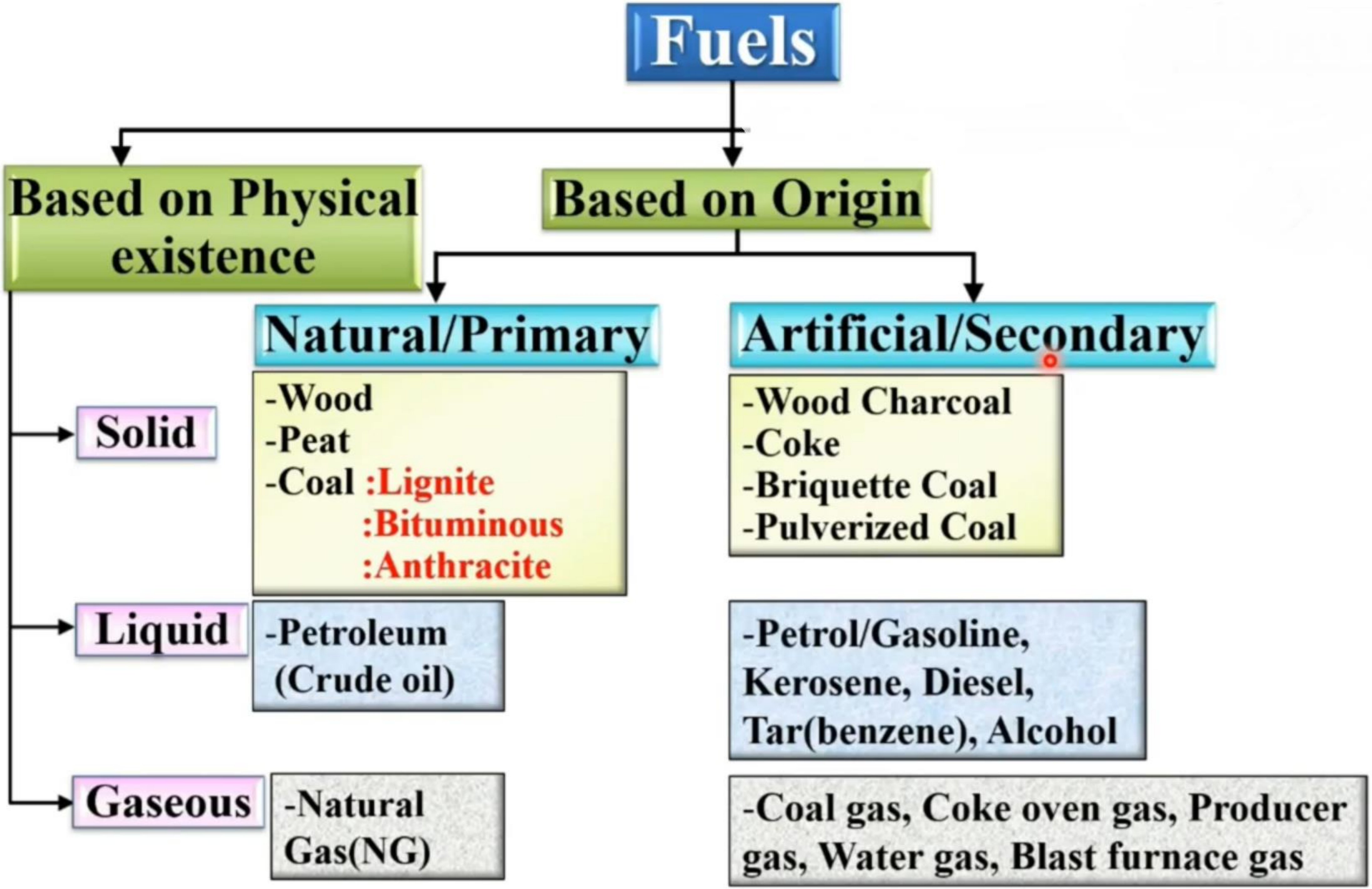
Fuel Classification, Characteristics and Application

