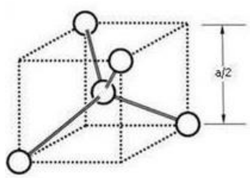
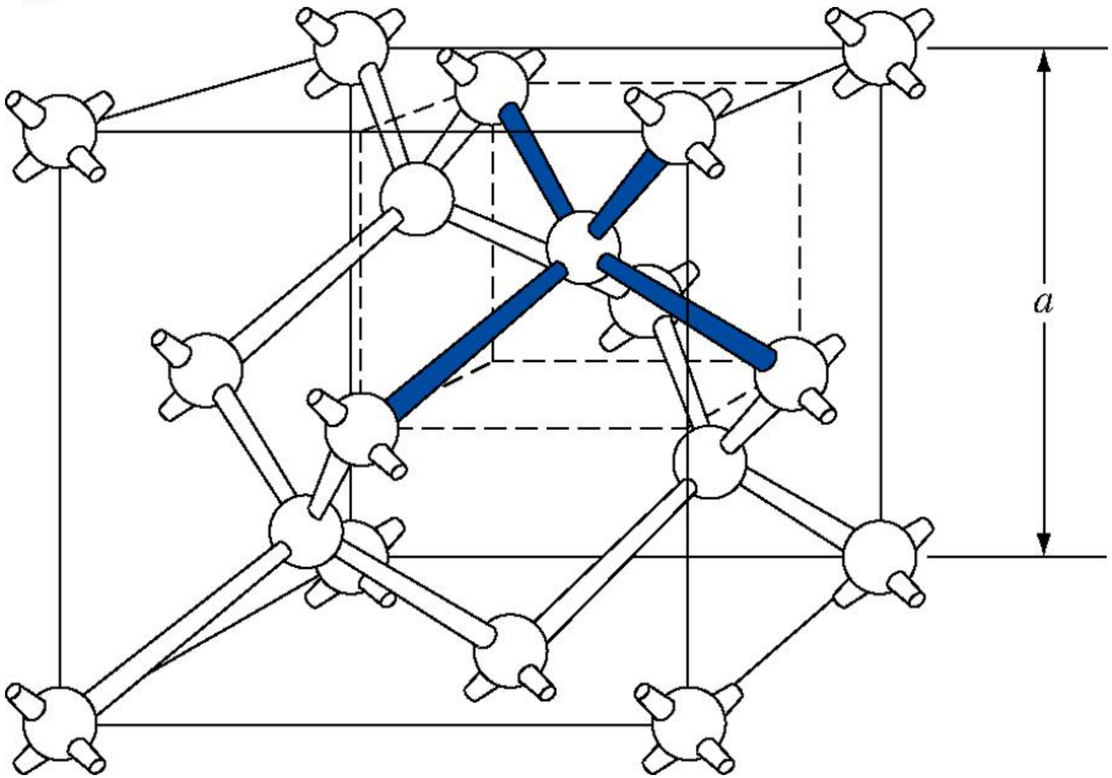
DIAMOND LATTICE





