* Discovery of Electron

Properties of cathode rays:

1. They are negatively charged \( \text{pressure} = 10^{-3} \text{m} \)
2. They travel in a straight line.
3. They possess kinetic energy.
4. They are made up of small particles.
5. They are deflected towards a plate in an electric field.
6. They are deflected in a magnetic field.
7. They produce fluorescence.
8. They produce X-rays.

9. It is made up of electron.

On changing the gas or electrode material, the properties of cathode rays remain same.

The particle of cathode rays are Fundamental.

\[ \text{This further known as electron} \]

* J.J. Thomson (v.v.i.m.p) discovery.

\[ \frac{\text{Charge Ratio}}{\text{Mass}} = \frac{e}{m} \]

\[ e = 1.75 \times 10^{-11} \text{C} \]

\[ m = \text{kg} \]

On changing the gas or electrode material, the \( \frac{e}{m} \) of cathode rays remains same.
Discovery of Proton (by E. Goldstein)

Properties of Anode Rays
1. May are made up of charged particles - +ve
2. Origin - gaseous ions
3. May also produce X-rays
4. May depend upon nature of gas in tube

Note: Anode Rays are not made up of protons

Charge Ratio depends upon nature of gas

Charged particles have highest charge/mass ratio

- Hydrogen -> lightest gas
- Protons -> highest charge/mass ratio

\[ q = +1.6 \times 10^{-19} \text{ C} \]
\[ m = 1.625 \times 10^{-27} \text{ kg} \]

\[ 16.7 \text{ times mass of electron} \]

Discovery of Proton (by E. Goldstein)

Discovery tube + gas pressure -> ions
- Perforated cathode
- Colored rays
- By Anode Ray
- As cathode rays
- Goes past the 60 cm
- Has negative charge
- May produce fluorescence

So, we know the value of \( \frac{q}{m} = 1.75 \times 10^{10} \text{ C/kg} \)

\[ q = 1.6 \times 10^{-19} \text{ C} \]
\[ m = 1.625 \times 10^{-27} \text{ kg} \]
\[ \text{\textcopyright 1997 Heisenberg Model} \]

\[ \text{\textcopyright Subatomic particles} \]

\[ \text{\textcopyright Atom is a sphere of positive charge where \textbf{e} are embedded} \]

\[ \text{\textcopyright Plus building (watermelon)} \]

\[ \text{\textcopyright Atom is electrically neutral} \]

\[ \text{\textcopyright As this further rejected by doing research on \textbf{e}.} \]

\[ \text{\textcopyright Rubintoff - \textbf{e} particle scattering experiment} \]

\[ \text{\textcopyright \textbf{e} -> 12 change} \]

\[ \text{\textcopyright 40p \textit{(mass of proton)} or 1am} \]

\[ \text{\textcopyright Only few \textbf{e} \textit{(20000)} \textbf{e} particle returns back that is deflected by large angle \textbf{1500}°} \]

\[ \text{\textcopyright It is the nucleus of He (Helium)} \]

\[ \text{\textcopyright Nucleus of He = 2 \textit{proton + 2 neutron}} \]
The electron revolves around the nucleus due to the electrostatic force of attraction.

The speed of the revolving electron is given by the equation:

\[ v = \sqrt{\frac{\text{Ze} \times 1.6 \times 10^{-19} \text{ J}}{r}} \]

where \( v \) is the speed of the electron, \( Z \) is the atomic number, \( e \) is the electron charge, \( r \) is the radius of the orbit, and \( m_e \) is the mass of the electron.

The size of the nucleus is very small compared to the size of the electron's orbit.

The negative charge of the electron is exactly equal to the positive charge of the nucleus.

The electron's negative charge is balanced by the positive charge of the nucleus to maintain electrical neutrality.

Due to the negative charge of the electron, the electron experiences an electrostatic force that keeps it orbiting the nucleus.

The mass of the electron is very small compared to the mass of the nucleus.

The electron's speed is very high, allowing it to complete an orbit in a very short time.

The electron's orbit is not circular but rather an ellipse due to the electrostatic force acting on the electron.

The electron's energy is quantized, meaning it can only exist in certain energy levels.

The number of electrons in an atom is fixed, determined by the atomic number.
Bohr's Quantisation Condition

\[ \frac{ny}{2\pi} = n \hbar \]

where \( \hbar = 6.626 \times 10^{-34} \text{ Js} \) = plank's constant \( \hbar^2 = \text{planck's constant}^2 \)

5) While revolving in a particular orbit, an electron gains energy nor loses energy.