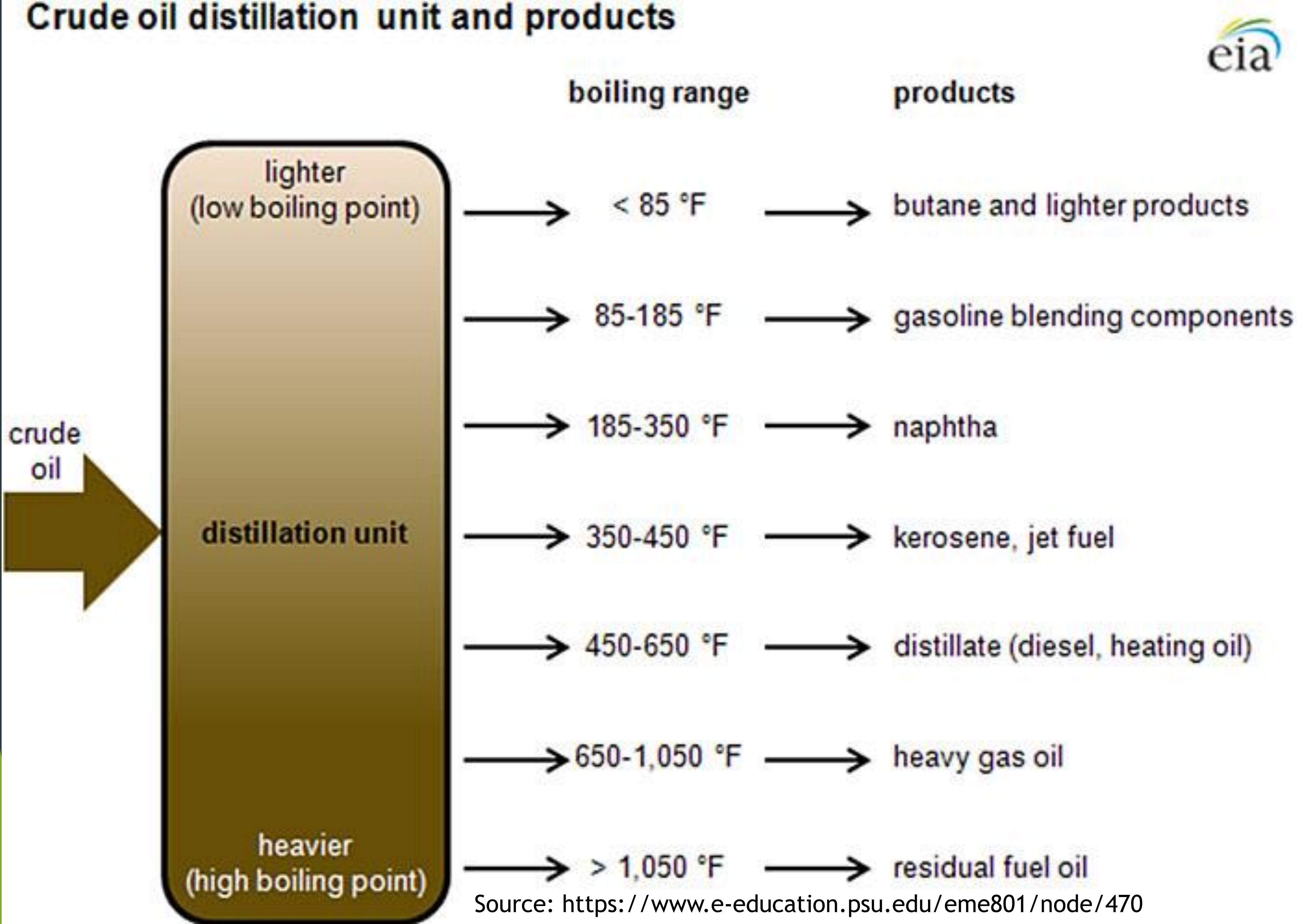
Introduction

A fuel is defined as any substance used to produce heat or power by combustion. Any chemical process accompanied by the evolution of light and heat is called *combustion*. It is simply the reaction of substances with oxygen and converts chemical energy into heat and light.

$$\text{Fuel} + \text{Oxygen} \rightarrow \text{Combustion products} + \text{Heat}$$

Engineering Chemistry (revised edition)
ISBN: 978-81-265-4475-2


Fuels
Based on Physical existence
Based on Origin
Natural/Primary
Artificial/Secondary
Solid
-Wood
-Peat
-Coal :Lignite
:Bituminous
:Anthracite
-Wood Charcoal
-Coke
-Briquette Coal
-Pulverized Coal
Liquid
-Petroleum (Crude oil)
-Petrol/Gasoline, Kerosene, Diesel, Tar(benzene), Alcohol
Gaseous
-Natural Gas(NG)
-Coal gas, Coke oven gas, Producer gas, Water gas, Blast furnace gas



