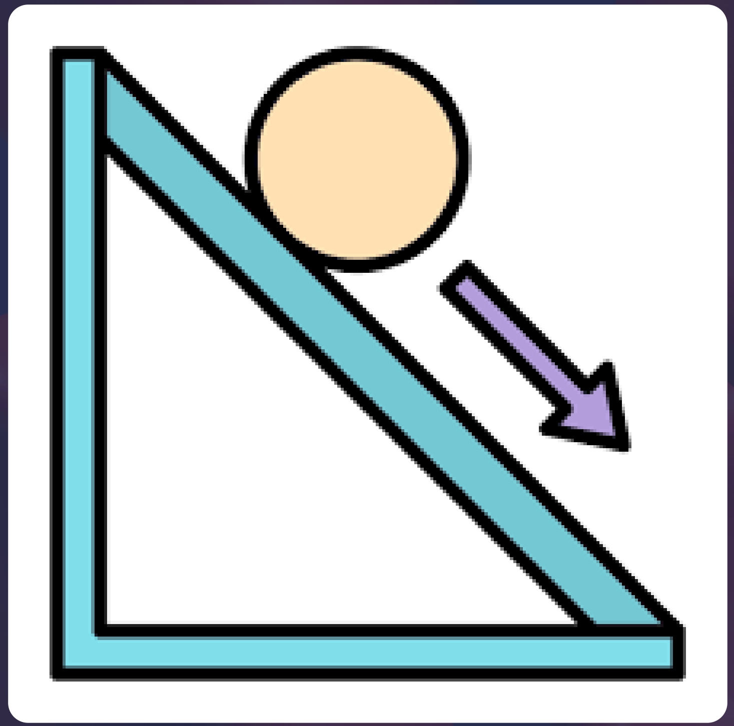
FSC-MIT-1

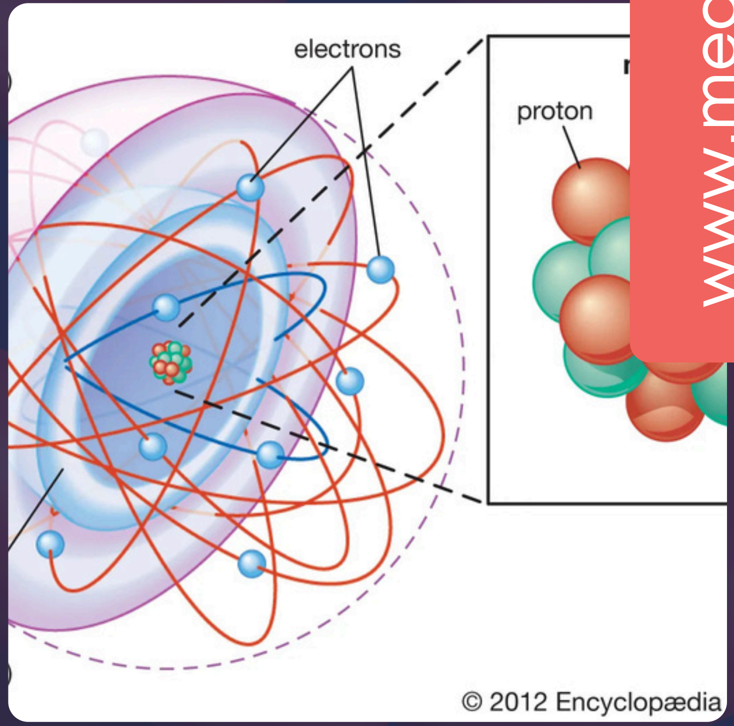
LEC#6 (5/11/2024)

FIRST-YEAR PHYSICS
FOR RADIOGRAPHERS

CHAPTER# 3

INVERSE SQUARE LAW
LUMINESCENCE





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Electromagnetic Spectrum Of EM-Radiation

- The EM spectrum of EM radiation is the range of all EM radiations in the terms of its wavelength and frequency.

- EM spectrum includes:-

  1. Gamma rays
  2. X-rays
  3. Ultraviolet rays
  4. Visible light
  5. Infrared rays
  6. Micro-waves

6. Micro-waves

Plank Equation for EM-radiation :-

$$\boxed{E \propto \nu} \Rightarrow E = h\nu$$

$$E = \frac{hc}{\lambda} \quad \because \nu = \frac{c}{\lambda}$$

$$\boxed{E \propto \frac{1}{\lambda}}$$

Here :- h = plank constant

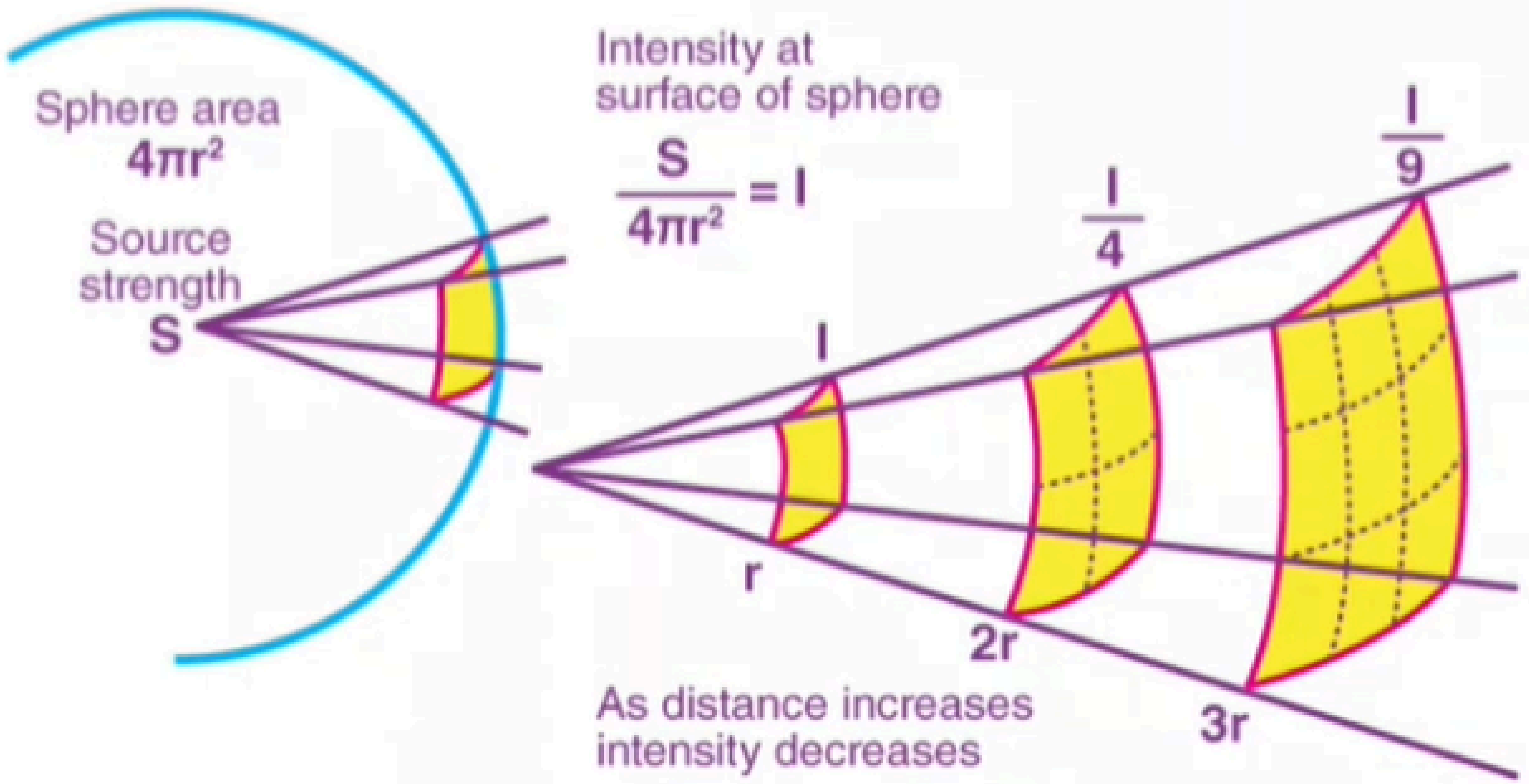
ν = frequency

c = speed of light (constant)