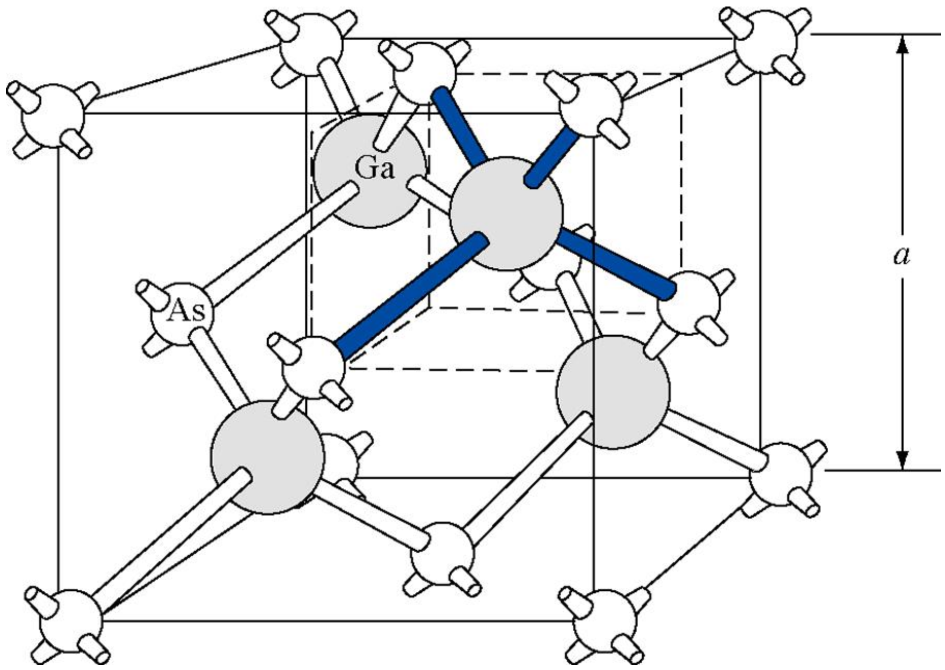
A unit cell of diamond structure

Silicon and Germanium are two examples of semiconductor materials that have a diamond crystal structure.

A unit cell of the diamond structure is more complicated than the simple cubic structures.

An important characteristic of the diamond lattice is that any atom within the diamond structure will have four nearest neighboring atoms.

ZINC-BLENDE LATTICE



A unit cell of Zinc-blende lattice:
e.g. GaAs Lattice

The zinc-blende structure differs from the diamond structure only in that there are two different types of atoms in the lattice. Compound semiconductors, such gallium arsenide (GaAs) have the zinc-blende structure.