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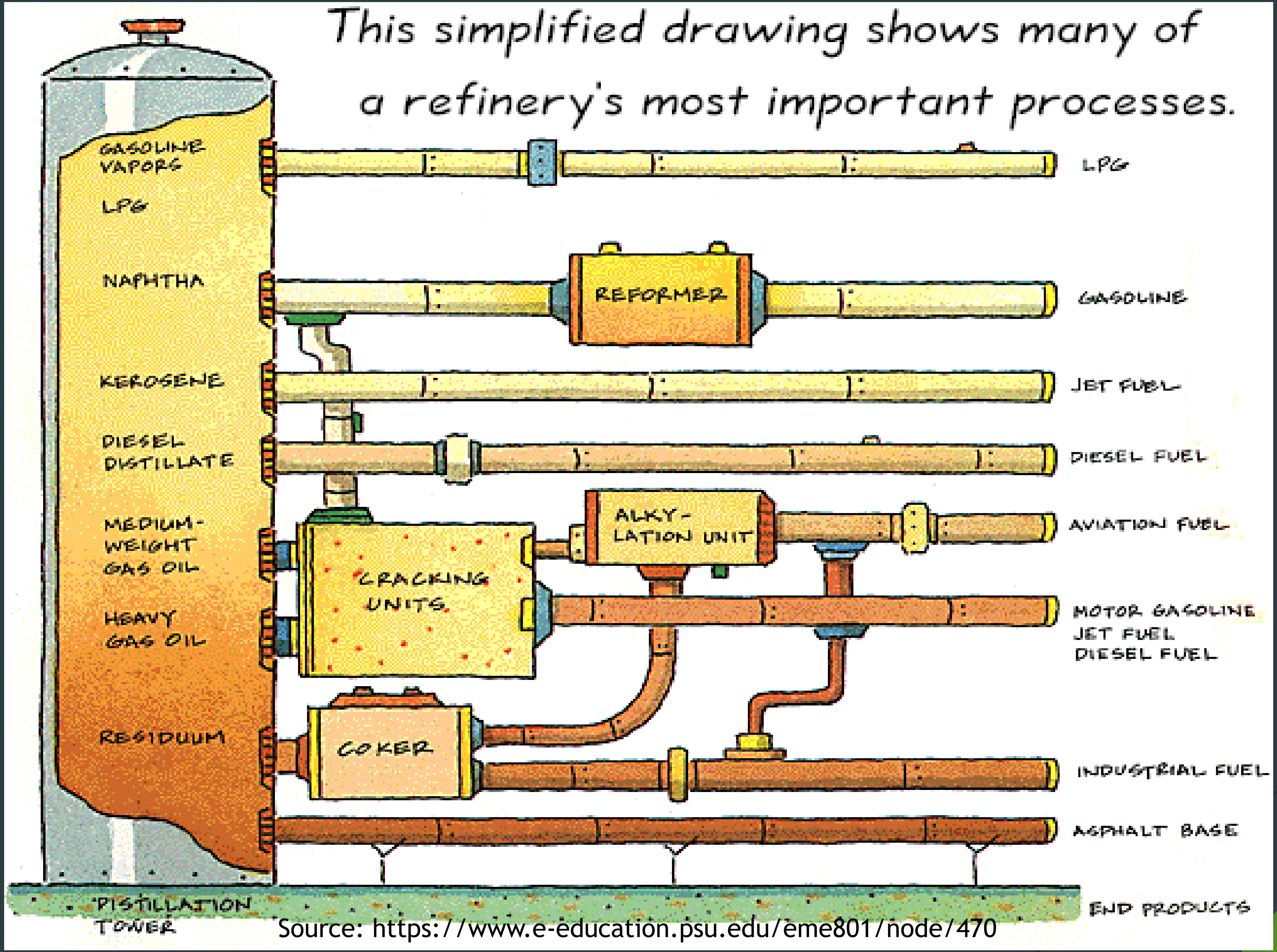

