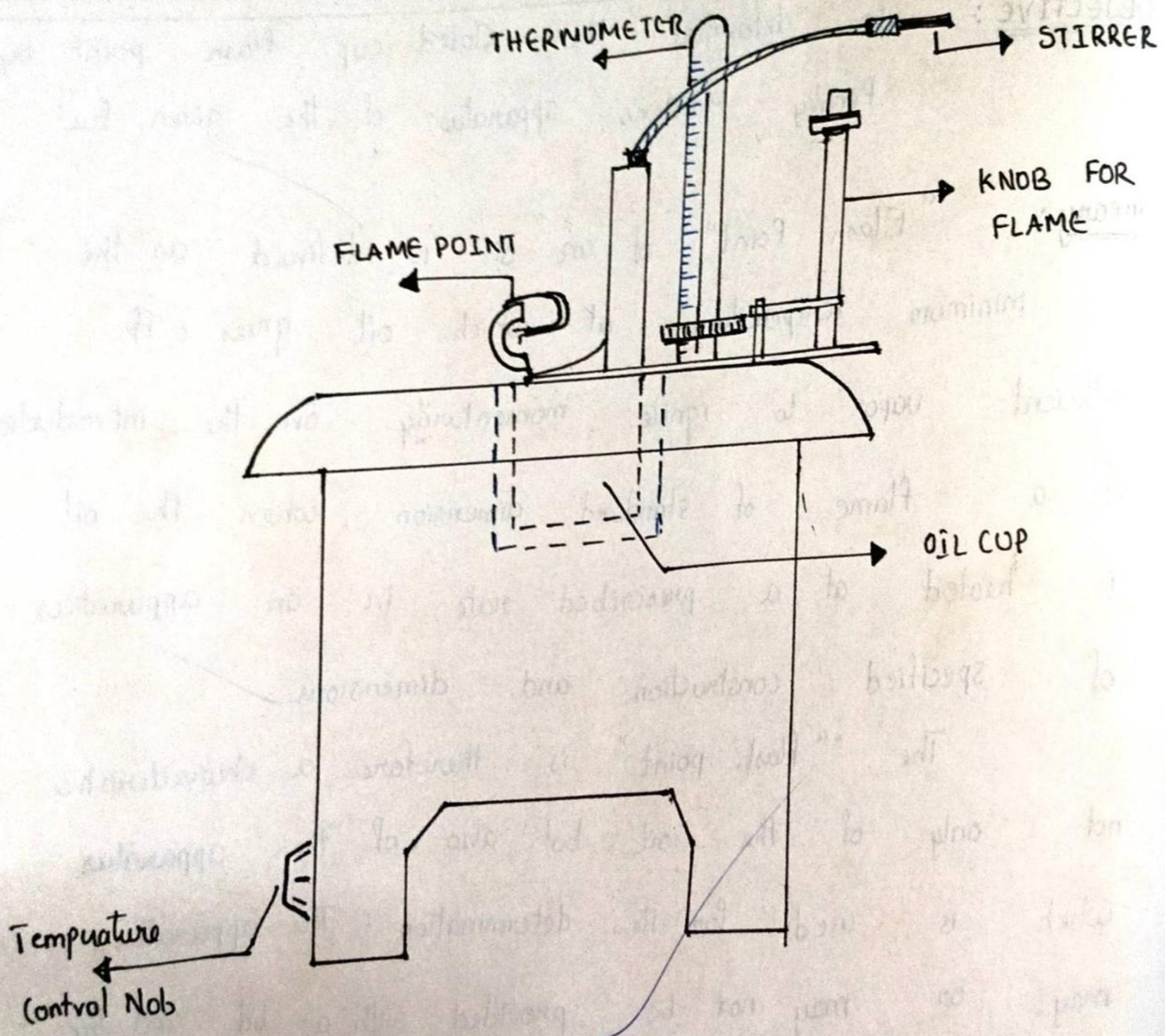
SHEET NO. 23

OBJECTIVE: To determine the closed - cup flash point by Pensky - Martens apparatus of the given fuel

Theory: "Flash Point" of an oil is defined as the minimum temperature at which oil gives off sufficient vapor to ignite momentarily on the introduction of a flame of standard dimension, when the oil is heated at a prescribed rate in an apparatus of specified construction and dimensions. The "flash point" is therefore a characteristic not only of the oil, but also of the apparatus which is used for its determination. The apparatus may or may not be provided with a lid and the "flash - point" is correspondingly called "closed" or "open". There are two forms of standard apparatus specified by Institute of petroleum (U.K)

P.R.E.

Fig. Penley - Marten Apparatus



APPARATUS ↗

- (i) Pensky - Marten closed cup arrangement
- (ii) Bunsen Burner
- (iii) Thermometer
- (iv) Stirrer

PROCEDURE: The oil cup was cleaned, dried and filled upto the given mark. The lid is placed in position, the thermometer is inserted in the thermometer holder and the cup is put in position. The test flame is adjusted to the size of a bid., 6mm in diameter. Heating is standard and continued at a rate of 9 to 11°F per minutes and stirrer is rotated at an rpm of 60 to 120. Stirring at a temperature of at least 30°F below the "flash-point". The test flame is applied at temperature intervals of 2°F. Stirring should be stopped when the test flame is applied at temperature intervals of 2°F. Stirring should be stopped when the test flame is applied.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 25

The temperature at which a distinct flash is visible with characteristic sound is noted for two observations.

OBSERVATION :-

Material Taken :- Kerosine Oil

Pressure :- 756 mm Hg

Temperature (°C)	Observation
35	No
36	No
37	No
38	No
:	
43	Flash point observed

RESULT :- Flash point of a given sample (Kerosene) = 45.5°C

The flash point is the lowest temperature

DISCUSSION :- The vapors of a volatile material will ignite at which it will be given an ignition source. The when flash point may be confused with the auto ignition

P.R.E.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 26

temperature which the vapor will ignite spontaneously without any ignition source. The fire point is the lowest temperature at which the vapor will keep burning after being ignited and the ignition source is removed. The fire is higher than the flash point, because at the flash point the vapor may be reliably expected to cease burning when the ignition source is removed. Neither flash point nor the fire point depends directly on the ignition source temperature, but it may be understood that ignition source temperature will be considerably higher than either the flash or fire point.

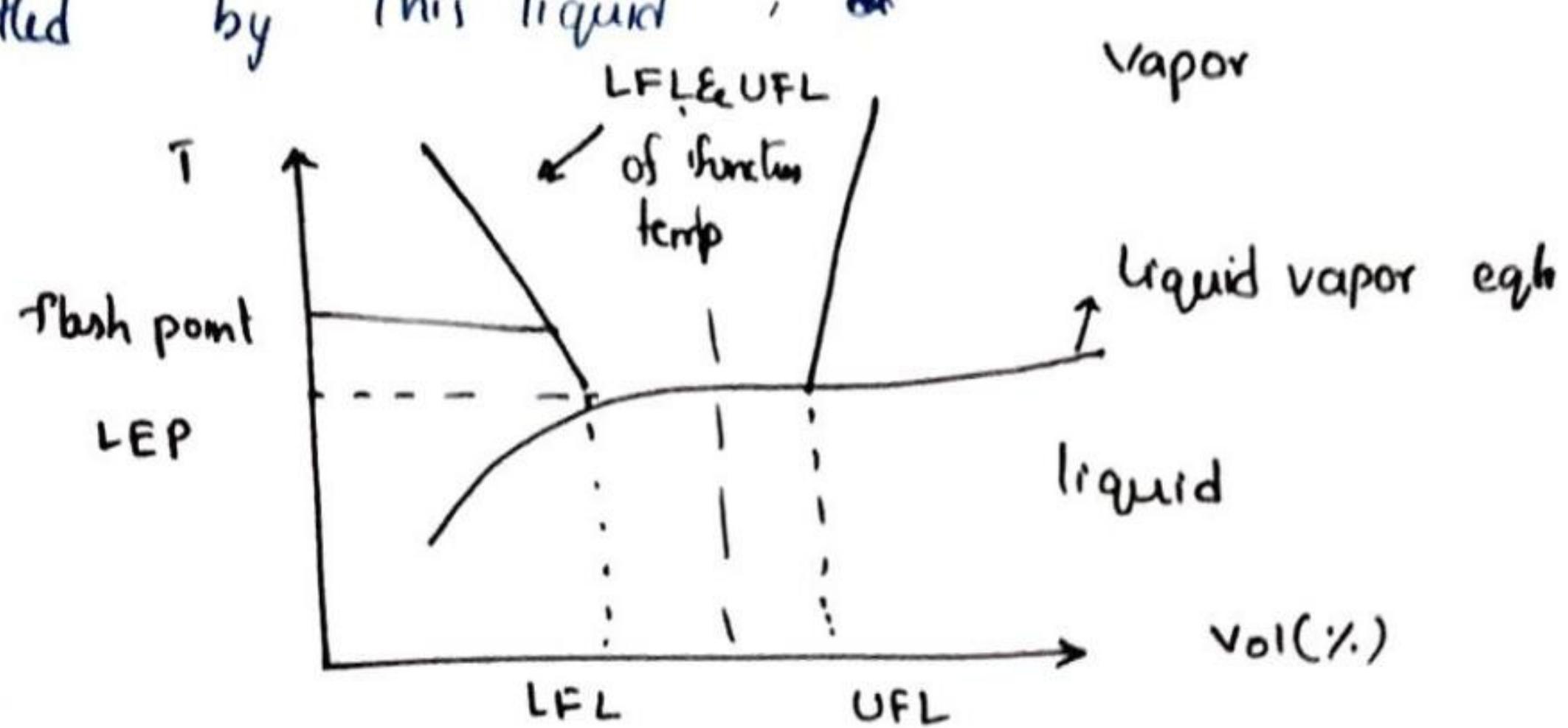
The experimental determination of flash point is described in many national and international standards which differ in their scope and in the specified conditions we bullet points
Precautions?

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 7

The lower point of explosion (LPE) of a liquid is defined as the temperature at which the concentration of vapors emitted by this liquid, in thermodynamics liquid vapors emitted by this liquid.



~~FOOT~~

Fuel	Flash point	Auto ignit Temp
Ethanol	16.6°C	363°C
Gasoline	-43°C	280°C
Diesel	> 52°C	256°C
Jet fuel	> 38°C	210°C
Kerosene	> 38.7°C	220°C
Bio diesel	> 130°C	-
Vegetable Oil	> 327°C	424°C

P.R.E.

INDIAN INSTITUTE OF TECHNOLOGY

DATE 20/3/17

Experiment 3 : Determination of Gum content
(existent) in petrol sample.

SHEET NO. 28

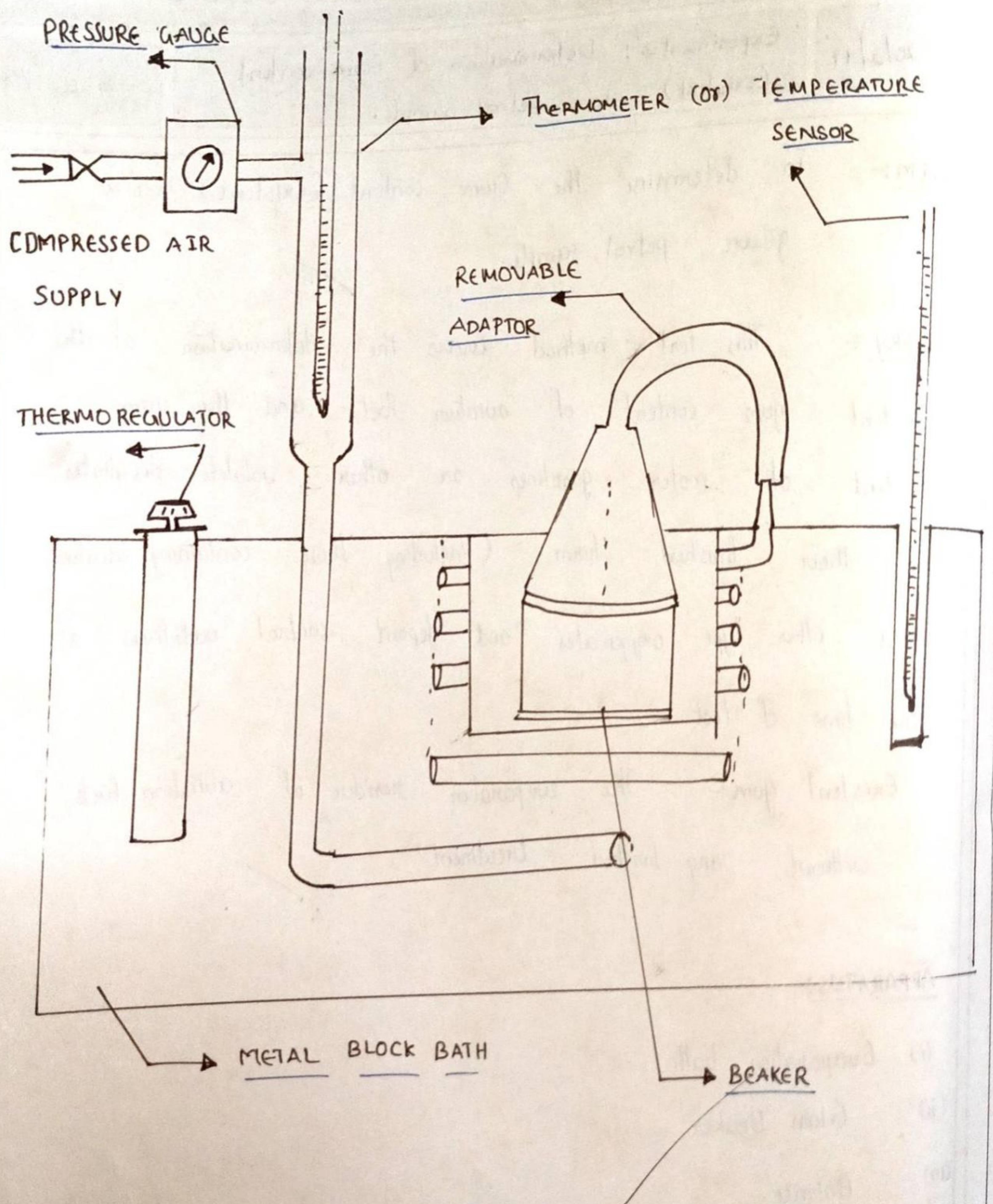
AIM To determine the Gum content (existent) in a given petrol sample.