Energy of an orbit/ shell is fixed

Shells \( \rightarrow \) Stationary Energy Levels

\[
\begin{array}{c|c}
\text{Shell} & \text{Energy Level} \\
\hline
n = 1 & k \\
1 = 1 \\
2 = 2 & M \\
3 = 3 & N \\
4 = 4 & P \\
\end{array}
\]

3) How many protons in nucleus = atomic no. = Z

\[
\begin{align*}
\text{Radius, velocity, kinetic energy, potential energy, and total energy} \\
\text{radius: } & \text{ } r \\
\text{velocity: } & \text{ } v \\
\text{kinetic energy: } & KE = \frac{1}{2} mv^2 \\
\text{potential energy: } & PE = \frac{1}{2} kx^2 \\
\text{total energy: } & E = KE + PE
\end{align*}
\]

4) \( E = F_r \)

\[
\begin{align*}
E &= k \frac{Ze^2}{r} \\
\Rightarrow \frac{1}{2} m v^2 &= \frac{kZe^2}{r} \\
&= \frac{kZe^2}{\gamma} \\
&= \frac{1}{2} m v^2 \\
\Rightarrow \gamma &= \frac{1}{2} m v^2 \\
&= \frac{1}{2} m v^2 - (I) \\
2 \gamma &= \frac{1}{\gamma} \text{ (ii)} \\
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\end{align*}
\]

Squaring eq. 1 & divide by 2 eq.

6) \( n^2 \hbar^2 = m^2 v^2 r^2 \implies n^2 \hbar^2 x^2 y^2 = m^2 xy \)

\[
\begin{align*}
\frac{\hbar^2}{m} & \text{ } \frac{x^2}{y} \\
\frac{\hbar^2}{m} & \text{ } \frac{x}{y^2} \\
\frac{\hbar^2}{m} & \text{ } \frac{x^2}{y^2} \\
\frac{\hbar^2}{m} & \text{ } \frac{x}{y} \\
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\frac{\hbar^2}{m} & \text{ } \frac{x^2}{y^2} \\
\frac{\hbar^2}{m} & \text{ } \frac{x}{y} \\
\end{align*}
\]
\[ r_n = \left( \frac{\hbar^2 e^2}{8 \pi^2 m} \right)^{\frac{1}{2}} n^2 \alpha^2 \]

Note: \( \hbar^2 e^2 \) is constant, \( n^2 \alpha^2 \) is variable.

The value used from \( \hbar^2 e^2 = 0.53 \) \( \text{J} \cdot \text{m}^2 \).

So formula used in sum problems:

\[ r_n = 0.53 n^2 \alpha^2 \]

\( \alpha \) is shell no., \( n \) is atomic no., \( \alpha \) here \( n^2 \) is used to measure radius of an atom.

Find radius of 1st, 2nd, 3rd shell of H-atom (Atomic no. of \( H = 2 \)).

\[ r_1 = 0.53 \times \frac{3}{2} \alpha^2 \]

\[ r_2 = 0.53 \times \frac{4}{2} \alpha^2 \]

\[ r_3 = 0.53 \times \frac{5}{2} \alpha^2 \]

So 1st, 2nd, 3rd shell of H-atom.

\[ 1, 2, 3 \]

\[ r_1 = 0.53 \times \frac{3}{2} \alpha^2 \]

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2nd shell.

\[ r_3 = 0.53 \times \frac{5}{2} \alpha^2 \]

3rd shell.
Beck Atomic Model is valid only on single e-space:

1. H → He
   He → Zn  H⁺ → Zn
   Li → Zn  Li⁺⁺ → Zn
   Be → Zn  Be⁺⁺ → Zn

2. Velocity
   \[ \nu = \frac{Z}{\hbar} \]
   \[ x = \frac{Ze^2}{2\hbar c} \] → main formula

3. Energy
   \[ E = \frac{1}{2} m v^2 = \frac{1}{2} m \left( \frac{2e^2}{2\hbar c} \right)^2 \]
   \[ E = \frac{1}{2} m \frac{Z^2 e^4}{4\hbar^2 c^2} \]

