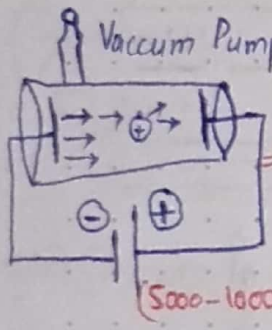
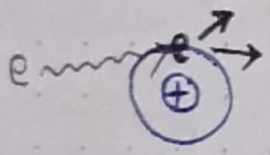
ATOMIC STRUCTURE

SUB-ATOMIC PARTICLES

- Daltons → Atoms could not be further divided.

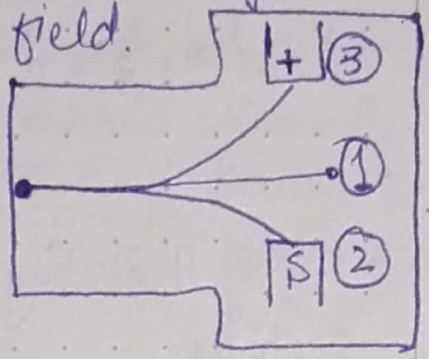
CATHODE RAYS (Cathode Rays)



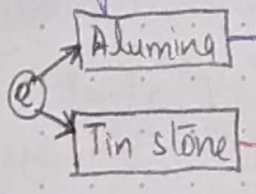


PROPERTIES

- Negatively charged.
- Show deflection in e⁻ & magnetic field.



- Green fluorescence on striking walls of the glass tube.

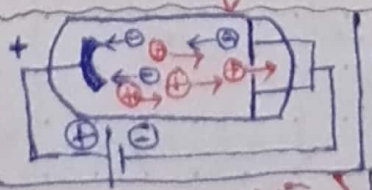


- Cast a shadow.
- Drive a small paddle wheel
  $v \times m = p$ → particle nature.
- Can produce X-rays when strike with large atomic mass
- Can produce heat
- Cathode rays from a concave cathode are focussed on pt foil, it begins to glow.
- Can ionize gases.
- Can cause chemical change (Reducing effect).
- Can pass through thin metal foil like Al & Au foil.
- e/m of cathode rays shows that they are simply electrons.

Stoney named Particles as electrons

- Cathode rays are independent of nature of gases/matter.

POSITIVE RAYS (Protons)



- 1886, E. Goldstein
- Produce glow opposite to Anode.
- Canals (holes of cathode) canal rays.

(depends upon Nature of Gas.)

$$M + e^- \longrightarrow M^{+} + 2e^-$$

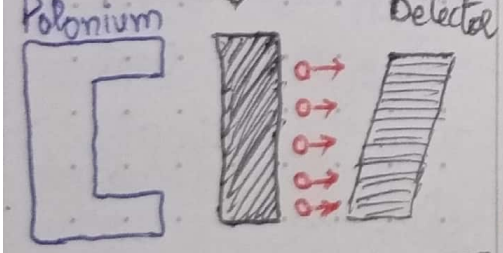
- Deflection in e⁻ & mag field.
- Flashes on ZnS.
- $\frac{e}{m}$ for H is highest so protons.
- Mass of P is 1836 times larger than e⁻.

LUNES MARTES MIÉRCOLES

Discovery of Neutrons

- Rutherford in 1920 found some kind of neutral particles equal to protons.
- Chadwick discovered neutrons 1932 and was awarded Nobel prize in physics 1935.

$${}^{4}_{2}He + {}^{9}_{4}Be \rightarrow {}^{12}_{6}C + {}^{1}_{0}n$$



$${}^{65}_{29}Cu + {}^{1}_{0}n \rightarrow {}^{66}_{29}Cu + (\gamma)$$

Properties of Neutrons

$${}^{1}_{0}n \rightarrow {}^{1}_{+1}P + {}^{0}_{-1}e + {}^{0}_{0}n$$

- Cannot ionize gases.
- Highly Penetrating particles.
- Expel high speed protons from paraffin, water, paper & cellulose
- 1.2 MeV → Fast Neutrons

1 eV → Slow Neutrons

Slow neutrons are more effective in fission purpose

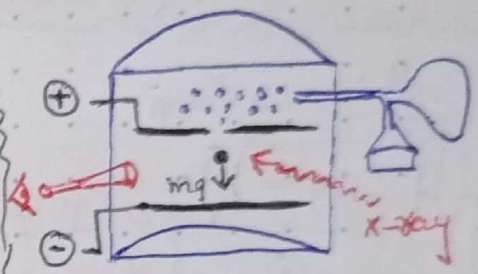
$${}^{14}_{7}N + {}^{1}_{0}n \rightarrow {}^{11}_{5}B + {}^{4}_{2}He$$

$${}^{66}_{29}Cu \rightarrow {}^{66}_{30}Zn + {}^{0}_{-1}e$$

e/m of Electron

$1.7588 \times 10^{11}\ C\ kg^{-1}$

Millikan's Oil Drop ($\frac{e}{m}$)



