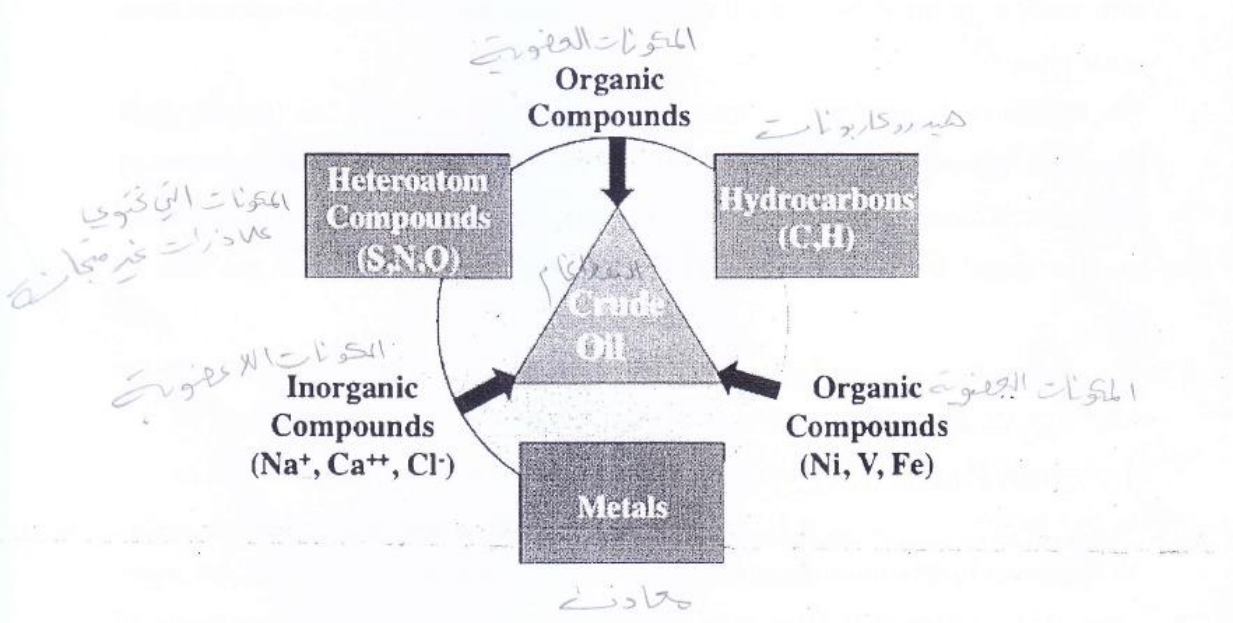
Topics
Chapter 1 : Classification of Crude Oil.
Chapter 2 : Physical and Chemical Properties of Crude Oil.
Chapter 3 : Evaluation of Crude oil.
Chapter 4 :Natural Gas properties and composition.
Chapter 5: Gases Production from Petroleum Products.

References:
1- Petroleum Refinery Engineering, by W.L.Nelson.
2- Petrochemicals , by Hazim.K.Yahya. & Faaz.A.Jameel.
3- اسس الكيمياء الصناعية, by Mohammed. A. Ameen.



A- Hydrocarbons components:
All the petroleums contains the same hydrocarbons groups such as normal, branch, cyclic paraffins, olefins and aromatic. They generally have from 1 to 60 carbon atoms per molecule.

I- Paraffins:
The paraffins, also known as alkanes, are saturated hydrocarbons with straight, branched or cyclic chains which contain only carbon and hydrogen. It is found in different formula as follows:

i- Normal /or series paraffins:
The hydrocarbon chain is straight , the general formula C_nH_{2n+2}, example n butane mean n=4= carbon atoms (C_4H_{10}). The properties of normal paraffins are:

- High molecular weight.
- High boiling point.
- Low octane number.

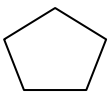
$CH_3 – CH_2 – CH_2 – CH_3$
n- butane

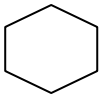
ii- Branch /or iso paraffins:
The hydrocarbon chain is branched, the general formula C_nH_{2n+2}, example iso butane mean n=4= carbon atoms (C_4H_{10}). The properties of branch paraffins are:

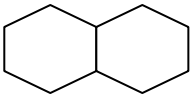
- Low boiling point.
- High octane number therefore is favorite in cars fuel.
- The common in crude oil is one branch and less tow branches.

$CH_3 – CH(CH_3) – CH_3$
iso butane

iii- Cycloparaffins (Naphthenes):
The cycloalkanes, also known as napthenes; are saturated hydrocarbons which have one or more carbon rings to which hydrogen atoms are attached according to the formula C_nH_{2n}. Cycloalkanes have similar properties to alkanes but have higher boiling points.


