



Introduction to FIRE, types & cause of fire, patterns of fire, Thermodynamics of fire, Accelerant & incendiary devices, Forensic Analysis of Fire Debris

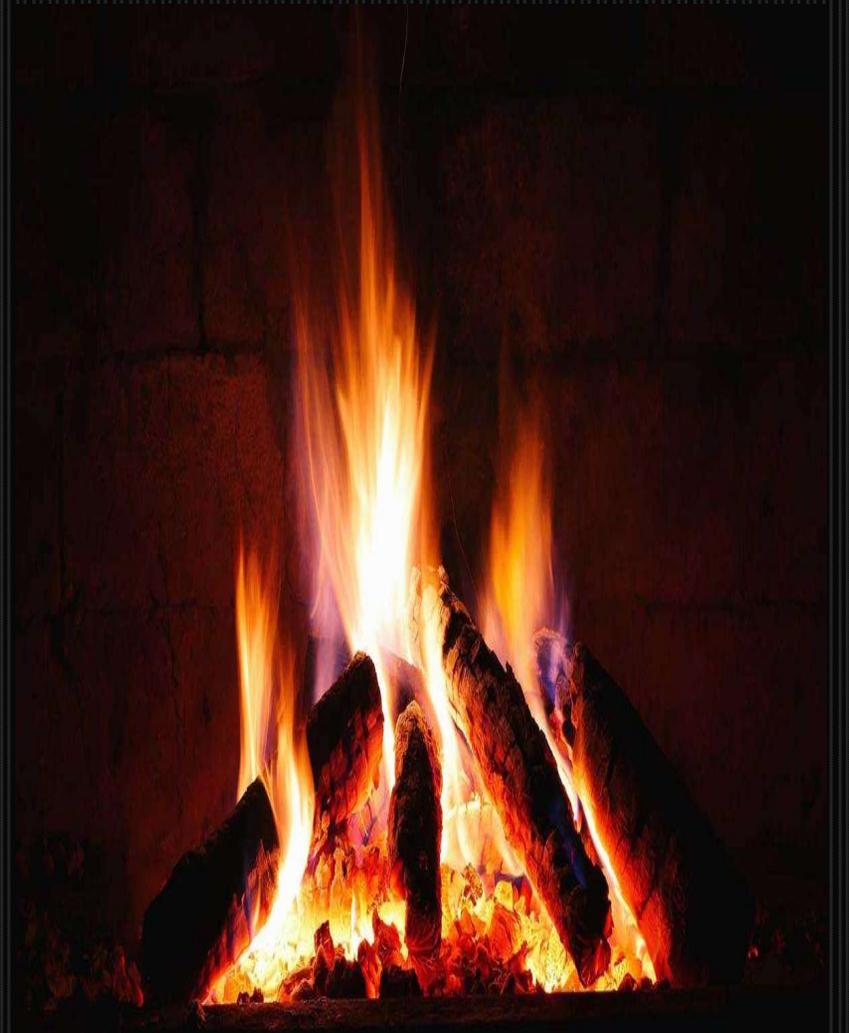


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Introduction to Fire:-

- Fire is an *Exothermic* chemical reaction and self-sustaining for some extent.
- It develops from a *combustible material*(which has C and H bond like wood stick, plastic, petrol, etc).
- Fire needs 3 things to develop:-
 - Oxygen
 - Combustible material
 - Initial energy



What is Fire?



It is a process in which substances combine chemically with oxygen from the air and typically give out bright light, heat, and smoke; combustion or burning.

Fire is the rapid oxidation of a material in the exothermic chemical process of combustion, releasing heat, light, and various reaction products.

Uses:-



amFear.com

Importance of Investigation :-

- *Homicidal, Accidental, Suicidal.*
- *Investigation is done to know :- Cause of Fire
Origin of Fire*



Chemistry and Behaviour of Fire :-

- Three elements must be present at the same time to have fire. A fire will burn until one or more of the element is removed.

Fuel

Any combustible material – Solid, Liquid or Gas.