λ = Wavelength

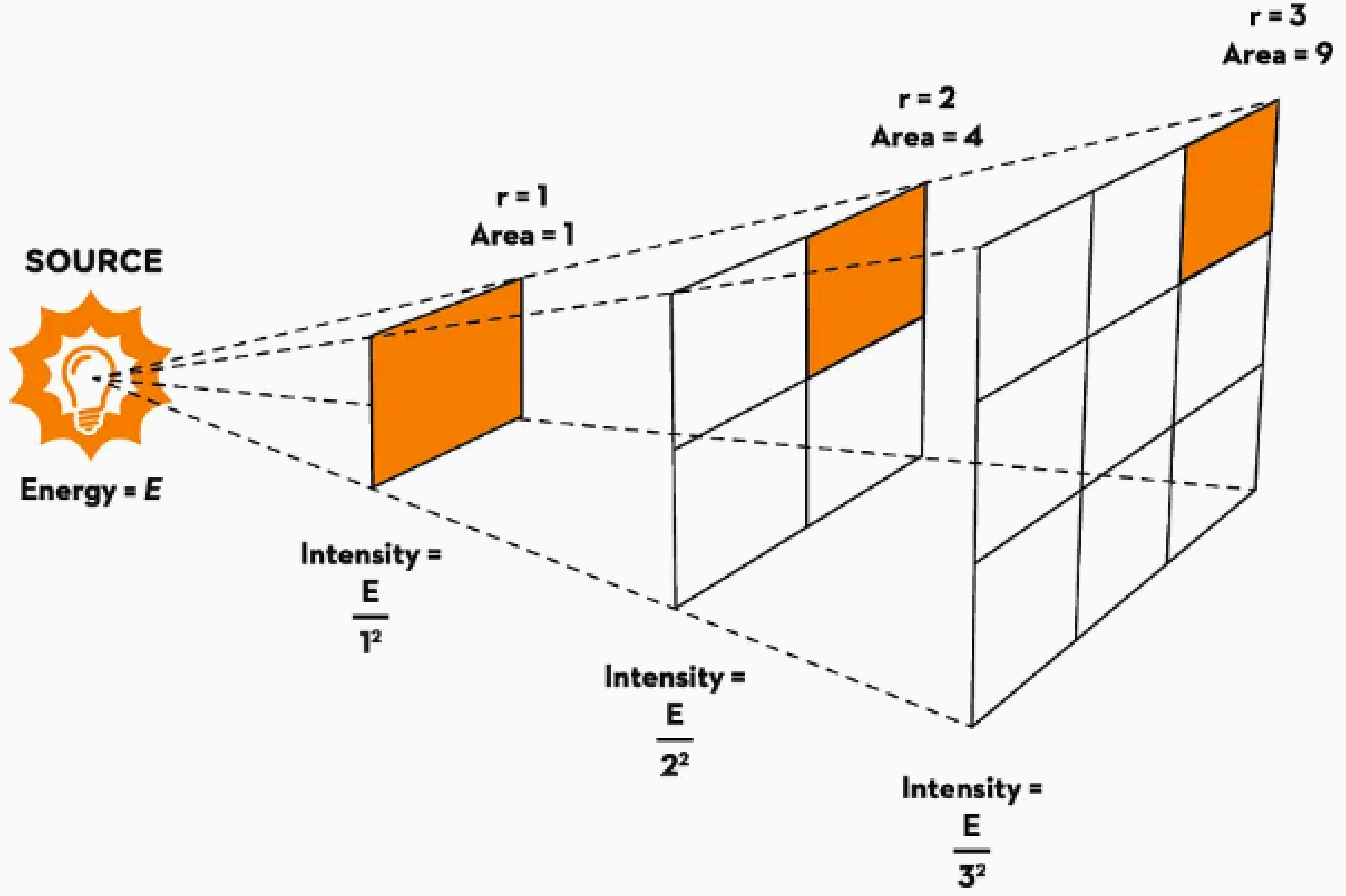
Inverse Square Law

- *The intensity of EM radiation is inversely proportional to the square of the distance from the source is called inverse square law.*