Cyclopentane


Cyclohexane


Decalin

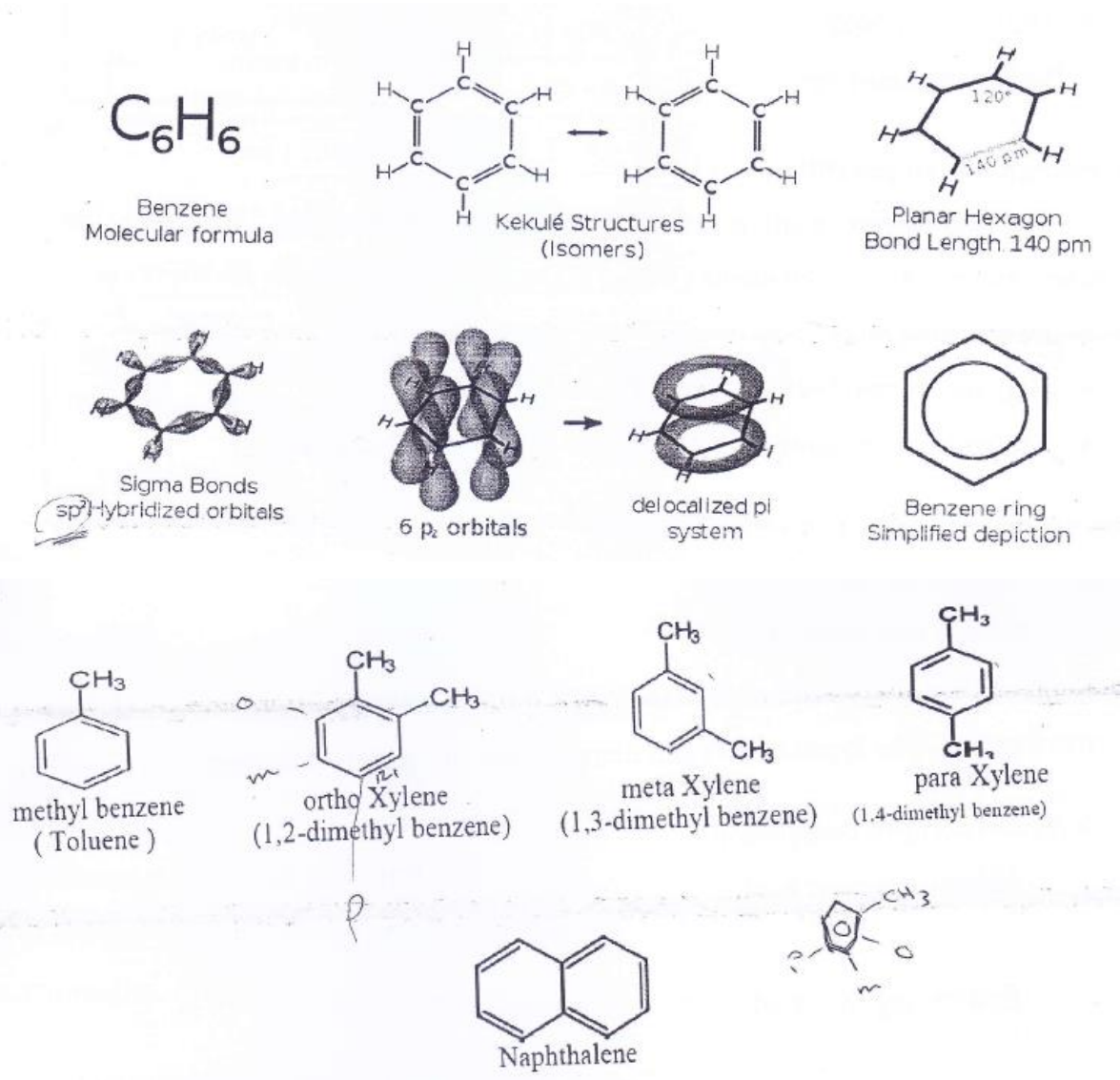
II- Olefins:

The olefins, also known as alkenes, are unsaturated hydrocarbons with general formula (C_nH_{2n}). The low boiling olefins are probably not present in crude petroleum, but they are found in cracked products.

$CH_3 - CH_2 - CH = CH_2$
1- butene

III- Aromatics:

The aromatic hydrocarbons are unsaturated hydrocarbons which have one or more planar six-carbon rings called benzene rings, to which hydrogen atoms are attached with the formula (C_nH_n) and many have a sweet aroma and a carcinogenic.