THEORY :- This test method covers the determination of the existent gum content of aviation fuel, and the gum content of motor gasolines or other volatile distillates in their finished form, (including those containing alcohol and other type oxygenates and deposit control additives) at the time of test.

Existent gum:- The evaporation residue of aviation fuels, without any further treatment.

APPARATUS:

- (i) Evaporation bath,
- (ii) Glass Beaker
- (iii) Balance.



► Fig. Setup for determination of Gum Content in a gasoline sample

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 29

PROCEDURE: The beakers were cleaned with the solvent (ethanol) until free from gums and dried in oven. Weight of the test beakers were weighed nearest O ring 5ml of gasoline (petrol) was taken in each beaker using conical measuring jar. Then the beakers were weighed again Now using conical jet air nozzles, the sample petroleum was evaporated with hot air. Air temperature and pressure were maintained at a certain constant value. Finally the empty beakers (after evaporation of liquid petrol) were weighed.

OBSERVATION:-

Sno	Wt of empty Beaker (g)	Wt of Beaker + Petroleum	Wt of beaker after evaporation
1.	55.681	58.982	55.682
2.	54.173	57.692	54.172
3.	55.871	59.362	55.873
4.	60.088	68.467	60.090
5.	45.692	49.174	45.693

P.R.E.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 30

Specific Gravity Bottle :-

$$\text{wt of empty bottle} = 31.926 \text{ g}$$

$$\text{wt of after adding sample} = 67.936 \text{ g}$$

$$\text{density} = \frac{67.936 - 31.921}{50 \text{ ml}} = 0.7202 \text{ g/ml}$$

Calculation

For data set 3

$$m_{\text{empty}} = 55.681 \text{ g}$$

$$m_{\text{G + Petrol}} = 58.982 \text{ g}$$

$$m_{\text{beaker after evopovat}} = 55.682 \text{ g}$$

$$\begin{aligned} \text{Existent gum content of beaker 1} &= 55.682 - 55.681 \\ &= 0.001 \text{ g} \end{aligned}$$

$$\text{volume of petrol} = \frac{58.982 - 55.681}{0.7202} = \frac{3.301}{0.7202} = 4.58 \text{ ml}$$

$$\text{Gum content / 100ml Sample} = \frac{100 \times 0.001}{4.58} = 0.021 \text{ g}$$

P.R.E.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 31

S.no.	mass of gasoline(m)	Volume of gasoline = $\frac{m}{p}$ (ml)	Gum content/ml	Gum content per 100 ml
1	3.301 g	4.58 ml	0.001g	0.0218g
2	3.519 g	4.88 ml	0.001g	0.0204g
3	3.491 g	4.84 ml	0.002g	0.0413g
4	3.379 g	4.69 ml	0.002g	0.0426g
5	3.482 g	4.83 ml	0.001g	0.0207g

Average Gum Content =
$$\frac{0.0218 + 0.0204 + 0.0413 + 0.0426 + 0.0207}{5}$$

= 0.02936g / 100ml gasoline sample

RESULT: Existant Gum Content in given sample

= 0.029 g / 100ml of sample.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

DISCUSSION :- Gasoline is a volatile mixture of hydrocarbons that is used in spark-ignition engines. It is a complex mixture composed of olefin, paraffin, naphthenic, and aromatic hydrocarbons (C_6-C_{12}), among other substances in a smaller concentration. In several countries, such as Brazil, ethanol is used as a renewable fuel for SI engines. During storage some classes of hydrocarbons in gasoline blends particularly olefins and diolefins, are able to slowly react, at ambient temperatures, with the oxygen in air. The formed oxidation products are responsible for the formation of an insoluble solid commonly called gums/deposits. Consequently it is necessary to predict gasoline blend behavior and prevent gum formation, improving gasoline quality and using additives. Even if the number of publications dedicated to gum content formation in gas gasoline blends is reduced, results available in the literature for other fuels can be applied to gasoline issue. ✓

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

The gum content can be used to judge the quality of various products. The amount of gum indicates the condition of the sample at the time of measurement. Large quantities of gum are an indicator for the contamination of fuel caused by higher boiling oils or particles. Since the gum content can change according to the age of the fuel and the exposure to oxygen, the reported content is only true at the time of measurement.

Generally the gum content reflects inappropriate production process and poor fuel handling in the refinery or the storage facility. The amount of gum should be as low as possible since the use of fuels with high gum content can lead to deposits in induction systems or cause intake valves and fuel injections to stick.

According to the fuel specifications ASTM D1655 and ASTM D4814 the limitations for the gum content are 7 mg per 100ml for aviation fuel & 5mg /100ml for motor gasoline

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO. 35

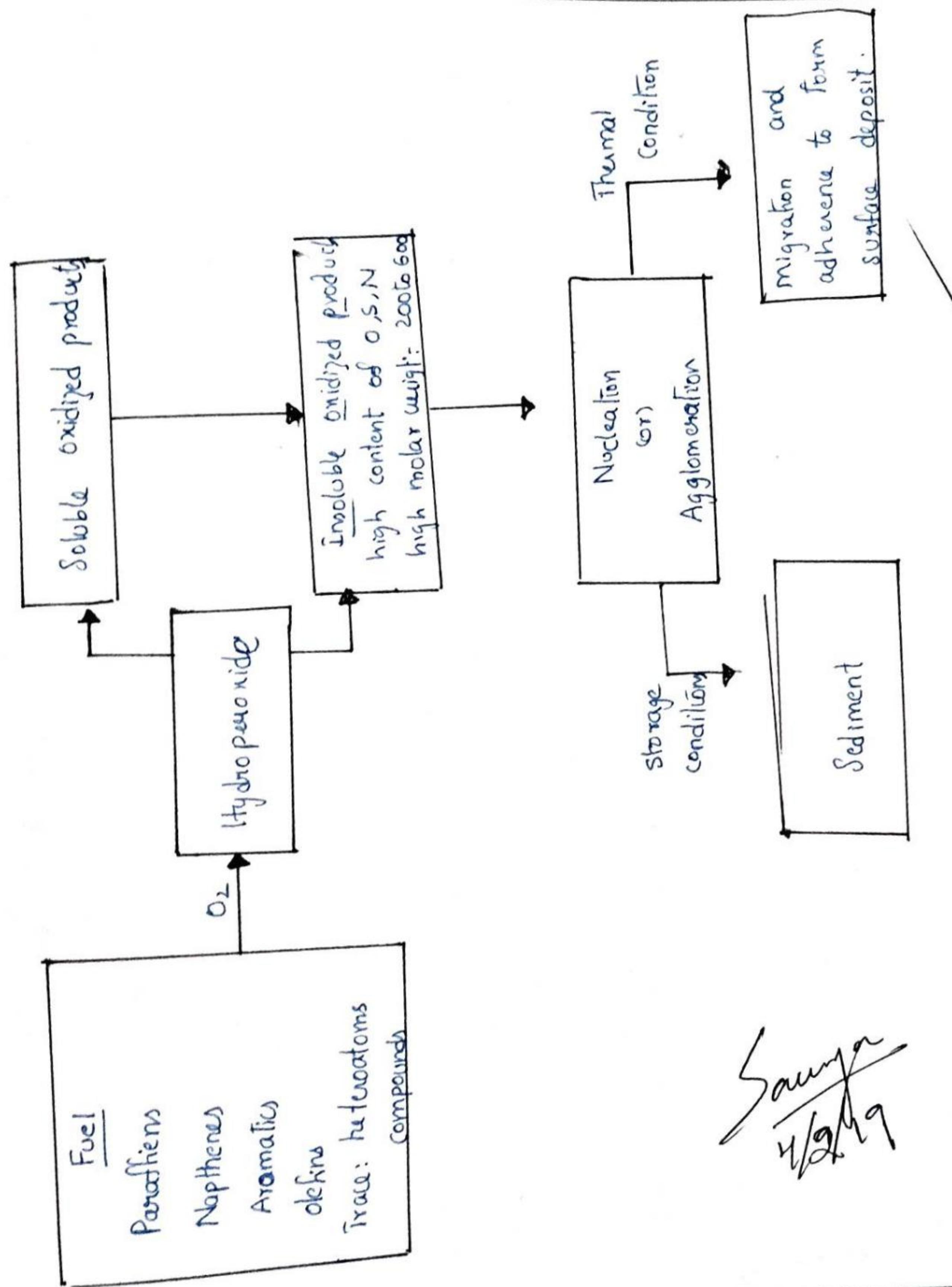


Fig: Formation of Gum.

~~Sawyer~~
1/9/19

P.R.E

INDIAN INSTITUTE OF TECHNOLOGY

DATE

Experiment 4-a. Determination of smoke point of kerosine

SHEET NO. 36

OBJECTIVE:-

Determination of smoke point of kerosine.

THEORY:-

The smoke point is the maximum flame height in millimeters at which kerosine will burn without smoking, tested under standard conditions, this test method provides an indication of the relative smoke producing properties of kerosene and aviation turbine fuels in diffusion flame. The smoke point is related to the hydrocarbon type composition of such fuels. Generally more aromatic the fuel more the fuel is smokier. A high smoke point indicates a fuel of low smoke producing tendency.

APPARATUS

- (i) Smoke point Lamp
- (ii) wick
- (iii) Oil container

①

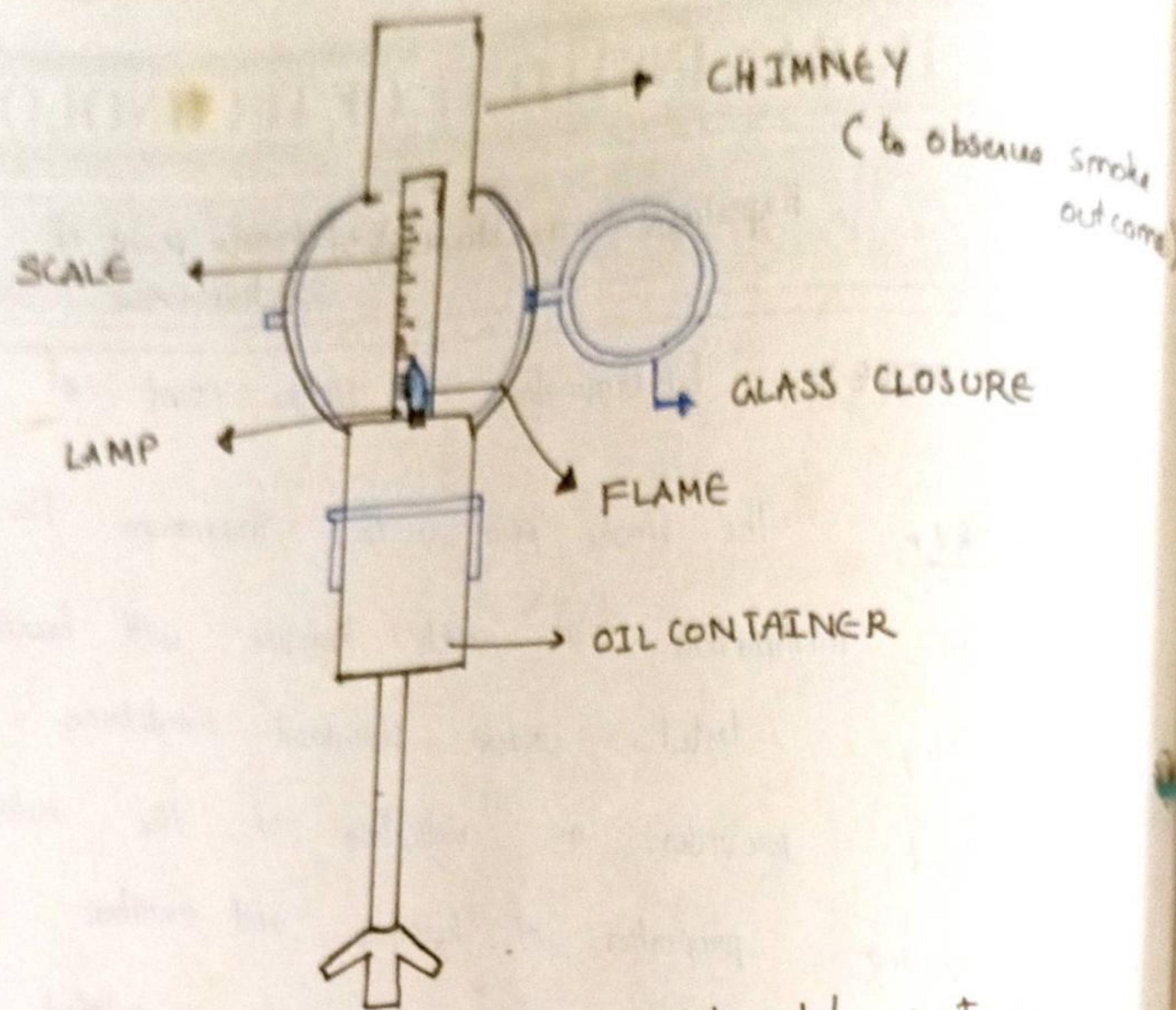


Fig. Apparatus for smoke point determination.