$$I \propto \frac{1}{r^2}$$

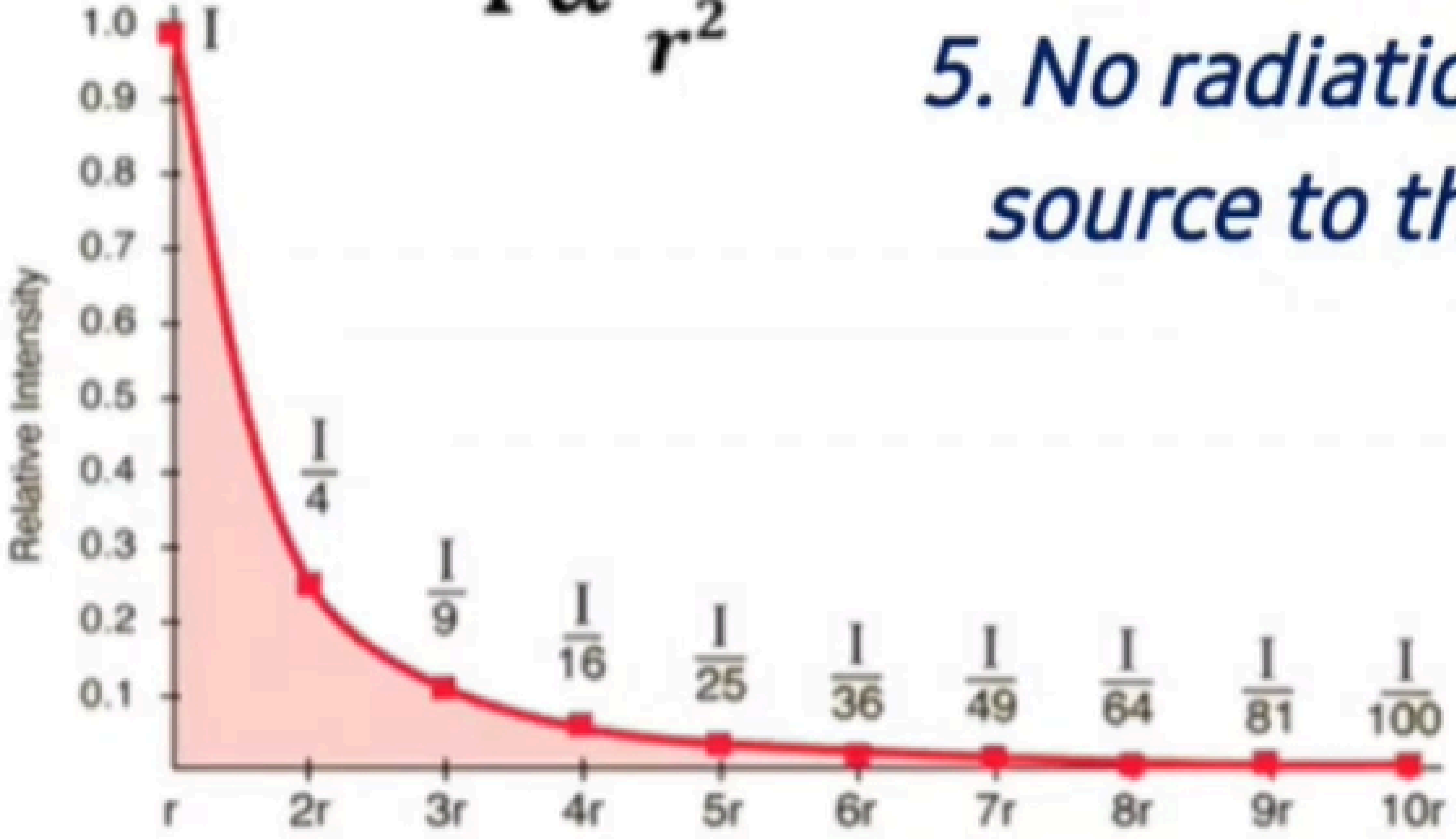
Inverse Square Law



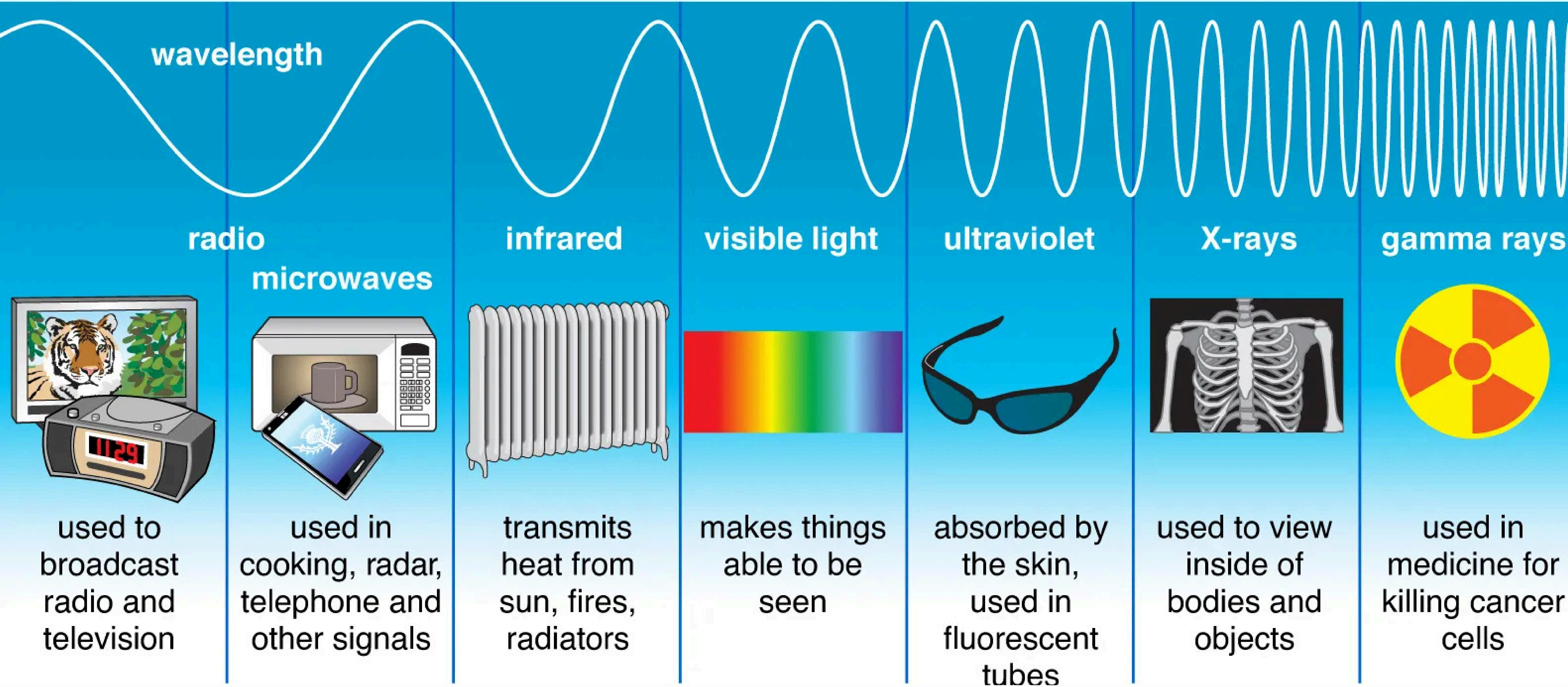
▪ Assumptions for inverse Square Law :-

1. The source of radiation is a point source.
2. The radiation travels in straight line.
3. The radiation is emitted equally in all directions.
4. Radiation emitted at constant rate.
5. No radiation energy loss from the source to the point of measurement.

$$I \propto \frac{1}{r^2}$$



Types of Electromagnetic Radiation

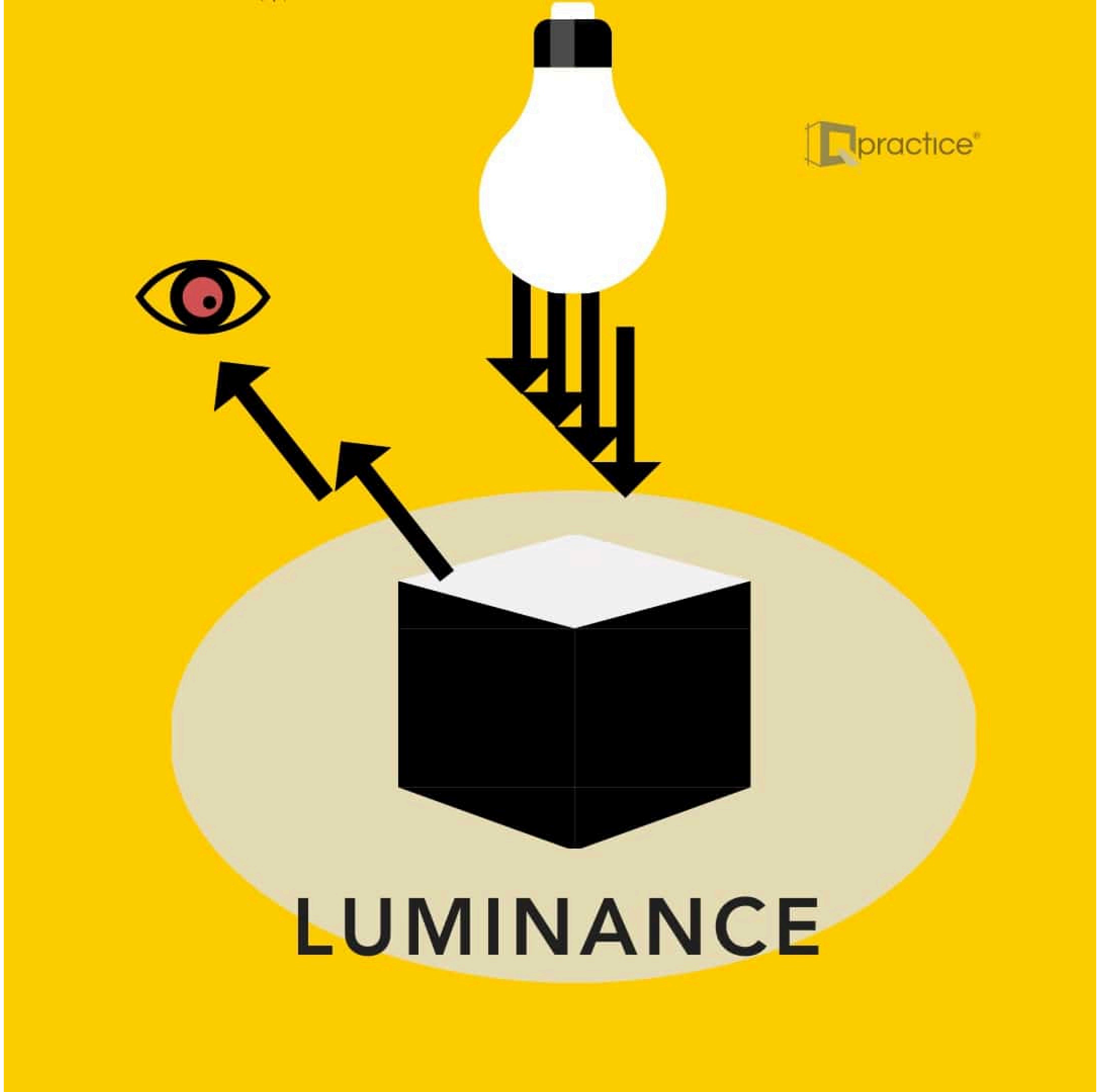


Luminescence

- *When EM radiation fall on certain materials (ex - Phosphor materials) then they emits visible or UV-light photons, this property of these materials is called luminescence.*

- *The EM radiation gives energy to the valence electrons, after then these electrons are jumped into the conduction band.*

- *Later the electrons return to the valence band to fill up the holes then they falls through the luminescence centers, they emits extra absorbed energy in the form of flashes of light this phenomenon is called as luminiscence.*

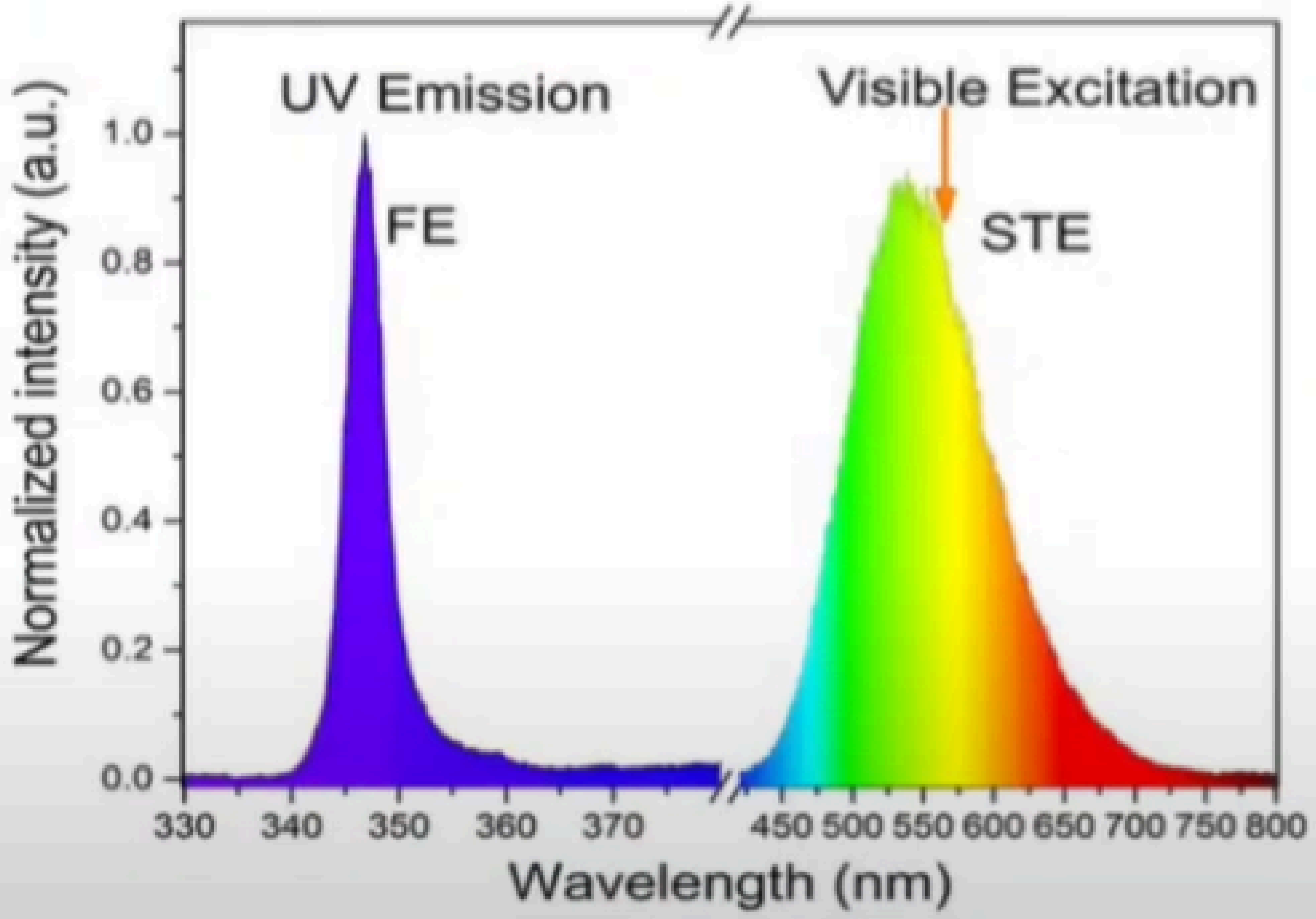

LUMINANCE

Examples :-

Phosphor materials/Fluorescent phosphors

Like:-

1. NaI : Tl (Thalium activated Sodium iodide in Gamma camera)
2. Gd2O2S : Tb (Terbium activated gadolinium oxysulphide in Intensifying Screen)
3. CsI : Na (Sodium activated cesium iodide in Image intensifier)



