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Increased Efficiency of Smouldering by Altering External Factors

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ABSTRACT

Our aim in this research was to increase the efficiency of smouldering of incense stick by changing external factors.

In this paper, we tried increase the efficiency of smouldering.Smouldering is a flame-less type of combustion which can never achieve 100% efficiency in combustion which makes it an incomplete type of combustion.So, we tried to achieve maximum possible level of complete combustion.

In our first part of experiment we compared smouldering of smouldering material of shape of cube and cylinder of same volume. By analyzing the results, we compared the efficiency of smouldering on changing the surface area available for combustion. Then, in next part of experiment ,we tried to increase efficiency of smouldering by changing other external factors of air fuel ratio and oxygen supply.

In the end, we concluded our experiments by analyzing the data and finding out the relation between surface area and efficiency of smouldering and also the relation between oxygen supply and the efficiency of smouldering.

Then, in the end by using the analysis of data collected, we tried to design a more efficient incense stick holder and a design of a barbecue grill with increased efficiency.

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CHAPTER-1
INTRODUCTION

Smouldering is a flame-less type of combustion which can never achieve 100% efficiency in combustion which makes it an incomplete type of combustion. In this paper we tried to increase the efficiency of smouldering by changing external factors of exposed surface area and air fuel ratio or oxygen supply.

In our experiments we measured conductivity of co_2 emitted, which can be co-related to the amount of co_2 emitted to determine the efficiency of combustion. We measured the amount of CO_2 released, because it is direct indicator of efficiency of combustion as the amount of CO_2 is maximum in complete combustion and minimum in incomplete combustion .We did only experiments on smouldering of charcoal sticks but it can be similarly applicable to smouldering of other types of coal and wood also because of similar properties. To increase the oxygen supply for combustion and to control the environment, we designed a new instrument which will be perfect for our purpose of experiments.

In the end, we drew some conclusions from our experiments by analyzing the data we collected. We tried to design more efficient versions of incense stick holders and barbecue grill using our results and conclusions.

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CHAPTER-2
PROPOSED HYPOTHESIS

For this research, we proposed two hypothesis related to smouldering, which are as follows :-

1) More the surface area of the fuel exposed for the smouldering, more will be the efficiency of smouldering.
i.e., the surface area exposed for burning is directly proportional to the efficiency of smouldering.

2) If we increase the amount of oxygen supplied for smouldering, the efficiency of smouldering will also increase
i.e, the amount of oxygen supplied is directly proportional to the efficiency of smouldering.

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CHAPTER-3
EXPERIMENTAL SETUP