Note:
The atoms in both the diamond and zinc-blende structures are joined together to form a <u>tetrahedron</u>.

TYPES OF BONDING

The type of bond, or interaction, between atoms depends on the particular atom or atoms in the crystal. If there is not a strong bond between atoms, they will not "stick together" to create a solid.

(i) Ionic Bonding : A coulomb interaction between oppositely charged ions.
Ex: Sodium chloride (NaCl)
Materials of Group I and VII.

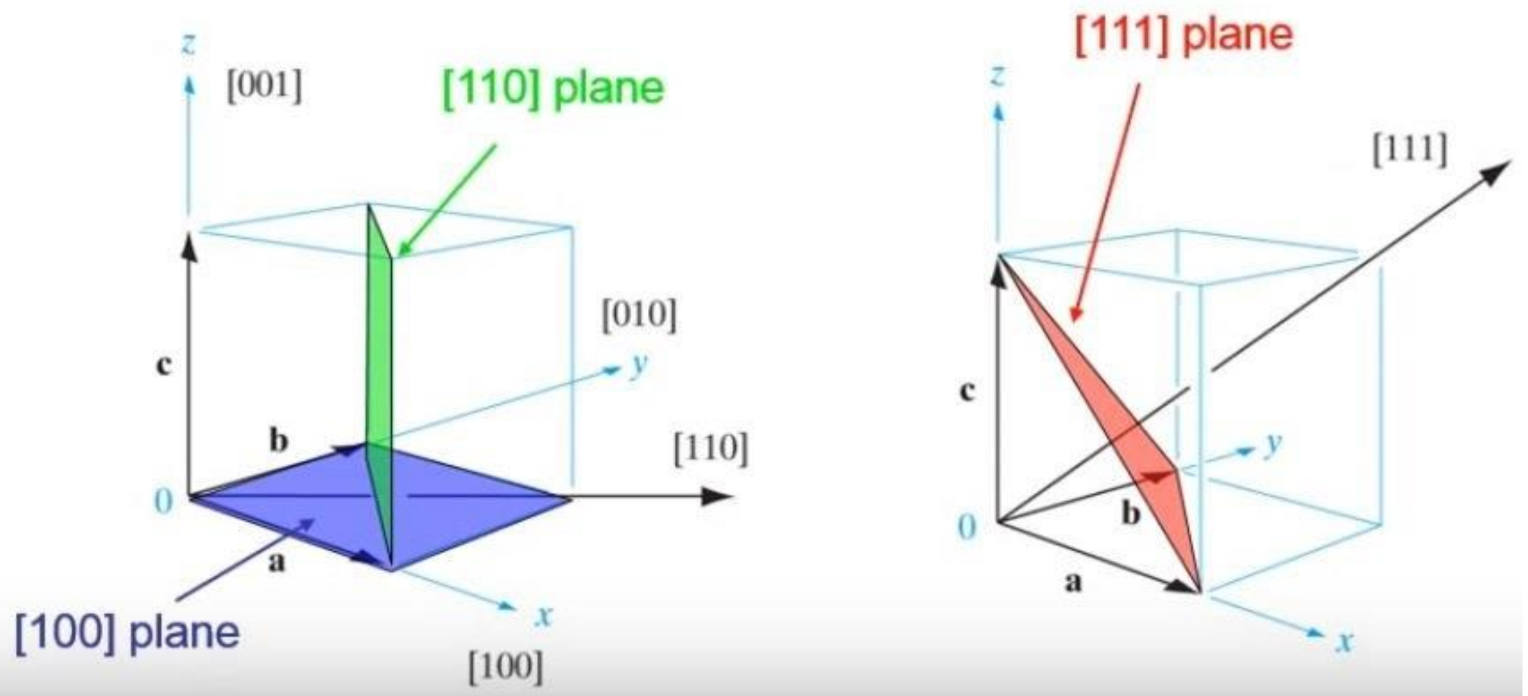
(ii) Covalent Bonding : Sharing of electrons between two atoms, so that in effect, the valence energy shell of each atoms is full.
Materials of Group IV.