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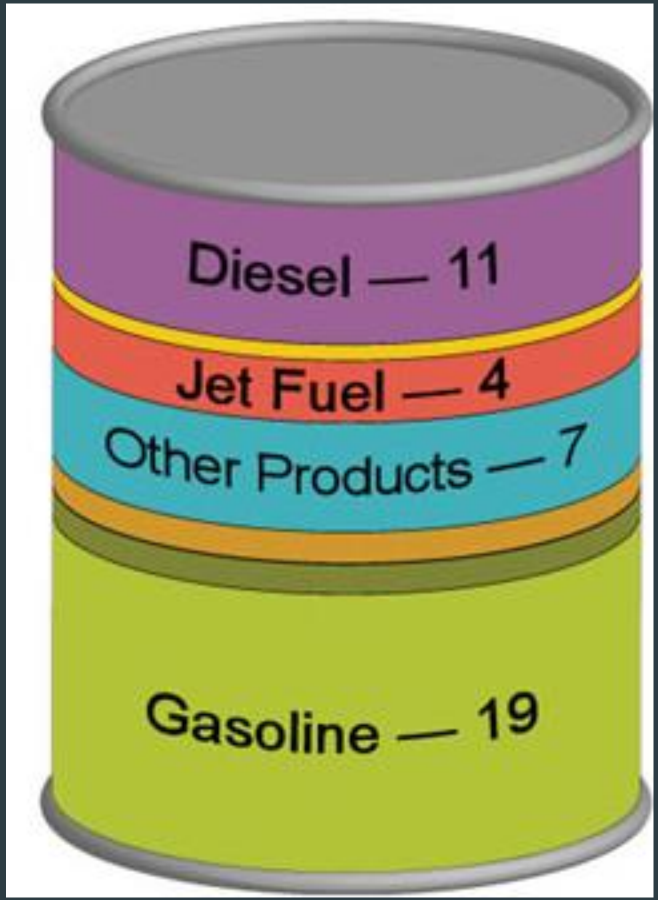
Products Made from a Barrel of Crude Oil (Gallons)

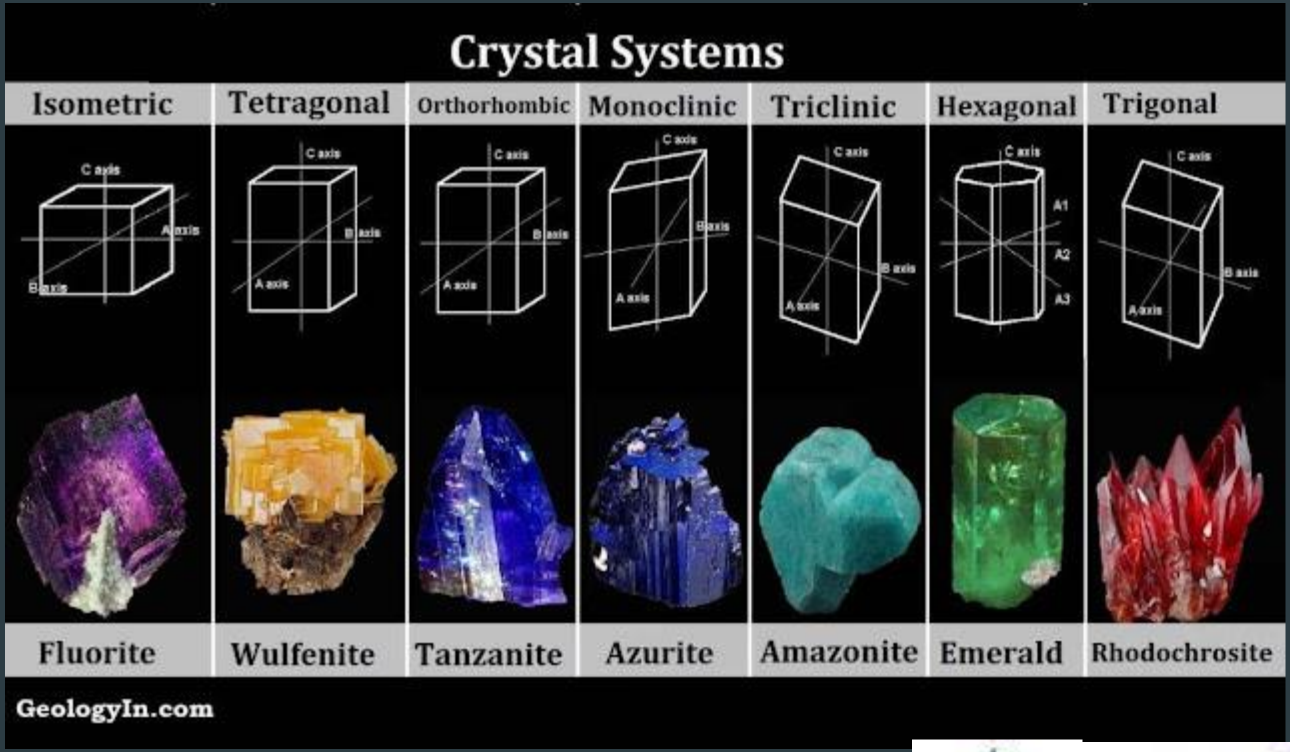


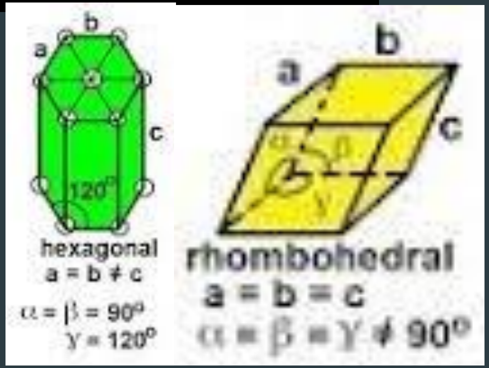
Source: https://www.e-education.psu.edu/eme801/node/470