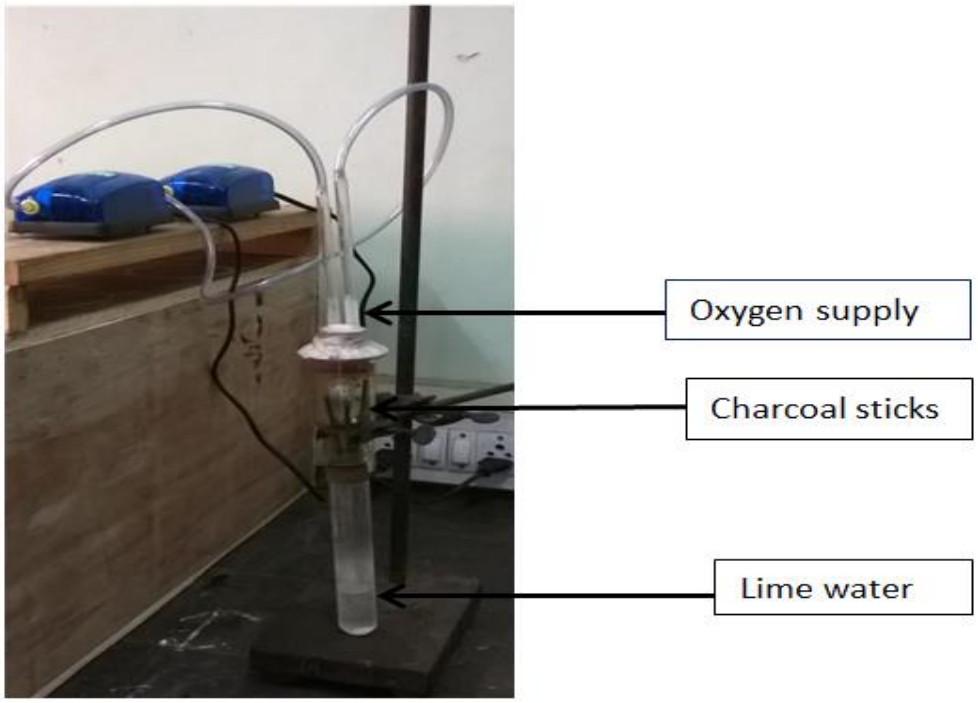

Fig 1

To perform the experiments, we required a air tight chamber which can sustain a high temperature and high amount of heat inside .So, we decided to use the material of hard glass testube for this experiment with some special modifications.

For controlled oxygen supply, we used two O_2 pumps as a inlet for oxygen. To measure the amount of CO_2 produced during combustion, we decided to measure the conductivity of CO_2 emitted. To measure the conductivity, we used freshly prepared lime water as reference and then dissolved the CO_2 emitted in it and then by finding out the difference between the conductivities of reference freshly prepared lime water and the lime water with dissolved CO_2 , we got the conductivity of the CO_2 ,which can be co-related to the amount of CO_2 produced.

And as we said earlier, the amount of carbon die oxide produced is an indicator of the efficiency of combustion, as the more efficient combustion evolves more amount of CO_2 per gram of fuel.

CHAPTER-4

HYPOTHESIS NO. 1

➢ *Relation between Surface Area Exposed and Efficiency of Smouldering*

To check whether the hypothesis was true or not, we compared the efficiency of smouldering of two different shapes i.e. a cube with surface area of 8.1cm^2 and a cylinder of surface area of 12.6cm^2. The mass and remaining all other factors of both objects during smouldering were kept same and constant.

➢ *Observations*

Object 1= cylinder Object 2= cube

Mass= 1 gm Mass= 1gm

Volume= 1.6 cm^3 Volume= 1.6 cm^3

Surface area= 12.6 cm^2 Surface area= 8.1 cm^2

Rate of constant oxygen flow or supply = 15.75 litre per hour

➢ Observation table:-

	Charcoal cylinder [higher surface area]	Charcoal cube [lower surface area]
Time	Conductivity of CO_2 produced(in mhos)	Conductivity of CO_2 produced(in mhos)
2 minutes	-1.057	-1.044
	- 1.126	-1.023
	- 0.838	-1.117
avg	- 1.007	-1.061
4 minutes	-1.135	-1.068
	-1.097	-1.047
	-1.053	-1.106
avg	-1.055	-1.073
6 minutes	-1.138	-1.143
	-1.113	-1.126
	-1.129	-1.157
avg	-1.126	-1.142
At the end of combustion	- 1.376	- 1.418
	- 1.361	- 1.433
	- 1.313	- 1.372
avg	- 1.352	- 1.407