②

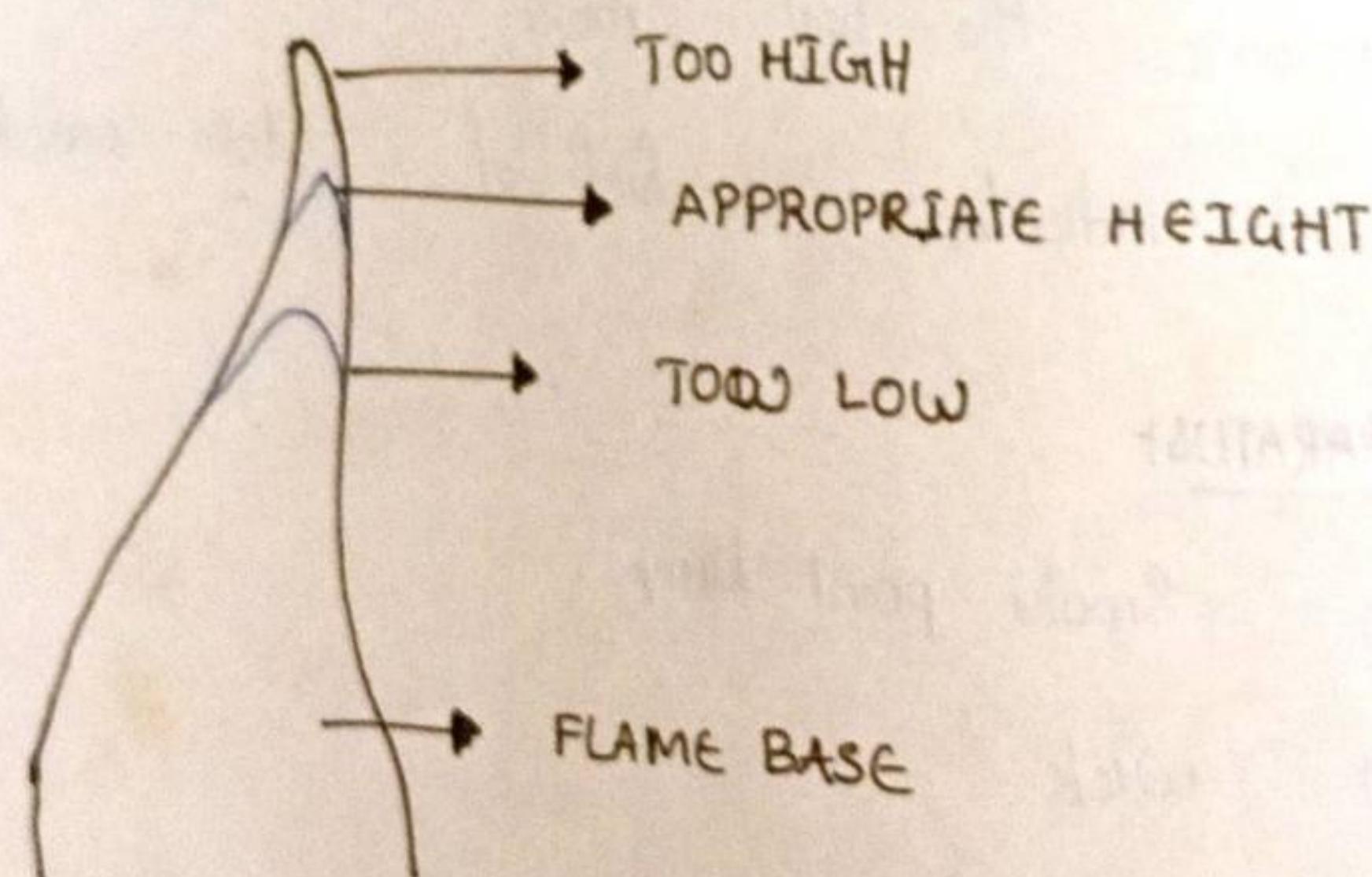


Fig. Typical FLAME APPEARANCE

PROCEDURE: 20ml of kerosene was taken in the clean dry oil container. A wick was taken out and soaked in sample. The wick was placed properly in the holder. Then the wick was horizontally trimmed and was made free of frayed end. Then the oil container was properly placed inside the lamp. The wick was raised gradually up to a certain height so that smoke started to form beyond that form. Height of the flame, which was maximum without any smoke was noted. The steps from trimming the wick twice to generate three readings were performed.

OBSERVATIONS:

Sno	FLAME height(mm) at smoke point
1.	23
2.	24
3.	23

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

CALCULATION :-

Average Flame height at smoke point

$$\frac{23 + 24 + 23}{3} = 23.33 \text{ mm}$$

 $\approx 23 \text{ mm}$ (near by integer)RESULT :- Flame height at smoke point for the given sample is23 mm.DISCUSSIONS :-

- The smoke point test is very important in evaluating the quality of petroleum products such as kerosine and aviation turbine fuels, because it detects undesirable components of fuel such as aromatic compounds and sulfur. When the sample contains big amount of aromatic compounds such as benzene, toluene, it produce a lot of smoke in a short time and the smoke point would be small.

- It is quantitatively related to the potential radiant heat transfer from the combustion products of the fuel. Because radiant heat transfer exerts a strong influence

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

on metal temperatures of combustion liners and other hot section parts of gas turbines, the smoke point provides a basis for correlation of fuel characteristics with the life of these components.

In order to improve the smoke point of kerosine, smoking tendency should be decreased. This can be done by increasing paraffinic contents of kerosine and also by decreasing the ratio C/H of kerosine. Kerosene hydrotreating plays an important role in improving the smoke point of kerosine. Hydrotreating is to upgrade raw kerosene distillate to produce specification products suitable for marketing as kerosene and jet fuels. Sulphur and mercaptans in the raw kerosene cuts coming from the crude distillation unit can cause corrosion problems in aircraft. Nitrogen in the raw kerosene feed from crude oil may cause color stability problem.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

Exp-4-b

Determination of Conradson Carbon Residue

SHEET NO.

OBJECTIVE: To determine Conradson carbon residue of a heavy oil sample.

APPARATUS +

- (1) Skid more Iron Crucible
- (2) HOOD
- (3) BURNER

THEORY: This test method covers the determination of the amount of the amount of carbon residue left after evaporation and pyrolysis of an oil and is intended to provide some indication of relative coke-forming propensities. This test method is generally applicable to relatively non-volatile petroleum product which partially decompose on distillation at atmospheric pressure. Petroleum products containing ash-forming constituents as determined by the test method will have an erroneously high carbon residue depending upon the amount of ash formed.

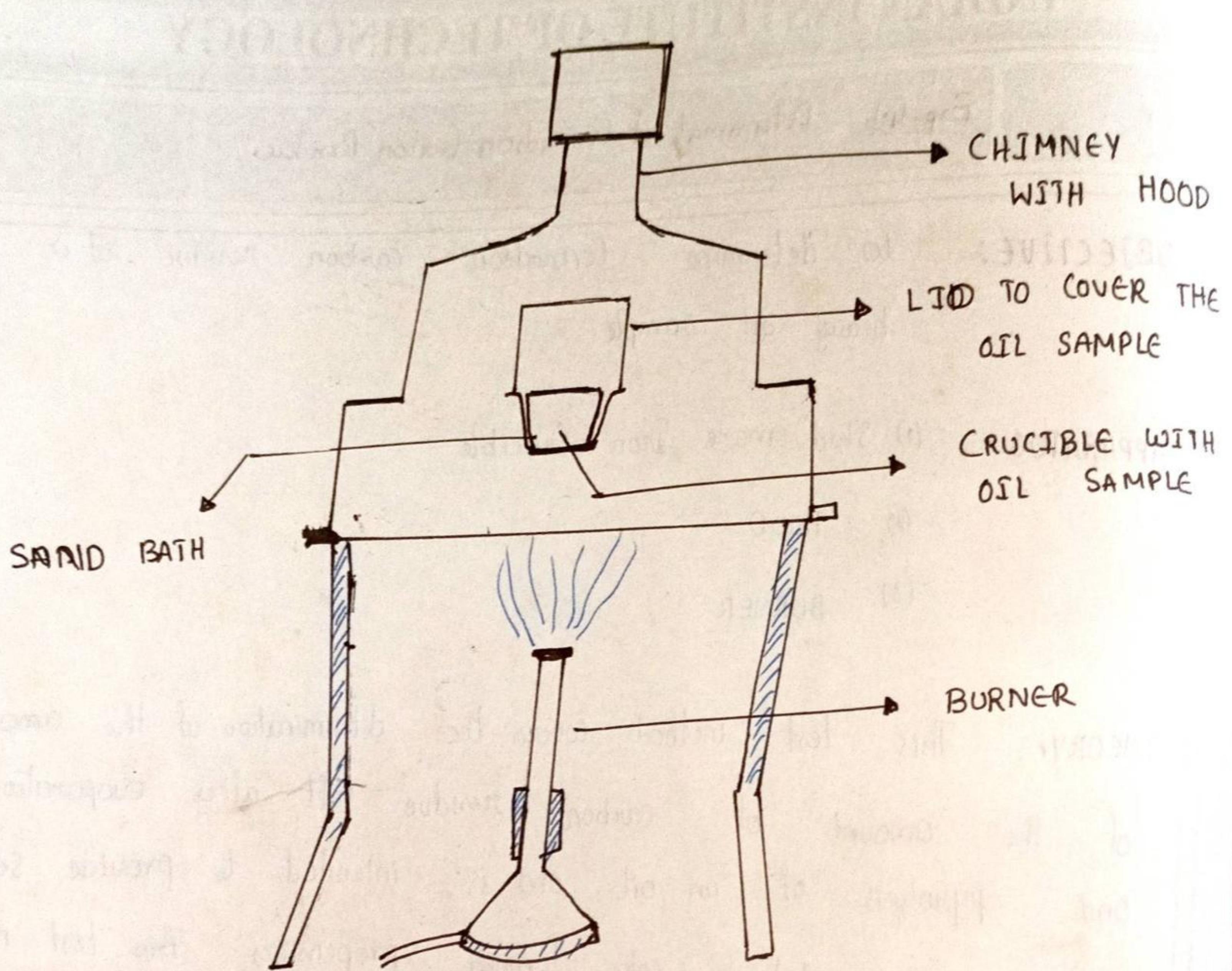


Fig. Apparatus for Cannadon - Carbon Residue determination.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

PROCEDURE:- (i) Oil sample was weighed and taken in a crucible by a mass of ~ 5 grams.

(ii) The crucible was placed inside sand bath and covered by a chimney and hood.

(iii) The entire setup was placed on a suitable stand.

(iv) The setup was strongly heated for 30 minutes with help of gas burners.

OBSERVATIONS +

$$\text{Mass of empty crucible} = 67.972\text{g}$$

$$\text{Mass of crucible + heavy oil sample} = 73.002\text{g}$$

$$\text{Mass of heavy oil} = 73.002 - 67.972 = 5.03\text{g}$$

$$\text{Mass of crucible+carbon residue} = 68.154$$

$$\text{Mass of carbon residue} = 68.154 - 67.972 = 0.182\text{g}$$

$$\% \text{ Carbon Residue} = \frac{0.182}{5.03} \times 100 = 3.618\%$$

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

RESULT

Conradson Carbon residue in the heavy oil sample is 3.58%.

Discussion

- The Carbon residue value of burner fuel serves as a rough approximation of the tendency of the fuel to form deposits in vaporizing pot-type and sleeve-type burners. Similarly provided alkyl nitrates are absent (or if present) provided the test is performed on the base fuel without additive. The carbon residue of diesel fuel correlates approximately with combustion chamber deposits.
- For burner fuel, Conradson provides an approximation of the tendency of the fuel to form deposits in vaporizing burners. This correlates approximately with
- For diesel fuel, Conradson provides that alkyl nitrates are absent.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

for gas fuel Con carbon provides a useful correlation in the manufacture of gas there from.

for delayed cokers, the Concarbon of the feed correlates positively to the amount of coke that will be produced.

for fluid catalytic cracking unit, the Concarbon of the feed can be used to estimate the feed's coke forming tendency.

CCR is expressed as a percent of the whole fuel. Fuels with high CCR values have an increasing tendency to form carbon residue on injection, nozzles, pistons and in the ports of two stroke engines. This cause reduction in the efficiency and performance of those components and increased wear. The maximum permissible CCR depends on engine speed.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

Experiment 5(b) : Determination of kinematic viscosity of given oil in Redwood viscometer

SHEET NO.

Objective : To determine kinematic viscosity of a liquid fuel sample by Redwood viscometer.