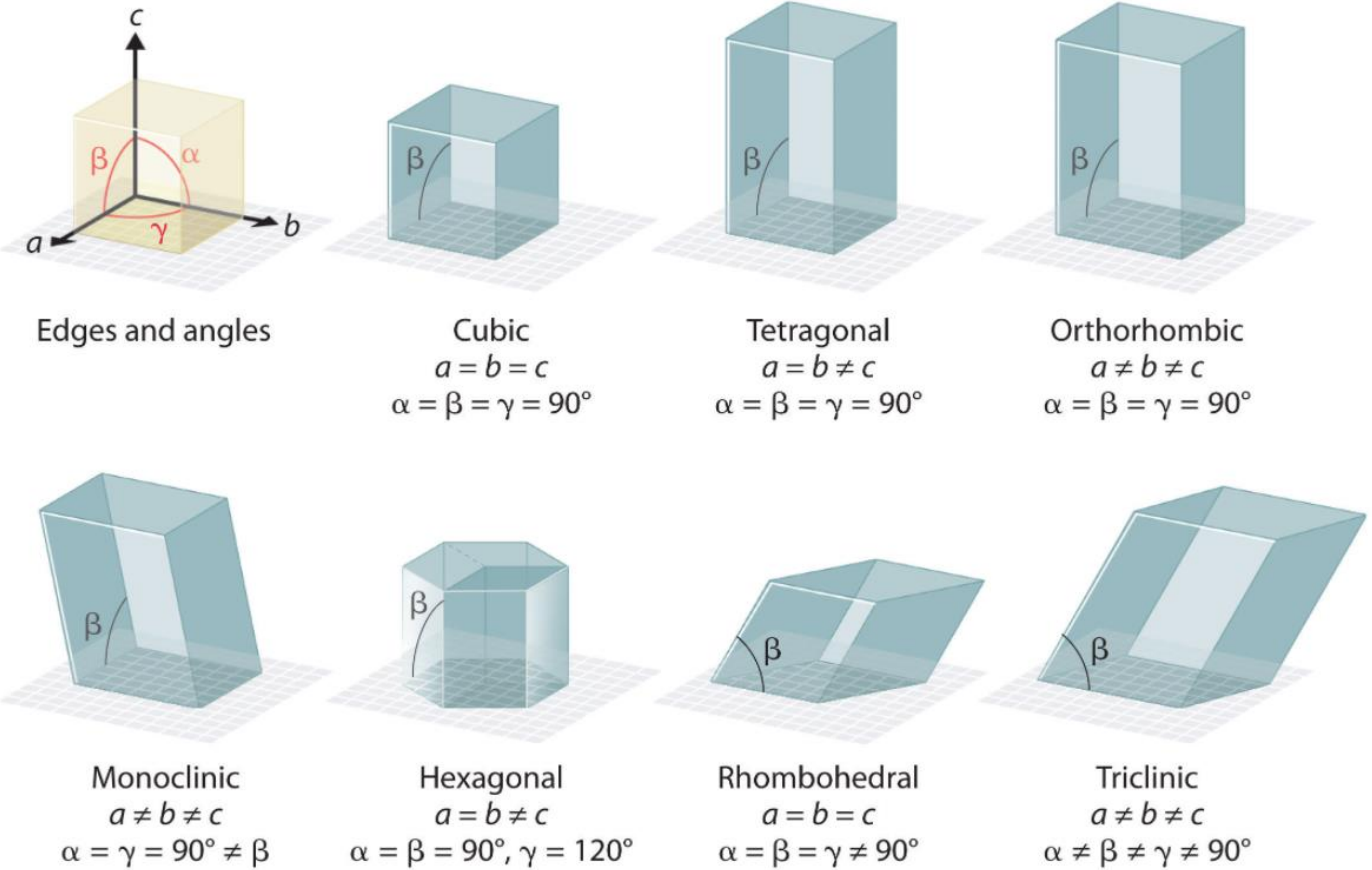

Fossil fuels
Fuel from deep under the ground
Coal, oil and gas are fossil fuels.
Fossil fuels are used in the home...
...in industry, and to power transport.
Lots of things are made from fossil fuels.
FGHIJK
LMNOP

Crystal Structures, Types and Properties


simple cubic
a = b = c
α = β = γ = 90°
tetragonal
a = b ≠ c
α = β = γ = 90°
orthorhombic
a ≠ b ≠ c
α = β = γ = 90°
monoclinic
a = b ≠ c
α = γ = 90° β ≠ 90°
triclinic
a ≠ b ≠ c
α ≠ β ≠ γ ≠ 90°


Crystal Systems
Isometric
Tetragonal
Orthorhombic
Monoclinic
Triclinic
Hexagonal
Trigonal
Fluorite
Wulfenite
Tanzanite
Azurite
Amazonite
Emerald
Rhodochrosite
GeologyIn.com


hexagonal
a = b ≠ c
α = β = 90°
γ = 120°
rhombohedral
a = b = c
α = β = γ ≠ 90°



c
β
α
γ
a
b
Edges and angles
β
Cubic
$a = b = c$
$\alpha = \beta = \gamma = 90°$
β
Tetragonal
$a = b \neq c$
$\alpha = \beta = \gamma = 90°$
β
Orthorhombic
$a \neq b \neq c$
$\alpha = \beta = \gamma = 90°$
β
Monoclinic
$a \neq b \neq c$
$\alpha = \gamma = 90° \neq \beta$
β
Hexagonal
$a = b \neq c$
$\alpha = \beta = 90°, \gamma = 120°$
β
Rhombohedral
$a = b = c$
$\alpha = \beta = \gamma \neq 90°$
β
Triclinic
$a \neq b \neq c$
$\alpha \neq \beta \neq \gamma \neq 90°$

Characteristics of Various Types of Crystals

Characteristics	Molecular Crystals	Covalent Crystals	Metallic Crystals	Ionic Crystals
Unit that occupy lattice points	Molecules	Atoms	+ve ions in a sea of electrons	(+)ve and (-)ve ions
Binding Force	van der Waals & Dipole-dipole	Shared electrons	Electrical attraction between +ve & -ve ions	Electrostatic attraction
Physical Properties	Very soft, low MP, good insulators	Very hard, very high MP, non-conductors	Hard or soft, moderate to high MP, good conductors	Semiconductors due to crystal imperfections
Examples	NH_3, H_2O, CO_2	Diamond, quartz	Na, Cu, Fe	NaCl, KNO_3, Na_2SO_4

Molecular Crystals

- The lattice points in molecular crystals consist of specific molecules which do not carry any ions
- The forces binding the molecules together are mainly two types such as **(i) Dipole-dipole forces**, and **(ii) The van der Waals forces**
- Dipole-dipole forces occur in solids which consist of polar molecules
- Thus, in the case of water molecules (in ice), the negative end of one molecule attracts the positive end of a neighboring molecule (Fig.)
- The van der Waals forces are more general and occur in all kinds of molecular crystals
- Both types of forces are much weaker than the coulombic forces attraction between oppositely charged ions existing in ionic crystals
- Binding energy is considerably weaker in molecular crystals than the ionic crystals
- The heat of vaporization in molecular crystals is very low in comparison to ionic crystals
- The molecular crystals are more volatile and have lower melting and boiling points

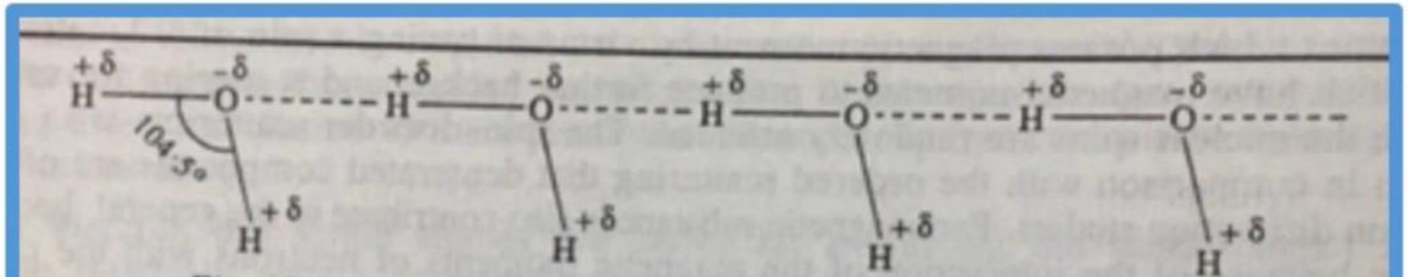
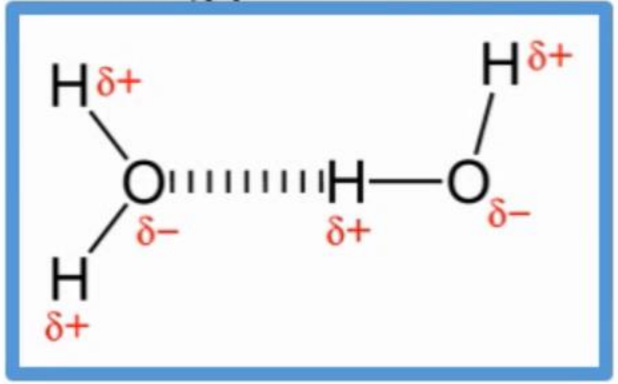


Fig. 15. Dipole–dipole forces of attraction between water molecules.



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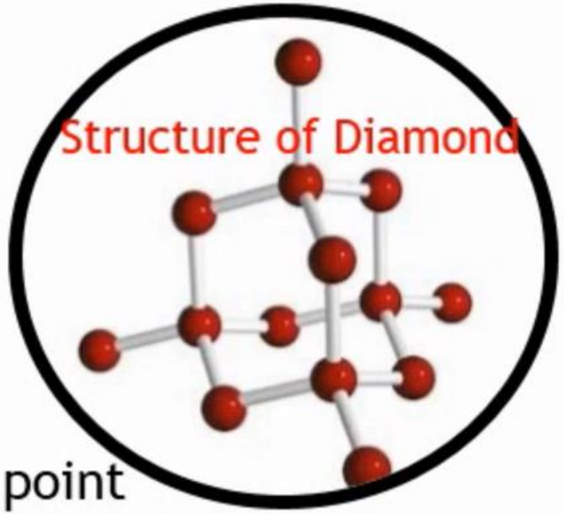
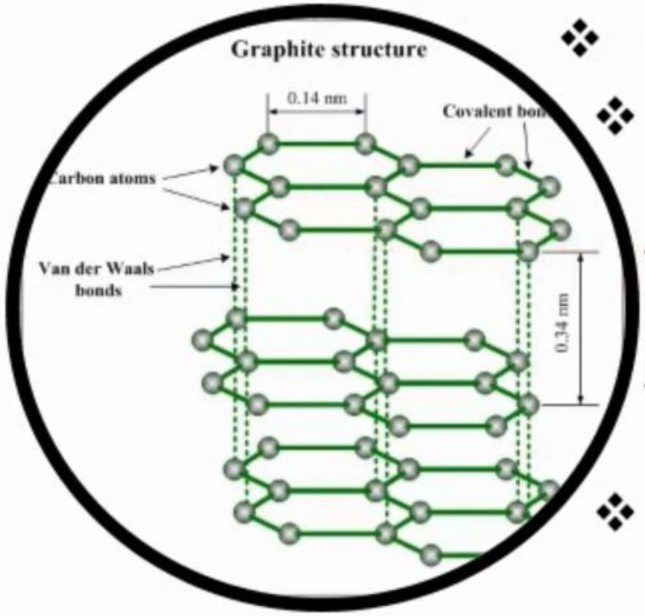
Covalent Crystals

- The lattice in covalent crystals consists of atoms linked together by a continuous system of covalent bonds
- Diamond furnishes a good example of this type
- Each carbon atom is covalently bonded by sharing of electrons to four other atoms involving *sp*^{3} hybrid orbitals
- Thus each carbon atom is surrounded by four others at the four corners of a regular tetrahedron; This gives rise to a rigid 3-D network



- That's why diamond is the hardest substance with a high density and melting point
- The entire crystal is regarded as on large carbon molecule and is called a macromolecule



- In some crystals, the continuous network of covalent bonds is 2-D, **Graphite**
- Each carbon atom is covalently bonded to three others involving *sp*^{2} hybrid orbitals instead of four as in diamond
- Thus, all atoms in a single plane are linked to give flat hexagons as in benzene, naphthalene, etc.
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- The hexagons are held together in sheet-like structures, parallel to one another

