SUBJECT	FORENSIC SCIENCE
Paper No. and Title	PAPER No. 5: Forensic Chemistry & Explosives
Module No. and Title	MODULE No. 19: Arson-General Introduction & Chemistry of Fire
Module Tag	FSC_P5_M19

Principal Investigator	Co-Principal Investigator	Co- Principal Investigator (Technical)
Prof. (Dr.) A.K. Gupta Professor and Head, Department of Forensic Science Ex-Head, Department of Chemistry Sam Higginbottom Institute of Agriculture, Technology &Sciences	**Dr. G.S. Sodhi** Associate Professor Forensic Science Unit Department of Chemistry SGTB Khalsa College University of Delhi	**Dr. (Mrs.) Vimal Rarh** Deputy Director, Centre for e-Learning and Assistant Professor, Department of Chemistry, SGTB Khalsa College, University of Delhi *Specialized in : e-Learning and Educational Technologies*
Paper Coordinator	**Author**	**Reviewer**
Prof. (Dr.) A.K. Gupta Head, Department of Forensic Science S.H.I.A.T.S., Allahabad	**Dr. (Mrs.) Vimal Rarh** Assistant Professor, Department of Chemistry & Forensic Science unit SGTB Khalsa College, University of Delhi **Mr. Ranjeet Kumar Nigam** Research Scholar, Department of Forensic Science S.H.I.A.T.S., Allahabad	**Dr. M. S. Rao** Ex-Chief Forensic Scientist, MHA, GOI Hon. Advisor GFS University Gandhinagar
Anchor Institute : SGTB Khalsa College, University of Delhi		

TABLE OF CONTENTS

1. Learning Outcomes

After studying this module, you shall be able to know

- What is Arson?
- What are the reasons behind arson?
- How fire happened and its essential components?
- Understand the fire mechanism?
- What are the different Classes of Fire?
- Various Stage of fire?

2. Introduction to Arson

It is the crime of intentionally setting fire to buildings, vehicles or other property in order to cause damage. This also includes setting of fire to others property or sometimes to own property in order to advantaged insurance facilities.

- The lighting of fire – It is the essential element of arson, in the absence of fire lit, there is no arson.
- Intention or willfulness – This does not includes fire caused by natural causes or accidents,
- Malice – this does not include fire i.e. intentionally set with positive intention and property.
- The element of intent is critical to a definition of arson. People deliberately light fires for many reasons, including for some legitimate and legal purposes.
- Fire follows the well-defined principles of burning. It produces heat, flame, smoke, and gases. The byproduct in combustion processes may or may not be seen readily. Flame includes both open flame and smoldering glow. Smoke is composed of very fine solid particles and condensed vapors. The composition of fire gases emitted by the burning materials depends on the chemical makeup of the burning material, the amount of oxygen available during burning, and the temperature of the fire.

- Most fire gases are highly toxic. They are the biggest cause of fire deaths. This includes carbon monoxide not because it is very toxic in nature but due to its abundance. When breathed in quantity, carbon monoxide causes unconsciousness and, eventually, death. At lower concentrations, it results in disorientation and confusion and may cause other health hazards to victims. The second most dangerous gas produced by a fire is carbon dioxide. While not toxic in itself, a 2 percent increase in carbon dioxide in the air causes a 100 percent increase in a human's breathing rate.

- Fire burns up and out. It leaves a V-shaped char pattern on walls and vertical structures. A fire which is hot and fast at the point of origin will leave a sharp V pattern. A slow fire will produce a shallow V. While burning, if fire interacts with an obstruction, for example a ceiling then it will burn across it and look for place to go up. Fire travels in the direction of air.

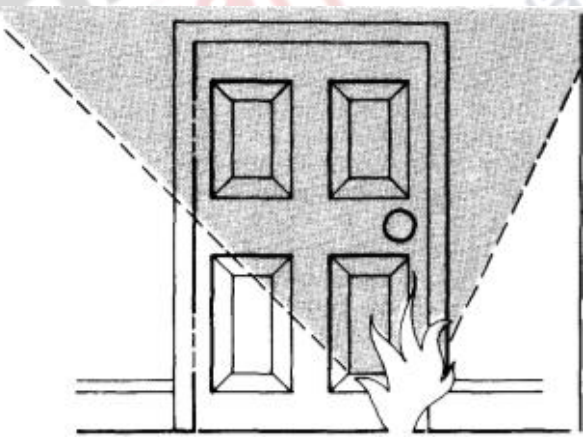

Figure No. 1: Behaviour of fire in indoor fire case.