4. Speed of e⁻ in first orbit of H
   \( n=1, \ z=1 \)
   \[ v = 2.18 \times 10^6 \text{ m/s} \]

5. Speed of e⁻ in second orbit of He
   \( n=2, \ z=2 \)
   \[ v = 2.18 \times 10^6 \text{ m/s} \]
   \[ v = 2.18 \times 10^6 \text{ m/s} \]

\[ \nu = 2.18 \times 10^6 \text{ Z m/s} \]

Formulas used for sums/problems:

- \[ K_F = 13.6 \times Z^2 \text{ eV} \text{ (eV = electron volt) \]
\[\text{Total Energy} = E_E + E_k\]

\[E_E = 1 - e^2 / 4\pi\varepsilon_0 r^2\]

\[E_k = -2 \cdot 13.6 \cdot e^2 / n^2 + 13.6 \cdot e^2 / \alpha \cdot n^2\]

\[E = -13.6 \cdot e^2 / n^2\]

Total energy of electron in \(n\)th shell (Krypton) \((n=2)\):

\[E = -13.6 \cdot e^2 / n^2\]

Formula used for sums/problems:

\[E = -13.6 \cdot e^2 / n^2\]

\[E_1 = -13.6 \cdot e^2 / 4 = -3.4 \text{ ev}\]

\[E_2 = -13.6 \cdot e^2 / 9 = -1.51 \text{ ev}\]

\[E_3 = -13.6 \cdot e^2 / 16 = -0.95 \text{ ev}\]
1) Electron can accept energy & can lose energy.
2) If e⁻ accepts an energy, it jumps to higher energy level → excitation of e⁻.
3) If an e⁻ loses an energy, it recedes back to lower energy level → deexcitation of e⁻.

An e⁻ gains or loses only those energy which are equal to difference in two energy levels.

Here if E > 0, then e⁻ is free from nucleus.

This shows that ionisation has occurred.
Things to Remember:

1. \( m \nu = n h \) (Bohr's quantization condition)

2. \( \frac{1}{2} m \nu^2 = n^2 \) (Formula for energy)

3. \( m = n^2 \frac{\nu^2}{\gamma^2} \) (Main radius formula)

4. \( \gamma \ = \ 0.5 \text{ a.u.} \) (Formula for solar radius)

5. \( V = \frac{1}{2} m \nu \) (Main velocity formula)

6. \( V = \frac{1}{2} n \nu \) (Formula for solar velocity)

7. \( k \cdot E = \frac{1}{8} m^2 \nu^2 \) (Main kinetic energy)

8. \( k \cdot E = \frac{1}{8} n^2 \nu^2 \) (Formula for solar kinetic energy)

9. \( P = -\frac{m^2 \nu^2}{2} \nu \) (Main potential energy)

10. \( P = -2 \times 13 \times 6 \times 2 \times n^2 \) (Formula for solar potential energy)

11. \( \nu = \frac{1}{\lambda} \) (Wavelength)

12. \( \nu = \frac{1}{n \lambda} \) (Frequency)

13. \( \nu = \frac{n}{2 \pi} \) (Formula for frequency)

14. \( \lambda = \frac{1}{2 \pi} \) (Formula for wavelength)

15. \( \lambda = \frac{1}{n} \) (Formula for wavelength)

16. Total energy = \( -13.6 \times 2 \text{ eV} \) (for H atom)

17. Maximum energy of electron of H-atom

18. \( V = -13.6 \text{ eV} \) (for H atom)

19. Maximum energy of electron of H-atom

20. \( V = 0 \) (for H atom)

21. Where \( n = \infty \)

22. \( E = 1.75 \times 10^{-4} \text{ eV} \) (for H atom)

23. Charge of electron = \( 1.6 \times 10^{-19} \text{ C} \)

24. Mass \( m = 9.1 \times 10^{-31} \text{ kg} \)

25. \( \text{Hydrogen = Lighter gas} \)

26. \( \text{Charge} = 1.6 \times 10^{-19} \text{ C} \)

27. \( \text{Mass} = 1.625 \times 10^{-24} \text{ kg} \)

28. \( \text{L1437 Time of mass of 1} \)
**Photoelectric Spectrum**

- Electron energy must remain in lowest energy level.
- **Electromagnetic Waves**

- An electron in an atom can jump from n=2 to n=1. Find energy & wavelength of emitted radiation.