B- Non hydrocarbons components:

The non hydrocarbon components are caused:

1- Corrosion
2- Break clown in the refinery operation.

The non hydrocarbon components are divided to:

I- Sulphur components:

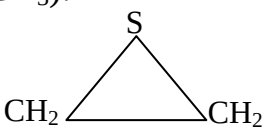
It is the most important one that increase as the density increased . The types of sulphur components in the petroleum are :-

i- Hydrogen Sulphide H- S- H (or H_2S)

ii- Mercaptance: H- S- R , where R is Alkyl (H- S- CH_3).

iii- Sulphides:

- Aliphatic sulphide: R- S- R
- Cyclo sulphide:



Disadvantages of Sulphur components:

l- Corrosion the metal parts of the engine .
2- Reduce O.N (octane number).
3- Reduce oxidation resistance.
4- Solids deposition.

II- Oxygen components:

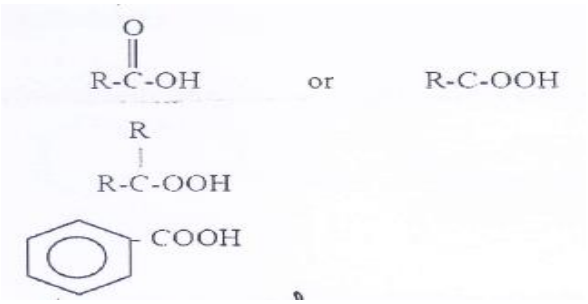
These compounds increase (b.p. = boiling point) with increasing the of the fraction. The types of oxygen components in the petroleum are:

i- Acidic oxygen components:

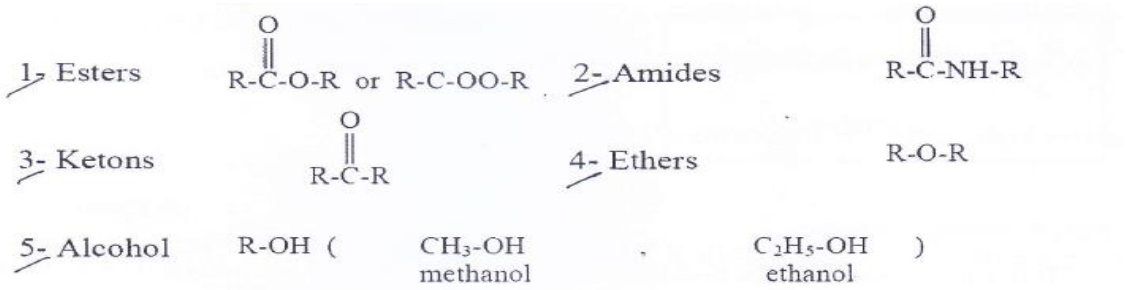
1- Normal organic acid :

2- Branch organic acid :

3- Aromatic acid :



ii- Non acidic oxygen components:



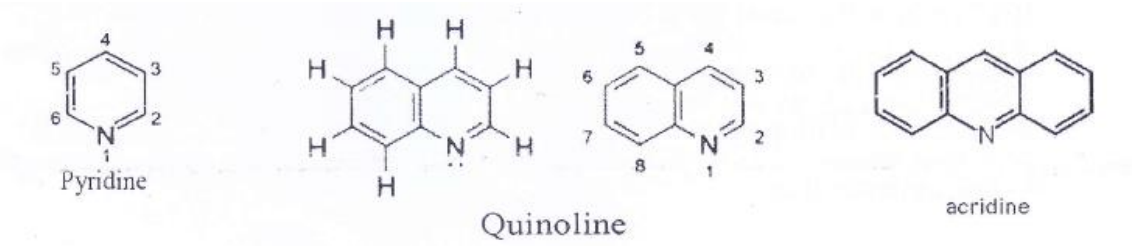
III- Nitrogen components:

More asphaltic crudes will contain N_2 compounds. They usually tolerate up to 0.25 wt% .

Disadvantages:

1- Can poison catalysts.
2- Increased carbon residue .
3- Decreased API.

Types of nitrogen components in the petroleum:



IV- Metallic components:

Disadvantages:

1- Affected on catalyst activity.
2-Coke formation.
3- Reduced the yield of the gasoline
4- Form ash deposits-power generation plants.
5- Corrosion .

Types of metallic components in the petroleum:

1- Organic metallic (Iron Fe, Nickel Ni, Vanadium V, Cadmium Cd,..).
2- Soap metallic (Magnesium Mg, Calcium Ca,…).
3- Salt metallic (Na^{+2}, Ba^{+2} ,….).