Table 1

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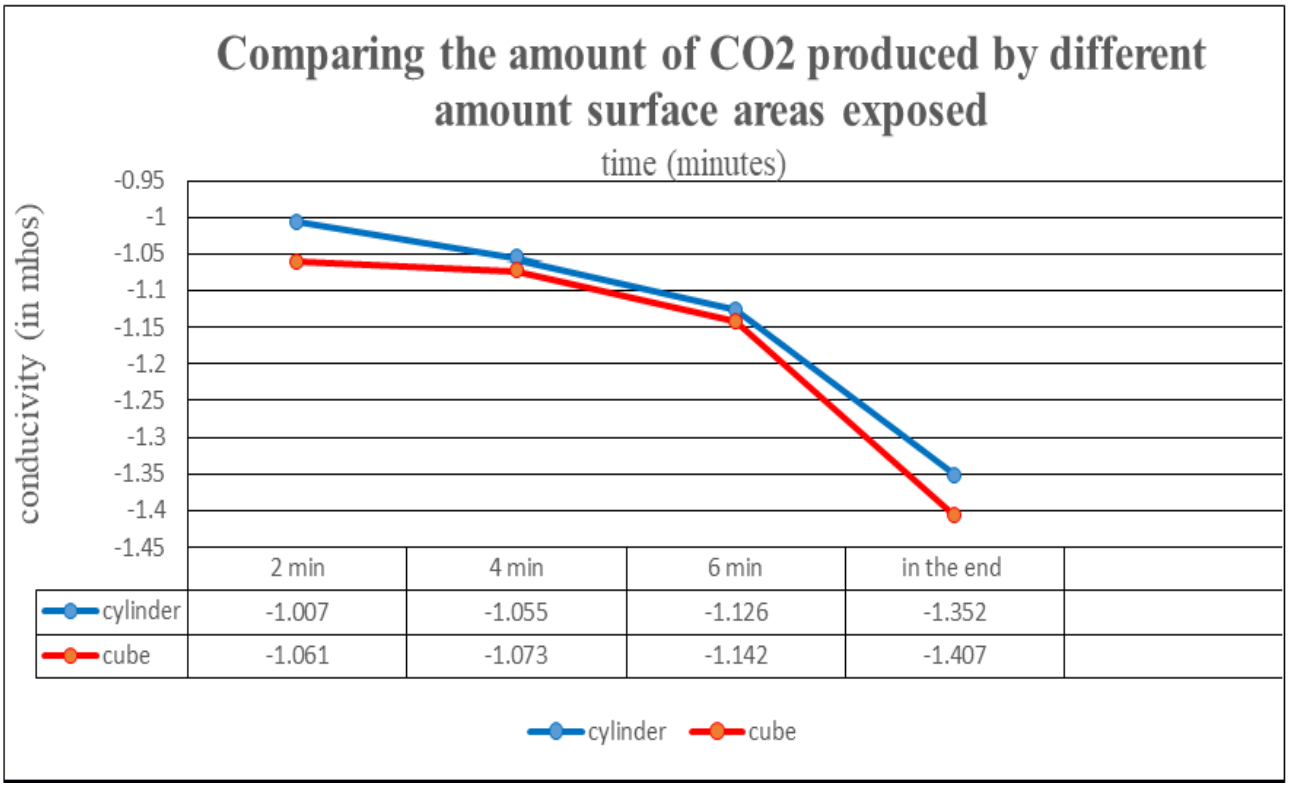

Fig 2

➢ *Analysis*

From the above graph we can clearly see that the surface area exposed to burning is an essential factor affecting the efficiency of smouldering.

Here, we can now say that, if the surface area exposed to burning is increased, the efficiency of smouldering will also increase. There for the shape and exposed surface area are also important factors when we consider the efficiency of smouldering.

The main reason behind this is, when we increase the surface area exposed , it also increases the amount of oxygen in contact with the smouldering fire and because oxygen is an important reactant in the process of combustion, increase in it's amount will also boost the combustion and hence the combustion will be more efficient.

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CHAPTER-5

HYPOTHESIS NO.2

➢ *Relation between amount of Oxygen Supplied and Efficiency of Smouldering*

To check whether the hypothesis was true or not, we compared the efficiency of smouldering at different amounts of oxygen supplied. During the experiment, the mass and remaining all other factors of both objects during smouldering were kept same and constant.

➢ *Observations*

Rate of constant oxygen flow or supply:-

Speed 1 = 15.75 litre per hour Speed 2 = 31.5litre per hour

Speed 3 = 47.25litre per hour Speed 4 = 63 litre per hour

Conductivity of CO_2 produced (in mhos)			
Rate of oxygen supply	At 2 minutes	At 4 minutes	At the end of combustion
Speed 1	-1.647	-1.668	- 1.701
	-1.620	-1.675	- 1.709
	-1.644	-1.653	- 1.697
Avg.	-1.637	-1.665	- 1.702
Speed 2	-0.911	-1.107	- 1.577
	-1.039	-1.286	- 1.562
	1.186	-1.259	- 1.644
Avg.	-1.040	-1.217	-1.630
Speed 3	- 1.057	-1.076	- 1.408
	- 1.126	-1.167	- 1.662
	- 0.838	-1.093	- 1.615
Avg.	-1.001	-1.112	- 1.562
Speed 4	- 0.915	-1.134	- 1.376
	- 0.684	-0.966	- 1.361
	- 0.897	-1.075	- 1.313
Avg.	-0.832	-1.058	- 1.350