\[ \Delta E = E_f - E_i \]

\[ = 13.6 \times 1 - 13.6 \times 1 \]

\[ = 13.6 - 13.6 = 0 \text{ eV} \]

\[ E = 12.375 \text{ eV} \]

\[ \lambda = \frac{hc}{E} \]

\[ \lambda = \frac{6.63 \times 10^{-34} \text{ Js} \times 3 \times 10^8 \text{ m/s}}{12.375 \text{ eV}} \]

\[ \lambda = 123.73 \text{ Å} \]

**Radiation**

- **Emission Spectrum**

\[ \text{So, } E = 12.375 \text{ eV} \]

\[ \lambda = 123.73 \text{ Å} \]
E-jump \( n=2 \) to \( n=1 \)

\[ \Delta E = E_2 - E_1 \]

\[ h\nu = -13.6x2^2 - 13.6x2^2 \]

\[ \lambda = \frac{n^2}{n^2 - 1} \]

\[ \lambda = \frac{-13.6x2^2 + 13.6x2^2}{n^2 - 1} \]

Multiply & divide with \( hc \)

\[ h\nu = -13.6 \times 2^2 \left( \frac{1}{n^2} - \frac{1}{n^3} \right) \]

\[ \lambda = \frac{R \times 2^2}{n^2 - 1} \]

where \( R = 109,677 \) or \( hc = 2.18 \times 10^{-19} \)

\[ \nu = 1.0 \times 10^{14} \text{ s}^{-1} \]

Lyman series

1. \( \text{First line of Lyman series} \)
   \( \lambda = n^2 - 1 \)

2. \( \text{Last line of Lyman series} \)
   \( \lambda = n^2 - 1 \)

3. \( \text{The limit of Lyman series} \)
   \( \lambda = 1216\text{A} \)

4. Shortest wavelength = 911\text{A} (shortest transition)

5. Largest wavelength = 1216\text{A}
Super series (visible region)

1. if any go on to $n=2$

\[ \begin{align*}
\text{nes} & \quad 0 \quad 0.5 \quad N \\
\text{N} & \quad 0.5 \quad M \\
\text{M} & \quad 1 \quad L \\
L & \quad 0.5 \quad K \\
K & \quad 0 \quad 0
\end{align*} \]

2. The series is known as Balmer series.

3. **Shortest wavelength**
   - $n=2, \infty$

4. **Longest wavelength**
   - $n=3, 2$

5. **Shortest wavelength**
   - $n=2, 2$

\[ \begin{align*}
\lambda_{\text{longest}} &= \frac{R}{\left( \frac{1}{n^2} - \frac{1}{\infty^2} \right)} \\
\lambda_{\text{shortest}} &= \frac{R}{\left( \frac{1}{4} - \frac{1}{\infty} \right)}
\end{align*} \]

\[ \begin{align*}
\lambda_{\text{longest}} &= \frac{R}{\left( \frac{1}{3^2} - \frac{1}{\infty^2} \right)} \\
\lambda_{\text{shortest}} &= \frac{R}{\left( \frac{1}{4} - \frac{1}{\infty} \right)}
\end{align*} \]

\[ \lambda_{\text{longest}} = \frac{R}{\left( \frac{1}{3^2} - \frac{1}{\infty^2} \right)} = \frac{R}{\left( \frac{1}{9} - \frac{1}{\infty} \right)} = \frac{R}{\frac{8}{9}} = \frac{9R}{8}
\]

\[ \lambda_{\text{shortest}} = \frac{R}{\left( \frac{1}{4} - \frac{1}{\infty} \right)} = \frac{R}{\left( \frac{1}{4} - 0 \right)} = \frac{R}{\frac{3}{4}} = \frac{4R}{3}
\]

\[ \lambda_{\text{shortest}} = \frac{4R}{3}
\]

\[ \lambda_{\text{shortest}} = \frac{4 \times 1}{R} = \frac{4 \times 911 \times 10^4}{4} = 3644
\]

\[ \lambda_{\text{longest}} = \frac{9R}{8}
\]
2. If \( n^2 \) any new to \( n = 3 \)
   - This is called Paschen (short infra-red)

2. If \( n^2 \) any new to \( n^3 \)
   - This is called Bracket (short infra-red)

2. If \( n = 4 \) any new to \( n^3 \)
   - This is called Pfund (long infra-red)

2. If \( n = 4 \) any new to \( n^6 \)
   - This is called Humphrey Series (long infra-red)

\[ \text{No. of spectral lines} \]