Oxygen

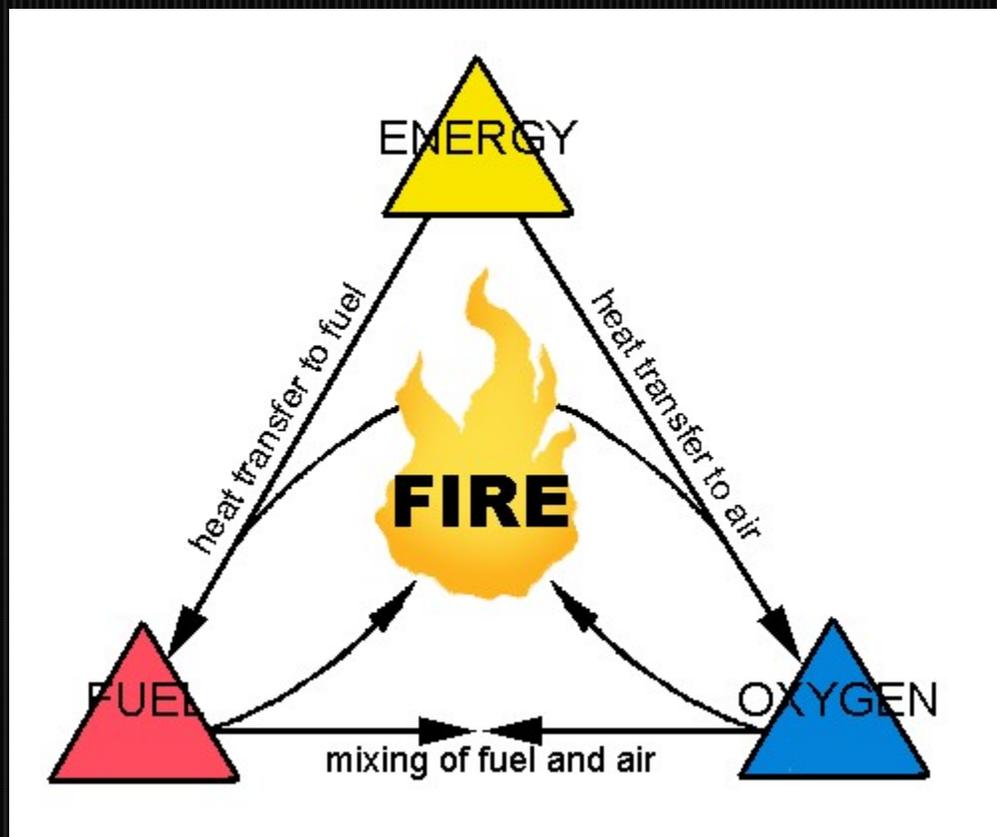
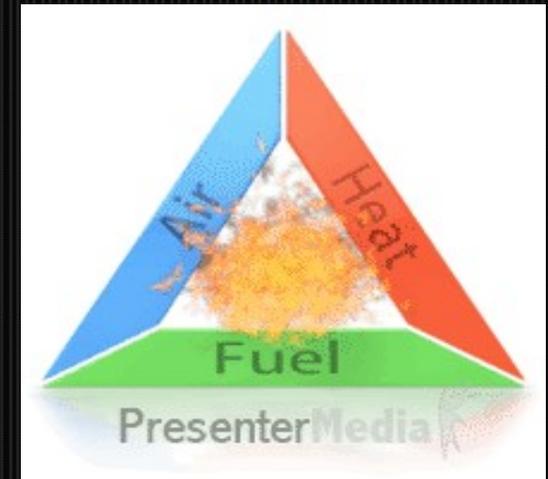
We breathe 21% of oxygen from air but fire needs only 16% of oxygen.

Heat

The energy necessary to increase the temperature of fuel to where sufficient vapour are given off for ignition to occur.

Basic of Fire Triangle-

- Fuel doesn't undergo auto-ignition, an external igniting source must be supplied before a self-sustaining exothermic chemical reaction will commence.