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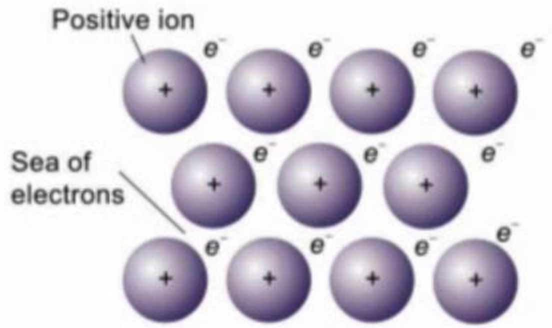
Metallic Crystals

- Based on the metallic structure, metals are characterized by high electrical and thermal conductivity, bright luster, malleability, ductility, and high tensile strength
- Metals have low ionization energy because the valency electrons can be taken out relatively easy
- The valency electron in metal are weakly bound to the kernel; they are not localized at each atom, they are mobile in the crystal
- Acc. to this model, metal behaves as if it is an assemblage of positive ions immersed in a sea of mobile electrons (Fig.)
- Thus, each electron belongs to a number of positive ions and each positive ion belongs to a number of electrons
- The high electrical conductivity and thermal conductivity of metals is due to the presence of mobile valency of electrons
- The bright metallic lustre can also be explained as due to the presence of high mobile electrons

The electron-sea model



The valence electrons do not belong to any specific atoms (not localized) but delocalize throughout the whole crystal structure.

- The model of free valency electrons can also explain the softness, malleability, and ductility associated with metals
- The force of attraction between the M+ ions and the valency electrons is uniform in all directions
- The bonds holding the crystal lattice in metals are not rigid as in covalent solids

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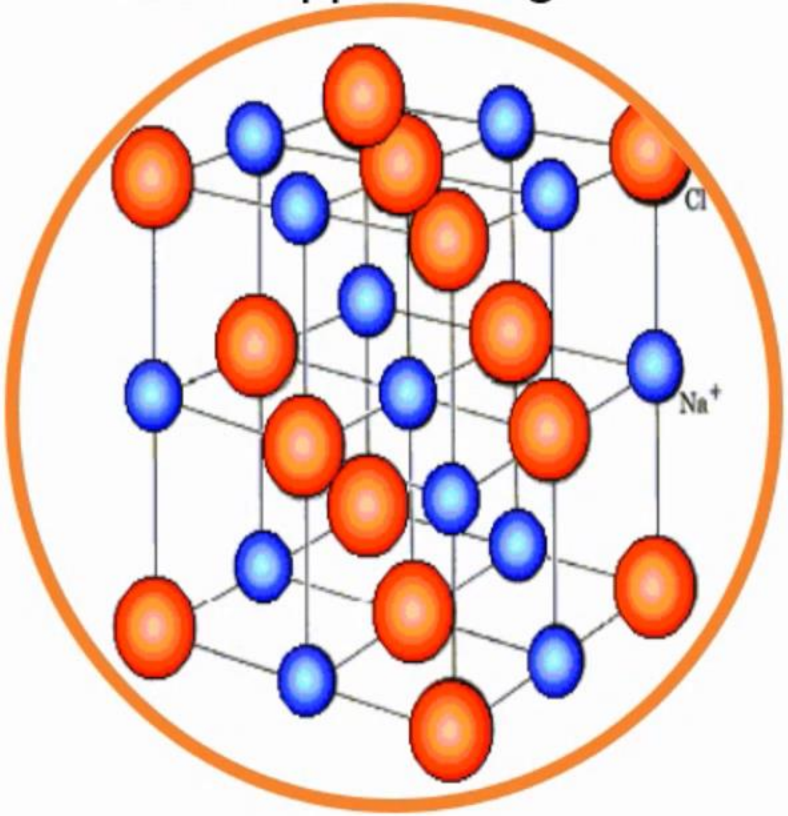
Ionic Crystals

- In ionic crystals, the units occupying lattice points are positive and negative ions. In NaCl, the units are Na^+ ions and Cl^- ions
- Each ion of a given sign in held by coulombic forces of attraction to all ions of opposite sign
- These forces are very strong and therefore the amount of energy required to separate ions from one another is high
- The ionic crystals have the following properties:
- The heat of vaporization of ionic crystals are high
- The vapour pressures of ionic crystals at ordinary temperatures are very low
- The melting and boiling points of ionic crystals are very high
- Ionic crystals are hard and brittle
- Ionic crystals are insulators in the solid state due to the fact of ions are entrapped in fixed places in the crystal lattice ad cannot move



- Ionic crystals are soluble in water and also in other polar solvents, not soluble in non-polar solvents such as benzene, etc.

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