Inorganic Chemistry-Sem-V Course No.502

Paper-II Unit-IV. Some Selected Topics

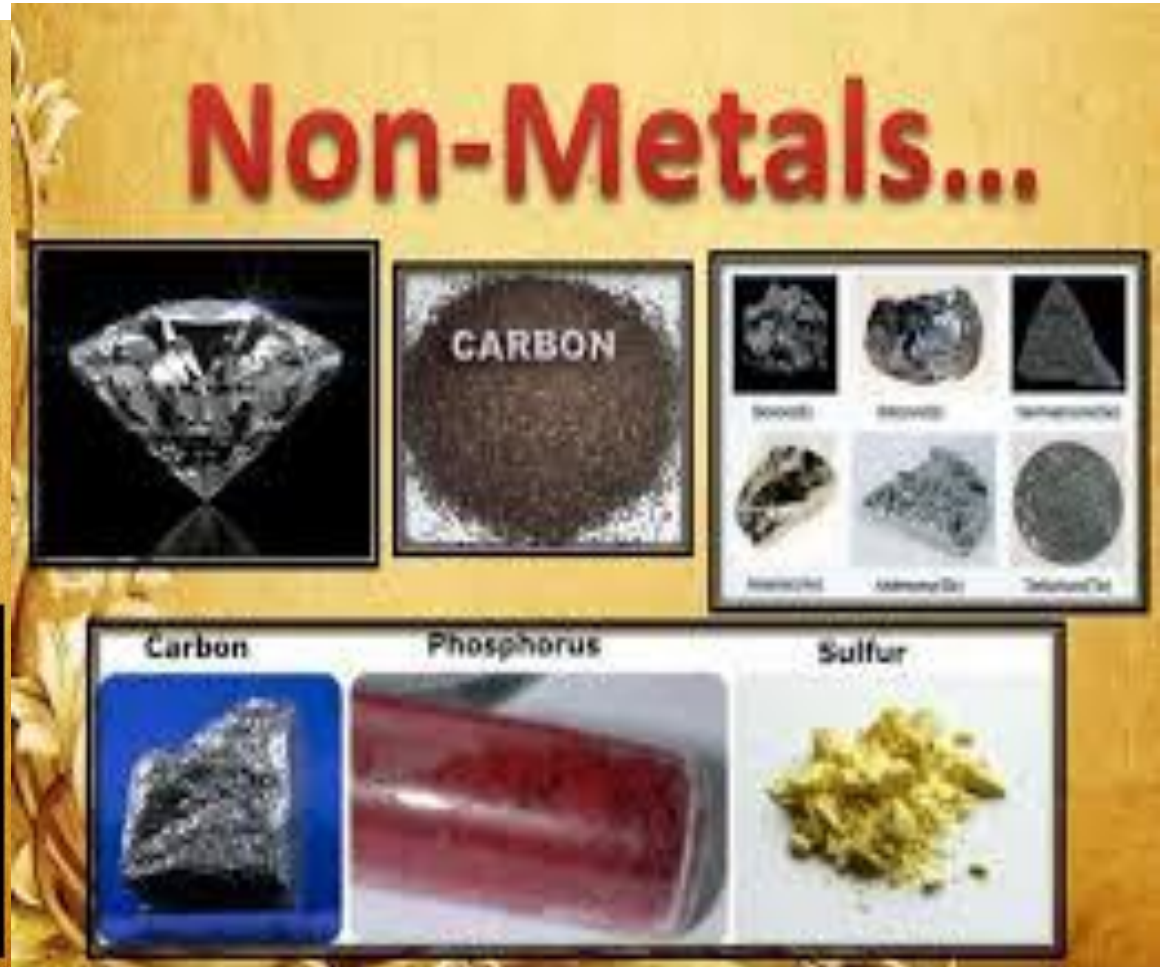
- Chemistry of Non-Aqueous Solvents
- Comparative Chemistry of group 16 and 17 elements
- Chemistry of Interhalogens

Paper Pattern

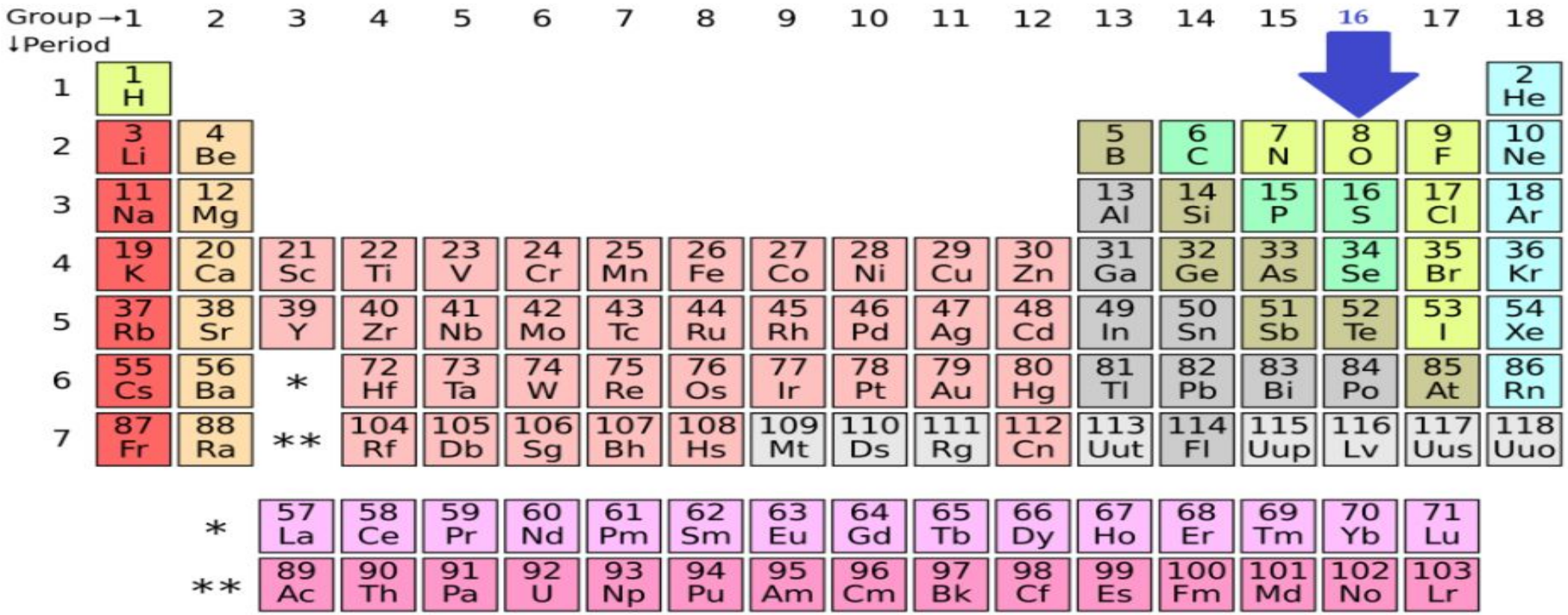
- **Main Theory Papers**
  - Physical
  - Inorganic
  - Organic
  - Analytical
- Applied component – Drugs and Dyes
- Each paper-100mark
- Unit-I (25) +Unit-II(25) +Unit-IV(25)=100
- Total Five Questions-Each Q of 20marks
- Unit-1+2+3+4+5th Q(1+2+3+4)

What is Inorganic Chemistry?

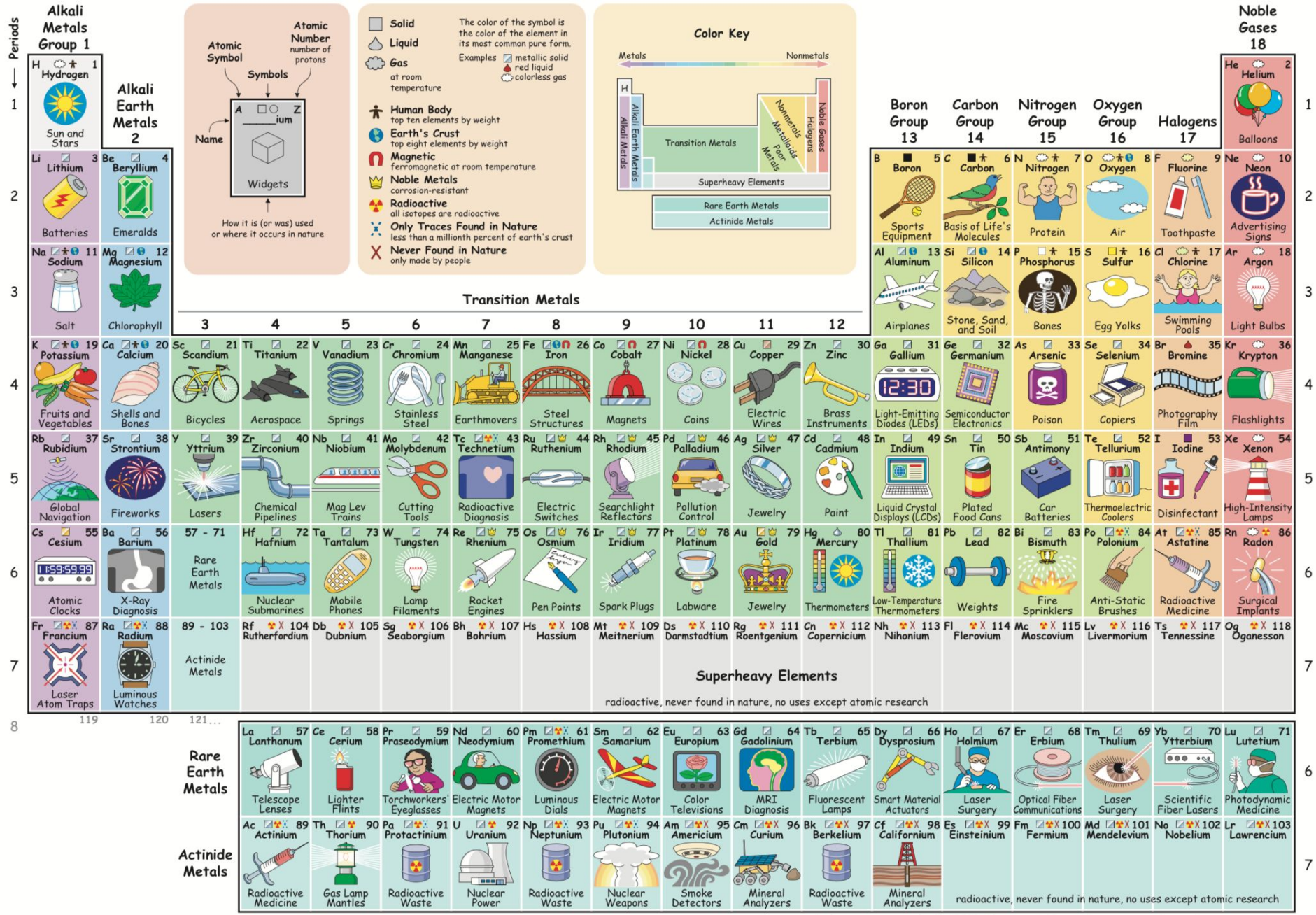
- Inorganic chemistry involves the study of metals and non-metals



Periodic Table



The Periodic Table of the Elements, in Pictures

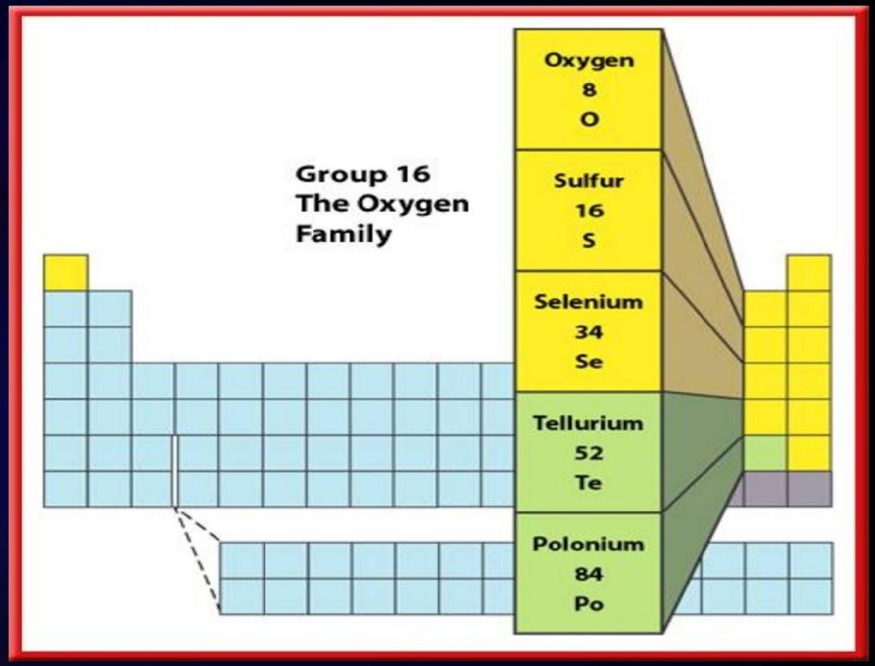


Comparative Study of Group 16 Elements

Representative Elements

Group 16—The Oxygen Family

- The first two members of Group 16, oxygen and sulfur, are essential for life.
- The heavier members of the group, tellurium and polonium, are both metalloids.



Electronic Configuration of Group 16 Elememts

Element	Symbol	Atomic No.	Electronic Configuration	Abundance In Earth's Crust (in ppm)
Oxygen	O	8	$[He]\ 2s^2\ 2p^4$	4.66×10^5
Sulphur	S	16	$[Ne]\ 3s^2\ 3p^4$	5.20×10^2
Selenium	Se	34	$[Ar]\ 3d^{10}\ 4s^2\ 4p^4$	9.0×10^{-2}
Tellurium	Te	52	$[Kr]\ 4d^{10}\ 5s^2\ 5p^4$	9.0×10^{-2}
Polonium			$[Xe]\ 4f^{14} 5d^{10} 6s^2\ 6p^4$	2×10^{-3}

Oxidation State

Group 16 Elements (Oxygen Family)

Group 16 Elements (ns^2np^4)

Element	At. No.	Electronic Configuration	Oxidation State
Oxygen (O)	8	[He] $2s^2 2p^4$	$-2, -1, +1, +2$
Sulphur (S)	16	[Ne] $3s^2 3p^4$	$-2, +2, +4, +6$
Selenium (Se)	34	[Ar] $3d^{10} 4s^2 4p^4$	$-2, +2, +4, +6$
Tellurium (Te)	52	[Kr] $4d^{10} 5s^2 5p^4$	$-2, +2, +4, +6$
Polonium (Po)	84	[Xe] $4f^{14} 5d^{10} 6s^2 6p^4$	$+2, +4, +6$
Livermorium (Lv)	116	[Rn] $5f^{14} 6d^{10} 7s^2 7p^4$	–

Trends in Physical Properties

- Atomic Size,Atomic Volume and Density
- Ionisation Energy,Electropositive and Electronegative Character
- Non metallic and Metallic Character
- Melting and Boiling Point
- Conductivity
- Oxidation State
- Catenation
- Tendency towards formation of hydrogen bond
- Molecular Structure
- Allotropy

Property	Oxygen	Sulfur	Selenium	Tellurium	Polonium
atomic symbol	O	S	Se	Te	Po
atomic number	8	16	34	52	84
atomic mass (amu)	16.00	32.07	78.96	127.60	209
valence electron configuration*	$2s^2 2p^4$	$3s^2 3p^4$	$4s^2 4p^4$	$5s^2 5p^4$	$6s^2 6p^4$
melting point/boiling point (°C)	−219/−183	115/ 445	221/685	450/988	254/962
density (g/cm^3) at 25°C	1.31 (g/L)	2.07	4.81	6.24	9.20
atomic radius (pm)	48	88	103	123	135
first ionization energy (kJ/mol)	1314	1000	941	869	812
normal oxidation state(s)	−2	+6, +4, −2	+6, +4, −2	+6, +4, −2	+2 (+4)
ionic radius (pm)†	140 (−2)	184 (−2), 29 (+6)	198 (−2), 42 (+6)	221 (−2), 56 (+6)	230 (−2), 97 (+4)
electron affinity (kJ/mol)	−141	−200	−195	−190	−180
electronegativity	3.4	2.6	2.6	2.1	2.0

***The configuration shown does not include filled *d* and *f* subshells.**

†The values cited for the hexacations are for six-coordinate ions and are only estimated values.

Electronegativity

- The most electronegative element of the group is oxygen
- Elec. Conf. Is 1s2,2s2,2p4
- Outer elec. Conf. Has six electrons
- Oxygen elements needs only 2 electrons to complete the stable octet (ie inert gas configuration)
- This can be achieved by gaining 2 electrons
- Hence oxidation state is -2

Non metallic and metallic character

- Oxygen and Sulphur are stronger non-metallic character
- Selenium and tellurium has weaker non-metallic character
- The polonium is distinctly a metal. It is , however radioactive and short lived.
- Thus from oxygen to polonium,Non-metallic character decreases and metallic increases.

Conductivity

- O & S are non-conductors.
- Se And Te are semiconductors.
- Polonium being a metal, shows electrical conductivity

Oxidation States

- The outer elec. Conf. Is ns2 np4 hence need 2 electrons to form octet. This is achieved by the following ways

- By gaining two electrons to form dinegative ions O-2,S-2
- By sharing two electrons forms hydrides
- By forming double bonds with another elements CO2,CS2 etc
- By accepting a pair of electron (CH3)3 N →

Hydrides are formed by sharing of 2electrons with two hydrogen atoms.

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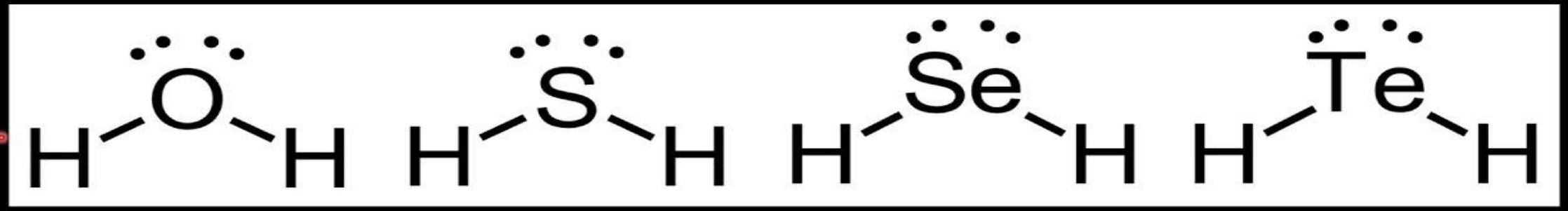
Group 16 hydrides

The group 16 hydrides are composed of group 16 elements (O, S, Se and Te) bonded to two hydrogen atoms.



H_2O H_2S H_2Se H_2Te

Catenation

- Oxygen and sulphur shows the property of catenation
- H-O-O-H, H-S-S-H,   H-S-S-S-S-H

Tendency to form Hydrogen Bond

ronegativity of the element.

fference between the hydrogen and element
towards formation of hydrogen bond also

drogen bond decreases from O to Se as
ases.

nts,oxygen forms the strongest bond with

Molecular structure

- Molecular structure changes from Diatomic linear molecule through rings and chains to a metallic lattice.
  - Oxygen-Diatomic linear molecule
  - Sulphur-Rhombic,puckered S8 ring
  - Sellenium-Red form has8-membered ring and grey form has Zig-Zag chain of Se atoms.
  - Tellurium is similar to that of sellenium.
  - Pollonium is dimorphism,alpha has cubic lattice,beta has rhombohedral.

Anomalous Behaviour of Oxygen

- The main reason for the difference are

 Smaller atomic size,high electronegativity and absence of d-orbital

- Oxygen is a diatomic gas whereas others are solids.
- It shows negative oxidation states while others shows +ve & -ve both.
- It easily form hydrogen bonding
- Most of the compounds of oxygen are stable & ionic.
- Maximum covalency is 2 while others show 4 &6.
- In all state,it is paramagnetic.sulphur is paramagnetic in S2,others not paramagnetic.
- Highly stable with 496.6KJ/mole bond dissociation energy.

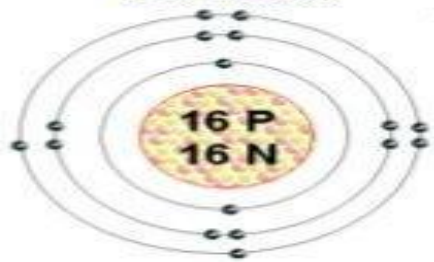
Sulfuric Acid o

Group 16: Oxygen Family

- Physical Properties
  - Oxygen is a nonmetal gas
    - most abundant element in Earth's crust (1/5 Earth's atmosphere)
  - Sulfur is a yellow, nonmetal solid
    - smells like rotten eggs

Lewis Structure

Bohr Diagram



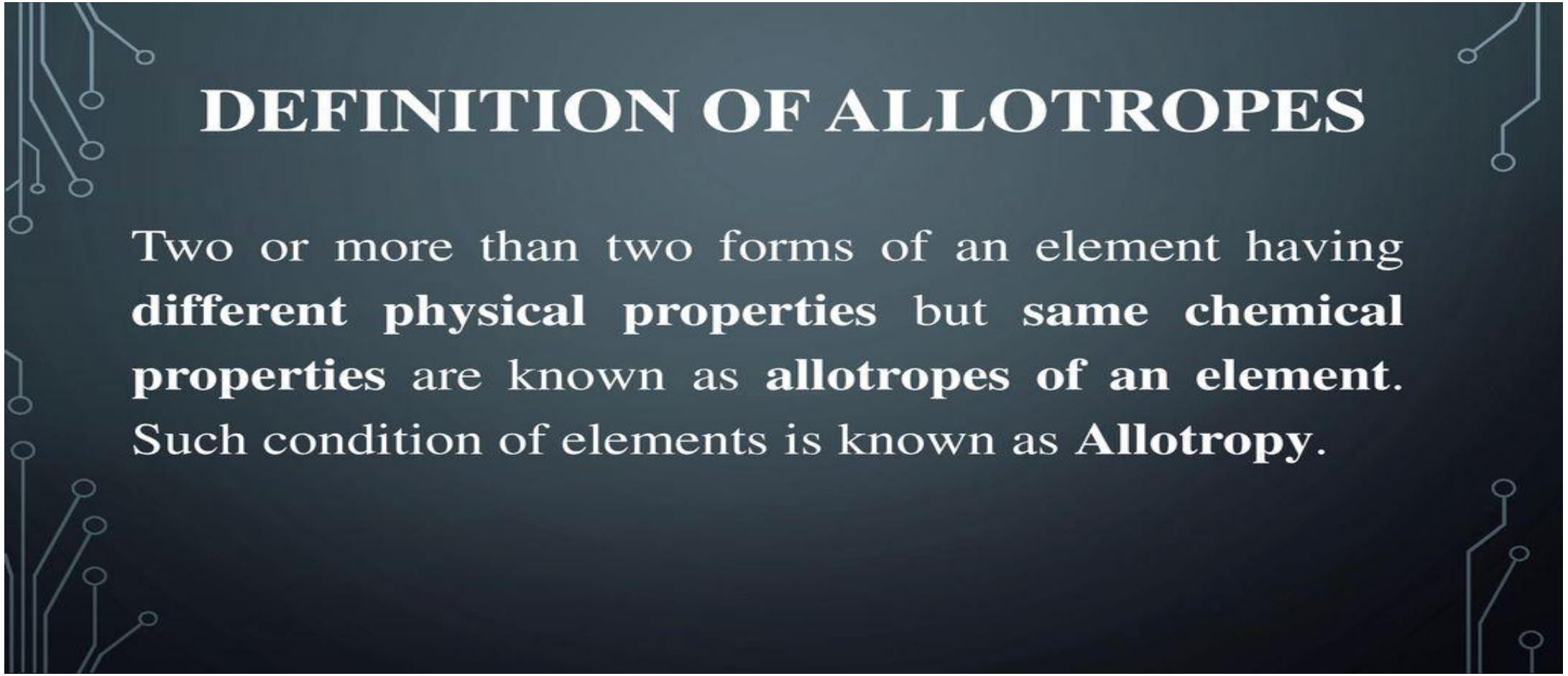
Sulfur

8	O	Oxygen
16	S	Sulfur
34	Se	Selenium
52	Te	Tellurium
84	Po	Polonium

- Selenium is a nonmetal solid
  - conducts electricity with sunlight
- Te & Po are metalloids

- Chemical Properties
  - **have 6 valence electrons**
    - elements vary in reactivity

Allotropy


DEFINITION OF ALLOTROPES
Two or more than two forms of an element having different physical properties but same chemical properties are known as allotropes of an element. Such condition of elements is known as Allotropy.

Allotropes of oxygen

- The two allotropic form of oxygen are diatomic dioxygen O2 & triatomic Ozone O3.

 Diatomic Oxygen O2

- It is paramagnetic.
- Bond order 2, suggesting a double bond of which one is sigma ,other is pi.
- Presence of double bond indicates high dissociation energy and two unpaired electrons confirms its para magnetic behaviour.

Ozone

- It is less stable than O2,a powerful oxidising agent,light blue in colour and is diamagnetic.
- It is angular in shape with O-O-O bond angle is 116.48
- Structure is resonance hybrid

Physical Properties of Group 16 Elements

Allotropy : All elements of the group 16 show allotropy.

- Oxygen exists as O_2 (dioxygen) and O_3 (ozone).
- Sulphur is found to exist in several allotropic forms such as rhombic, monoclinic, plastic and colloidal sulphur.

Allotropes of Oxygen

Group 16: Oxygen Group

Group 16 properties:

- group contains three nonmetals, one metalloids, and one metal
- 6 electrons in the outer level
- reactive
- solids at room temperature (except for oxygen, which is a gas)

End of Slide

Allotropes of Sulphur

- Large no of allotropes.Some important allotropic forms are as follows

 Rhombic or alpha sulphur

 Monoclinic or beta sulphur

 Gamma sulphur

 Plastic sulphur

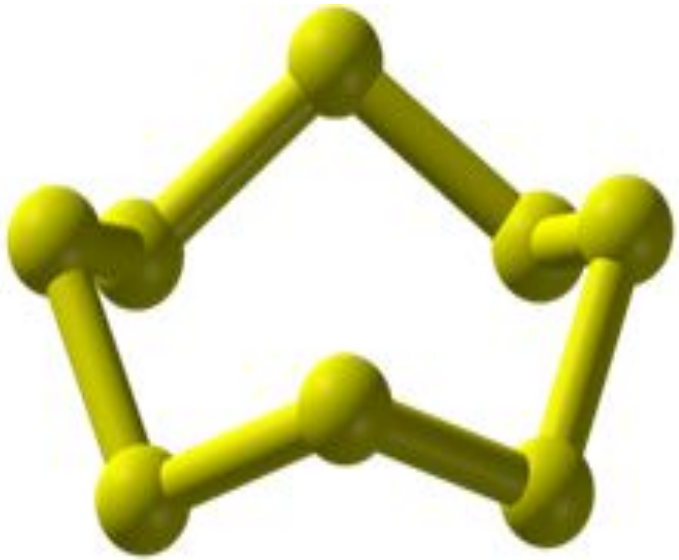
Rhombic Sulphur

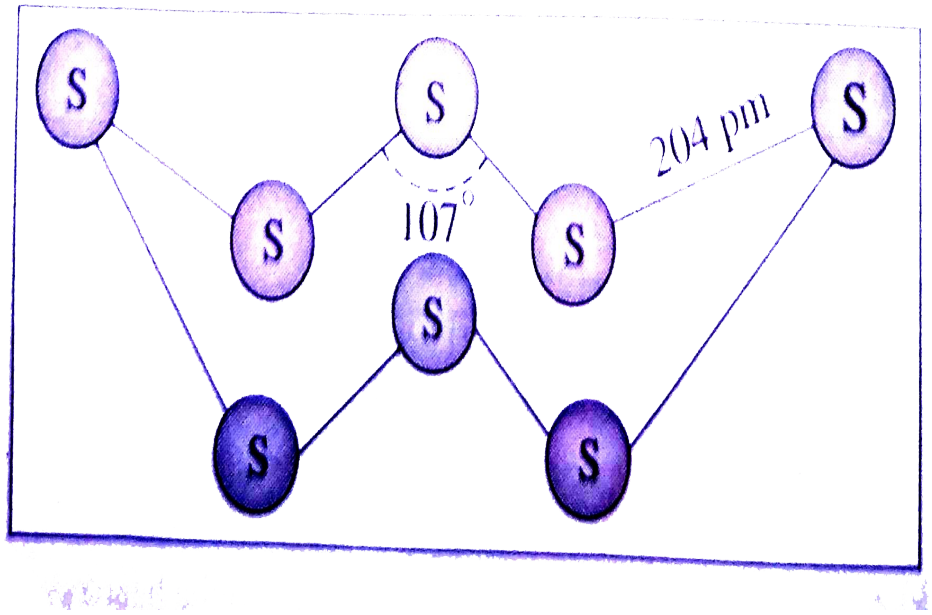
- It is the crystalline form of sulphur occurs in yellow crystals in volcanic areas.

 Preparation

- A solution of roll sulphur evaporated slowly in CS2
- Its crystal structure has cyclic S8 rings packed to form rhombic crystal

Allotropes of Sulphur





Plastic Sulphur

- Prepations

- When sulphur is heated to about 625K and the molten sulphur is poured into cold water,a soft rubber-like mass is obtained called as plastic sulphur.
- Its specific gravity is 1.95 and is dark coloured
- This sulphur is a mixture of many allotropes of sulphur containing cyclic S8 ring and long helical or Zig-Zag long chains of S-atoms.

Structure of plastic Sulphur

Chemical properties of Group 16 Elements

- Reactivity decreases with increase in atomic number.
- Hence oxygen is most reactive element
- S,Se and Te are moderately reactive.

 Action of air

 Action of acids

 Action of alkalies

 Action of non metals

 Action of metals

Chemical Properties of Group 16 Elements

Hydrides : These elements form volatile hydrides such as H_2O, H_2S, H_2Se, H_2Te and H_2Po.

$$Na_2S + H_2SO_4 \longrightarrow Na_2SO_4 + H_2S$$

- Thermal stability decreases down the group because the size of the atom increases and hence the bond length also increases.
- Acidic character increases down the group.

H_2S Molecule

$$H_2S + aq \rightleftharpoons H^+ + HS^-$$