(iii) Metallic Bonding

(iv) Van der Waals Bonding

PLANES IN A CRYSTAL LATTICE

- In a cubic lattice, there are three families of planes: {100}, {110}, and the {111} planes



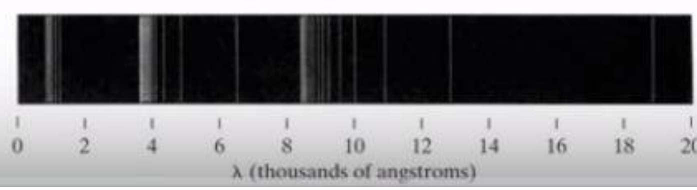
ATOMIC SPECTRA

- Plasma (aka "Neon") tubes are tubes filled with a single type of gas. When electrical voltage is applied, an electric discharge excites the gas, and it glows. *Why does each gas glow a different color?*

Courtesy Wikipedia

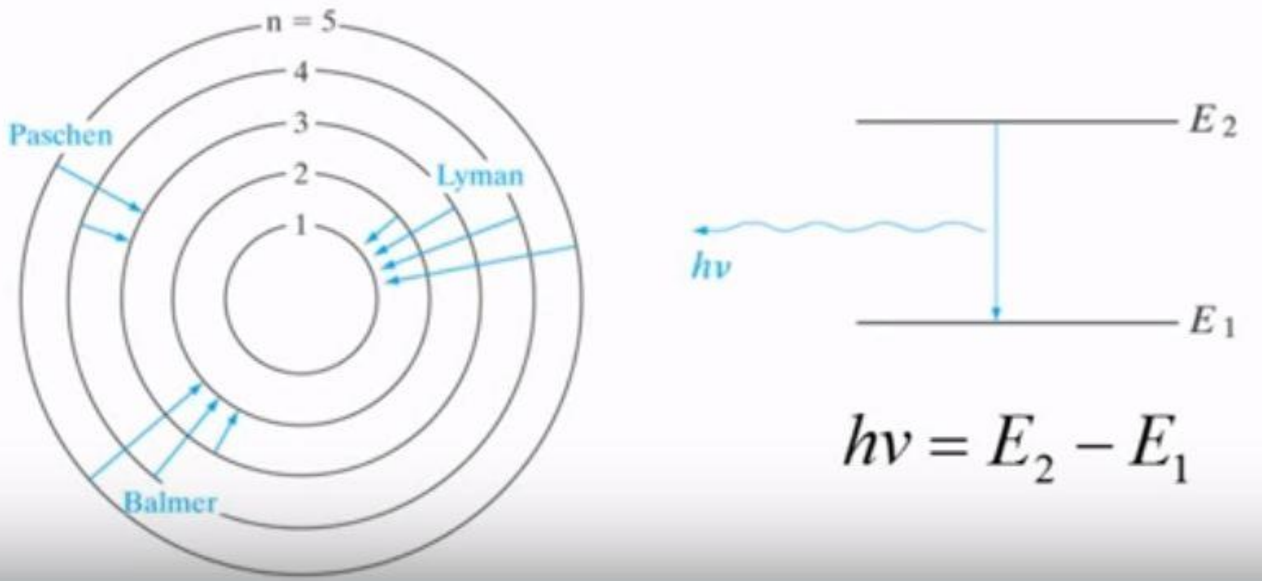
- Spectroscopists noticed that
  - When a gas is excited by an electric discharge, it emits light at discrete wavelengths (ie specific colors).
  - Each type of gas has a characteristic spectra (set of lines)
  - The spacing between the wavelengths follows a pattern.
- Atomic Spectra provided early experimental evidence that electrons are arranged in **discrete energy levels**