Theory : Viscosity of a fluid is measure of its resistance to flow. The ratio of coefficient of viscosity to the density of the fluid is known as kinematic viscosity. The apparatus used is known as Redwood viscometer. The kinematic viscosity of a oil can be calculated from the formula.

$$\gamma = AT - B/T$$

where γ - kinematic viscosity of oil (centistokes)
 T - time of collection of 50ml sample (seconds)
 A, B are instrument constant.

Apparatus :

1. Redwood Viscometer
2. 50ml conical flask
3. Thermometer
4. Stopwatch

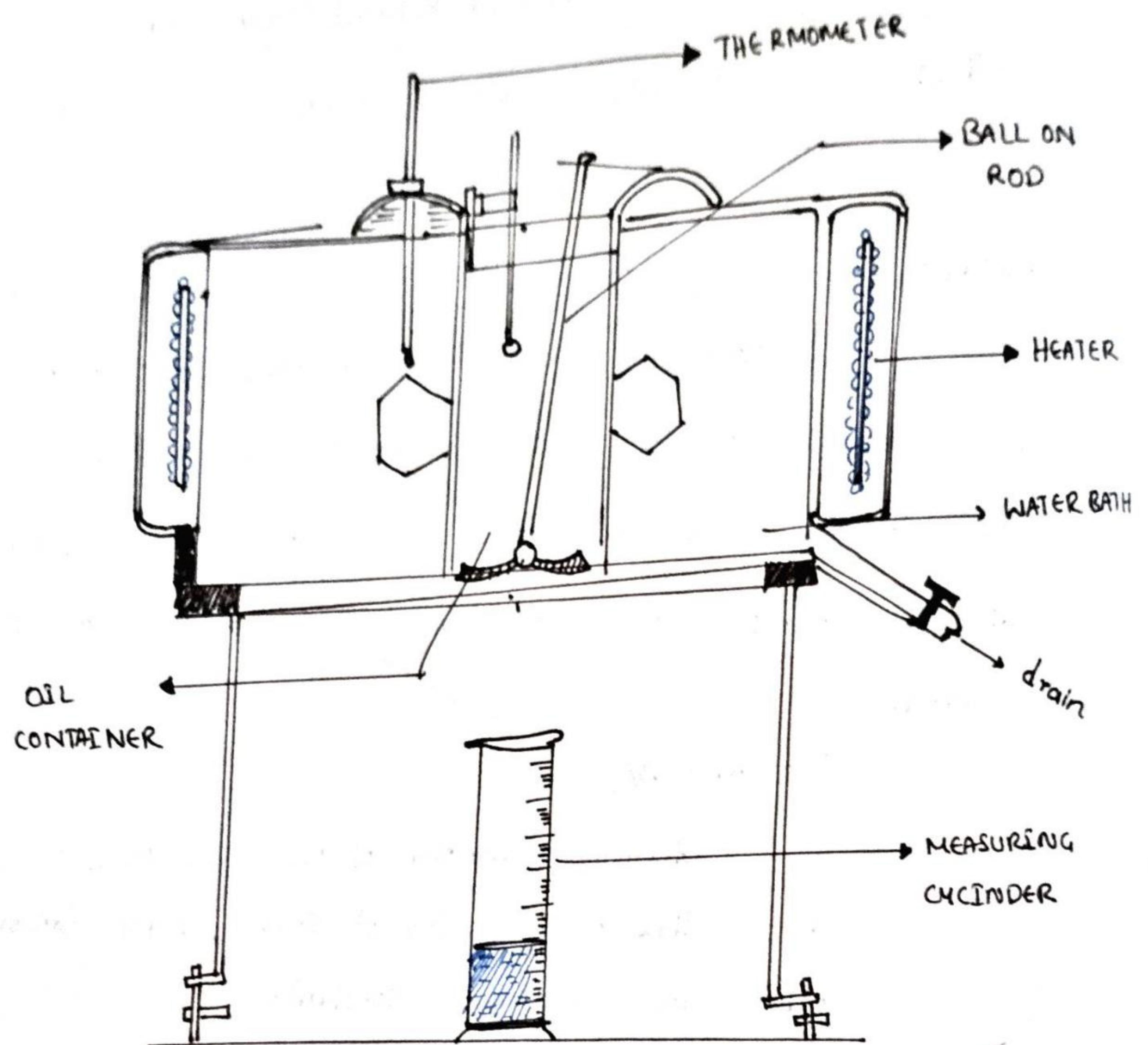


Fig. Redwood Viscometer

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHREETHO

OBSERVATION

S.no:	Temperature (°C)	Time for collection of 50 ml sample (sec)
1.	40°C	326 sec
2.	45°C	264 sec
3.	50°C	219 sec

CALCULATION

$$\text{Kinematic viscosity } (\nu) = AT - \frac{B}{T}$$

$A = 0.247, B = 65$ for the given setup apparatus

1) $T = 326 \text{ sec}$

$$\nu = AT - \frac{B}{T} = 0.247 (326) - \frac{65}{326} = \underline{\underline{80.323 \text{ cS}}}$$

2) $T = 264 \text{ sec}$

$$\nu = AT - \frac{B}{T} = \underline{\underline{64.962 \text{ cS}}}$$

3) $T = 219 \text{ sec}$

$$\nu = AT - \frac{B}{T} = \underline{\underline{53.796 \text{ cS}}}$$

INDIAN INSTITUTE OF TECHNOLOGY

DATE _____ SHEET NO. _____

RESULT:-

S.no	Temp (°C)	η (cs)
1.	60°C	80.323
2.	65°C	64.962
3.	50°C	53.7961

DISCUSSION:-

The main disadvantage of the capillary tube viscometer is the errors that variation in the head loss and other parameters, the Hagen Poiseuile formula can still be applied by designing a efflux type viscometer that works on the principle of vertical gravity flow of a viscous liquid through a capillary tube. A Redwood viscometer is another efflux type viscometer that works on same principle of saybolt. Here the stopper is replaced with an orifice and Redwood seconds is defined for collection of 50ml of liquid to flow out of orifice.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

Similar expressions can be written for Redwood viscometer ($\eta = AT - \frac{B}{T}$) as

- (i) There is no change in instrumental constants due to change of test, so that instruments may be calibrated at any convenient temperature, varying the viscosity either by change of temperature or by blending.
- (ii) The error due to inaccuracy of the Heisser formules
- (iii) The error due to change in volume of the oil after it leaves the outlet tube is not major error in viscometry and is negligible at all usual temperatures.



INDIAN INSTITUTE OF TECHNOLOGY

DATE

Experiment 5(a): Determination of Aniline point of an oil sample.

SHEET NO.

AIM:- Determination of aniline point of diesel

TERMINOLOGY :- For the purpose of this method, the following definition shall apply.

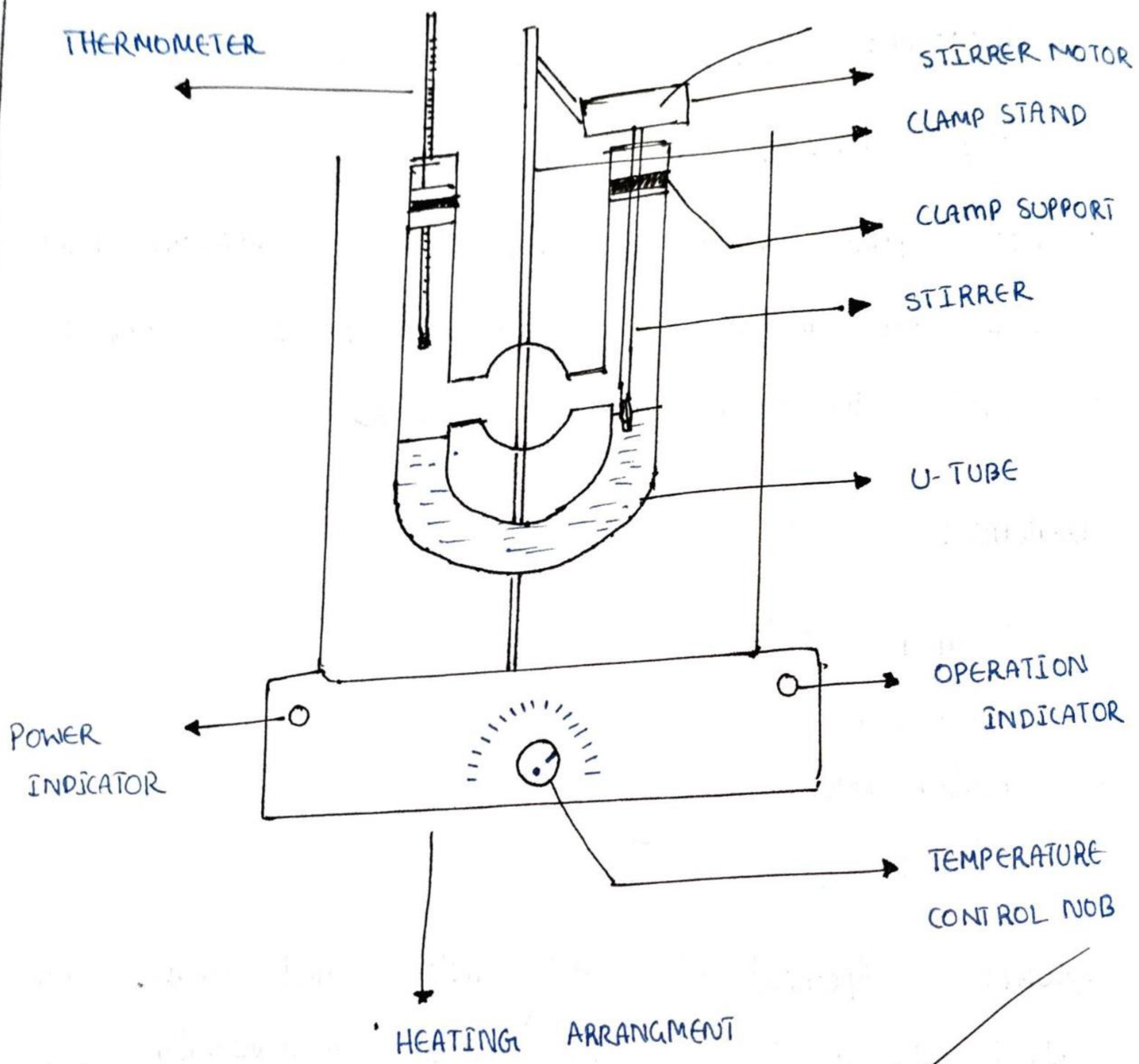
- Aniline point of an oil sample is the minimum equilibrium temperature at which equal volume of oil is completely miscible in equal volume of aniline.

APPARATUS:-

- U shaped test tube
- water jacket
- heating arrangement
- stirrer.

THEORY:- Specified volume of aniline and sample are placed in a U-tube and mixed mechanically. The mixture is heated at controlled rate until two components are completely miscible. The mixture is then

Fig. Apparatus setup for determination of aniline point



INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

cooled at controlled rate and the temperature at which the layers separate again in two components is recorded.

PROCEDURE

The O-shaped test tube was cleaned carefully and dried completely.

Aniline of 20ml and 20ml of dried diesel sample were taken in the test tube.

The test tube was dipped in water bath. In one arm of the test tube a thermometer was put and in the other a mechanical stirrer.

The test tube was heated consistently at a rate of $1^{\circ}-3^{\circ}\text{C}/\text{min}$ until the two components are completely miscible. The equilibrium temperature was recorded.

During heating, the mixture was stirred at regular interval.

Then, the test tube was cooled down at uniform rate.

The temperature at which turbidity again starts to appears

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

is recorded.

- The steps (i) - (vii) were performed twice with two different samples

OBSERVATIONS:-

S.no

Temperature (Aniline point) - during cooling

1.

 81°C

2.

 81°C

3.

 81°C

Calculations:-

$$\text{Average aniline point} = \frac{81 + 81 + 81}{3} = 81^{\circ}\text{C}$$

Result:-

Aniline point of given sample is ~~81~~ 81°C

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

DISCUSSIONS :-

- (1) Aniline point is called "aniline point temperature", which is the lowest temperature ($^{\circ}\text{F}$. or $^{\circ}\text{C}$) at which equal volumes of aniline ($\text{C}_6\text{H}_5\text{NH}_2$) and the oil form a single phase. The aniline point (AP) correlates roughly with the amount and type of aromatic hydrocarbons ~~in an oil sample~~.
- (2) Aniline being an aromatic compound freely mixes with aromatic so aniline is used for this ~~experiment~~.
- (3) A low aniline point indicates low diesel index (because of high percentage of aromatics). A high aniline point indicates that the fuel is highly paraffinic and hence has a high diesel index & good ignition quality.
- (4) The aniline point is a reasonable proxy for aromaticity of oils consisting mostly a saturated hydrocarbons or unsaturated compounds (mostly aromatic).

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

A petroleum stock with a high aniline point temperature will be high in paraffins and low in aromatics and naphthalenes. Aniline point temperature has also been used to a lesser extent in correlation methods for calculating the properties of petroleum fractions such as the heat of combustion, hydrogen content, diesel index and smoke point.



INDIAN INSTITUTE OF TECHNOLOGY

DATE 11/3/19

Experiment 6 - Proximate Analysis of Coal Sample.

SHEET NO.

AIM: To estimate the contents of a coal sample approximately that means to estimate moisture content, volatile matter and ash content of the coal sample and therefore calculating the fixed carbon content.

