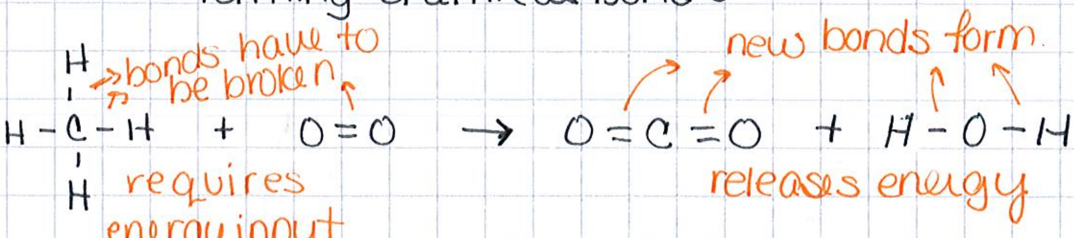
# Unit 5 - Arson, Explosives, Ballistics, & Impressions

## I. Arson

### A. The Chemistry of Fire

1. Combustion - rapid combination of oxygen w/another substance, accompanied by noticable heat & light
2. 3 Requirements to Initiate & Sustain combustion
   (A) A fuel must be present.
   (B). Oxygen must be avaiable in sufficient quantity to combine w/ the fuel.
   (C) Heat must be applied to initiate the combustion & sufficient heat must be generated to sustain the reaction.
3. combustion is a form of oxidation - reaction of a substance w/oxygen ($O_2$) to form new products.
   (A.) All fire begins w/ oxidation
   very fast (1) methane + oxygen → carbon dioxide + water — requires ignition
   $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
   very slow (2) iron + oxygen → rust (iron(III)oxide) — doesn't need ignition
   $4Fe + 3O_2 \rightarrow 2Fe_2O_3$
4. Energy - the ability or potential of a system or material to do work
   (A.) Energy takes many forms: heat, electrical, mechanical, nuclear, light, & chemical.
   (B.) combustion converts chemical energy to heat & light energy
   (1) The amount of heat from a chemical reaction comes from the difference in energy of breaking & forming chemical bonds.




   (2) exothermic reactions - more energy is released than was initally needed to break bonds & start the reaction
   (a) heat of combustion - the excess energy released
   (3) endothermic reactions - reaction requires more energy to break bonds than it releases when forming new bonds

(2)

5. Heat
   (A) ignition temperature - minimum temperature at which a fuel spontaneously ignites.
      (1) once combustion starts, enough heat is released to keep the reaction going, like a chain reaction. It will continue until either the fuel or oxygen run out.

6. Speed (Rate) of Reaction of Combustion
   (A) The faster the molecules move, the greater the # of collisions between them, & the faster the reaction.
   (B) Factors Affecting Rate of Combustion
      (1) Physical state of fuel - The only state of matter that has a rate fast enough to produce a flame is the gas state.
         (a) Liquid and solid fuels have to become gases to burn!
      (2) Fuel temperature
         (a) Liquids - the temperature must be high enough to vaporize the fuel.
            (i) The vapor (gas) mixes w/ $O_2$ and combusts
            (ii) flash point - lowest temperature at which a liquid gives off enough vapor to support combustion. Flash point is always lower than ignition temperature
            Ex) gasoline: f.p. = -50°F i.t. = 495°F

         (b) Solids - only burn when exposed to heat intense enough to decompose the solid into gas, called pyrolysis
         (c) The rate increases when the temperature is raised for most reactions - an 18°F (10°C) increase in temperature will double or triple the rate

      (3) Fuel-Air mixture - combustion will occur only if there is the correct fuel to air (oxygen) ratio
         (a) flammable range - the range of possible gas/vapor fuel concentrations in air that are capable of burning
         Ex) gasoline - 1.3-6.0%
      (4) Glowing Combustion - combustion only on the surface of a solid fuel in the absence of heat high enough to pyrolyze the solid
         Ex) glowing, red hot charcoals

(5) Spontaneous Combustion - fire caused by a natural, heat-producing process in the presence of enough air and fuel!
Ex) hay, grain silos, oil soaked rags in an improperly ventilated container.