- Shortcut for line spectral no. also called no. of transitions

\[ = \frac{(n^2 - n_1)(n^2 - n_2 + 1)}{2} \]

Eg: Find line spectral no. from \( 4 \times 2 \times 1 \)

\[ = \frac{(4-1)(4-1+1)}{2} \]

\[ = \frac{3 \times 4}{2} = 12 = 6 \]
The light is made up of small particles or quanta, which is called photons or quanta.

\[ E = h \nu \]

If energy of photon is used for some use, use this formula:

\[ E = \frac{1}{2} \cdot m \cdot v^2 \]

\[ \nu = \frac{1}{\lambda} \]  

\[ v = \lambda \cdot \nu \]  

\[ \lambda = \frac{c}{\nu} \]

The light sometimes have wave and same time has particles so it is called Dual Nature of light.

De-Broglie Hypothesis (idea or suggestion)

- Mass of electron: \( \text{9.1} \times 10^{-31} \text{ kg} \)
- Speed of electron: \( 2.18 \times 10^6 \text{ m/s} \)

According to De-Broglie the electron also can be called particles or wave so that he said that it is the:

Dual Nature of Electron

He said that if electron has wave then it is also have wavelength and it has particle so it has also mass, so he gave it kind...
to find wavelength & mass

\[ \lambda = \frac{h}{p} \quad \text{and} \quad m = \frac{h}{\lambda v} \]

\[ \text{mass} \times \text{wavelength} = \text{momentum} \]

\[ m \times \lambda = \frac{h}{v} \cdot \lambda \]

\[ m = \frac{h}{v \lambda} \]

\[ \text{mass} \times \text{velocity} \]

\[ m \cdot \lambda = \frac{h}{v} \cdot \lambda \]

\[ m = \frac{h}{\lambda v} \]

\[ \text{momentum} = \frac{h}{\lambda v} \]

\[ \text{mass} \times \text{speed} \]

\[ m \cdot v = \frac{h}{\lambda} \]

\[ m = \frac{h}{\lambda v} \]

\[ \text{mass} \times \text{velocity} \]

\[ m \cdot v = \frac{h}{\lambda} \]

\[ m = \frac{h}{\lambda v} \]

\[ \text{mass} \times \text{speed} \]

\[ m \cdot v = \frac{h}{\lambda} \]

\[ m = \frac{h}{\lambda v} \]

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\[ \text{mass} \times \text{velocity} \]

\[ m \cdot v = \frac{h}{\lambda} \]
According to him, we cannot measure the accurate position as well as the accurate state of a microscopic moving particle.

It is impossible to find

Momentum Measure Error = $\Delta p$
Position Measure Error = $\Delta x$

$\Delta p \Delta x > \frac{\hbar}{2\pi}$

If the error in position $\Delta x = 0$

Then, $\Delta x \Delta p > \frac{\hbar}{2\pi}$

$\Delta p \Delta x > \frac{\hbar}{2\pi}$

If asked to find error of velocity $

1.1 \times 10^{-10} \times 9.1 \times 10^{-31} \Delta V > 6.626 \times 10^{-34}$

$\Delta V > 6.626 \times 10^{-34}$

$\frac{\hbar}{8\pi x} \times 10^{-10} \times 9.1 \times 10^{-31}$
\[ \Delta v = 6.626 \times 10^{-34} \times 3 \times 10^8 \times 1.1 \times 10^{-31} \]

\[ = 0.052 \times 10^{-7} \]

\[ = 5.2 \times 10^{-8} \text{ s}^{-1} \]

- **Error in Measurement of** \( p \Delta x \)

\[ \Delta p = \Delta x \]

- **Drawbacks/Failure of Bohr Model Reasons**

  1. Bohr Model is valid only for single \( e^- \) species H-atom (H & H-like atom) \( \text{H, He}, \text{Li}, \text{Be} \)

  2. Bohr considered \( e^- \) as a moving particle, whereas according to de Broglie, \( e^- \) is also a wavelength as well as moving particle where Bohr only considered \( e^- \) as moving particle.

  3. Bohr measured position of \( e^- \), \( \frac{\hbar}{2} \delta x \)

  4. Velocity of \( e^- \), \( v = 2.14 \times 10^6 \times 2 \text{ m/s} \)

  5. Spectral lines, they show splitting in magnetic field & in electric field.

  6. **Ultra fine spectrum.**
Quantum Mechanics

As, heizing called electron as aura.