$V_1 \propto mg$ ↕ $V_2 \propto E_e - mg$

$$\frac{V_1}{V_2} = \frac{mg}{E_e - mg}$$

$$\Rightarrow e = 1.6022 \times 10^{-19}\ C$$

$$\frac{e}{m} = 1.7588 \times 10^{11}$$

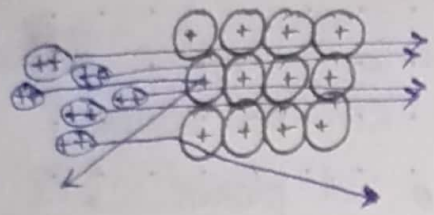
$$\frac{1.6022 \times 10^{-19}}{m} = 1.7588 \times 10^{11}$$

$$m = 9.1 \times 10^{-31}\ kg$$

	Mass (kg)	Mass in amu
Protons	1.6726×10^{-27}	1.0073
Neutrons	1.6750×10^{-27}	1.0087
Electrons	9.1095×10^{-31}	5.4858×10^{-4}

Mass of one mole of e^- = ____ (mg)

• RUTHERFORD'S MODEL



- 1911
- Gold foil = 0.00004cm thickness.
- ZnS was used as a detector.
- Rutherfoed proposed Planetary model.
- Electeons gradually falls into nucleus

• Show continuous spectrum if exist

• PLANK'S QUANTUM THEORY (1900)

- Energy emitted or absorbed continuously.
- $E \propto f$ $\quad v = f\lambda$

$E = hf$ $\quad f = \frac{v}{\lambda}$

$E = \frac{hv}{\lambda}$ {if $v = c$

$E = \frac{hc}{\lambda}$ $\quad \frac{1}{\lambda} = \bar{v}$

$$E = hc\bar{v}$$

- $h = 6.6 \times 10^{-34}\ Js$
- Energy emit or absorb by whole number.
  ie hf or 2hf, 3hf....
  It can never be 1.7hf or 3.9hf etc.

Photoelectric Effect

- Photoelectric current $\propto$ intensity of beam of specific threshold frequency.
- K.E$_{(max)}$ of emitted electeon is completely independent of intensity of beam.
- Retarding Potential

$$\frac{1}{2}mv^2_{max} = e.P_s$$

$$V_{max} = \sqrt{\frac{2eP_s}{m}}$$

- SATURATION CURRENT is max potential achieved.

EINSTEIN THEORY

- Whole energy is not transfered.

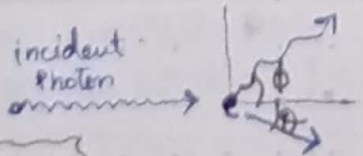
(i) To bring e on surface
(ii) Release from surface
(iii) Giving K.E to electeon

$$\frac{1}{2}mv^2_{max} + W = hf$$

$$e.P_s = h(f - f_0)$$

$$P_s = \frac{hf}{e} - \frac{hf_0}{e}$$

COMPTON'S EFFECT



$$\Delta\lambda = \frac{2h}{m_0c}\sin^2\left(\frac{\phi}{2}\right)$$ or $$\Delta\lambda = \frac{2h}{m_0c}(1 - \cos\phi)$$

$\phi = 0$ $\cos\phi = 1$ $\quad \Delta\lambda = 0$

$\phi = 180°$ $\cos(180) = -1$ $\quad \Delta\lambda = 2\left(\frac{2h}{mc}\right)$

$\phi = 90°$ $\cos 90 = 0$ $\quad \Delta\lambda = \frac{h}{m_0c} = \lambda_c$

$$\lambda_{max} = 0.048\text{Å}$$

BOHR'S MODEL:

- $mvr = \frac{nh}{2\pi}$
- **Radius**
- $r = \frac{\epsilon_0 n^2 h^2}{\pi m Z e^2}$

for H, Z = 1.

$$r_n = 0.529 \times n^2 \text{ Å}$$

$r_1 = 0.529$ Å | $r_2 = 0.529 \times 4$ Å

$r_3 = 0.529 \times 9$ Å

- **Energy**

$$E = -\frac{Z^2 e^4 m}{8\epsilon_0^2 n^2 h^2} \text{ J}$$

$$E_n = -2.178 \times 10^{-18} \left[\frac{1}{n^2}\right] \text{ J}$$

$$E_n = -1313.315 \left[\frac{1}{n^2}\right] \text{ kJ/mol}$$

$$\Delta E = 1313.315 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

Ionization Energy of Hydrogen

$n_1 = 1$, $n_2 = \infty$

$$\Delta E = 1313.315 \text{ kJ/mol}$$

WAVE NUMBER

$$\Delta E = \frac{Z^2 e^4 m}{8\epsilon_0^2 h^2} \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$\Delta E = hc\bar{\nu}$$

$$\bar{\nu} = \frac{Z^2 e^4 m}{8\epsilon_0^2 ch^3} \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

$$\bar{\nu} = 1.09686 \times 10^7 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \text{ m}^{-1}$$

→ Rydberg's constant

DEFECTS OF BOHR'S MODEL.