All are use in diagnostic radiology

Types of Luminiscence

- *On the basis of time of light emission luminiscence is two type :-*

1. Fluorescence

2. Phosphorescence

1. Fluorescence

- *In the luminescence process the emission of light is instantaneous, within 10^{-8} sec ($< 10^{-8}$ sec), it is called fluorescence.*

Examples :-

Phosphor materials/Fluorescent phosphors Like:-

1. NaI : Tl (Thalium activated Sodium iodide in Gamma camera)

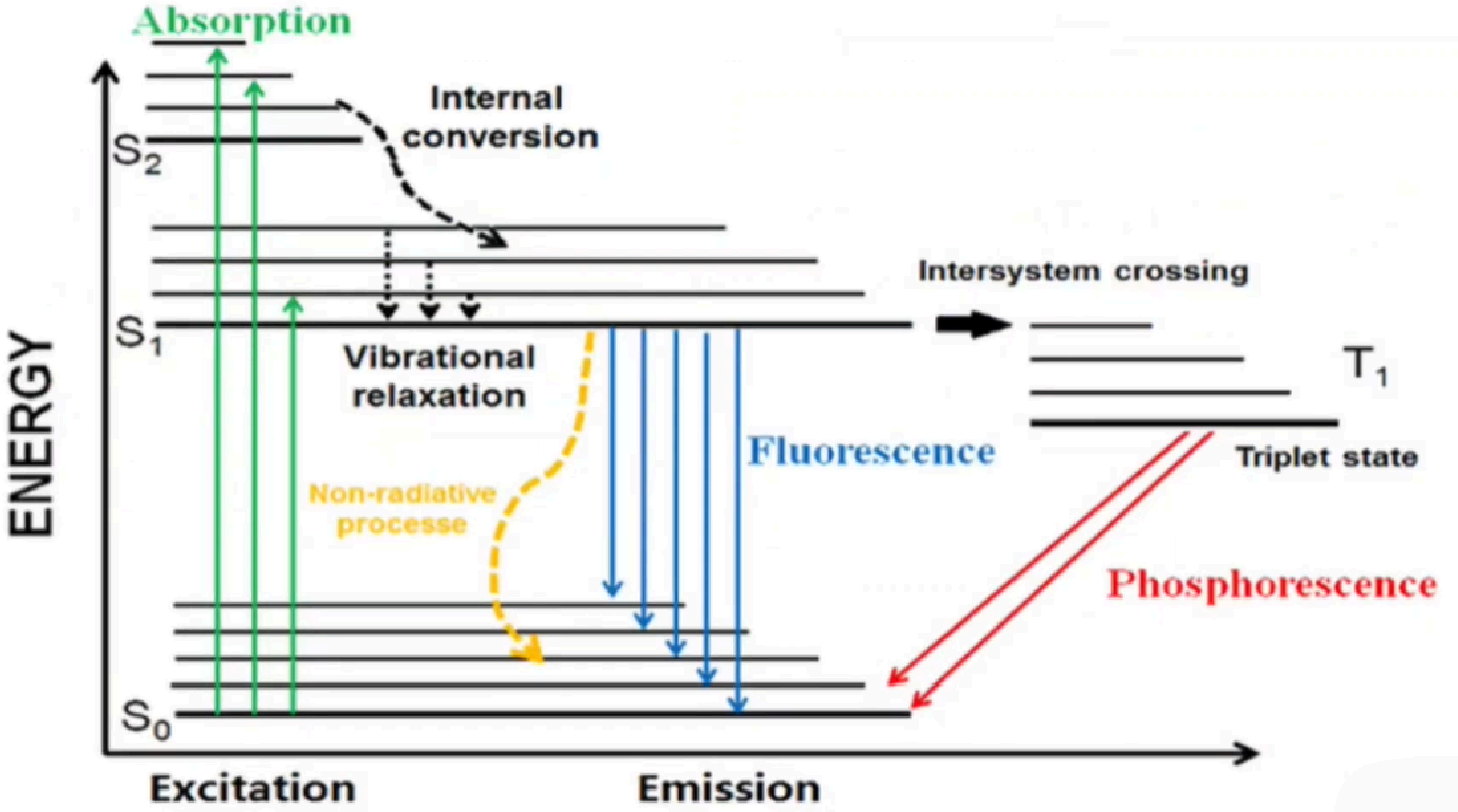
2. Gd2O2S : Tb (Terbium activated gadolinium oxysulphide in Intensifying Screen)

3. CsI : Na (Sodium activated cesium iodide in Image intensifier)

- *All are use in diagnostic radiology*

2.Phosphorescence

- *In the luminescence process the emission of light is delayed after then 10^{-8} sec (> 10^{-8}sec) , it is called phosphorescence.*
- *It is also called after glow or delayed emission bcz emission of light delayed in this process.*
- *It is random process.*
- *It is responsible for film fog in Screen-film radiography.*



Absorption
Internal conversion
S2
S1
S0
Vibrational relaxation
Intersystem crossing
T1
Triplet state
Fluorescence
Non-radiative processe
Phosphorescence
ENERGY
Excitation
Emission

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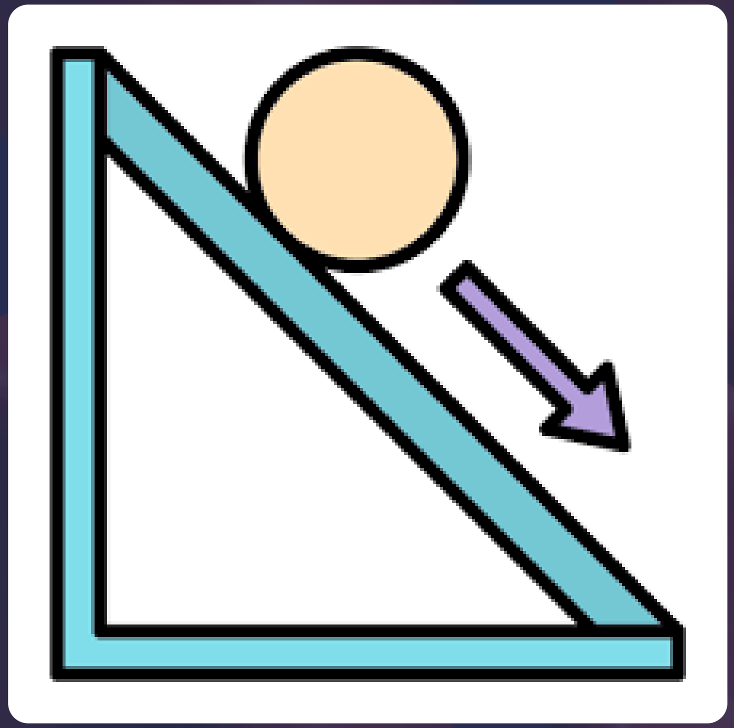
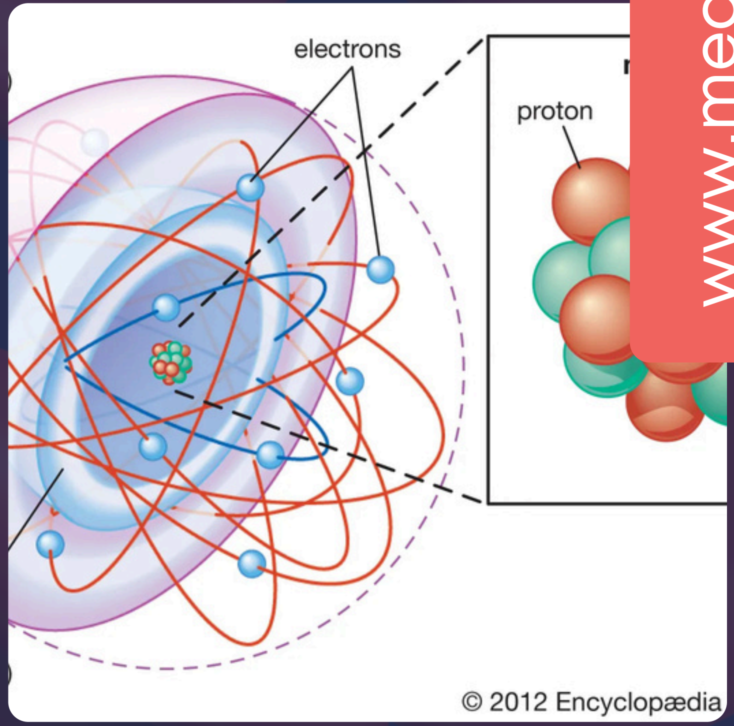
FIRST-YEAR PHYSICS
FOR RADIOGRAPHERS