APPARATUS :- 1) Electric oven, 2) Nettle Furnace 3) Crucible, 4) Desicator.

SIGNIFICANCE

OF PROXIMATE ANALYSIS :-

Each Constituent determined under proximate Analysis has its own implication and importance in the assessment of coal sample.

MOISTURE:- Moisture increases due to the transport cost. Excessive surface moisture may cause difficulties in handling the coal. Moisture reduces the calorific value. Hence, higher moisture content is undesirable.

VOLATILE MATTER:- The volatile matter is not a constituent of coal but it consists of a complex mixture

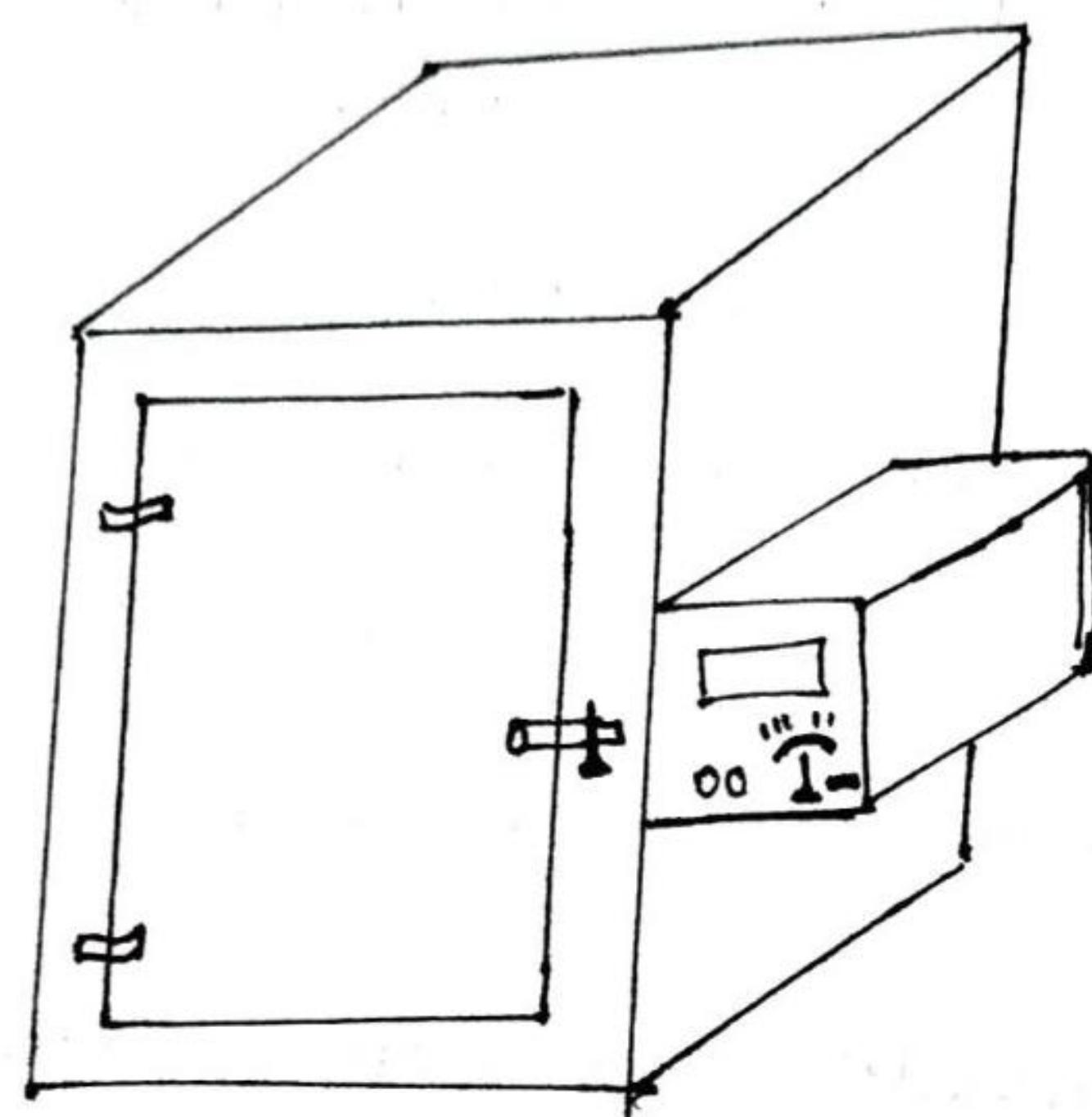


Fig: Muffle Furnace.



Fig: Crucible

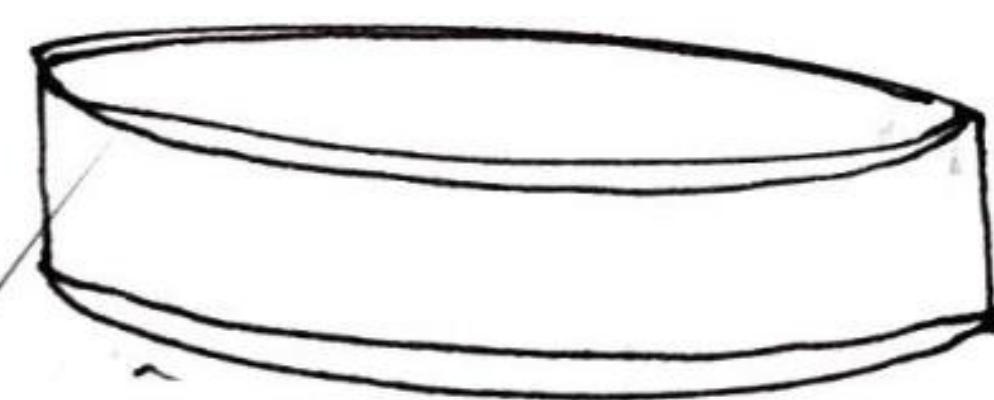


Fig: Petridish

of gaseous and liquid products resulting from the thermal decomposition of the coal substance. High volatile matter coal gives long flames, high smoke and relatively low heating values. Coal with low volatile content burns with shorter flame.

ASH:- The ash which intimately interspersed within mass of the coal is called ash. The nature of ash and its amount in coal reduces the heating value of coal. Ash usually consists of silica-alumina, iron oxide and lime, magnesia.

FIXED CARBON: The fixed carbon content amounts higher in the high grade coals and is also responsible for the calorific value.

PROCEDURE:-

(i) Moisture:- 1g of coal sample (air dried) in a crucible in an electric oven maintained at $100-110^{\circ}\text{C}$ is heated for 1hr. Then the crucible is cooled down in the desilator and weighed again. The loss in mass gives the moisture content (present on surface).

INDIAN INSTITUTE OF TECHNOLOGY

NOTE

SHEET NO.

Volatile Content :- The dried sample of coal left in the crucible is then covered with a lid and placed in an muffle furnace maintained at 925°C for 7 minutes. Next the crucible is rapidly cooled. Further loss in mass this time gives the volatile content withing the coal.

b) ASH :- The residual coal in the crucible from step a is heated without lid in a muffle furnace at 750°C for $\frac{1}{2}$ hr. The crucible is cooled down in desicated and weighed again. The mass of residual gives ash content

(ii) FIXED CARBON :- The sum total of the percentage of volatile matter, moisture and subtracted from 100, gives the percentage of fixed carbon.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

OBSERVATIONS :-

MOISTURE CONTENT :-

wt of empty crucible (w_1) g	47.8379
wt of crucible + coal sample (w_2)g	$47.837 + 2 = 49.8379$
wt of crucible + sample after heating (w_3)g	49.8359

Volatile content :-

wt of empty crucible (w_1) g	14.5769
wt of crucible + coal sample (w_2)g	15.5769
wt of crucible + sample after heating (w_3)	15.3659

Ash Content :-

wt of empty crucible (w_1'')	15.0469
wt of crucible + coal sample (w_2'')	16.0469
wt of crucible + sample after heating (w_3'')	15.3549

P.R.E.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

CALCULATIONS:

$$1) \% \text{ Moisture} = \frac{w_2 - w_3}{w_2 - w_1} = \frac{49.837 - 49.835}{2} \times 100 = 0.1\%$$

$$2) \% \text{ Volatile content} = \left[\frac{w_1' - w_3'}{w_2 - w_1} - \text{moisture content} \right] \times 100$$

$$= \left[\frac{15.576 - 15.365}{15.576 - 14.576} - 0.001 \right] \times 100 = 0.21 \times 100 = 21\%$$

$$3) \% \text{ Ash content} = \frac{w_2'' - w_3''}{w_2 - w_1} = \frac{15.354 - 15.046}{1} \times 100 = 30.3\%$$

$$4) \text{ Fixed Carbon} = 100 - (0.1 + 21 + 30.3)$$

$$= 49.1\%$$

$$\text{percentage of fixed carbon} = 49.1\%$$

Result:

DISCUSSION:

Coal Analysis techniques are specific analytical methods designed to measure the particular physical and chemical properties of coals.

There are two methods to analyze coal which are called Proximate Analysis and Ultimate Analysis.

The proximate Analysis determines only the fixed carbon, volatile matter moisture and ash percentages. It is determined by simple apparatus.

Coal comes in 4 main types or ranks : lignite or brown coal, bituminous coal or black coal, anthracite and graphite.

Moisture is important property of coal as all coals are mined wet.

Ground water and other extraneous moisture is known as adventitious moisture and is readily evaporated. Surface Moisture :- Water held on the surface of coal particles or ~~material~~ materials.

Compliance with International standards Moisture (ASTM D3173, ISO 1172)

Volatile Matter (ASTM D3175, ISO 562, VFS 1038-3) Volatile matter include the components of coal except for the volatiles which is liberated at high T.

FIXED CARBON [ASTM D5142, ISO 17246] The fixed carbon content of

Coal is determined by subtracting the percentages of moisture, volatile matter and ash. The solid combustible residue that remains after a coal has had all volatility driven off.

- » The moisture content of most of the samples appears to be lower than expected. There may be several explanations for this outcome. The samples may have been intentionally or unintentionally dried by supplier before shipment.
- » The volatile matter and fixed carbon results for the samples follow the expected trend. That is, on going from anthracite to bituminous, to lignite, to peat the volatile matter content should increase and fixed carbon content should decrease.
- » Ash content of all the samples which fall within the expected range of (3-15%) are termed to be useful for specific purposes. These determine the grade of the coal (A, B, C, D, E, F, G) based on calorific value. (It may vary across nations).

INDIAN INSTITUTE OF TECHNOLOGY

DATE 18-3-19

Experiment 7(a)

Determination of Cloud Point and Pour Point of heavy oil

SHEET NO.

AIM: Determination of cloud point and pour point of a heavy oil. This experiment is performed to ensure safety of cross continent crude oil pipelines.

APPARATUS: Jars, cork, analog thermometer and methanol bath cooling system

~~THEORY~~

PROCEDURE: Oil is poured in the test jar up to the level mark. Close test jar with the cork carrying the thermometer. The thermometer bulb should be immersed in the oil sample. Place the jar in the cooling bath and maintained the bath temperature within the expected pour point range of the oil. After the oil is cooled enough, remove the jar carefully from the bath and tilt it enough to ascertain whether there is a movement of oil in the test jar. The complete operation of removal and replacement shall not take more than 3 minutes. This is done several times carefully.

→ Numbered list! Passing
marks

Part Tense!

P.R.E.