VI- Brine water:

Water molecules are suspension in crude oil with extremely high concentrations of dissolved salt ions nearly 300-300,000 ppm . The ions are divided to types:

1- Positive ions (Na^{+} , Ba^{+2} ,Mg^{+2} , Al^{+3} ,....).
2- Negative ions (Cl^{-}, Br^{-}, SO_4^{-2} , I^{-},…..).

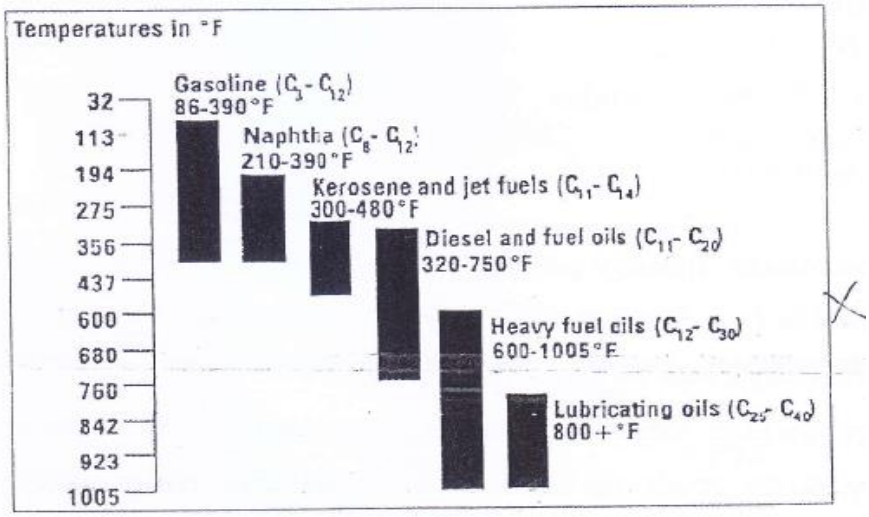


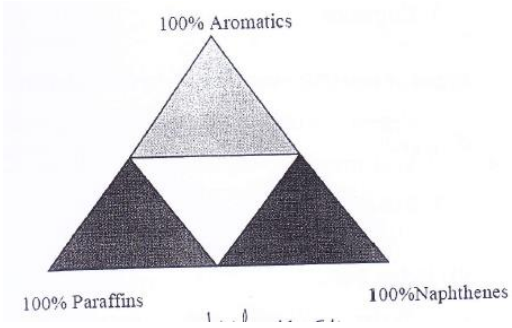
Fig. A-1 Hydrocarbon composition and boiling ranges for maior refined products

7- Classification of crude oil:

The first crude oil classification is by the types of hydrocarbon (paraffins, naphthenes, and aromatics)' This rating is important to the refinery since the value of the crude oil decreases from classification 1to6.

Crude Classifications (in order of decreasing value):

1) Paraffinic Crudes
   - Paraffins + naphthenes > 50%
   - paraffins > naphthenes
   - paraffins> 40%



2) Naphthenic Crudes
   - Paraffins + naphthenes >50%
   - naphthenes > paraffins
   - naphthenes >40%

3) Paraffinic - Naphthinic Crudes
   - aromatics < 50%
   - paraffins < 40%
   - naphthenes < 40%

4) Aromatic - Naphthenic Crudes
   - aromatics > 50%

5) Aromatic - Intermediate Crudes
   - aromatics > 50%
   - paraffins >10%

6) Aromatic - Asphaltic Crudes
   - naphthenes> 25%
   - paraffins < 10%

The petroleum industry generally classifies crude oil by the geographic location it is produced in (e.g. West Texas, Brent, or Oman), is API gravity (an oil industry measure of density), and by its sulfur content.

The geographic location is important because it affects transportation costs to the refinery . Light crude oil is more desirable than heavy oil since it produces a higher yield of gasoline , while sweet oil commands a higher price than sour oil because it has fewer environmental problems and requires less refining to meet sulfur standards imposed on fuels in consuming countries . Each crude oil has unique molecular characteristics which are understood by use of crude oil assay analysis in petroleum laboratories.