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CHAPTER# 3

BAND THEORY

N TYPE

P TYPE

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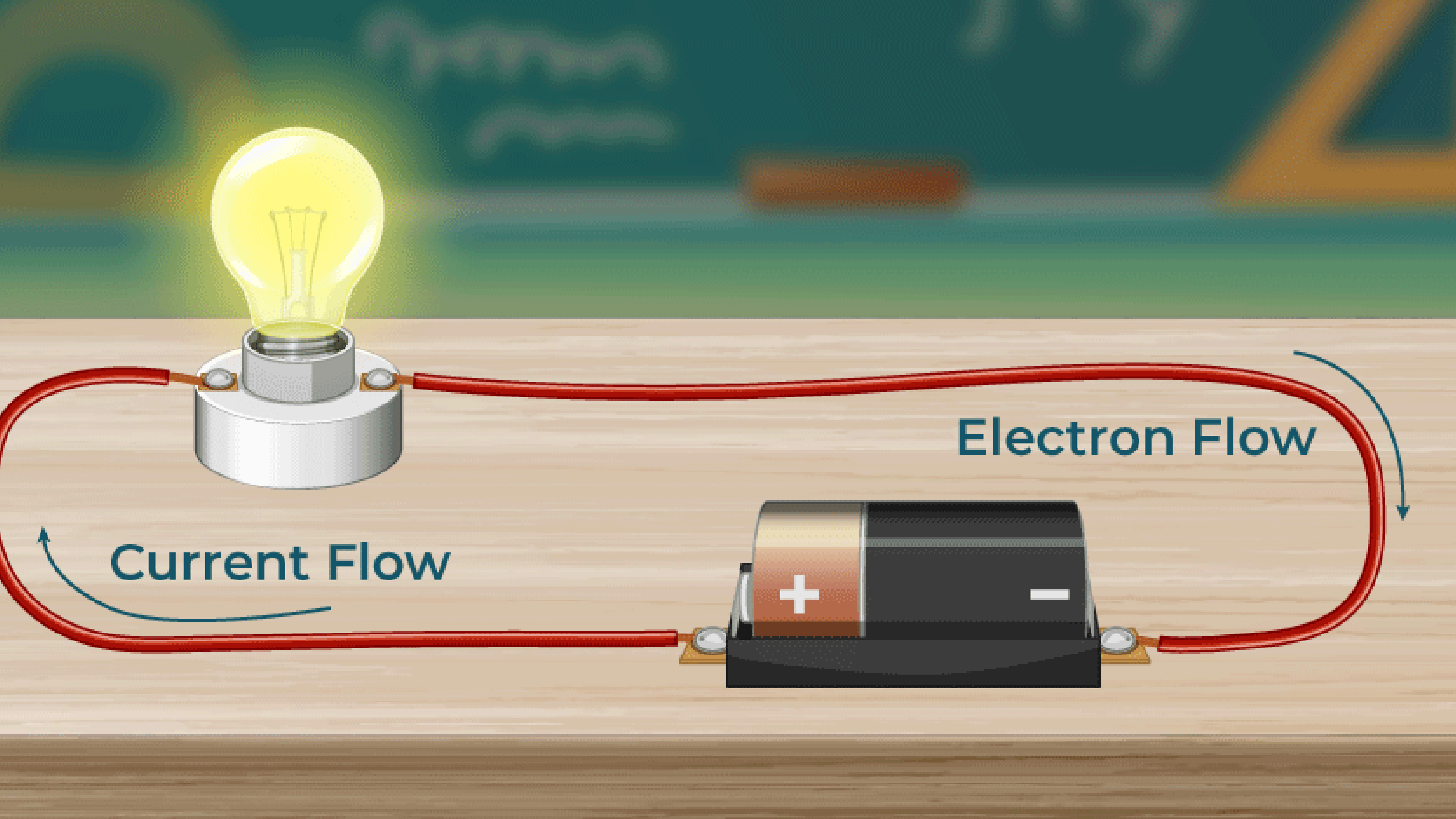
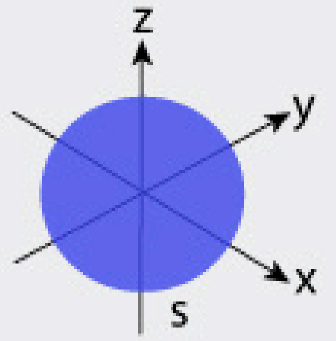