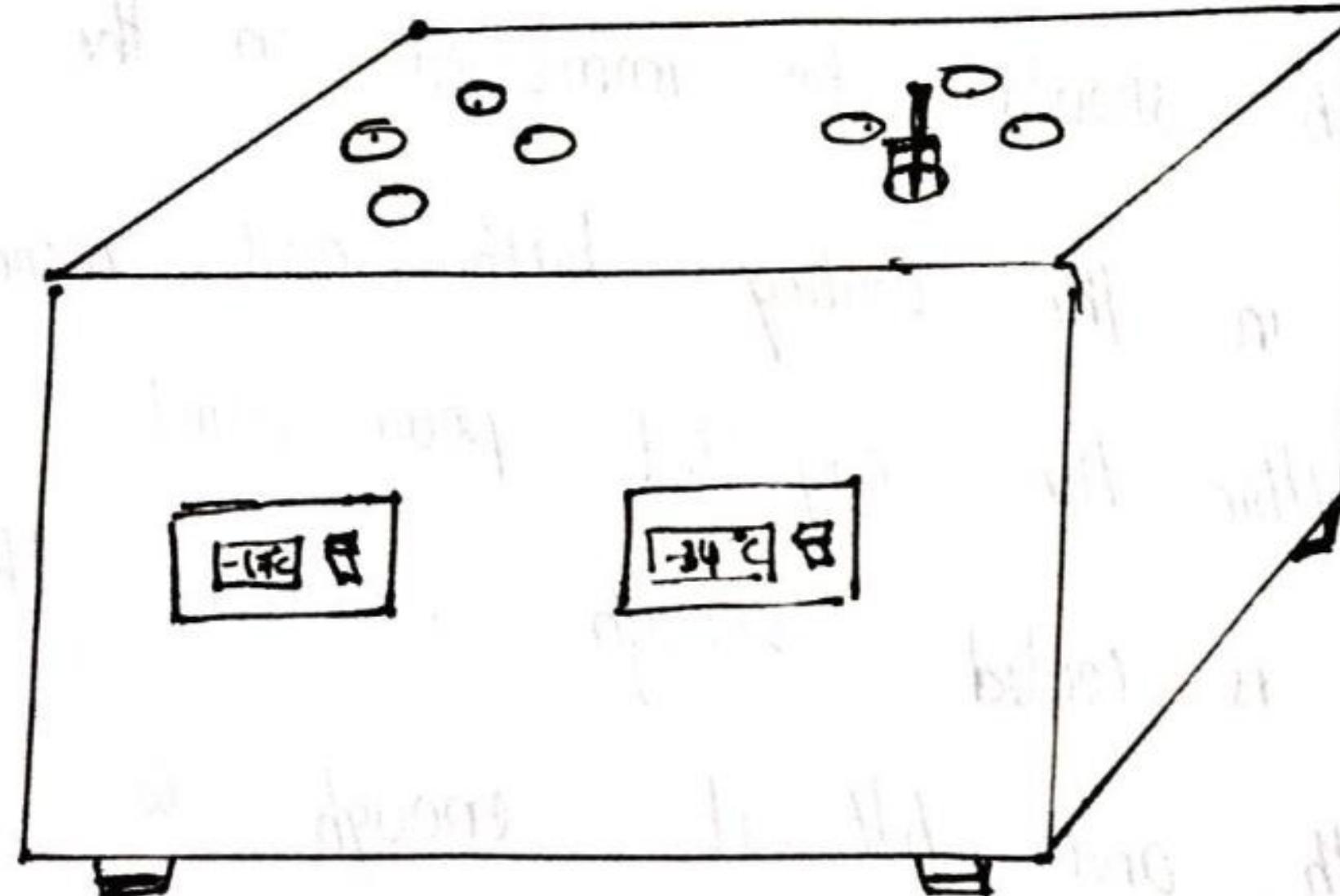
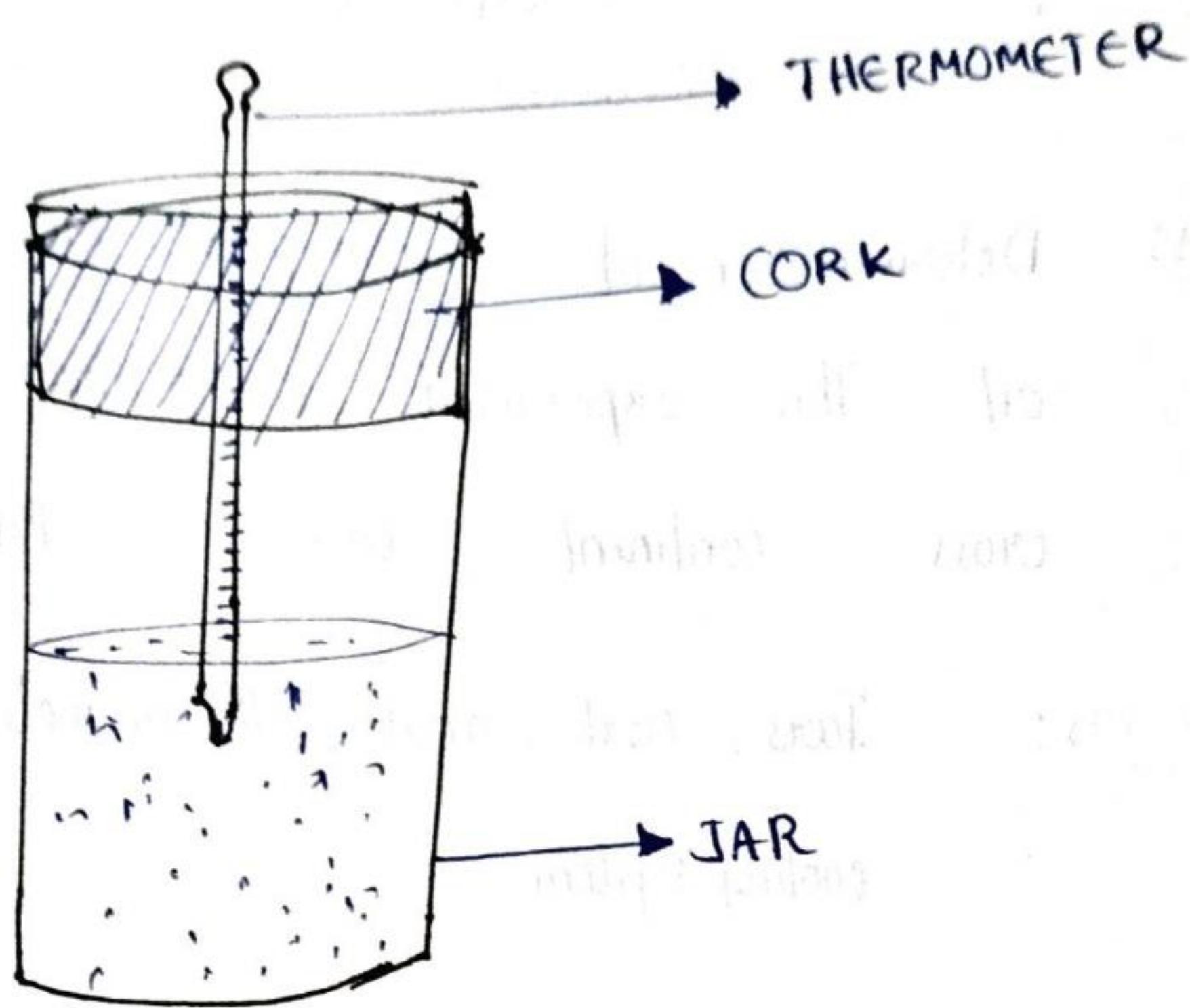


Fig Methanol Bath Cooker

OBSERVATIONS

SNO.	CLOUD POINT (°C)	POUR POINT (°C)
(1)	12°C	(-10 + 3°C) = -7°C
(2)	11°C	-9°C + 3°C = -6°C

DISCUSSION:

CLOUD POINT: The cloud point of a fluid is the temperature at which dissolved solids are no longer completely soluble, precipitating as a second phase giving the fluid a cloudy appearance. This is expressed as multiple of 1°C

POUR POINT: The pour point of a liquid is the temperature at which the viscosity of the oil increases to such an extent that it becomes semi solid and loses its flow characteristic.

IMPORTANCE - The cloud' point is important for determining storage stabilities and Pour point is the lowest temperature at which oil is capable of flowing under gravity. It is one of the important low-temperature characteristics of high boiling fractions. When the temperature is less than the pour point of a petroleum product , it cannot be stored or transferred through a pipeline. ✓

If there are regions where the pipelines need to cross across a very low temperatures (below pour point) the oils may freeze . One way is to heat them which would be a very expensive task . So we can add some substances that increases its pour point and make it easier to transport across the cold or low temperature regions. ✓

INDIAN INSTITUTE OF TECHNOLOGY

Date 18-3-19

Experiment - 7(b)

SHEET NO.

Determination of Caking index of Coal

AIM:

To determine Caking Index ie, binding property of bituminous coal

APPARATUS:-

- (i) Alumina Crucible
- (ii) Lids
- (iii) Electric Muffle Furnace
- (iv) Weight Box

PROCEDURE: 4 mixtures of sand and coal (each having ratio of sand and coal 1:1, 4:1, 7:1 and 9:1 are prepared.

Mixture after proper mixing and is taken in a crucible and the crucibles are kept inside a muffle furnace at a temperature of 925°C for 7 minutes. The crucibles are then taken out, allowed to cool and the said mass is separated

from the crucible. Over each cake a 50g weight is placed which cause to break the loose materials.

These are collected and weighed. The percent of loose grains are plotted against corresponding sand coal ratio and from this graph of cracking index is determined \rightarrow Numbered List!

Part Tense! Passive Voice! PRE

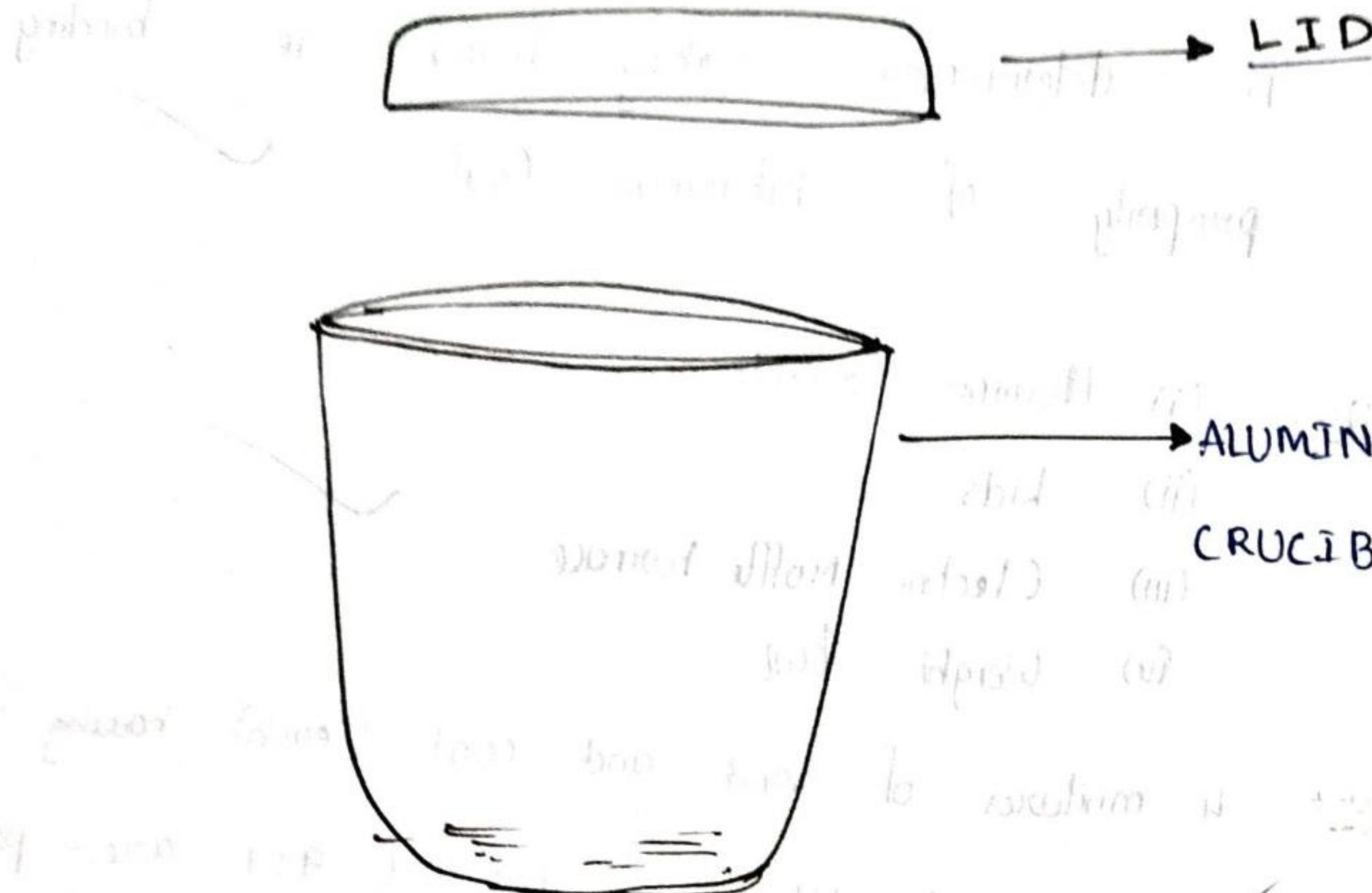


Fig. Crucible.