Table 2

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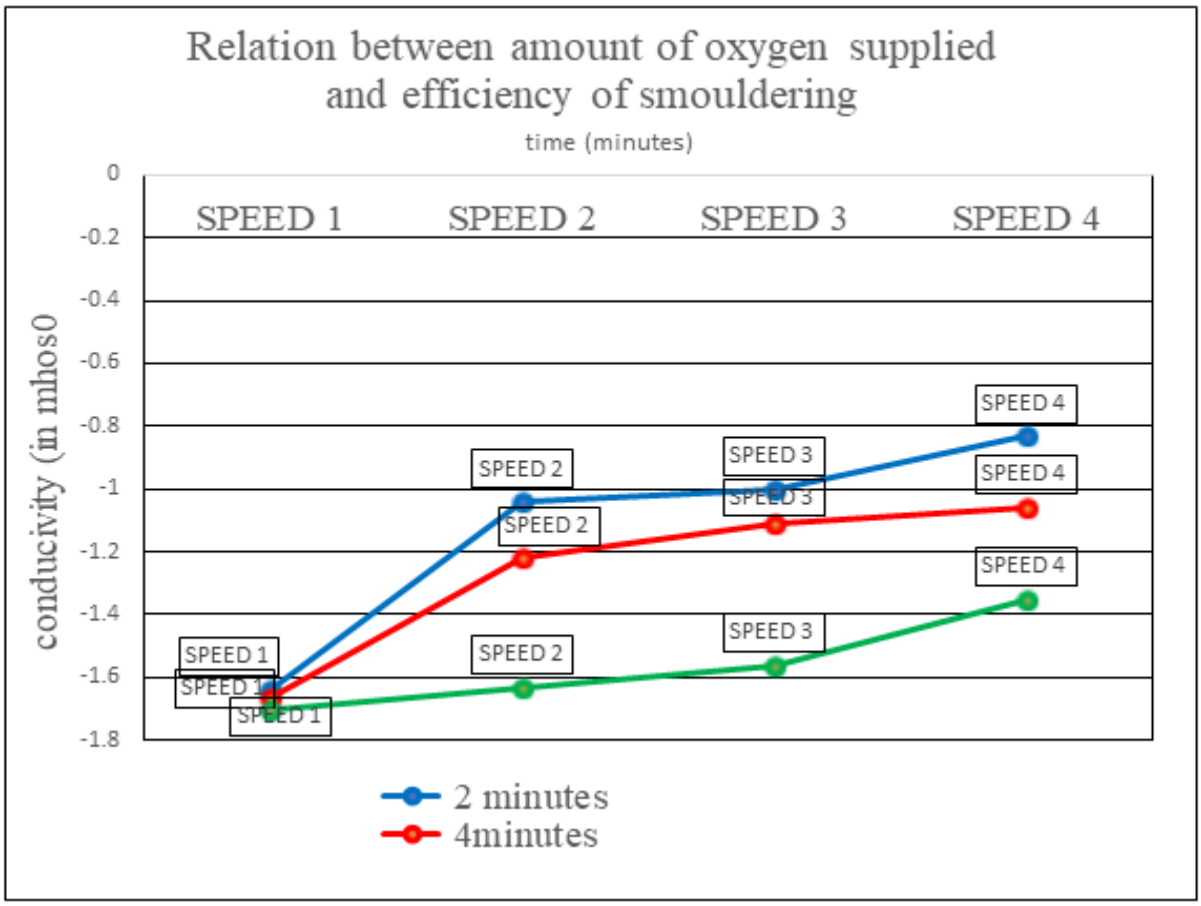

Fig 3

Conductivity of Gases in Mhos	2 minutes	4minutes	at the end of the combustion
SPEED 1	-1.637	-1.665	-1.702
SPEED 2	-1.04	-1.217	-1.63
SPEED 3	-1.001	-1.112	-1.562
SPEED 4	-0.832	-1.058	-1.35

Table 3

➢ *Analysis*

From the above graph we can clearly see that the amount of oxygen supplied to burning is an essential factor affecting the efficiency of smouldering.

Here, as we can see in the graph, as we go ahead in time the amount of oxygen supplied becomes the game changing factor for the efficiency of smouldering. The increase in the efficiency of smouldering after doubling the initial rate of oxygen supply is quite high and unexpected.

Now, we can say that, if the oxygen supplied to burning is increased, the efficiency of smouldering will also increase. There for the amount and rate of oxygen supplied are also important factors when we consider the efficiency of smouldering.