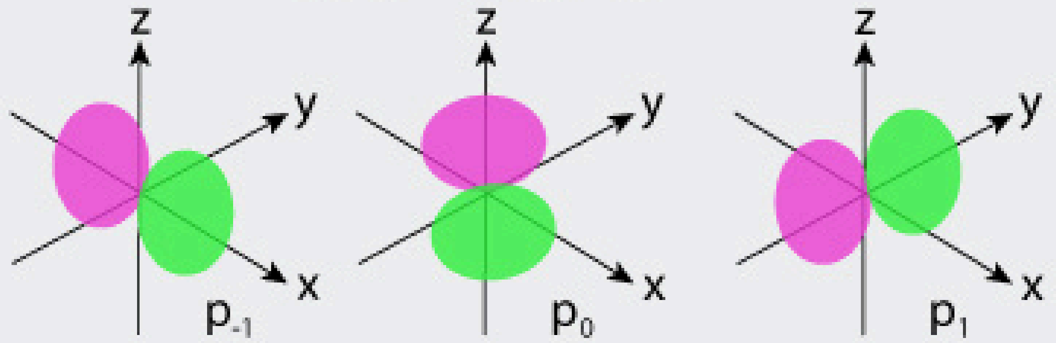
Electron Flow
Current Flow
+
−

Atomic Orbitals

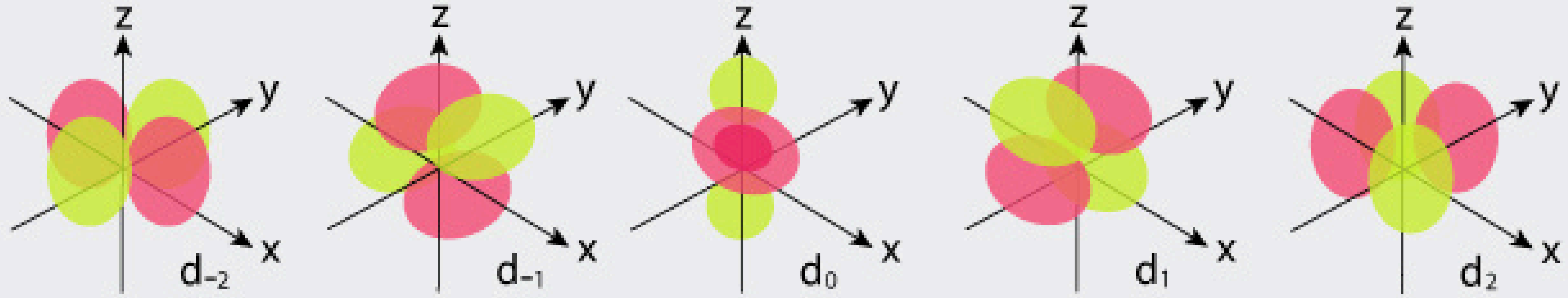
1. s-orbital



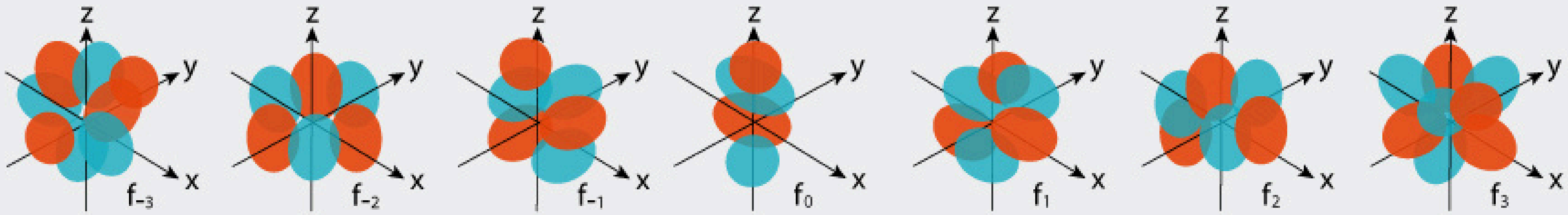
2. p-orbital



3. d-orbital



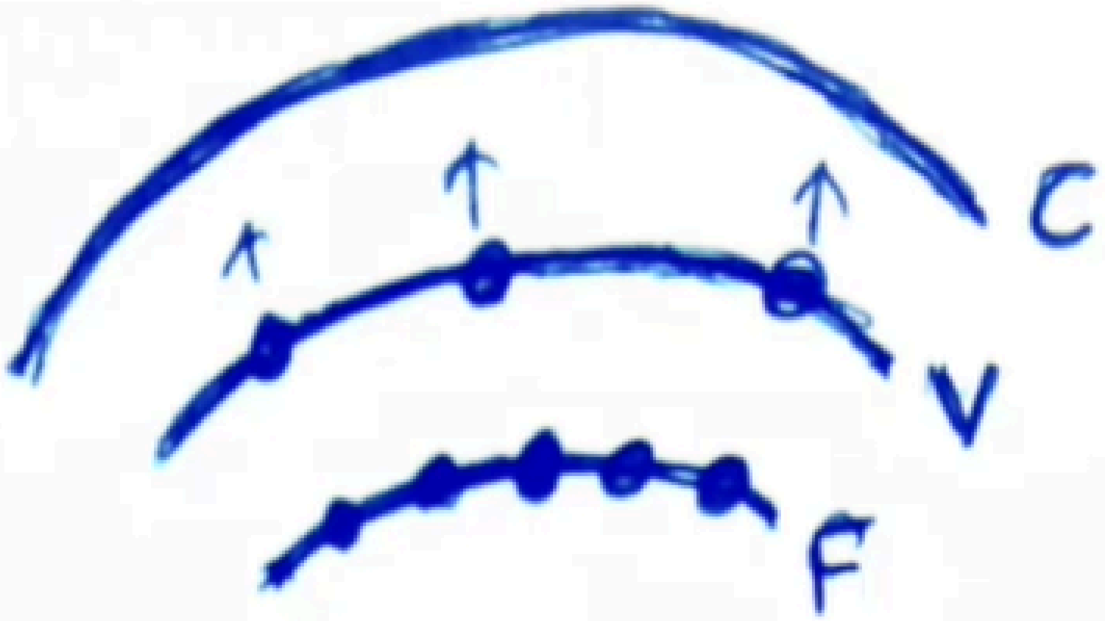
4. f-orbital



Band theory of Conduction

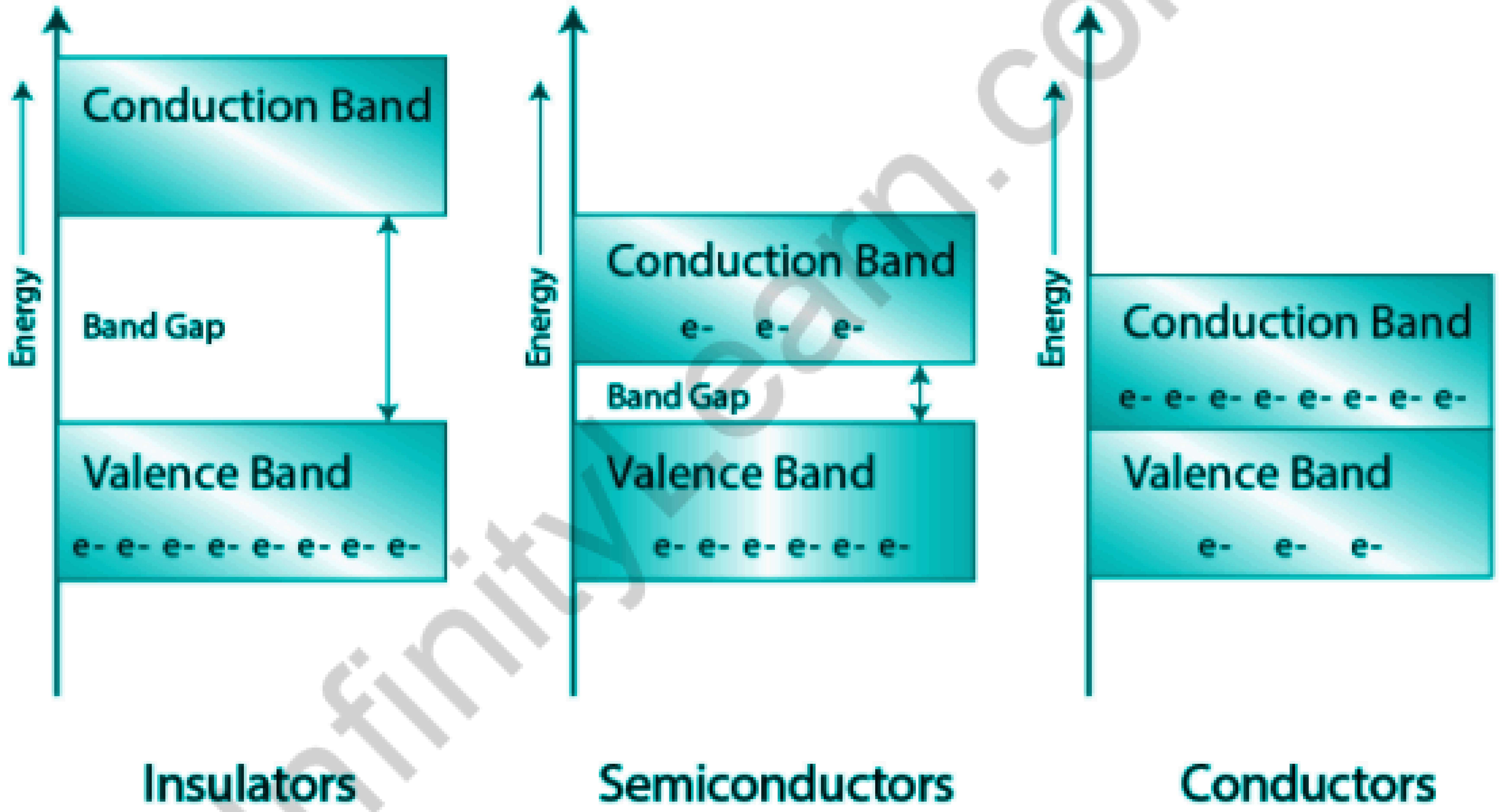
- According to the band theory of conduction:-

3Energy bands presents In matters :- 1. Filled band
2. Valence band
3. Conduction band



1. Filled band : - Present below the Valence band in atoms.
- No contribution in electrical conduction.
- Hence, it is normally not included in energy band diagram.

2. Valence band: - Present below the conduction band in atoms.
- In this band electrons are tied (बंधा हुआ) up to individual atoms.
- Have lower energy than conduction band and partiall filled by the e-s.


Energy
Conduction Band
Band Gap
Valence Band
e- e- e- e- e- e- e- e-
Insulators
Energy
Conduction Band
e- e- e-
Band Gap
Valence Band
e- e- e- e- e- e-
Semiconductors
Energy
Conduction Band
e- e- e- e- e- e- e- e-
Valence Band
e- e- e-
Conductors

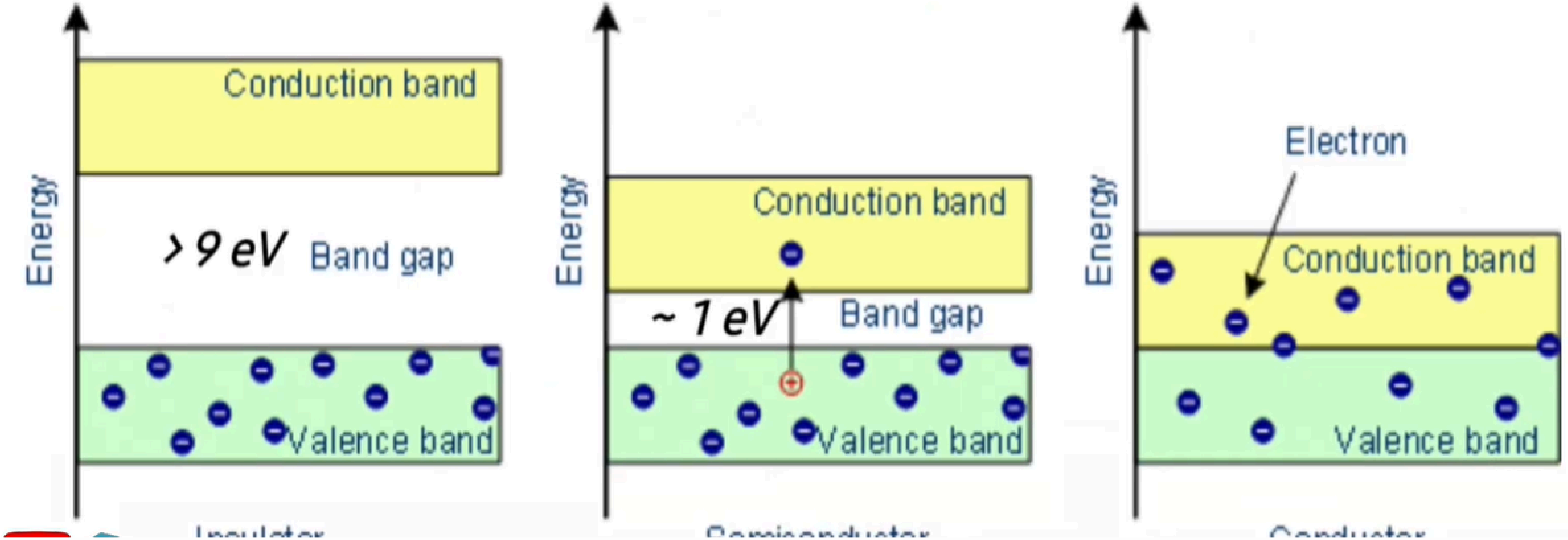
3. Conduction band : - Highest energy band in atoms.

- In this band electrons are free to move bcz electrons are not tied to individual atom.
- Hence, electrical conduction occurs in this band.

Note :- The gap between valence band & conduction band is called forbidden gap.