Hydrogen Spectrum



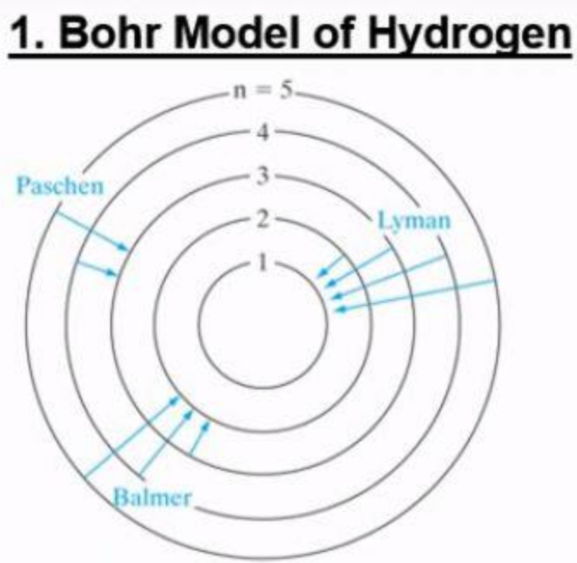
BOHR MODEL OF LIGHT EMISSION

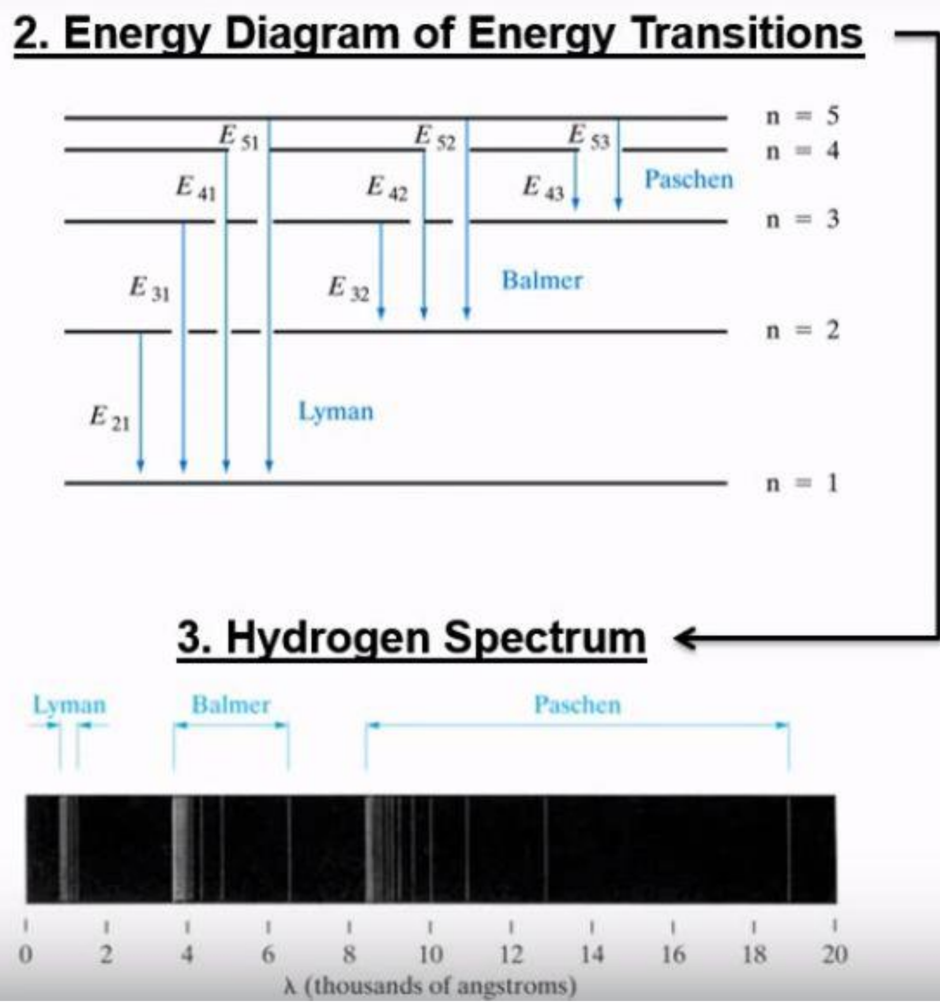
- Neils Bohr explained the atomic spectra using a planetary model of the atom, where electrons orbit in discrete energy levels
  - Light or electric discharge can excite and electron, causing it to jump from one energy level (E_1) to a higher one (E_2)
  - When the electron falls back down to its original energy level, it emits a **photon of light**.
  - The energy (and frequency) of the photon is equal to E_2-E_1



$$h\nu = E_2 - E_1$$

EXAMPLE: HYDROGEN ATOM

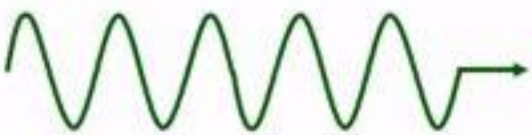




- Each type of atom has its own unique atomic structure, therefore it also has its own distinct energy transitions and a unique spectra

WAVE-PARTICLE DUALITY

- Light energy is contained in discrete units called photons, which behave both as a particle and as a wave
- Electrons also exhibit the same behavior



Wave Nature of light:
Explains interference, diffraction, polarization, and reflection/refraction