The main reason behind this is, when we increase the rate of oxygen supply, it also increases the amount of oxygen in contact with the smouldering fire and because oxygen is an important reactant in the process of combustion, increase in it's amount will also boost the combustion and hence the combustion will be more efficient.

CHAPTER-6

RESULT

- Amount of surface area exposed to the combustion is directly proportional to the efficiency of the smouldering.
- Amount of oxygen supplied to the combustion is directly proportional to the efficiency of the smouldering.

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CHAPTER-7
CONCLUSION

We found that smouldering with more exposed surface area is more efficient and complete combustion than smouldering with smaller exposed surface area because even if both objects are of same mass,the amount oxygen supply per unit mass for the combustion changes with change in the surface area.

So, as a result we can say that, we should prefer using cylindrical surface over cube because of greater surface area and greater efficiency and more faster the rate of fragrance spread.

We also conclude that if we increase oxygen supply then the smouldering becomes more complete because of more availability of the oxygen. And if we increase oxygen/air supply then smouldering rate also increases. As a result, in case of incense sticks the rate of spread of fragrance also increases.

So, now after analyzing the results of our project and by studying the results and conclusions,we tried to design some modifications and changes in our day-to-day products in which smouldering is used. During the designing, we tried to make the smouldering more practical, more efficient and more productive.

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CHAPTER-8
PROPOSED MODELS

So, we designed 2 models the daily using items, which are –

1] Incense stick holder

2] Barbecue grill

1] Incense stick holder

Diagram:-

➢ *Structure :-*

- Height = 30 cm, base diameter=12 cm
- Holding capacity = 25 incense sticks at one time
- attached fan to increase air supply with thermoelctric motor
- attached ash collector to keep the place clean.
- plenty of exit holes with fragrance directioner attached to it.
- frame material= stainless steel
- insulation protection on both ends to make the holder easy to carry.
- cost of manufacturing = approx 4-5 US dollars

➢ *Working :-*

- The fan works on the heat generated by the smouldering of incense stick .It uses heat sinks to absorb the heat and hobby motor to convert heat energy to electric energy which in turn is used to increase the oxygen supply to increase the efficiency of smouldering.

- For further information of the thermoelctric motor, please visit to https://macgyverisms.wonderhowto.com

- The dierectioner blocks the exit holes from one side so that the fragrance will spread in the direction in which the user wants to spread in the room preventing loss of fragrance outside the room.

➢ *Benefits :-*

- increased efficiency of smouldering.
- increased rate of spread of fragrance.
- easy to use , safe for children.
- no external electric supply required.
- not expensive to buy .
- easy to clean , no damage to the surface bellow.
- can be used in multiple places like , meditation centre, kodo in japan, holy temples in Indian, Chinese and Japanese cultures ,in the thurible used by Catholics.
- This is just a prototype model, for large scale use in holy temples, it can be further modified and used with more efficiency.

Also, we can use air pumps like aquarium pumps for this purpose instead of the thermoelectric motor.