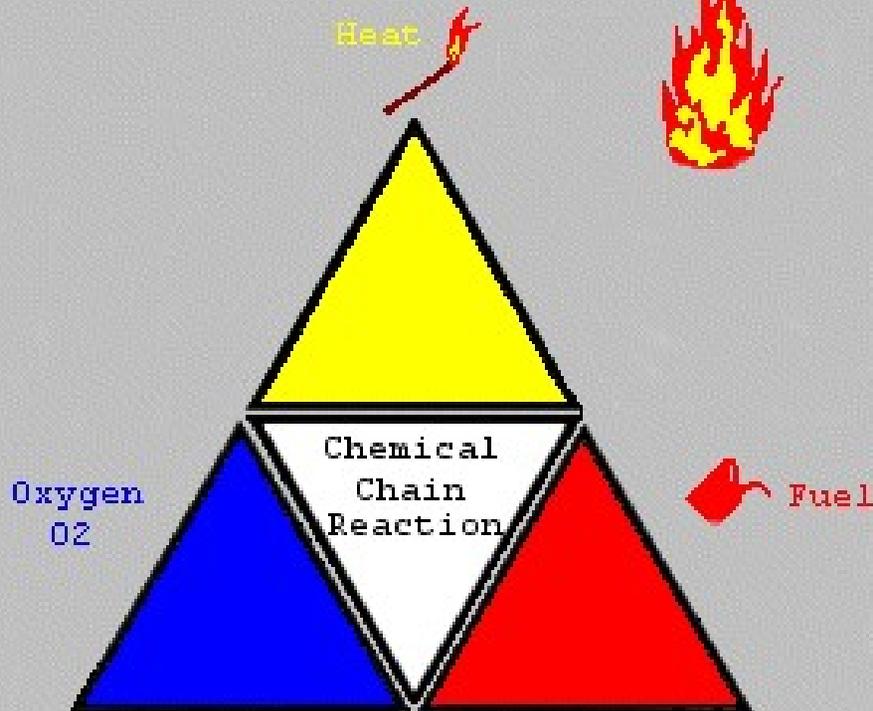


Oxygen- Oxidizing agent.

Fuel- Commonly fuels are organic compounds(contains sufficient amount of C & H). Includes **Naturally Occuring Compounds**(wood, cotton), **Synthetic Materials**(plastics, paints, rubbers), and **Refined Fuels**(petrol, kerosene).

Heat Energy- Energy in the form heat transfers to both fuel and oxygen.

Fire Tetrahedron



- Four-sided geometric representation.

- Factors required for fire:-

Fuel

Heat

Oxygen

Chemical

Chain Reaction

↓
Sufficient exothermic reaction energy to produce continuous ignition.

Once a fire has started it can only be suppressed when one of the three elements is removed, thus stopping the chemical chain reaction.

Heat :

- It is the energy possessed by a substance due to molecular activity.
- Heat production :
 - Can be produced in 5 ways:
 - Chemical – due to rapid oxidation
 - Mechanical – due to friction
 - Electrical – due to shorting or other electrical malfunctions, poor wire connections.
 - Compressed gas
 - Nuclear – due to fission or fusion

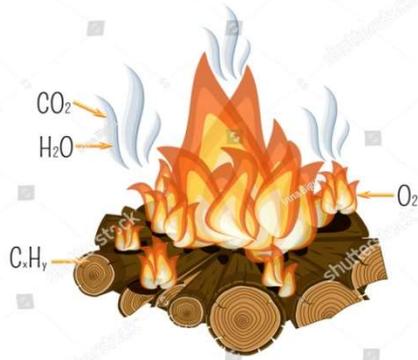
Heat transfer

- Conduction – Transfer of heat by mol. activity within a material, usually a solid. Direct contact is the underlying factor.
 - Thermal conductivity : ability of the substance to conduct heat as well as electricity.
 - Superheated pipes, steel girders and other structural members may conduct sufficient heat to initiate fires in other areas.

- Convection : Transfer of heat by a circulating medium, usually air or liquid.
 - Chiefly responsible for spread of fire in compartment fires.
 - Superheated gases evolved from fire rise as they are lighter than air. They travel and accumulates in the upper areas and create more damage and increases the overall temperature as well.