- Can't Explain multi-electron atoms.
- Not planer orbits
- Can't explain intensity of spectral lines.
- Can't Justify Zeeman's & Starks effect.

CORRECTION OF MASS

- nucleus is also rotating

$$\bar{\nu} = \frac{Z^2 e^4}{8\epsilon_0^2 ch^3} \times \left[\frac{Mm}{M+m}\right] \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

m is replaced by reduced mass $\left[\frac{Mm}{M+m}\right]$.

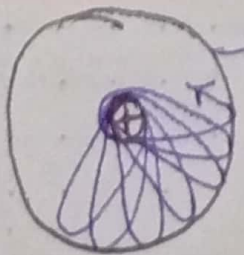
SOMMERFELD'S ATOMIC MODEL

- electrons are revolving in eliptical path, with different eccentricities.

Major Axis

Minor Axis

$$E_n = \frac{me^4 Z^2}{8\epsilon_0^2 h^2 n^2} \left(1 + \frac{\alpha^2 Z^2}{n} \left[\frac{1}{k} - \frac{3}{4n}\right]\right)$$



- Electron will have diff values of radii. It means electrostatic force varies from point to point.

SPECTRUM.

- Continuous.
- Line → Emission.
  → Absorption
- Hydrogen.

→ Lyman	n_1	U.V
→ Balmer	n_2	Vis
→ Paschen	n_3	I.R
→ Brackett	n_4	I.R
→ Pfund	n_5	I.R

DUAL - NATURE OF MATTER

$$\lambda = \frac{h}{mv}$$

for e^- $m = 9.1\times10^{-31}$ kg, $v = 2.3\times10^{6}$ ms^{-1}

$\lambda = 3.16\times10^{-10}$ m

$\lambda = 3.16$ Å

for $m = 1$ g $= 10^{-3}$ kg & $v = 10$ ms^{-1}

$\lambda = 0.66\times10^{-31}$ m $= 0.66$ Å $\times10^{-21}$

Davisson & Germer

$$\lambda = \frac{12.27}{\sqrt{P}}\ \text{Å}$$

$P = 54$ V.

$\lambda = 1.668$ Å

- $\bar{e}$ on Ni-crystals.
- Diffraction like waves

HEISENBERG'S UNCERTAINITY PRINCIPLE.

→ Reverse of compton effect.

$$\Delta X\ \Delta P \geq \frac{h}{4\pi}$$

ΔX (Position) $\propto \frac{1}{\Delta P}$ (momentum)

Uncertainity of velocity

$$\Delta X \cdot m \times \Delta V \geq \frac{h}{4\pi}$$

$$\Delta X \cdot \Delta V \geq \frac{h}{4\pi m}$$

$$\boxed{\Delta X \propto \frac{1}{\Delta V}}$$

on Energy & Time

$$\Delta f = \frac{1}{\Delta t} \quad \& \quad \Delta E = h\,\Delta f$$

$$\Delta E = h \times \frac{1}{\Delta t}$$

$$\Delta E \times \Delta t = h$$

$$\boxed{\Delta E \propto \frac{1}{\Delta t}}$$

we can't find energy & time simultaneously.

velocity > speed of light.

Apply on Hydrogen.

$$\Delta X \cdot m\Delta V = \frac{h}{2\pi}$$

$$\Delta V = \frac{h}{2\pi m \Delta X}$$

$\Delta X = 4$ pm $= 4\times10^{-12}$ m

$m = 9.1\times10^{-31}$ kg

$$\Delta V = \frac{6.6\times10^{-34}}{2(3.14)(9.1\times10^{-31})(4\times10^{-12})}$$

$\boxed{\Delta V = 2.9\times10^{7}\ ms^{-1}}$

Practically $= 2.2\times10^{6}$ m/s

So, Bohr's orbits becomes meaningless.

Let.
- 2g ⇒ mass
- position $= 10^{-10}$ m

$\boxed{\Delta V = 0.525\times10^{-21}\ m/s}$

velocity is negligible,

Hence position & velocity can be determined precisely

$\bar{e}$ in Nucleus:-

$\Delta X = 10^{-14}$

$\boxed{\Delta V = 5.7\times10^{9}\ m/s}$

LUNES MARTES MIÉRCOLES

X-RAY'S AND At.No.