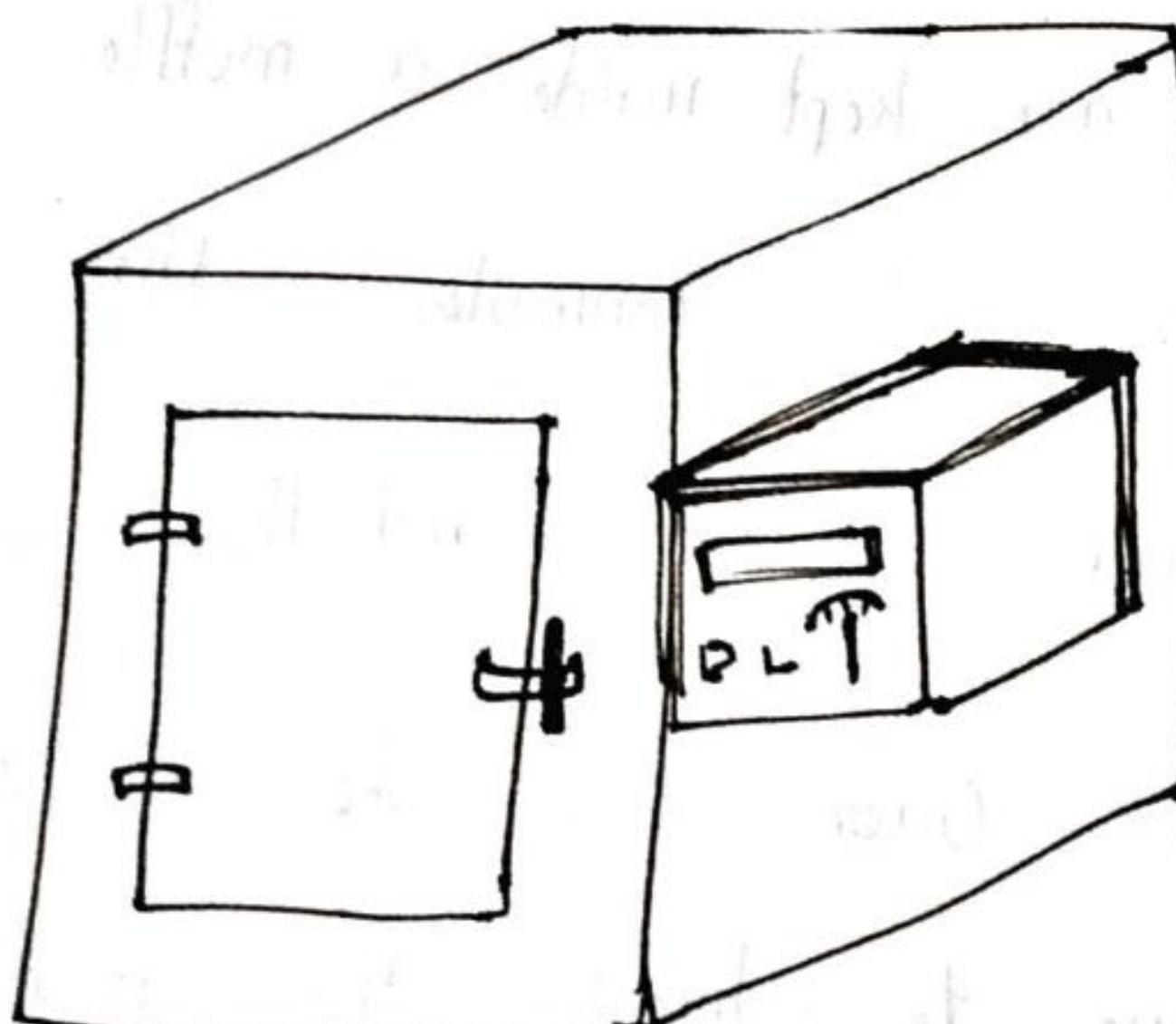
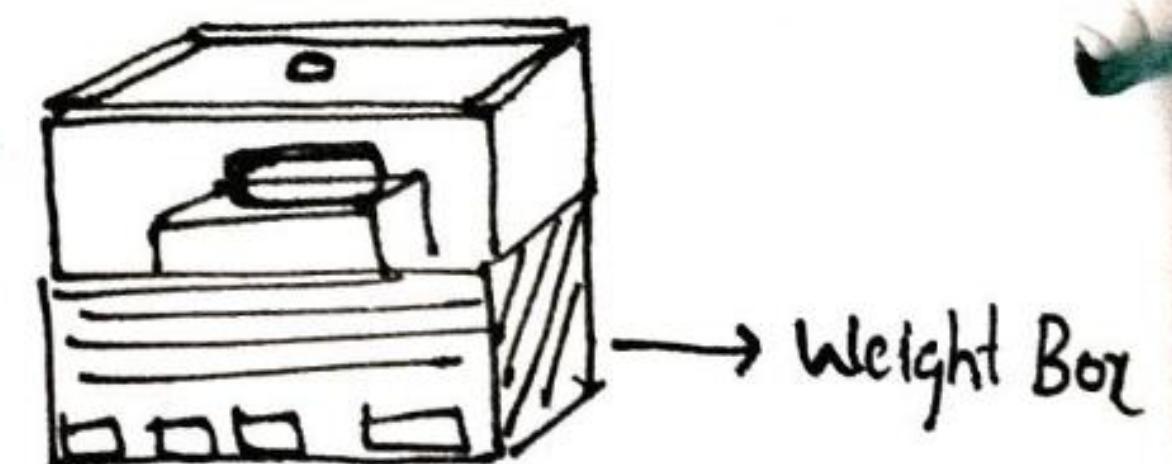


Fig. Muffle Furnace



The composition of component within the crucible are as follows.

- (i) 12.5g of sand and 12.5g of coal in a ratio of 1:1
- (ii) 16.67g of sand and 8.34g of coal in a ratio of 2:1
- (iii) 18.75g of sand and 6.25g of coal in a ratio of 3:1
- (iv) 20.0g of sand and 5.00g of coal in a ratio of 4:1



OBSERVATION :-

<u>Wt Ratio</u>	<u>Wt obtained</u>	<u>% loose grains</u> $= \frac{\text{wt}}{\text{Total}} \times 100$
1:1	3.619	12.04%
4:1	1.336g	5.333%
3:2	1.266g	5.066%
2:1	1.137g	4.548%
1:1	1.074g.	4.296%

Sample Calculation ① wt of loose grains = 1.266g

$$\% \text{ loose grains} = \frac{1.266}{25} \times 100 = 5.04\%$$

$$\text{② wt of loose grains} = 1.074g, \% \text{ loose} = \frac{1.074}{25} \times 100 = 4.296\%$$

$$X\text{-axis} - \text{constant} = 17.7 \text{ cm}$$
$$Y\text{-axis} - 250 \text{ ml} = 9 \text{ cm}$$

Result:

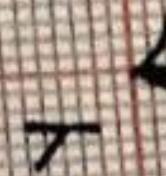
Cutting index : $\frac{2}{1}$



>X



SAND : COAL RATIO



$$\text{from } 1040 \text{ to } 1000 = 50 \text{ %}$$

3

2

6

5

7

4

8

1

3

5

7



0

1

5

7

9

6

4

2

8

7

6

5

4

3

2

1

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

4

5

6

7

8

9

0

1

2

3

</div

DISCUSSION:- The Caking index of a Coal is measure of binding strength between coal particles or between coal particles and inert particles after coal is heated at 925°C . Bituminous coal must meet a set of criteria for use as caking coal. These include moisture content, ash content, sulphur content, volatile content, tar and plasticity. Coking coal is different from thermal coal, but it differs not by the coal forming process from thermal coal. Coking coal has different macerals from thermal coal. The different macerals are related to source of material that compose the coal. However the coke is of widely varying strength and ash content and is generally considered unsellable except in some cases as a thermal product.

INDIAN INSTITUTE OF TECHNOLOGY

DATE

SHEET NO.

The Caking Index, has been widely popularized and applied in coal geological exploration, production and utilization departments in China. This index was established after improving the Roga Index, an international method used for determining the caking power of bituminous coal. It has become one of the main indices to classify bituminous coals in the new classification of Chinese coals. ✓

INDIAN INSTITUTE OF TECHNOLOGY

25/8/19

DETERMINATION OF GROSS CALORIFIC VALUE OF COAL USING BOMB CALORIMETER.

SHEET NO. 1

AIM: To determine the gross calorific value of coal sample by a Bomb Calorimeter.

APPARATUS:

- Bomb Calorimeter
- Thermocouple
- Stop watch
- Cotton Thread
- Nichrome wire

PROCEDURE:

1. Sufficient finely ground air dried coal (00 mesh IMM sieve) was compressed in to a cylindrical pellet and was weighed into the crucible of the calorimeter.
2. A piece of fine nichrome wire was lightly stretched across the pole pieces of the bomb and one end of a piece of sewing cotton was tied around the wire.

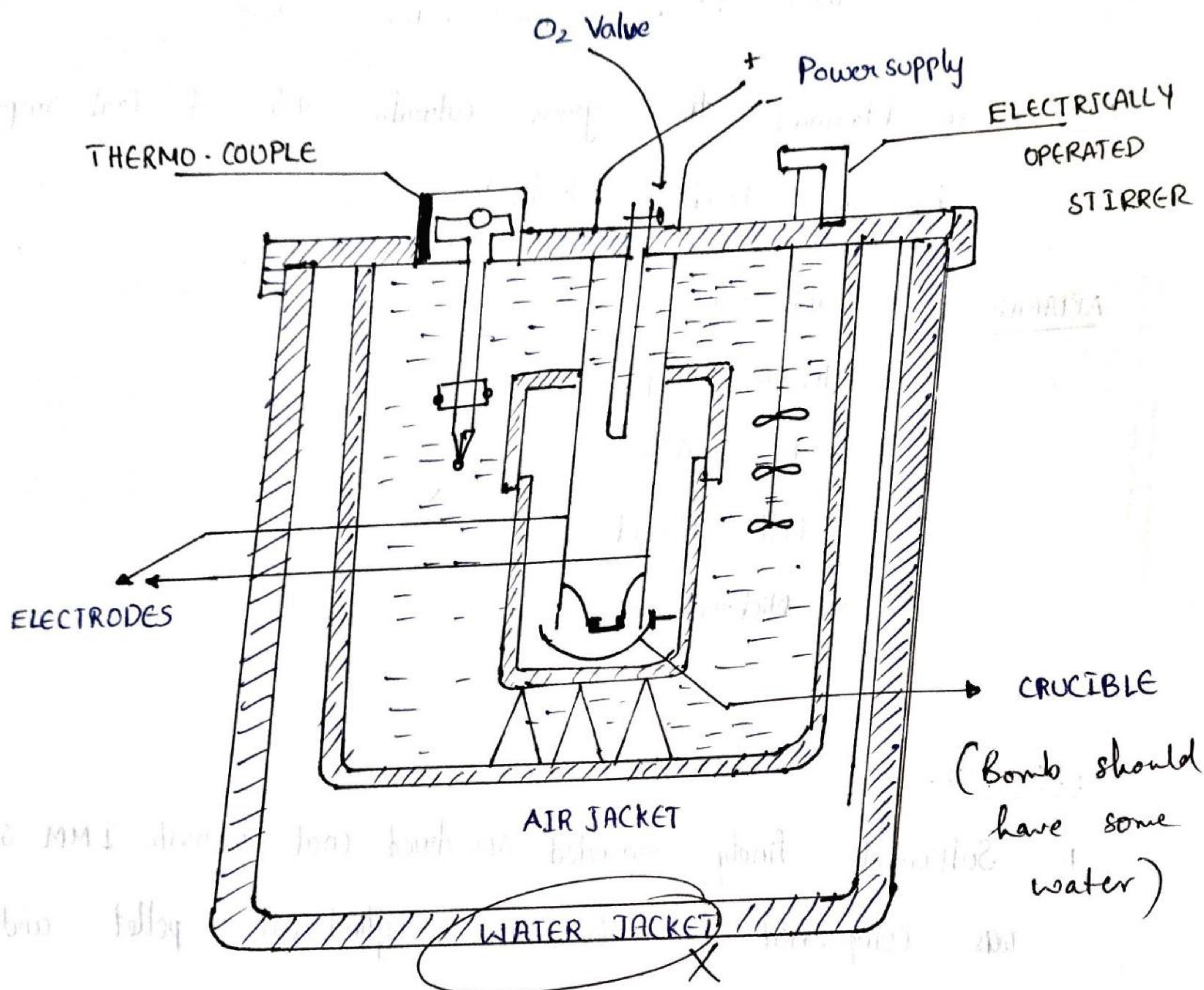


Fig. Schematic diagram of BOMB CALORIMETER

Good.

About 10ml of distilled water was introduced into the bomb and the bomb was connected with an oxygen cylinder.

4. Oxygen was slowly supplied and the pressure was raised to 25 atm
5. Bomb was then introduced into the calorimetric vessel with sufficient water inside to submerge the cover of the bomb. ✓
6. Then the stirrer was started and was allowed to run for 5 minutes
7. The ends of firing wires were connected to ignite the charge off and readings were taken at every 30sec interval using a stop watch. ✓

OBSERVATIONS :-

Table I

Sno.	QUANTITY	MAGNITUDE
1.	weight of water inside the calorimeter assembly	1800ml
2.	Water Inside Bomb	10ml
3.	Weight of string	$0.01g = m_2$
4.	weight of wire	$0.02g = m_1$
5.	Oxygen gas pressure	25kg/cm ²
6.	wt of coal pellet	1.0gm = m
7.	Calorific value of wire	335 cal/g = C _{wire}
8.	Calorific value of string	4000 cal/g
9.	water equivalent of Bomb Calorimeter	450g = E



Table - 2 :-

	Time (sec)	Temp (°C)		Time (sec)	Temp (°C)		Time (sec)	Temp (°C)
1	0	0		720	2.85		1410	2.66
2	30	0.31		750	2.84		1440	2.66
3	60	1.61		780	2.83		1470	2.66
4	90	2.20		810	2.82		1500	2.66
5	120	2.50		840	2.82			
6	150	2.65		870	2.81			
7	180	2.75		900	2.80			
8	210	2.80		930	2.79			
9	240	2.84		960	2.79			
10	270	2.87		990	2.78			
11	300	2.88		1020	2.77			
12	330	2.83		1050	2.76			
13	360	2.84		1080	2.75			
14	390	2.84		1100	2.74			
15	420	2.84		1140	2.73			
16	450	2.84		1170				
17	480	2.83		1200	2.72			
18	510	2.82		1230	2.71			
19	540	2.82		1260	2.70			
20	570	2.87		1260	2.69			
21	600	2.87		1290	2.69			
22	630	2.87		1320	2.69			
23	660	2.86		1350	2.68			
24	690	2.86		1380	2.67			

✓

CALCULATION:-

$$T = 2.88^\circ\text{C}$$

$$\begin{aligned} CV &= \frac{1}{m} \left\{ (W+E) C_p \times T - m_1 (CV)_{\text{string}} - m_2 (CV)_{\text{wire}} \right\} \\ &= \frac{1}{1} \left[2250 \times 1 \times 2.88 - 0.02 \times 4000 - 0.01 \times 335 \right] \\ &= \underline{\underline{6556.65 \text{ cal/g}}} \quad \checkmark \end{aligned}$$

RESULT:- Thus, from the experiment we obtained that calorific value of given coal sample is 6.556 kcal/g.

