1 erg =1.0×10^{-7} joules

1 J = 10^{7} erg

1 **Joule** = Energy required to move a charge of 1 Coulomb through a potential difference of 1 volt.

Thus **1 Joule = 1 Coulomb x 1 Volt**

1 **eV** = Energy required to move an electron (Charge of an electron = 1.6 x 10^{-19} Coulomb) through a potential difference of 1 Volt.

Thus 1 eV = 1.6 x 10^{-19} Coulomb x 1 Volt

1 eV = 1.6 x 10^{-19} Joule

Thus **1 eV/1.6 x 10^{-19} = 1 Joule**

0.625 x 10^{19} eV = 1 Joule

(eV) = 1.602 x 10^{-19} J

❖ Wave Mechanics

In 1924 a young French doctoral student, **Louis de Broglie**, developed a hypothesis regarding the nature of particles. In this case, the particles were "real" particles such as electrons. **De Broglie** postulated that for electromagnetic radiation, the energy could be described by the **Planck** equation.

$$E = h\nu = \frac{hc}{\lambda}$$

According to **Einstein's** special theory of relativity (in 1905) is that a photon has an energy that can be expressed as

$$E = mc^2$$

For a given photon there is only one energy, so

$$mc^2 = \frac{hc}{\lambda} \quad \text{.....(26)}$$

Rearranging this equation leads to

$$\lambda = \frac{h}{mc} \qquad \text{.....(27)}$$

De Broglie considered the fact that photons have characteristics of both particles and waves. He reasoned that if a "real" particle such as an electron could exhibit properties of both particles and waves, the wavelength for the particle would be given by an equation that is equivalent to Eq. (27) except for the velocity of light being replaced by the velocity of the particle:

$$\lambda = \frac{h}{mv} \qquad \text{.....(28)}$$

λ = wavelength of the particle. h = Planck constant

m = mass of the particle. v = velocity of the particle

*<u>Ex:-</u> **Determine the de Broglie wavelength of**

a. an electron moving at 1/10 the speed of light.

b. a 400 g Frisbee moving at 10 km/h.

c. an 8.0-pound bowling ball rolling down the lane with a velocity of 2.0 meters per second.

d. a 13.7 g hummingbird flying at a speed of 30.0 miles per hour.

Ans.

a. $$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}\ \text{J s}}{(9.110 \times 10^{-31}\text{kg}) \times (0.1) \times (2.998 \times 10^{8}\ \text{m s}^{-1})} = 2.426 \times 10^{-11}\ \text{m}$$

b. $$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}\ \text{J s}}{0.400\ \text{kg} \times (10\ \text{km/hr} \times 10^{3}\text{m/km} \times 1\text{hr}/3600\text{s})} = 6 \times 10^{-34}\text{m}$$

c. $$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}\ \text{J s}}{8.0\ \text{lb} \times 0.4536\ \text{kg/lb} \times 2.0\ \text{m s}^{-1}} = 9.1 \times 10^{-35}\ \text{m}$$

d. $$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34}\ \text{J s}}{13.7\ \text{g} \times \text{kg}/10^{3}\text{g} \times 30.0\ \text{mi hr}^{-1} \times 1\ \text{hr}/3600\text{s} \times 1609.3\ \text{m/mi}}$$

$$= 3.61 \times 10^{-33}\ \text{m}$$

❖ **Note** ;- ***Lb*** is an abbreviation of the Latin word libra. The primary meaning of libra was balance or scales.

❖ **Heisenberg's uncertainty principle**

This states that it is impossible to know exactly the position and momentum of a particle simultaneously. The *x* component of this uncertainty is described as

$$\Delta x \, \Delta p_x \geq \frac{h}{4\pi}$$

Δx = uncertainty in the position of the electron

Δp_x = uncertainty in the momentum of the electron

***** Commonly applied to the position and momentum of a particle, the principle states that the more precisely the position is known the more uncertain the momentum is and vice versa.

* Zeeman Effect

* First reported by Zeeman in 1896. Interpreted by Lorentz.

*The Zeeman Effect is the splitting of emission lines when the emitting source is placed in a magnetic field.

* The Zeeman Effect is caused by the splitting of energy levels with deferent angular momenta in the atomic structure. The electron with non-zero magnetic momenta will have a non-zero magnetic dipole moment that will interact with the external magnetic field. This interaction will change the energy of the electron.

*Due to the Zeeman Effect, some degenerate atomic energy levels will split into several levels (sub level) with different energies. This allows for new transitions which can be observed as new spectral lines in the atomic spectrum. The Zeeman Effect represents Magnetic Quantum Number ($\mathbf{m_\ell}$).

❖ Electron Spin Effect

The external magnetic field affects the movement of the electrons within the orbital. Where the electron gets a movement around its axis and in two directions .This has led to the appearance of some double spectral lines in the spectra of alkali metals. This phenomenon refers to the Spin Quantum Number **(m_s).**

***** It would therefore be possible for the electron's energy to be divided into two different energies depending on the direction of its rotation around its axis.