2] Barbecue grill

Diagram:-

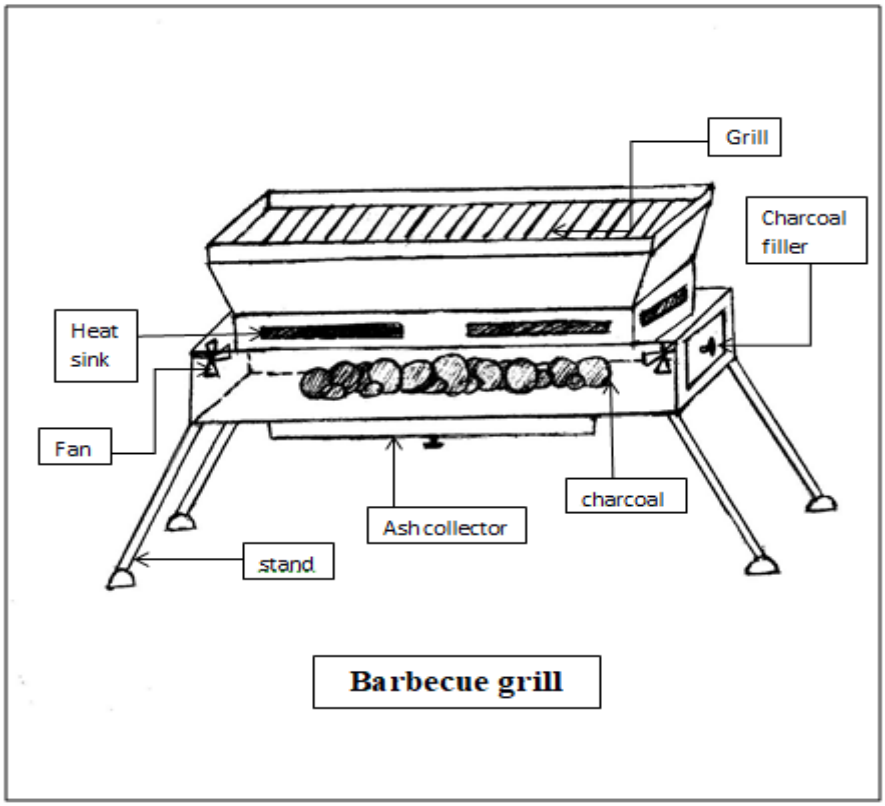

Fig 4

➢ *Structure :-*

- >Dimensions = BBQ surface 60 cm by 40 cm ,Height =40 cm(without stands) Retractable stands= can be extended up to 80 cm height.
- >two attached fans to increase air supply with thermoelctric motor.
- provision for charcoal filling from lateral side and ash collection from the bottom surface.
- attached stand with 4 retractable legs which can be fixed at any suitable height.this legs are with rubber pads at the base to keep the grill fixed and steady at on position
- well-insulated walls from outside.
- can be folded and packed in a suitcase like box of 60 cm by 40cm by 40 cm
- detachable lead above the grill is given to cover the grill when not in use
- cost of manufacturing = 25- 30 US dollars.

➢ *working :-*

- The fan works on the heat generated by the smouldering of charcoal .It uses heat sinks to absorb the heat and hobby motor to convert heat energy to electric energy which in turn is used to increase the oxygen supply to increase the efficiency of smouldering.
- >For further information of the thermoelctric motor, please visit to https://macgyverisms.wonderhowto.com
- stand is designed such that it can be fixed on un even surface at the required height.

➢ *Benefits :-*

- increased efficiency of smouldering of charcoal
- increased generation of heat. Hence, more efficient cooking over the grill.
- cost effective .
- safe and easy to use outdoor.
- easy to carry any where due to foldable compact structure.
- easy to use and clean.
- no damage to the surface bellow.
- small and compact to store.

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CHAPTER-9
GLOSSARY

[1]. Combustion – high temperature exothermic chemical reaction between fuel and oxygen. Usually in combustion light and energy is produced.

[2]. Complete combustion – fuel burns in sufficient oxygen supply producing very less waste products.

[3]. Incomplete combustion – fuel burns in insufficient oxygen supply producing lots of ash, Carbon Monoxide and water vapour.

[4]. Air fuel ratio – the mass ratio of air and fuel involved in combustion.

[5]. Chemical change – a change in which chemical properties of elements changes is known as chemical change.

[6]. Ash – black powder remained after combustion.

[7]. Conductivity – conductivity of an electrolyte solution is a measure of its ability to conduct electricity.

[8]. Siemens – SI unit of conductivity.

[9]. Conductivity meter – instrument is used to conductivity.

[10]. Lime water-aquatic solution of calcium hydroxide.

[11]. Wood – dead, hard, totally dried part of stem.

[12]. Electrolyte - An electrolyte is a substance that produces an electrically conducting solution when dissolved in a polar solvent, such as water.

[13]. Resistance - The electrical resistance of an electrical conductor is a measure of the difficulty to pass an electric current through that conductor.

[14]. Mho - Mho is an alternative name of Siemens (unit of electrical conductance).

[15]. Ions - An ion is an atom or a molecule in which the total number of electrons is not equal to the total number of protons, giving the atom or molecule a net positive or negative electrical change.

[16]. Calibrating - mark (a gauge or instrument) with a standard scale of readings.

[17]. Oxygen supply – supply of oxygen.

[18]. Hard glass tube - It is a hard glass test-tube made of Pyrex which is resistant to chemicals. It is used for strong heating.

[19]. Incense – fragrance

[20]. Carbon monoxide – poisonous gas emitted in in-complete combustion

[21]. carbon dioxide-green house gas emitted in large amount after complete combustion

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