- Radiation : Heat moves in waves and rays much like sunlight or X-rays.
 - Primarily responsible for exposure hazards that develops and exist during a fire. Heat waves travel in direct or straight line from their source until they strike an object and this heat wave is then subsequently absorbed into the mass through conduction.

Combustion reaction



When a substance burns

Molecules gets weaker

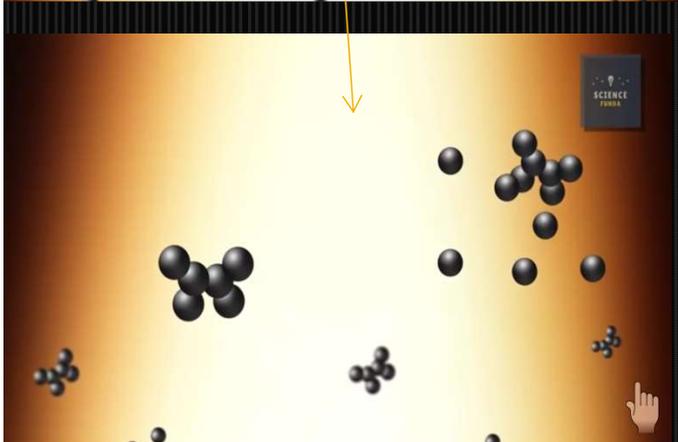
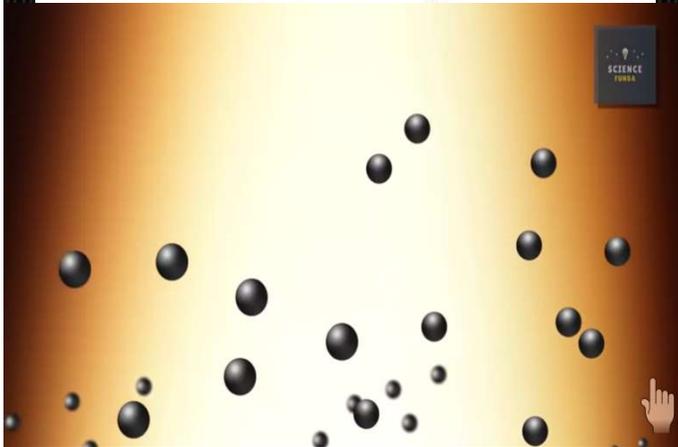
C & H atom releases from combustible material