1. But Erwin Schrödinger gave the equ.
   to find electron wave.

2. He said electron is a probability wave.

He gave equation:

\[
\frac{\partial^2 \Psi}{\partial x^2} + \frac{\partial^2 \Psi}{\partial y^2} + \frac{\partial^2 \Psi}{\partial z^2} + \frac{8m_e^2}{\hbar^2} \Psi = 0
\]

Where \( \Psi \) - Wave function.

1. We said that wave is 3-dimensional.

2. Solution to Schrödinger e- curve gives 3 variables.
   They represent position. Those positions where probability of finding electron is maximum.

C: Where 3 variables are 3 quantum no.

As there is total \( n \) quantum no.

\[ n = l + s \]
1. **n**: Principal Quantum Number
   - \( n \geq 1 \)
   - \( n = \frac{1}{2}, 1, 2, 3 \ldots \neq 0 \)
   - It gives the size of orbital
   - It also gives energy of orbital
   - It also gives the subshell (orbit)

2. **l**: Azimuthal/Angular Momentum Quantum Number
   - Value of \( l = 0, 1, 2, 3, \ldots \)
   - Name of value:
     - \( 0 \rightarrow s \)
     - \( 1 \rightarrow p \)
     - \( 2 \rightarrow d \)
     - \( 3 \rightarrow f \)
     - \( 4 \rightarrow g \)

3. **Shape**
   - \( s \rightarrow \\
   - \( p \rightarrow \\
   - \( d \rightarrow \\
   - \( f \rightarrow \\

4. \text{For JEE}
   - \( n \) orbitals, \( l \) subshells in a shell = no. of shell - orbit + 1
   - Orbital Angular Momentum of \( n \) electron
     - \( l \)
     - \( m = \frac{1}{2}, -\frac{1}{2} \)
     - \( \text{Inp for JEE} \)
1) Magnetic Quantum No. \( n \cdot \ell \cdot m \)
2) Subshell
3) Quantum No. of orbital \( m_l \)

-1 < \( m_l \) < 1

\[ M_l = m_l \text{ (no. of orbital)} \]

<table>
<thead>
<tr>
<th>Subshell</th>
<th>( m_l )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1s</td>
<td>0</td>
</tr>
<tr>
<td>1p</td>
<td>-1, 0, 1</td>
</tr>
<tr>
<td>2d</td>
<td>-2, -1, 0, 1, 2</td>
</tr>
<tr>
<td>3f</td>
<td>-3, -2, -1, 0, 1, 2, 3</td>
</tr>
</tbody>
</table>

No. of orbitals = \( 2\ell + 1 \)

In a given subshell

<table>
<thead>
<tr>
<th>( \ell )</th>
<th>No. of orbitals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

No. of subshells = \( 3 = \) shell no.
No. of orbitals = \( 9 = 3^2 = a^2 \) in a shell

\* No. of orbitals in a shell = \( a^2 \)
\* No. of orbitals in a subshell = \( 2\ell + 1 \)
4. Sign Quantum no.

\[ n - \ell \rightarrow \ell \] refers about its quantum.

\[ n > \ell \]

5. Pauli's Exclusion Principle:

- Any two \( e^- \), with opposite spin, can be present in an orbital.

- \( 1t \)

6. Total no. of \( e^- \) in 2\(^{nd}\) shell = 2

<table>
<thead>
<tr>
<th>( n )</th>
<th>( \ell )</th>
<th>( s )</th>
<th>( \text{Formula} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0</td>
<td>1</td>
<td>( 2 \times 2^2 )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>( 2 \times 4 = 8 )</td>
</tr>
</tbody>
</table>
1. Find $x$ if $e^{-x}$ has $x = 2.302548.$

\[ 1 \quad 2.302548 \
\frac{1}{e} \approx \text{value} \quad \text{approx.} \]

\[ \text{approx.} = 2.718 \
\]

2. Find $\theta$ for which $e^{3\theta} = 2.$

\[ \begin{array}{c|c|c|c|c}
\theta & 1 & 2 & 3 & 4 \\
\hline
\text{approx.} & 2.718 & 7.389 & 20.086 & 51.699 \\
\end{array} \]

\[ \text{approx.} = 2.718 \]

3. \[ \theta = \text{value} \
\]

4. \[ \theta = \text{value} \
\]

\[ \text{approx.} = 2.718 \]

5. \[ \theta = \text{value} \
\]

\[ \text{approx.} = 2.718 \]

6. \[ \theta = \text{value} \
\]

\[ \text{approx.} = 2.718 \]

7. \[ \theta = \text{value} \
\]

\[ \text{approx.} = 2.718 \]

8. \[ \theta = \text{value} \
\]

\[ \text{approx.} = 2.718 \]

9. \[ \theta = \text{value} \
\]

\[ \text{approx.} = 2.718 \]
1. Lewis dot structure.