Particle Nature of light:
Explains photoelectric effect, reflection/refraction

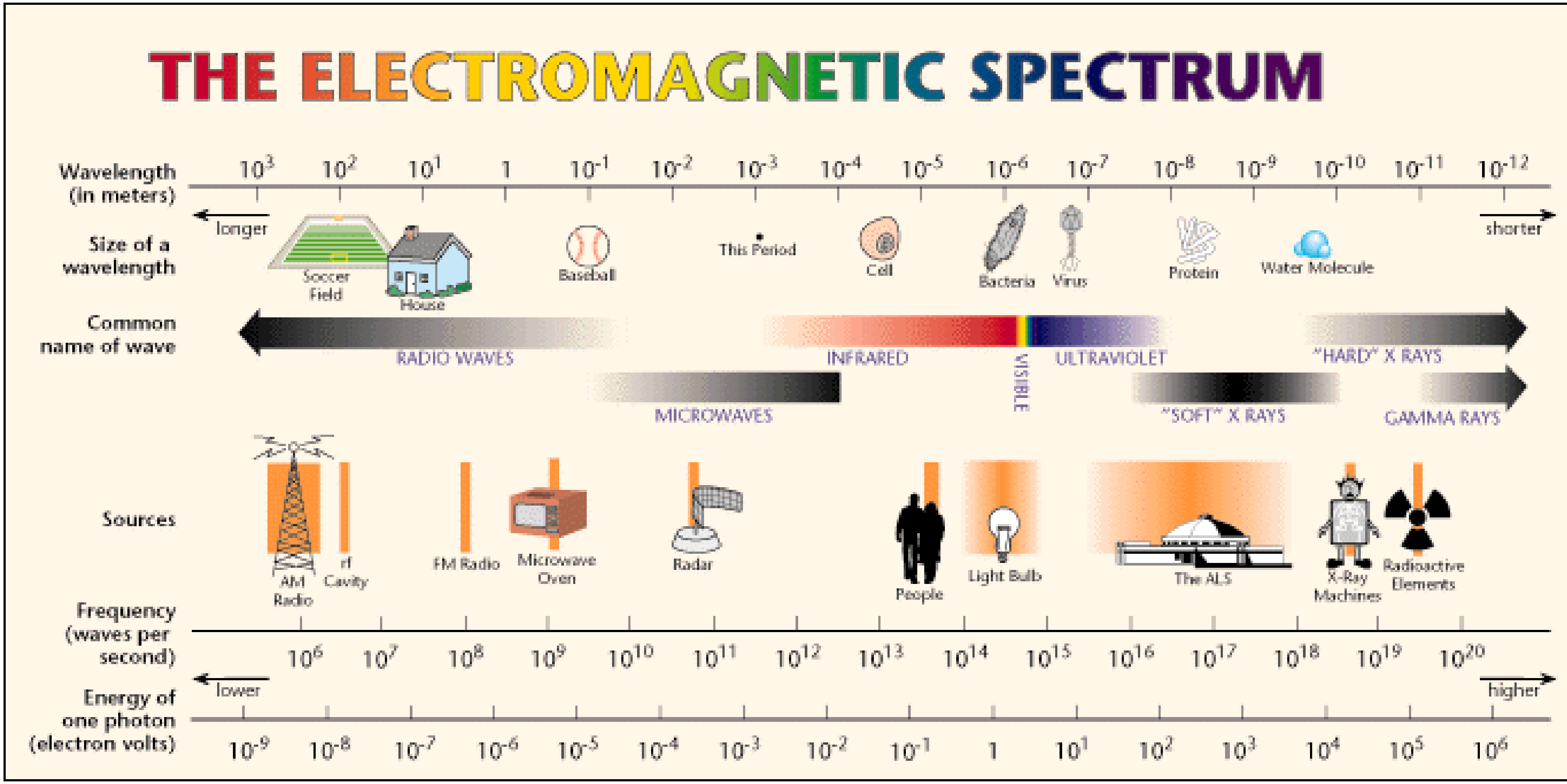
PHOTONS VS ELECTRONS

Photons	Electrons
A packet of electromagnetic energy (light)	A charged particle which carries electricity
Travels at the speed of light $c = 3 \times 10^8\ m/s$ (vacuum)	Can have a velocity greater than 0 and less than c
Has no charge	Has a negative charge $q = -1.6 \times 10^{-19}$C
Has no mass	Has mass $m = 9.1 \times 10^{-31} kg$
No mass, so no momentum	Momentum $p = mv$
Energy specified by Plancks' law $E = hf$	Kinetic energy specified by $E = mv^2/2$
Wavelength specified by dispersion relationship $\lambda = c/f$	Wavelength specified by Debroglie equation $\lambda = \frac{h}{p} = \frac{h}{mv}$

E = Energy of particle
h = Planck's constant = 6.63×10^{-34} m^2kg/s
f = frequency of light
λ = Wavelength

c = speed of light = 3×10^8m/s
p = momentum
m = particle mass
v = Velocity

ELECTROMAGNETIC SPECTRUM



WHAR IS ELECTRICITY ?

Electricity is the movement of charge

- Static charge: No electricity; For electricity to exist charges has to be present and it has to move
- In semiconductors:
  Electric current is due to the movement of electrons and holes
- To know electrical behavior of a material: 3 things to know about electrons
  - Where electrons are or location of electrons
  - Direction of movement
  - Energy of electron (Energy band diagrams of orbitals)