7. Heat Transfer
(A) Conduction - movement of heat through a solid object in which electrons and atoms within the heated object collide w/one another & transfer the heat energy.
(1) metals - contain loosely held electrons, conduct heat well
wood - tightly held electrons, poor conductors of heat, called insulators
(2) reconstruction of a fire scene
(a) heat will be conducted thru beams, nails, & bolts to places far from the heat source. Any fuel in contact w/ these things will ignite.
(b) paper, wood, & plastic are poor conductors. Heat will not spread well or cause ignition far from the initial heat source
(B) Radiation - transfer of heat energy from a heated surface to a cooler one by electromagnetic (em) radiation. EM radiation moves in a straight line from one surface to another.
(1) Plays a key role in understanding how fire spreads through a structure.
Ex) All surfaces that face a fire are exposed to radiant heat & burst into flame when the surface reaches ignition temperature. In large fires, nearby structures & cars can be ignited at a distance.
(C) Convection - transfer of heat by molecules moving within a liquid or gas.
Ex) In a structural fire, hot gaseous products of combustion expand & move to upper portions of the structure, becoming another source of heat & radiating the heat onto exposed surfaces that pyrolyze, releasing more gaseous products
(1) flashover - all combustible fuels spontaneously ignite, engulfing the entire structure in flame.

B. Searching the Fire Scene

1. Arson investigators begin examining the scene as soon as the fire has been extinguished
   (A.) most arsons start w/ petroleum based accelerants - material used to start or sustain a fire, like gasoline or kerosene
   (B) Look for containers that held the accelerant, ignition devices (candles to time-delay devices), & irregularly shaped pattern on the floor or ground (from pouring accelerant on the surface). Also look for signs of breaking & entering, theft
   (c) Interview eyewitnesses
2. Timelines of Investigation - Arson investigators do NOT need a search warrant to investigate or collect evidence (by supreme court decision)
   (A) accelerant residue can evaporate within hours or days

3. Locating the Fire's Origin
   (A) Focus on search for an accelerant or ignition device.
   (B) May find evidence of separate & unconnected fires or the use of "streamer" to spread fire from 1 area to another.
   (c) Since fires spread upward, probable origin is most likely closest to the lowest point that shows the most intense characteristics of burning
      (1) V-shaped pattern can form along a vertical wall
      (2) If a liquid accelerant was used, charring will be most intense at bottom of object since liquids flow down.
   (D) Air flow currents can direct the movement of the fire
   (E) other considerations
      (1) prevailing drafts & winds
      (2) secondary fires due to collapsing floors & roofs
      (3) physical arrangement of structure
      (4) stairways & elevator shafts
      (5) holes in floor, wall, or roof
      (6) effects of fire fighter surpressing the fire
   (F) Once origin is located, point of origin needs to be protected. Nothing should be moved. Sketches made & photos taken.

4. Searching for Accelerants
(A) Enough liquid accelerant may remain unchanged as it seeped into porous surfaces: cracks in the floor, upholstery, rags, plaster, wallboards, or carpet.
(B) Portable hydrocarbon detector or "sniffer" - looks for traces of accelerant residues.

good - screening device

(1) sucks in air surrounding questioned sample. passed over a heated element. If combustible vapor is present, it oxidizes & increases temperature of filament which registers on the detector's meter

5. Collection & Preservation of Arson Evidence

(A) 2-3 quarts of ash & soot debris is collected from the point of origin
(1) contains all porous materials & other substances thought to contain flammable residues.
(B) Packaging & Preservation
(1) immediately in air tight containers so residue is not lost to evaporation - clean, new paint cans with friction lids are often used. or wide-mouth glass jars w/ air-tight lids.
(a) fill ½ - ⅔ full
(2) fluids in open bottles or cans should be collected & sealed, even if they appear empty
(C) substrate control - uncontaminated control samples collected from another area of the fire scene
(D) Igniters and Other Evidence
(1) most common igniter - a match
(2) other igniters
(a) burning cigarette
(b) firearms
(c) ammunition
(d) mechanical match striker
(e) electrical sparking devices
(f) molotov cocktail
(E) Also collect the clothing of the suspected prepetrator.

## C. Analysis of Flammable Residues (hydrocarbons)

(1) The Headspace Technique – disadvantage - limit to the vapor volume that can be removed

(A) Heat the air-tight container containing the sample, the volatile residue vaporizes & is trapped in the container's headspace. The vapor is then removed with a syringe.

(B) Vapor is injected into a gas chromatograph & separated into its components, which are shown as peaks on a chromatogram.

(C) Classify components by comparing the chromatogram w/ ones of known accelerants.
(ILRC - The Ignitable Liquids Reference Collection ilrc.ucf.edu - over 500 liquids)

(2) Vapor Concentration

(A) A charcoal-coated strip is placed in container w/ debris. Heated to 140°F (60°C) for an hour. A significant quantity of accelerant vaporizes & is absorbed by the strip. Strip is washed w/ a small amount of carbon disulfide & then that solvent is injected into the gas chromatograph.

(1) increases detection at least 100x's over headspace technique.

(3) mass spectrometry - sometimes gas chromatography isn't useful

(A) pass the separated component from gas chromatographic column through a mass spectrometer

(1) fragments samples into ions. Analyst controls which ions will be detected or ignored. Eliminates extraneous peaks in the gas chromatogram.