2. Electron configuration.

3. Energy of an electron.

4. Energy levels of an electron.

---

- $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^10$
- $L = 3, 3, 4, 5, 6, 7, 8, 9$

---

1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p

- $\text{Li}^{+}$ is an ion that lacks an electron. It has a $1s^2 2s^2 2p^6$ configuration.
- $\text{H}_{2}^{+}$ has a $1s^2$ configuration.

---

Exception

- $\text{He}, \text{Ne}, \text{Ar}, \text{Kr}$
- $\text{H}_{2}^+$
- $\text{F}^-$

---

- Energy of a $3p$ electron

---

- $\text{K}^{+}$, $\text{Ar}^{3+}$, $\text{Li}^{+}$
- Single $e^-$ system
- Asked in December 2017
- $0.90$ MeV
\[
\begin{align*}
&S^2 \rightarrow 2\text{ electron} \\
&O^6 \rightarrow 6\text{ electron} \\
&O^{10} \rightarrow 10\text{ electron} \\
&O^{14} \rightarrow 14\text{ electron} \\
&H \rightarrow 1s^1 \rightarrow \text{ maximum} \\
&He \rightarrow 1s^2 \rightarrow \text{ maximum} \\
&Li \rightarrow 1s^2 2s^1 \\
&Be \rightarrow 1s^2 2s^2 \\
&B \rightarrow 1s^2 2s^2 2p^1 \\
&C \rightarrow 1s^2 2s^2 2p^2
\end{align*}
\]

For this Hund's Rule is used.
**Bohr's Rule:**

Based on electron pairing, electrons in a shell are arranged only when all orbitals of a shell is half filled with parallel spins.

- **Oxygen (O):**
  - 1s² 2s² 2p⁶
  - [He] 2p⁶

- **Fluorine (F):**
  - 1s² 2s² 2p⁵
  - [He] 2p⁵

- **Neon (Ne):**
  - 1s² 2s² 2p⁶
  - [He] 2p⁶

- **Calcium (Ca):**
  - 1s² 2s² 2p⁶ 3s²
  - [Ar] 3s²

- **Copper (Cu):**
  - 1s² 2s² 2p⁶ 3s² 3p⁶ 4s² 3d⁹

For Cu exceptional = 4s² 3d⁹

- **Barium (Ba):**
  - 1s² 2s² 2p⁶ 3s² 3p⁶ 4s² 3d⁹ 4p⁶

For Ba exceptional = 4s² 3d⁹

- **Argon (Ar):**
  - 1s² 2s² 2p⁶
  - [Ne] 2p⁶

- **Krypton (Kr):**
  - 1s² 2s² 2p⁶ 3s² 3p⁶
  - [Ar] 3s² 3p⁶

- **Xenon (Xe):**
  - 1s² 2s² 2p⁶ 3s² 3p⁶ 4s² 3d⁹ 4p⁶

For Xe exceptional = 4s² 3d⁹

- **Oxygen (O) with electron configuration:**
  - 1s² 2s² 2p⁶

- **Fluorine (F) with electron configuration:**
  - 1s² 2s² 2p⁵

- **Neon (Ne) with electron configuration:**
  - 1s² 2s² 2p⁶

- **Calcium (Ca) with electron configuration:**
  - 1s² 2s² 2p⁶ 3s²

- **Copper (Cu) with electron configuration:**
  - 1s² 2s² 2p⁶ 3s² 3p⁶ 4s² 3d⁹

For Cu exceptional = 4s² 3d⁹

- **Barium (Ba) with electron configuration:**
  - 1s² 2s² 2p⁶ 3s² 3p⁶

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- **Xenon (Xe) with electron configuration:**
  - 1s² 2s² 2p⁶ 3s² 3p⁶ 4s² 3d⁹ 4p⁶

For Xe exceptional = 4s² 3d⁹