Barrels from an area in which the crude oil's molecular characteristics have been determined and the oil has been classified are used as pricing references throughout the world. Some of the common reference crudes are:

- West Texas Intermediate (WTI), a very high-quality, sweet, light oil delivered at Cushing, Oklahoma for North American oil.
- Brent Blend, comprising 15 oils from fields in the Brent and Ninian systems in the East Shetland Basin of the North Sea. Oil production from Europe, Africa and Middle Eastern oil flowing West tends to be priced off the price of this oil which forms a benchmark.
- Dubai-Oman, used as benchmark for Middle East sour crude Asia-Pacific region .
- Tapis (from Malaysia, used as a reference for light Far East oil).
- Minas (from Indonesia, used as a reference for heavy Far East oil).
- The OPEC Reference Basket, a weighted average of oil blends from various OPEC (The Organization of the Petroleum Exporting Countries).

Chapter 1 : Classification of Crude Oil

1- Introduction:

Petroleum has been defined as Gaseous, liquid and solid mixture of hydrocarbon and non hydrocarbon components which are derivatives that occur naturally in the earth.

Petroleum (from Creek: *petra*: "rock" + *oleum*: "oil" or crude oil is a naturally occurring liquid found in formations in the Earth consisting of a complex mixture of hydrocarbons (mostly alkanes) of various lengths. The approximate length range is C_5H_{12} to $C_{18}H_{38}$. Any shorter hydrocarbons are considered natural gas or natural gas liquids, while long-chain hydrocarbons are more viscous, and the longest chains are paraffin wax . In its naturally occurring form, it may contain other nonmetallic element such as sulfur, oxygen, and nitrogen. It is usually black or dark brown (although it may be yellowish or even greenish) but varies greatly in appearance, depending on its composition. Crude oil may also be found in semi-solid form mixed with sand, as in the Athabasca oil sands in Canada, where it may be referred to as crude bitumen .

Petroleum is used mostly for producing fuel oil and gasoline (petrol), both important "primary energy" sources. 84% by volume of the hydrocarbons present in petroleum is converted into energy-rich fuels (petroleum-based fuels), including gasoline, diesel, jet, heating, and other fuel oils, and liquefied petroleum gas. Due to its:

. high energy density
. easy transport ability
relative abundance .

Gaseous hydrocarbon is composed of lighter fractions, of which the common is methane(CH_4) that refer to as natural gas. Liquid petroleum consists of the liquid hydrocarbon but also contain varying proportion OF dissolved gases and bituminous materials , it is most commonly called crude oil. Solid and semisolid petroleum is consists of heavier fraction from hydrocarbon and bituminous materials and had been refer to as bituminous or asphalt.

2- Definition of Petroleum :

It Is a mixture of hydrocarbon compounds and relatively small quantities of other materials such as oxygen,nitrogen, sulphur, salt, water, dissolved gases such as hydrogen sulphide (H_2S) and trace amounts of metals such as iron, nickel, copper and vanadium.

3- Origin of Petroleum:

Tow assumptions are explaining the formation of petroleum as follows:

A- Inorganic hypothesis:

This hypothesis assume the oil hydrocarbon reaction hot water vapor with carbides which will form under high pressure and temperature as follows:

$Al_4C_3 + l2H_2O \rightarrow 4Al(OH)_3 + 3CH_4$

$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$

$C_2H_2 \rightarrow$ petroleum

B- Organic hypothesis:

This hypothesis assume that the petroleum is formed from the decomposition of the animals and plants dead which converted to liquids and gases hydrocarbon by effect the high temperature, Pressure and catalyst (as a small microscopic beings). Some sources suggest this hypothesis to explain the formation of the Arabian Gulfs Petroleum.

4- Importance of Petroleum:

a- It represent the major sources for energy in the world (45% crude oil and 15% natural gases).
b- Electrical power generation.
c- Fuel for cars, ships and airliners.
d- Fuel for heating and cooking.

e- It is used in petrochemicals industrials to produce various materials useful such as cloths, plastic , drugs , ….etc.

f- It used for lubrication engines of different types.

5- Chemical analysis of crude oil:

The proportion of hydrocarbons in the mixture is highly variable and ranges from as much as 97% by weight in the lighter oils to as little as 50% in the heavier oils and bitumen.

The exact molecular composition varies widely from formation to formation but the proportion of chemical elements vary over fairly narrow limits as follows:

Element	**Wt%**
C (Carbon)	83 – 88
H_2 (Hydrogen)	11 – 14
S (Sulphur)	0.05 – 8
N_2 (Nitrogen)	1 – 2
O_2 (Oxygen)	0.05 – 1.5
Metals (Fe , Ni , Cu , V , ...)	< 0.03

6- Chemical composition of crude oil:

The hydrocarbons in crude oil are mostly paraffin , naphthene, olefin and various aromatic hydrocarbons while the other organic compounds contain nitrogen, oxygen and sulfur, and trace amounts of metals such as iron, nickel, copper and vanadium as follows: