

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 (H₂S) and trace amounts of metals such as iron, nickel, copper and vanadium. The elementary composition of crude oil usually fall within the following range

Elements	Percentage composition weight
Carbon	83 - 87
Hydrogen	10 - 14
Nitrogen	0.1 - 2
Oxygen	0.05 - 1.5
Sulfur	0.05 - 6
Metals	< 0.1

Importance of petroleum:

- a - It represent the major sources for energy in the world.
- 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 material useful such as clothes, plastics, drugs, pipes,etc .
- f – It used for lubrication engines of different types.

Chemical composition of crude oil :

A- Hydrocarbons components :

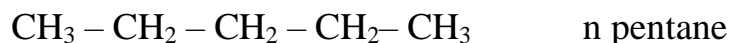
All the petroleums contain the same hydrocarbons groups such as normal, branch, cyclic paraffins, olefins and aromatic.

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 pentane mean n = 5 = carbon atoms (C₅H₁₂).

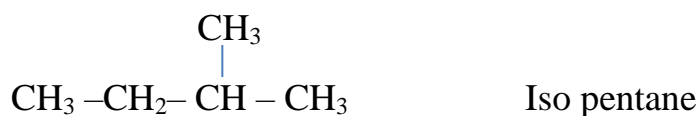


The properties of normal paraffin are:

- High boiling point .
- Low octane number.

ii- Branch /or iso paraffins:

The hydrocarbon chain is branched, the general formula $\text{C}_n\text{H}_{2n+2}$,
example iso pentane mean $n = 5 =$ carbon atoms (C_5H_{12})

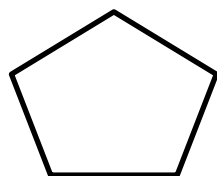


The properties of branch paraffin are:

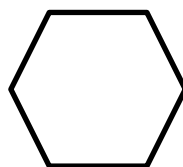
- Low boiling point .
- High octane number therefore is favorite in cars fuel.

iii- Cycloparaffins (Naphthenes):

The cycloalkanes, also known as naphthenes, 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 .



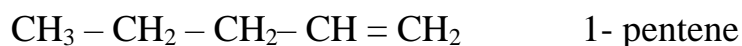
Cyclopentane



Cyclohexane

2- Olefins:

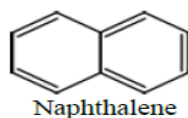
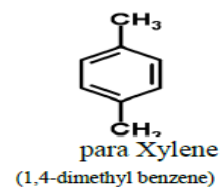
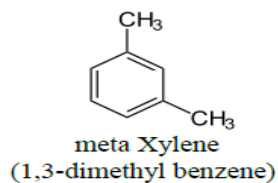
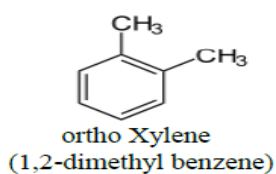
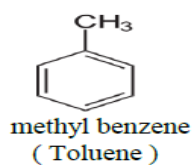
The olefins, also known as alkenes, are unsaturated hydrocarbons with general formula (C_nH_{2n}). They are very similar to paraffins, but they exhibit double bonds.



3-Aromatics

The aromatic series of hydrocarbons is chemically and physically very different from the paraffins and cycloparaffins (naphthenes). Aromatic hydrocarbons contain a benzene ring which is unsaturated but very stable

With the formula (C_nH_n) for examples



B- Non hydrocarbon components :

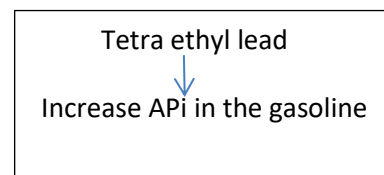
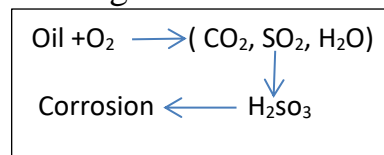
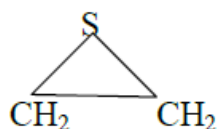
The non-hydrocarbon components are divided to

I- Sulphur components :

The types of sulphur components in the petroleum are :

- i- Hydrogen Sulphide $H-S-H$ (or H_2S)
- ii- Mercaptance (Thiols) : $R-S-H$, where R is Alkyl (CH_3-S-H).
- iii- Sulphides : reduce the activity of the tetra ethyl lead in the gasoline.

- * Organic sulphide : $R-S-R$
- * Organic disulphide : $R-S-S-R$
- * Cyclo sulphide :

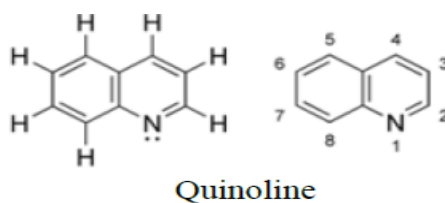
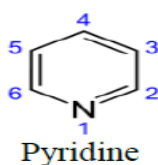


Disadvantages of Sulphur components :

- Corrosion the metal parts of the engine .
- Reduce O.N (Octane number).
- Reduce oxidation resistance .
- Solids deposition.

2- Nitrogen components :

Types of nitrogen components in the petroleum such as:



Disadvantages of Nitrogen components :

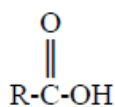
- Color unstability
- Storage unstability
- Decreasing API

Note : More asphaltic crudes will contain N₂ compounds.

3-Oxygen components :

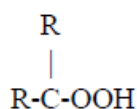
These compounds increase with increasing the boiling point of the fraction. The types of oxygen components in the petroleum are:

a-organic acids such as

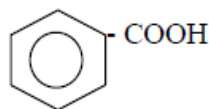


OR R-C-OOH

Normal organic acid

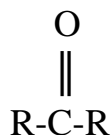


Branch organic acid

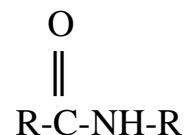


Aromatic acid

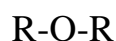
b- Ketones



c-Amides



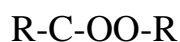
d- Ethers



e- Alcohol



f- Esters



4-Metallic components :

Types of metallic components in the petroleum

- a-Organic metallic (Iron Fe, Nickel Ni ,Vanadium V ,Cadmium Cd ...)
- b- Soap metallic (Magnesium Mg , Calcium Ca ,).
- c- Salt metallic (Na , Ba...)

Disadvantage :

- Affected on catalyst activity .
- Increase coke formation .
- Reduced the yield of the gasoline .
- Increasing the ash .
- Corrosion.

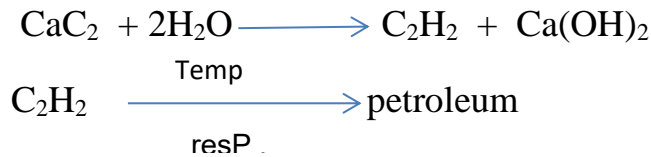
5- Water content

6- Naphthenic acids: R-C-OOH

Theories of petroleum formation

1- Inorganic theory :

This theory assume the oil hydrocarbon compounds produced from reaction hot water vapor with carbides which will form the hydrocarbon substances under high pressure and temperature as follows



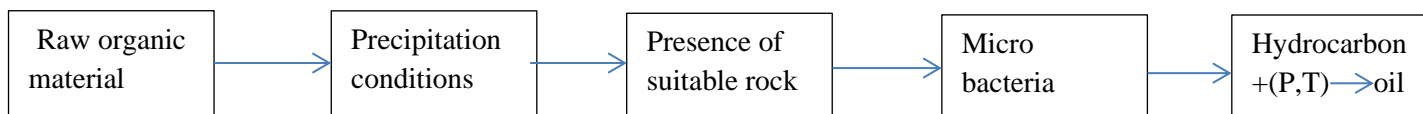
2- Organic theory :

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.

The reasons for accepting organic theory are:

- same major elements(C,H,O,N,S)between crude oil and (animals ,plants)
- the crude oil contains naphthenic acids (base organic)
- decomposition of the animals and plants gives sulphur and nitrogen gases
- most of petroleum fields are detected near of the beaches and seas.

The steps of oil production from organic sources



Classification of crude oil:

1- Simple classification:

It depends on the one of the physical properties of the crude oil such as API

$$\text{API} = \frac{141.5}{\text{Sp.gr}} - 131.5 \quad , \quad \text{API} \propto \frac{1}{\text{sp.gr}} \quad , \quad \text{API} \propto \text{light components content}$$

Api >35 light
Api < 28 heavy
APi 28-35 intermediate

2- Classification depends on the hydrocarbon structure.

- Paraffinic base —> best type with high light components
- Asphaltic base —> (asphalt content)
- Mixed base —> equilibrium structure (paraffine and asphalt)
- Hybrid base —> Naphthenic and wax paraffin

This classification depend on the distillation process to the crude oil and then test the residuum

Residuum contains < 20% paraffin → Asphaltic base
Residuum contains 20% to 50 %paraffin → Mixed base
Residuum contains > 50% paraffin → Paraffinic base

3-Classification depends on the hydrocarbon structure to the two of distillate

Such as kerosene and lube oil by taking the value of API

4-Classification depends on the sulfur content of the crude oil

Crude oil naturally contains sulfur compounds. Crudes are classed as sweet or sour depending on their sulfur content. If a crude has less than 0.5% sulfur in it, it is considered to be "sweet crude oil ". If has greater than 2.5% sulfur, it is "sour crude oil ". Crude with sulfur content between these two endpoints is called "intermediate"

5-Classification depends on the Correlation Index (C.I.)

This method based on the percentages of various hydrocarbons types in the crude oil which are classified into paraffinic or aromatic according to following formula:

$$C.I. = \frac{48640}{T_a} + 473.3 * Sp.Gr.(60 / 60)^{\circ} F - 456.8$$

T_a = average boiling point temperature, in Kelvin unit °K

Sp. Gr. (60/60) °F = specific gravity of crude oil at 60°F

$$Sp.Gr.60/60^{\circ}F = \frac{\text{Crude oil density at } 60^{\circ}F}{\text{Water density at } 60^{\circ}F}$$

The crude oil can be classified as follow as :

- C.I. = 0 normal paraffinic based crude oil .
- C.I = 0-15 predominance of n-paraffinic crude oil .
- C.I = 15 – 50 paraffinic, naphthene and aromatic mixture .
- C.I > 50 predominance of aromatic crude oil .
- C.I = 100 benzene (Aromatic).

6-Classification depends on the Characterization Factor (C.F.)

The most widely used index is characterization factor .It was originally defined as:

$$K_w = \frac{\sqrt[3]{T_a \cdot \dots}}{Sp.Gr.60 / 60^\circ F}$$

K_w = Watson characterization factor

T_a = average boiling point temperature Rankin unit ($^\circ R$)

$$Sp.Gr.60/60^\circ F = \frac{\text{Crude oil density at } 60^\circ F}{\text{Water density at } 60^\circ F}$$

$K_w > 12.5$ (Paraffinic Base)

$K_w < 11.5$ (Naphthene Base)

K_w between 11.5-12.5 (Intermediate Base)

Note: Temperature convertor relationships

From	To	Formulae
Celsius	Fahrenheit	$F = C \times 1.8 + 32$
Celsius	kelvin	$K = C + 273.15$
Celsius	Rankin	$Ra = C \times 1.8 + 32 + 459.67$