Reacts with O₂ atoms present in air

Production of combustible material & heat energy

C atoms, which are not oxidized due to incomplete burning of fuel make groupings

Comes up from fire in form of fume



For Example:- Burning of Paper-

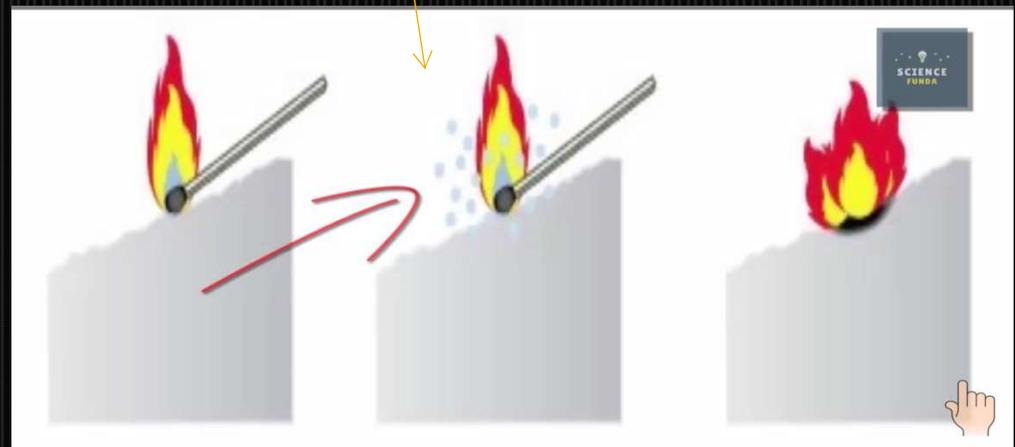
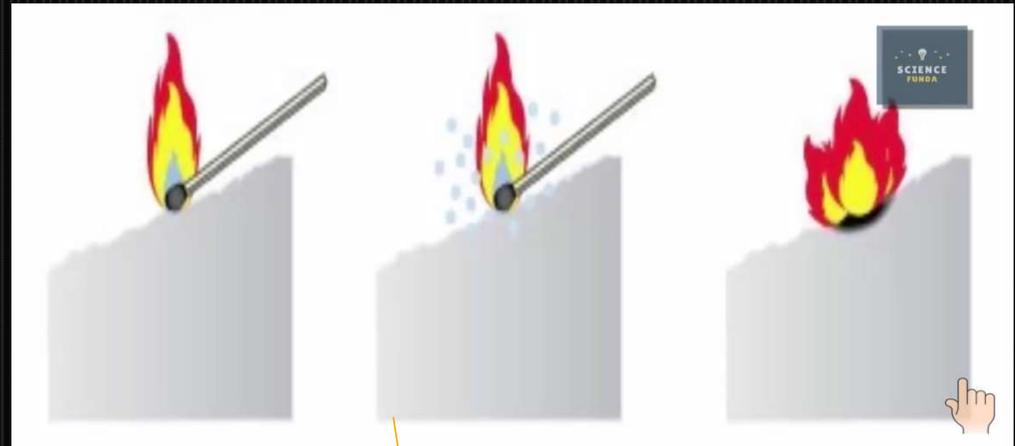
Breaking of molecule

*Production of gas i.e
sublimation process
(Solid \longleftrightarrow Gas)*

*Molecules get oxidized with
oxygen*

Paper continues burning

- It's like a chain reaction for which paper burns continuously.



Thermodynamics of Fire:-

- ***What is Thermodynamics?***

Thermo-Temperature

Dynamics- Study of effect and changes of temperature.

- ***Importance:-*** Enables the investigator to identify the origin of fire and determines the cause of fire.

Role of Thermodynamics in Fire

Investigation:-

The most important factors are:-

Temperature –

- Intensive state variable.
- Measured by use of a Thermometer.
- There are 3 temperature scales:- Celsius , Kelvin , Fahrenheit

The conversion formulate between 3 scales are-

$$0^{\circ} \text{C} = 273.15\text{K} = 32^{\circ} \text{F}$$

$$T(\text{K}) = T(^{\circ}\text{C}) + 273.15$$

$$T(^{\circ}\text{F}) = 9/5 T(^{\circ}\text{C}) + 32$$

- At a given atmospheric pressure there are certain temperature values, that indicates the possibility of ignition.

1. Flash Point
2. Point of Inflammation
3. Point of Auto-ignition

Heat-

- It is the form of energy.
- Generates by the transformation of energy.
- Unit- Joule(J)

$$1\text{kcal} = 10^3 \text{ J}$$

$$1 \text{ cal} = 4.185 \text{ J}$$

Physical Properties-

Heat Capacity,

$$C = dQ / dT, \text{ Unit} = \text{J/K}$$

Specific Heat Capacity,

$$c = 1/M dQ/dT, \text{ Unit} = \text{J /kg K}$$

Ideal Gas Law,

$$pV = nRT, \text{ where, } p = \text{pressure in Pa}$$

$V = \text{volume in m}^3$

$n = \text{no of moles}$

$R = \text{gas constant}$

$$= 8.315 \text{ J/ K mol}$$

$T = \text{temp. in K}$

When an ideal gas makes transition from one state to another, then the following formula applies,

$$p_1V_1 / T_1 = p_2V_2 / T_2$$

Types of Fire:-

- *On the basis of to establish the cause of the Fire:- 3 types*

→ *Negligence*

→ *An accident*

→ *A malicious act/ Arson*

- *On the basis of source of Ignition:- 5 types*

→ *Electrical*

→ *Machinery*

→ *Auto-ignition*

→ *Weather*

→ *Direct Ignition*

Patterns of Fire:-

- Fire patterns are formed when the products of combustion come into contact with a vertical or horizontal surface such as wall, floor, ceiling, or home furnishing.
- Smoke patterns of carbon are deposits on wall and ceiling.

"V" Pattern:-

It produces an arrow that points to the room where the fire started. Heat deposits carbon particles that leave an inverted cone pattern that resembles a "V" pattern. It is also called as triangular-shaped or inverted cone pattern.





Descending Heat

Pattern:- on a gypsum wall leading to the room of the fire origin. When comparing both side of the jamb ,if the fire is lower on one side of the jamb than other side , it indicates that fire coming from this side.



Charring on the right side of the door jamb framing:- indicates that the fire was to the right.



Circular Pattern on ceiling:-

Circular pattern on ceiling tiles directly occur where a fire originated.

Accelerants :-

- Substances, which accelerate or enhance the burning process are called as accelerants.

- Examples:
 - Gasoline
 - Kerosene
 - Diesel
 - Lighter fluids
 - Charcoal starters

Incendiary:-

- Often called as bombs but used as ignition not detonation.
- Signs:- Multiple Fires
 - Presence of Accelerants
 - Low level burning
 - Splash Pattern
 - Odors
 - Flashback
- Example:- Fire Ball

Introduction to Fire-scene:-

- *The appearance and evidential value of all items at the fire-scene depends upon 3 conditions.*
 - *The nature of the fire-scene and it's contents.*
 - *The behavior of the fire.*
 - *The fire-fighting and subsequent activities.*
- *Then the investigator establishes from where the fire originate and what is the cause of the fire.*
- *Evidences may not be suitable to recover immediately , but all steps should be taken to recover these samples.*
- *Structure of building and contents*
- *Behavior of the fire*

- ***Fire-fighting and subsequent activities***

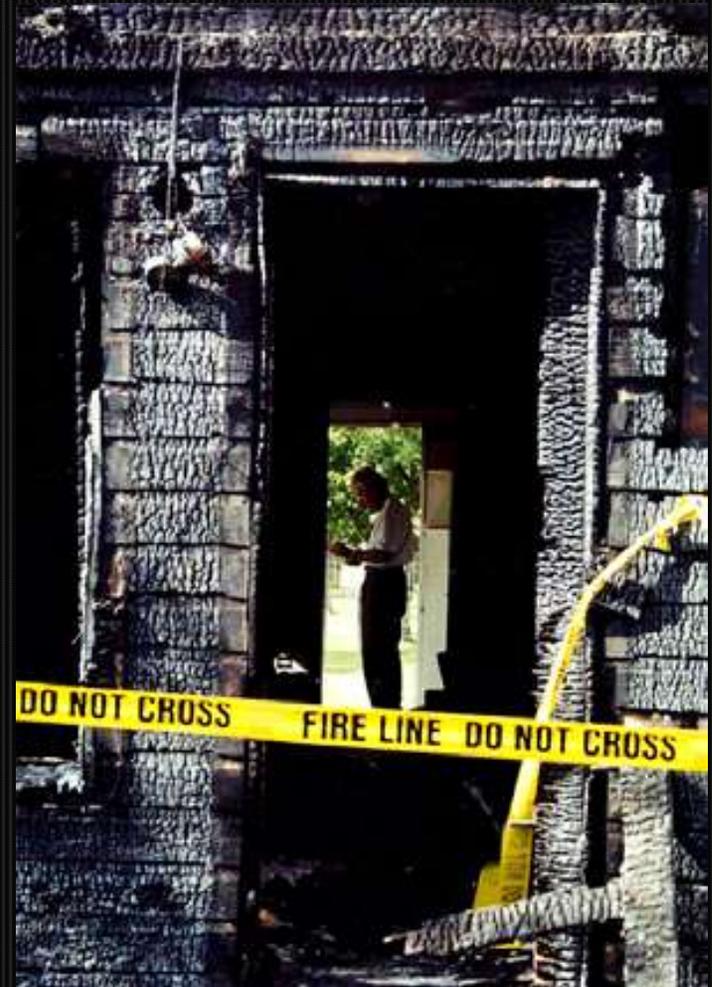
- ***Forcible Entry***
- ***Searching***
- ***Venting***
- ***Extinguishment***
- ***Movement of burned items***

- ***Fire investigation Objective***

- ***Preservation of Evidence***

- ***Recording of Information***

- ***Proper plans***
- ***Notes***



Fire –scene Examination:-

- ***Fire-scene examination of physical and chemical evidences should done by Scene Experts.***
- ***They are:-*** Fire cause investigator
Fingerprint examiner
Crime scene examiner
Crime scene recorder
Specialists of other discipline
(Electricians, Engineers, Drug
analysis experts)

Laboratory Analysis of Fire Debrises:-

- *Laboratory analysis includes some divisions for examination. These are:-*
 - Forensic Biology
 - Fingerprints
 - Criminalistics
 - Document Examination
 - Forensic Chemistry
 - Forensic Toxicology

▪ Major examinations are extraction and identification of flammable liquids and flammable liquid residues from debris, clothing, and other samples.

▪ Extraction:-

▪ *Direct Sampling:-*

- This technique can be used for both flammable liquid and gaseous substances.
- Liquid samples are diluted with appropriate solvent because most analytical methods are designed for low flammable liquid concentration.
- Gaseous samples can also be collected directly.
- From large amount of flammable liquid vapors, the headspace vapor can be collected using a syringe (2-5 ml).
- This is a less sensitive method.

▪ *Headspace Adsorption:-*

- This technique is most widely used at present.
- In this adsorption technique, in the former, the adsorption medium is placed in the sample container and allowed to stand for some time, in latter the headspace vapor is extracted through the adsorption medium by a pump.
- It is an extremely sensitive method.

▪ *Distillation:-*

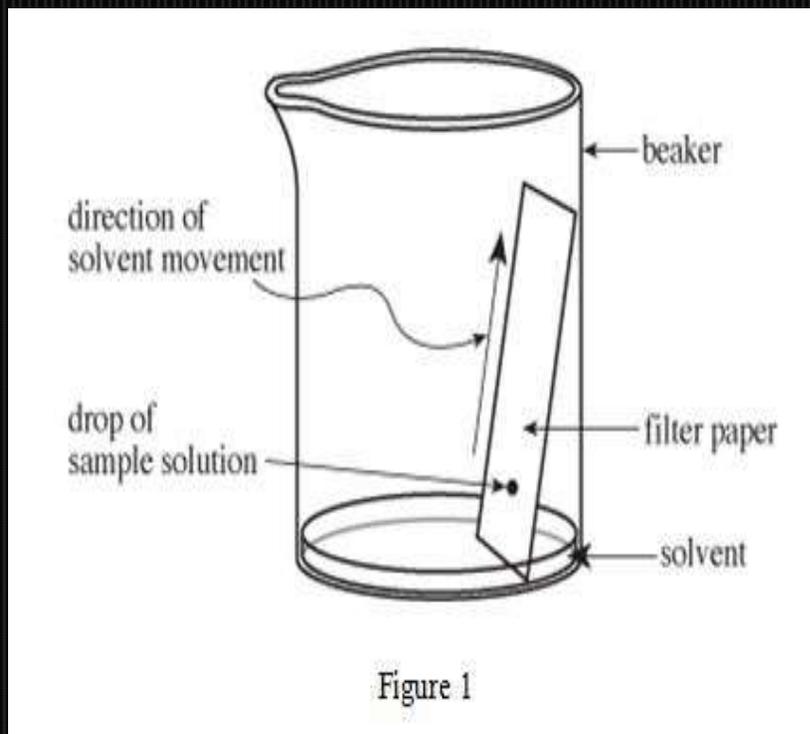
- *Oldest extraction technique.*
- *In Steam Distillation, steam is passed through the debris to vaporize and remove the flammable liquids.*

- Advantages is that it provides guide to the amount of flammable liquid is originally present.
 - It requires relatively large samples but less sensitive than other methods.
- *Solvent Extraction:-*
- It is a basic chemical technique and used for only solid and liquid samples.
 - It is conveniently applied to small samples and requires small to be immersed in a suitable solvent.
 - Any flammable liquid present is then adsorbed by the solvent, which is then removed.

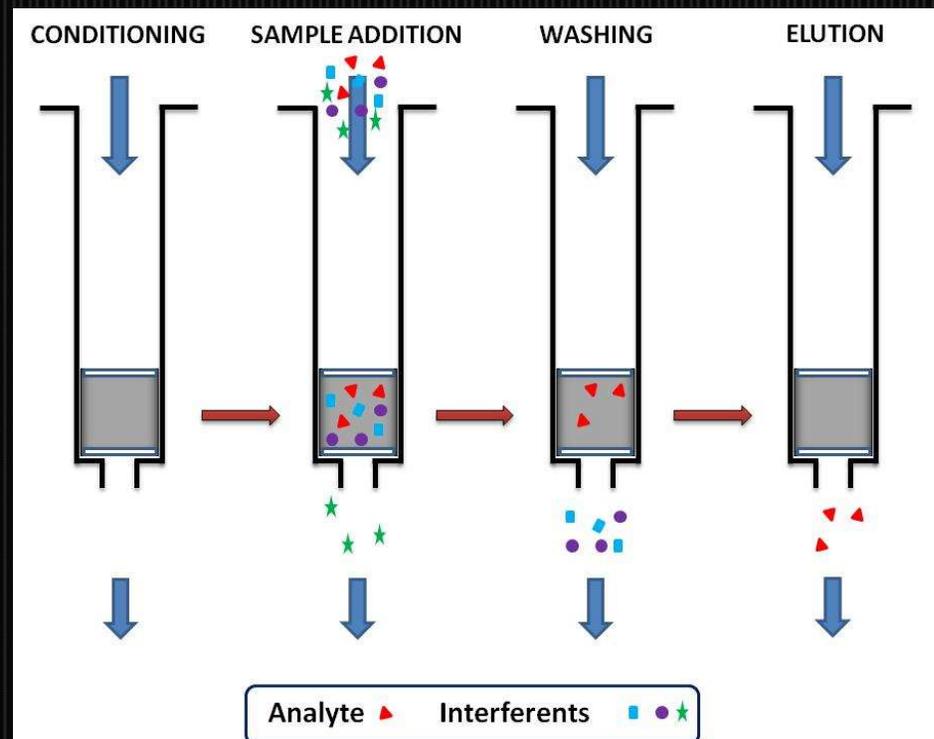
▪ Clean up:-

▪ Simple clean-up method is filtration. This can be used to remove suspected solids from a neat liquid sample or those resulting from a solvent extraction.

• TLC:-



Solid-phase Extraction:-



▪ *Disadvantage of clean up method is contamination due to simple handling mechanism. To minimize contamination further instrumental analysis can be done, which will produce more sensitive results.*

▪ **Analysis:-**

▪ **SEM:-**

- It is capable of magnification to 300000x, so that can be used to study the morphology of material.
- It also provide a rapid elemental analysis of microscopic samples, detailing amount and distribution of the medium to heavier elements.
- This can provide starting point of further investigation.

▪ *IR / FTIR:-*

- IR spectrum particularly useful for plastics and synthetic materials.
- The spectrum if IR reflects the chemical bonding and their structure of unknown substances.
- The advantages of FTIR is, it can analyze extremely small samples.

▪ **GC:-**

- **Mostly petroleum products are composed of many chemical components, so GC is the tool of identification of these products because GC separates the individual components and produces a "FINGERPRINT" of this product.**
- **From this Fingerprint , the product can be compared with the known standard for identification purpose.**

▪ **GCMS:-**

- **Same as the GC but here the mass of the present component can be also detected.**

▪ Analysis of Electrical Components:-

- Identification of one or more ignition sources, whether they are electrical or not .
- A laboratory examination includes the source of ignition, whether a timing device was operating, or an incendiary device, etc.
- SEM can be used for detail study of electrical components.

▪ Machinery:-

- The principle for the examination of machinery in forensic science laboratory is same as the electrical appliances.
- The machineries which are found to be severely damaged, it may necessary to consult with the manufacturer.