- $K_4[Fe(CN)_6]$ X-ray analyzer.

$K_\alpha, K_\beta, L_\alpha, L_\beta, M_\alpha, M_\beta$.

MOSLEY λ-range is 0.04 - 8 Å

K-Shortee λ

L-Longer λ

- Higher atomic No then λ becomes Shortee.

$\sqrt{f} = a(z-b)$

a, b are characteristics of metal

"b" is screening Constant

a is proportionality cons.

- frequency of spectral lines in X-ray spectrum varies as the square of At. no. of an e⁻ emitting it.

- Moseley arranged K, Ar, Ni & Co in proper way.
- Discovery of new elements like Tc(43), Pr(59), Rh(45).
- At no of rare earth can be determined by this Law.

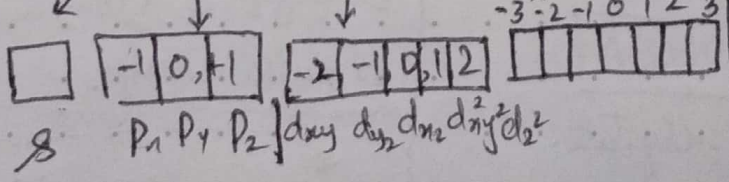
ORBITAL

95% chance for finding an electron "electron cloud"

- Magnetic Q.no:

$m = \pm l$

$= 0, \pm 1, \pm 2, \pm 3$



QUANTUM NUMBER'S

- PRINCIPAL Q. No. (n) Schrodingee named

$n \neq 0$ $n > 0$

$n = 1, 2, 3, 4, ----$

K, L, M, N, ----

Total no of $e^- = 2(n)^2$

$K = 2(1)^2 = 2$	$M = 2(3)^2 = 18$
$L = 2(2)^2 = 8$	$N = 2(4)^2 = 32$

- AZIMUTHAL Q. No (l)

$l = n - 1 = 0, 1, 2, 3, --$

n =	1	2	3	4	---
l =	0	1	2	3	---
	s	p	d	f	

$= 2(2l+1)$

$s = 2[2(0)+1] = 2$
$p = 2[2(1)+1] = 6$
$d = 2[2(2)+1] = 10$
$f = 2(2(3)+1) = 14$

- SPIN Q. no

$S = +\frac{1}{2}, -\frac{1}{2}$

JUEVES _____ VIERNES _____ SÁBADO _____

n+l Rule:

1s	1+0 = 1
2s	2+0 = 2
2p	2+1 = 3
3s	3+0 = 3
3p	3+1 = 4
~~3d~~	~~3+2~~ = 5
~~4s~~	4+0 = 4

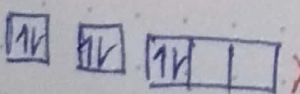
3d is filled after 4s.

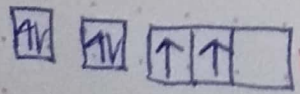
Aufbau

- e⁻ will fill in increasing energy order
- Pauli's Exclusion Principle

↑↓ opposite spin

Hunds Rule:

$_6C$  X

 ✓

Electronic configuration

$_{24}Cr$ [Ar] $3d^5, 4s^1$

Cu [Ar] $3d^{10}, 4s^1$

Schrödinger Eq

$$\frac{d^2}{dx^2}(\psi) + \frac{8\pi^2 m}{h^2}(E-P)\psi = 0$$

$$E = \frac{\int \psi H \psi \, d\tau}{\int \psi^2 d\tau}$$

ψ can be zero

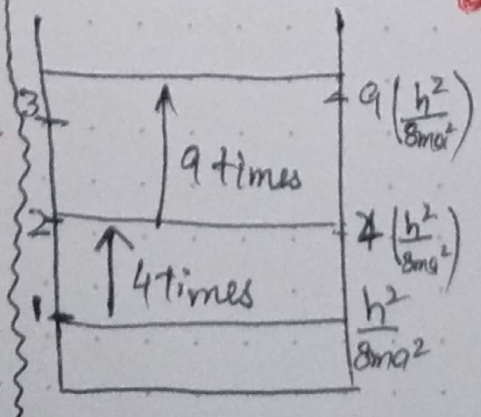
$\psi^2 = 1$

$\psi = 0$ at infinity

Particle in 1-D Box

$$E = \frac{n^2 h^2}{8ma^2}$$

$E \propto \frac{1}{m}$, $E \propto \frac{1}{a^2}$



Normalization

$$\psi^2 = \frac{2}{a}\sin^2\left(\frac{n\pi x}{a}\right)$$

DOMINGO _____

- (For moving P in one-d-box 1836 times lower.)
- Greater width of box, smaller gaps, macroscopic energy level.