Figure No. 2: Behaviour of fire in outdoor fire case.

3. Motive of Arson

Few of the reasons for arson are given below:

- Financial gain (Insurance Claim)
- Vanity
- Revenge
- Civil Disorder
- Crime Concealment
- Delinquent Behaviour
- Excitement
- Pyromania
- Dowry Death
- Communal Purposes

4. Chemistry of Fire

Fire is a chemical reaction that takes place when fuel, heat, and oxygen combine in an uninhabited chain reaction. To stop burning of fire, out of the three elements present in fire triangle should be removed. Remove any one of the elements and the fire goes out because you have stopped the continuing chemical reaction. Because only gases burn, solid and liquid fuels must be heated until they become vapour before they can burn. Heat chemically decomposes a fuel into its gaseous elements. This decomposition is known as pyrolysis.

For example: When wood is heated, it pyrolyzes to form hydrogen, oxygen, ethane and methane gases, and methyl alcohol. It is these highly flammable vapours which burn. Fuel in vapour form in its normal state, like natural gas, does not need to be pyrolyzed. Most fuels are compounds of carbon, hydrogen, and oxygen along with traces of mineral matter.

When the fuels burn completely and freely in air, the carbon reacts with the oxygen, forming carbon dioxide, and the hydrogen combines with the oxygen, forming water vapour. The mineral matter remains behind as ash. As the oxygen in the fuel is used up, oxygen is drawn from the air to continue the reaction. Mainly the fire spreads by transferring heat energy in three ways i.e. Radiation, Convection and Conduction.

4.1 Elements of Fire:

Fuel: This is anything that will burn. Fuel must be available for ignition. It may be in the form of a solid, a flammable liquid or gaseous state. Solids may be wood, cloth or paper. Examples of flammable liquids are kerosene, oil and gasoline. Vapours from paint, gasoline and other flammable materials are considered gaseous. Understanding that there are invisible, potentially dangerous vapours surrounding flammable chemicals is very important. Natural gas and propane are other examples of flammable materials in a gaseous state.

Oxygen: This is needed for combustion. Fires use oxygen to maintain a state of combustion (burning). Fires also produce smoke and poisonous gases.

Heat: Combustible materials may catch fire at ignition temperatures. Heat is needed to start a fire. For many items found in the home, the combustion temperature is 400 - 600 degrees Fahrenheit. Some items may ignite more easily than others.

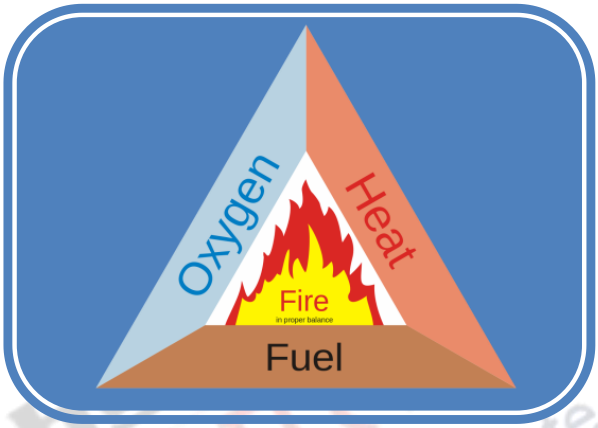

Figure: Element of a Fire Triangle.

4.2 Class of Fire

CLASS "A" FIRES

A class "A" fire can involve any material that has a burning ember or leaves an ash. Some examples of class "A" fires are wood, paper, or pulp. The adopted method for quenching fire of class "A" is to remove the heat. Water is considered to be most common agent, but other agents such as foam and dry chemical can be effectively used.

CLASS "B" FIRES

A class "B" fire involves flammable liquid or gas. Familiar examples would be gasoline, oil, propane, and natural gas. A variety of fire extinguishing agents is used on flammable liquid fires employing all theories of fire extinguishment. Which agent is best to use is dependent upon the circumstances involved. Flammable liquids do not ignite in their liquid state; rather it is the vapors being generated by these liquids that ignite. The mixture of oxygen and flammable vapors in proper proportion needs only an ignition source to start the combustion process.