DISCUSSIONS:-

- The calorific value which was calculated in our expt is Gross calorific value.
- Gross calorific value is greater than the Net calorific value.
- Gross calorific value refers to quantity of heat produced by combustion when the ~~water~~ ~~water~~ produced by combustion is permitted to return to the liquid state.

Net Calorific value refers to quantity of heat produced by combustion when the water produced by combustion continues to be in a gaseous state.

As water ^{vapor} releases heat when it condenses gross calorific value is greater than net calorific value.

High pressure ($25 \text{ kg/cm}^2 \text{ g} \approx 25 \text{ atm}$) is supplied to provide excess oxygen so that complete combustion takes place. 10ml water inside bomb absorbs gases such as SO_2 and stack gases.

Bomb calorimeter is a type of constant volume-calorimeter.

According to Indian grading system based on gross calorific value.

The coal sample we used is graded as G₂ as

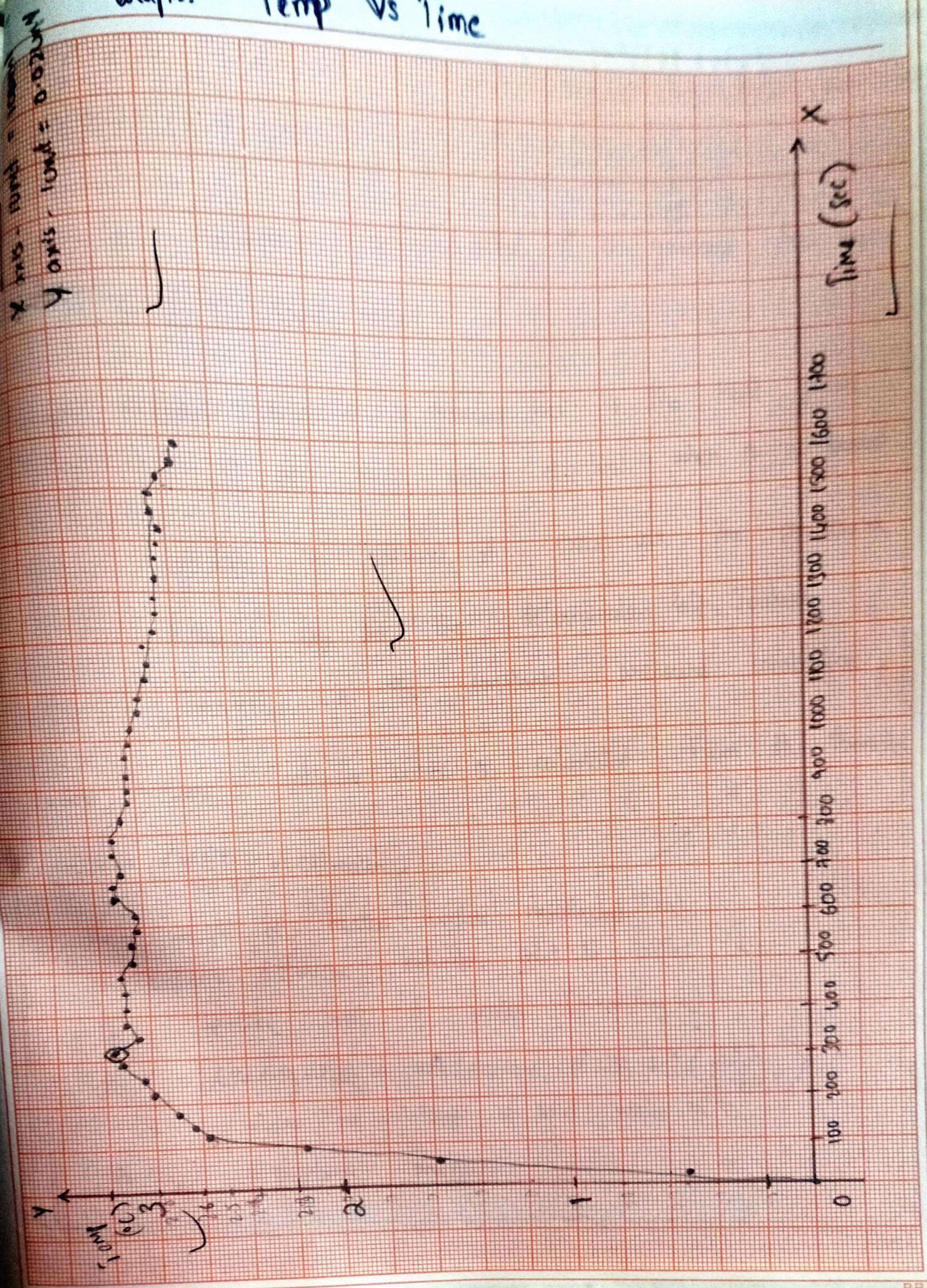
the value is between 6401 & 6700

According to IEA standard, the sample is a Bituminous type.

(G.CV > 5700 kcal/kg)

4/10/2019

Graph! Temp vs Time



AIM: To determine calorific value of a gaseous fuel by Junkers Calorimeter.

Theory: Calorific Value of a gaseous fuel is the heat given off by the unit volume of fuel when it is burnt completely in presence of excess air. The procedure followed for the determination by Junkers Calorimeter is the constant pressure combustion. The gross calorific value is calculated from the formula

$$CV = \left(\frac{W \cdot T}{V \cdot K} \right) \cdot (C_p)_{\text{water}}$$

W = weight of heated water recollected (kg)

T = Temp difference between inlet & outlet (K)

C_p = specific heat of water (kcal/kg K)

K = $[(P_a + P_g - P_w) \text{ in mm / 260mm of Hg}] \cdot \left(\frac{273}{273+t} \right)$
where t = temp of inlet water in °C

P_a = atmospheric pressure

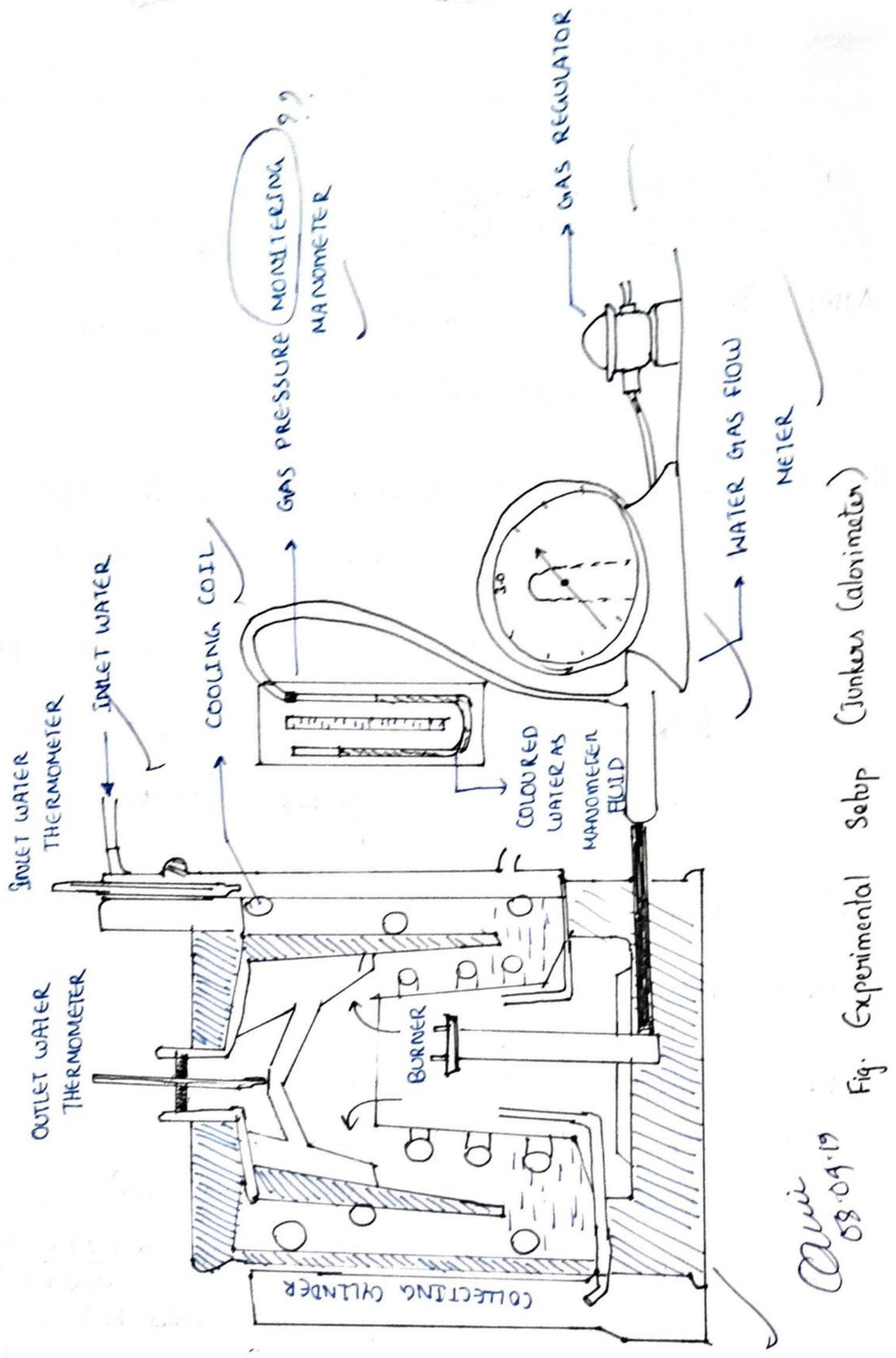


Fig. Experimental Setup (Junkers calorimeter)

P_g = Pressure of fuel gas

P_w = Saturated vapor pressure at temperature $t^\circ C$

APPARATUS REQUIRED:-

- (i) Junker's Calorimeter
- (ii) Gas flow meter
- (iii) Measuring Cylinder
- (iv) Stop watch
- (v) Barometer.

PROCEDURE:-

- (1) The fuel gas was allowed to flow successfully through a wet gas meter to the burner. The water inlet valve was opened to provide regular flow of water through the calorimeter.
- (2) The flow was so regulated that there exist a const temp difference between the inlet and outlet temperature.

- (iii) The inlet and outlet temperature as well as gas flown were noted down. Water flowing out was collected in a measuring cylinder for ten seconds.
- (iv) Then the measured volumes are noted down. The barometer pressure and fuel gas pressure were noted down.
- (v) The entire process was repeated for total of three times with different flow rate of fuel gas maintaining a constant pressure at water inlet.
- (vi) All the collected data were tabulated. Gross calorific value of the fuel gas was calculated in each term. An average of these three values was calculated in final turn to get G.C.V of the given fuel.

OBSERVATIONS

Gross flow Rate - (i) 0.96 L/min
 (ii) 0.90 L/min
 (iii) 0.94 L/min

$$\text{avg} = 0.93 \text{ L/min}$$

$$= 0.93 \times 10^{-3} \text{ m}^3/\text{min}$$

$$P_a = 755 \text{ mm of Hg}$$

$$P_g = 12.13 \text{ mm of Hg}$$

wt of Water Collected	1	2	3	t (°C)	T(K)	Pw (mm) of Hg
0.405	0.385	0.375	Avg 0.382	38	7	50.26
0.280	0.265	0.250	0.265	41	10	58.63
0.170	0.165	0.165	0.166	42	11	61.864

Calculation 1. $k = \left(\frac{7.55 + 12.13 - 50.26}{760} \right) \times \left(\frac{273}{273+38} \right) = 0.82$

$$CV = \frac{0.382 \times 7}{9.3 \times 10^{-4} \times 0.82} \times 1 = 3561.50 \text{ kcal/m}^3$$

2. $k = \left(\frac{7.35 + 12.13 - 58.63}{760} \right) \times \left(\frac{273}{273+41} \right) = 0.81$

$$CV = \frac{0.265 \times 10}{9.3 \times 10^{-4} \times 0.81} = 3517.81 \text{ kcal/m}^3$$

3. $k = \left(\frac{7.55 + 12.13 - 61.864}{760} \right) \times \left(\frac{273}{273+42} \right) = 0.80$, ~~Ans~~ r

$$CV = \frac{0.166 \times 11}{9.3 \times 10^4 \times 0.80} = 2454.30 \text{ kcal/m}^3$$

$$CV_{avg} = \frac{3561.50 + 3517.81 + 2454.34}{3}$$

$$= 3177.87 \text{ kcal/m}^3$$

RESULT :-

Average Gross calorific value of the gascous
fuel is 3177.870 kcal/m³.

Omair
08.09.19

In contrast to Thomas - Cambridge and the the Cutler hammer gas calorimeter, water is used as heat absorbing fluid for the Junkers Calorimeter. In the case of Junkers Calorimeter a wet gas meter and a water meter measure the amount of gas being burnt and the amount of the heat absorbing fluid. The increase in the temperature of the water in the heat exchanger is converted by the thermopile into an electric voltage and indicated As the gas is measured under its operating conditions but the calorific value is defined for the reference state, a corrector is inserted between the thermopile and the pen recorder. This corrector takes into account not only changes in ambient pressure but also temperature variations.

Qurir
08/04/19