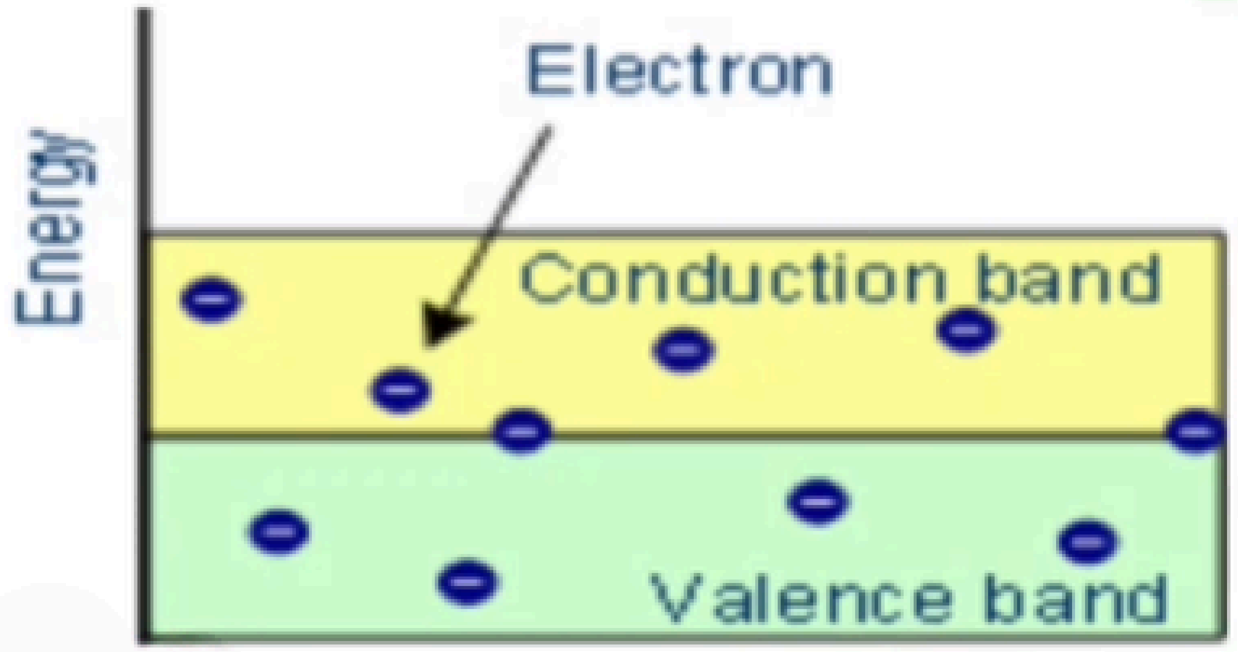
- On the basis of forbidden gap width materials classified into :-

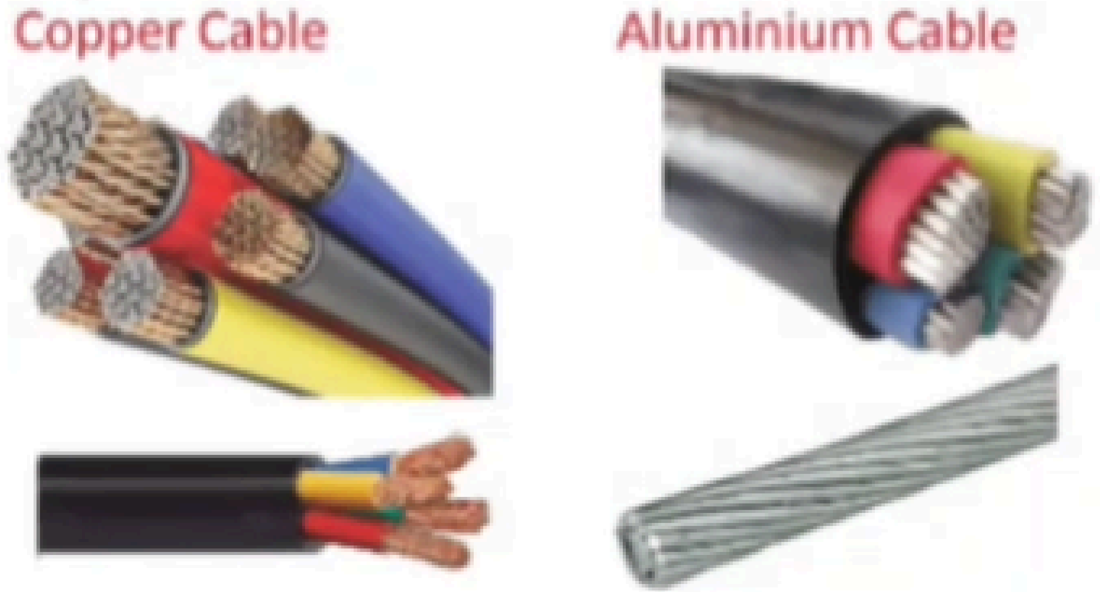
1. Conductor
2. Insulator
3. Semiconductor


Energy
Conduction band
>9 eV
Band gap
Valence band
Energy
Conduction band
~ 1 eV
Band gap
Valence band
Energy
Electron
Conduction band
Valence band

1.Conductor

- In conductors the forbidden gap or band width between valence band and conduction band is zero =(0).
- Hence, there are electrons are easily move from valence band to conduction band.
- Ex :- Metals such as
  - Ag (Silver)
  - Cu (Copper)
  - Al (Aluminium) are good electrical conductor





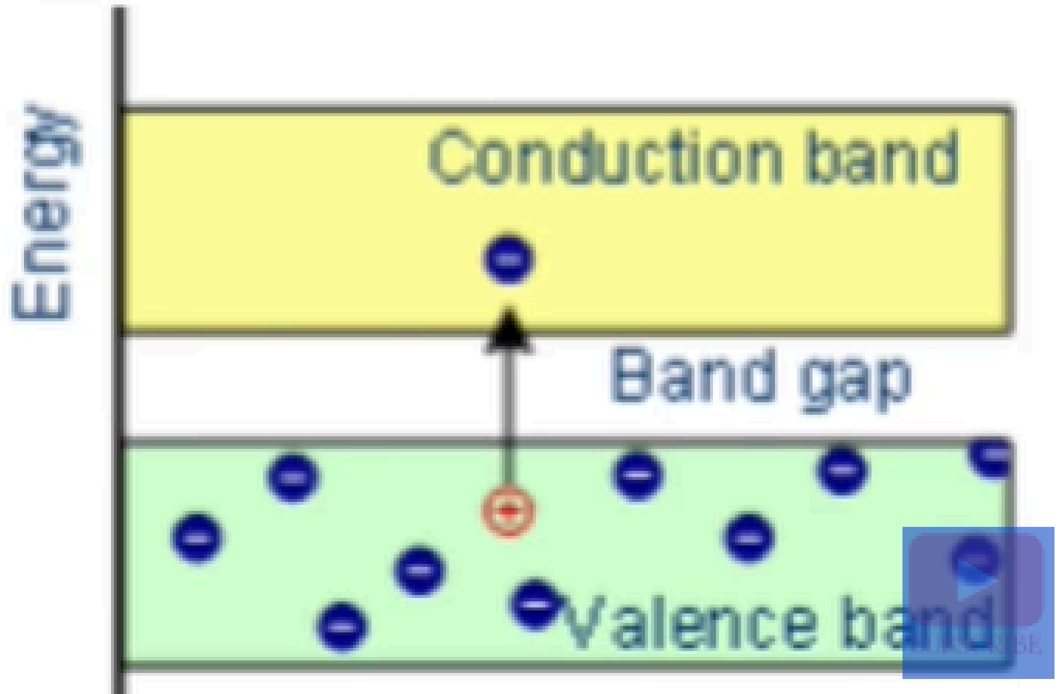
2.Insulator

- In insulator forbidden gap or band width is very large = >9eV.
- Therefore, electrons are unable to flow from valence band to conduction band due to high energy differance.
- Hence, there is no flow of electric current.
- Ex : Non metals such as- Oil, glass, wood, plastic and rubber.

- Note- At very high temperature few electrons may move from valence band to conduction band but the material undergo breakdown.

3.Semiconductor

- Width of forbidden gap or band width = ~ 1eV
- At low temperature there is no electrons flow from valence band to conduction band and they have behave like a insulator.
- At room temperature they are gain >1eV energy but limited electrons flow from V.B. to C.B.
- At high temperature electrons move from V.B. to C.B. and they are show higher electrical conductivity because also holes are created which responsible for higher conductivity.



3.Semiconductor

- This type of conduction take place in pure semiconductor which is calle intrinsic semiconductor.

Example :- 14th group elements like Germanìum (Ge) & Silicon (Si).

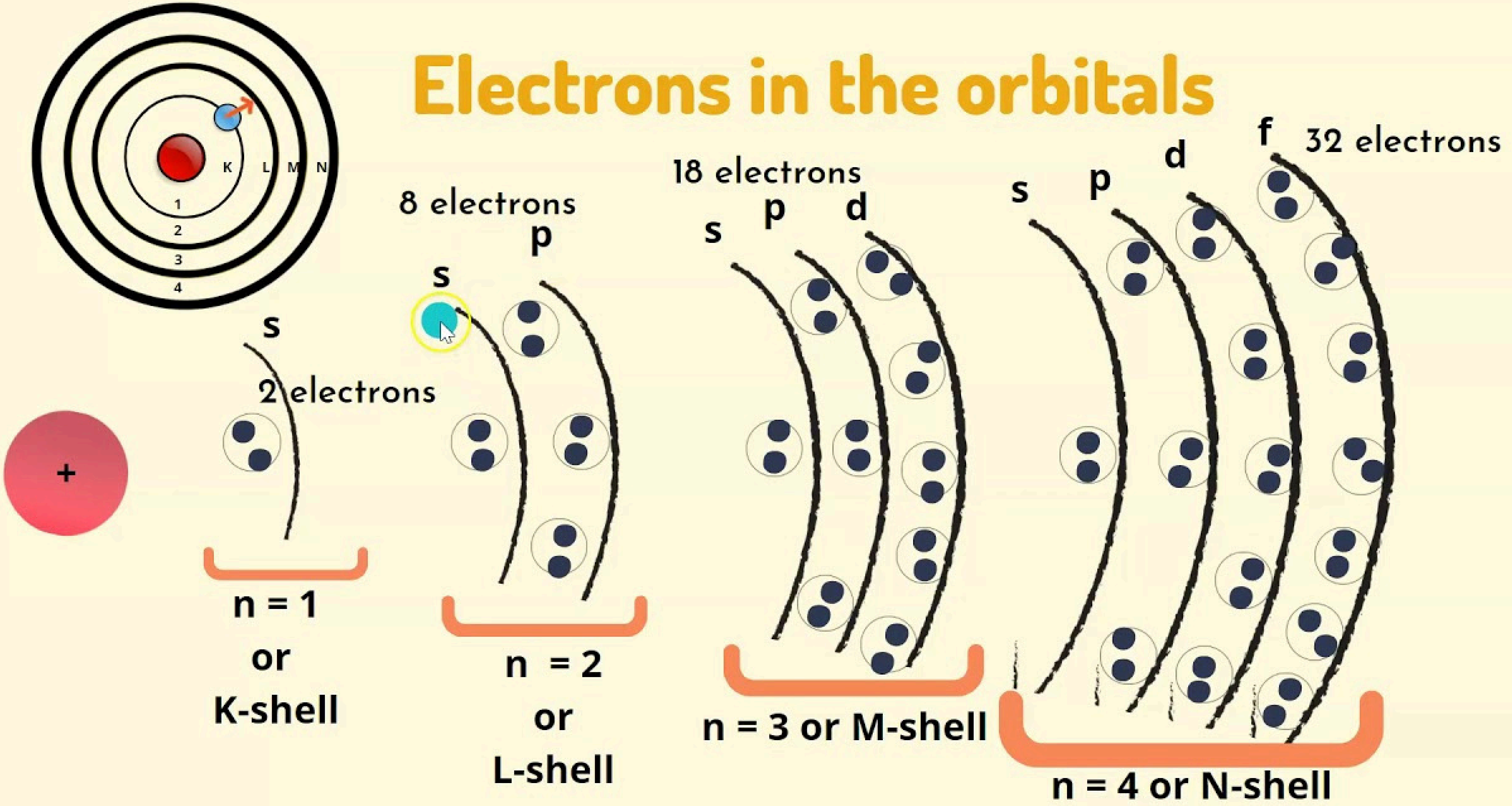
Note :- The conducting property of intrinsic semiconductor can be modified by adding impurities to it which is called doping.

- After doping they called extrinsic semiconductor.

- On the basis of doping extrinsic semiconductor is two type -

1. P-type Semiconductor
2. N-type Semiconductor

Electrons in the orbitals



1 H Hydrogen																	2 He Helium
3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
11 Na Sodium	12 Mg Magnesium											13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon
55 Cs Cesium	56 Ba Barium	57-71 Lanthanides	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89-103 Actinides	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

57 La Lanthanum	58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium
89 Ac Actinium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Alkali Metal | Alkaline Earth | Transition Metal | Basic Metal | Metalloid | Nonmetal | Halogen | Noble Gas | Lanthanide | Actinide

1. P-type Semiconductor

- *It is a type of extrinsic semiconductor.*
- *How to made :-* *Intrinsic semiconductor (14th group elements) Ex- Si & Ge*

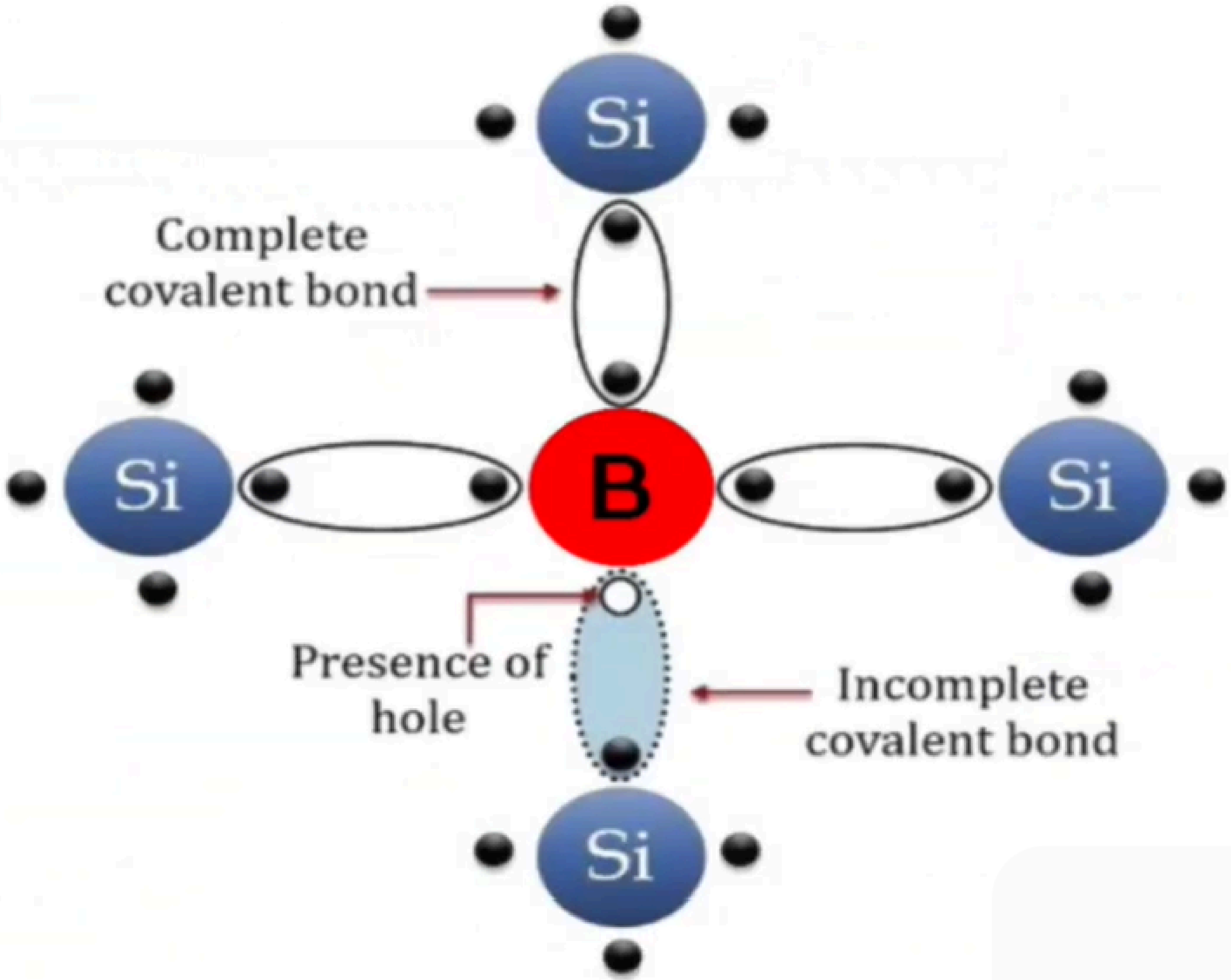
+

Doping with small amount of trivalent impurity (13th group elements) Ex- B, Al & Ga

Si	:	B
14th group element		13th group element
4 valence e-		3 valence e-

- *3 valence e- of each atom form 3 covalent bonds and 4th covalent bond cannot be completed, hence the missing e- is known as hole, which are the positive charge career, hence these are called P-type Semiconductor, where'P' stand for Positive.*
- *Majority careers = Holes*
- *Minority careers = electrons*
- *Density of holes > Density of electrons*

1. P-type Semiconductor



2. N-type Semiconductor

- *It is a type of extrinsic semiconductor.*
- *How to made :-* *Intrinsic semiconductor (14th group elements) Ex- Si & Ge*

+

Doping with small amount of pentavalent impurity (15th group elements) Ex- N, P, As & Sb

Si	*:*	*P*
14th group element		*15th group element*
4 valence e-		*5 valence e-*

- *4 valence e- of each atom form 4 covalent bonds and 5th e- is not bonded with any Silicon atom, therefore each pentavalent atom donate one e- which is negative charge career , hence it is called N type Semiconductor where 'N' stand for Negative.*
- *Majority careers = electrons*
- *Minority careers = holes*
- *Density of electrons > Density of holes*

2. N-type Semiconductor