CLASS "C" FIRES

Class "C" fires involve live electrical equipment and require the use of an extinguishing agent and/or extinguisher that will not conduct electricity back to the fire fighter(s). Electricity is an energy source and an ignition source, but by itself will not burn. Instead, the live electrical equipment may serve as a source of ignition for a class "A "fire such as insulation or packing, or a class "B" fire.

CLASS "D" FIRES

Class "D" fires involve exotic metals such as titanium, zirconium, magnesium, and sodium. These fires require special agents such as dry powders and special application techniques. The extinguishing agents and techniques used on "A", "B", or "C" fires will not work on class "D" fires, nor will the agents and techniques used for class "D" fires work on any other classification of fire. Many common agents like water will actually react to burning metals and increase the intensity of the fire in a violent manner.

Table No.1

Class/Classification of fires	Example
Class "A"	Solid materials: paper, wood, lumber, cloth
Class "B"	Flammable liquids: oils, paints, grease, gases
Class "C"	Electric: faulty fuse boxes, frayed wires, over-loaded electrical outlets
Class "D".	combustible metals

Major Principles:

1. Fuel, heat and oxygen are essential for combustion (burning).
2. Fuel must be ignited before it will burn.
3. Without a reaction, fire will not burn materials such as wood, cloth and paper. Chain reactions are crucial to fires. If the reaction is interrupted, the fire will be altered or extinguished.

4.3 Three Phases of Combustion

The burning process occurs in clearly defined stages. For a fire fighter it is important to recognize different phases of fire so that he can understand the different levels of burning fires and to fight against it using different tools. These phases are classified on the basis of atmospheric conditions.

Incipient/Initial Phase (Growth Stage):

This is the first phase; here fire produces water vapor, carbon dioxide, perhaps a small quantity of sulfur dioxide, carbon monoxide and other gases. Also in this phase the air oxygen content is reduced and produces fire. The fire may be producing a flame temperature well above $1,000^0$F (537^0C), yet the temperature in the room at this stage may be only slightly increased.

Free-Burning Phase (Fully Developed Stage):

The second phase involves the all burning activities of the fire. In this phase, air rich in oxygen is strained into the flame and convection carries heat to the upper most regions. The gases heated up spreads out from the top downward, resulting in increased concentration of cooler air at low levels and results in the ignition of combustible material. Due to this heated air, firefighters are taught to keep low and use protective breathing equipment. One breath of this super-heated air can sear the lungs. At this point, the temperature in the upper regions can exceed $1,300^0$F (700^0C). In the later stages of fire, it starts to progress and oxygen is continuously consumed by it and the point where there is insufficient oxygen to react with the fuel. The fire is then reduced to the smoldering phase and needs only a supply of oxygen to burn rapidly or explode.

Smoldering Phase (Decay Stage):

In the third phase, flame may cease to exist if the area of confinement is sufficiently airtight. In this instance, burning is reduced to glowing embers. The room becomes completely filled with dense smoke and gases to the extent that it is forced from all cracks under pressure. The fire will continue to smolder, and the room will completely fill with dense smoke and gases of combustion at a temperature of well over $1,000^0$F (537^0C). The intense heat will have vaporized the lighter fuel fractions such as hydrogen and methane from the combustible material in the room. These fuel gases will be added to those produced by the fire and will further increase the hazard to the firefighter and create the possibility of a backdraft.

5. Summary

- Arson: Willful/Intentional or Malicious Burning of property is deemed as arson.
- Numerous motives are evolved in Malicious Burning/Arson, (For Example: For getting Insurance advantage).
- Fuel + Oxygen + Heat (Components of fire) = Fire
- Eliminate any one of the component to check/seize the fire.
- Four Different classes of fire are:
  - **Class "A"** : Solid materials: paper, wood, lumber, cloth
  - **Class "B"** :Flammable liquids: oils, paints, grease, gases
  - **Class "C"** :Electric: faulty fuse boxes, frayed wires, over-loaded electrical outlets
  - **Class "D":** Combustible metals

Free Burning Phase or flaming fire (Temperature exceed $1,300^0$F (700^0C))

- Smoldering Phase/fire (Temperature near $1,000^0$F (537^0C))