Chapter 30 - Atomic Physics

Chemistry Review:

92
U
238.03

atomic # = # of protons = Z

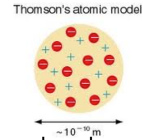
atomic mass = # of protons + # of neutrons = A

A - Z = # of electrons

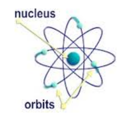
ex. $^{238}_{92}U$ ⟶ 92 p, 92 n, 238-92 = 146 e

History of Atomic Theory

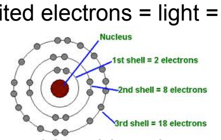
1) Thomson = plum pudding with + and - in atom



2) Rutherford = nucleus has most of mass & dense

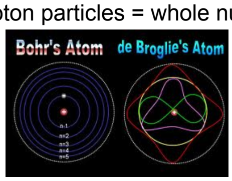


3) Bohr = excited electrons = light = atomic orbits = points

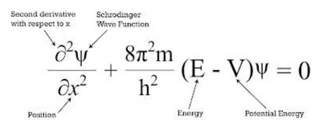


4) deBroglie = stable orbits = integer multiples of λ = standing waves

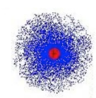
5) Planck = photon particles = whole number integers of h



6) Schrodinger - orbits are cloud or wave function = probability of being at certain point = electron can be ANYWHERE at ANY TIME



$$\frac{\partial^2\psi}{\partial x^2} + \frac{8\pi^2 m}{h^2}(E - V)\psi = 0$$



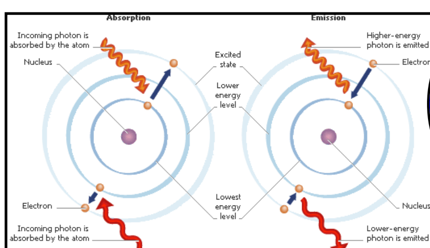
The blue area is the elctron cloud. The darker it is, the more likely the electron is there.

Light Emission - Demo spectrum tubes

Emission spectrum = electron jumps between orbits = energy released

$E_o - E_f = hf$

Electrons further from nucleus = more STORED energy



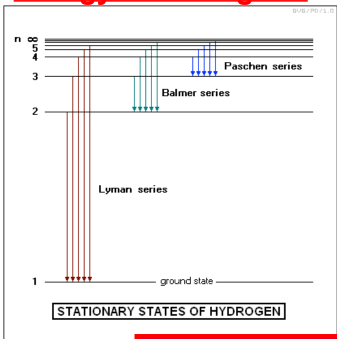
Bohr model for emission spectrum

$1/\lambda = RZ^2(1/n_1^2 - 1/n_2^2)$

R = Rydberg constant = $1.097 \times 10^7\ m^{-1}$

$n_1 < n_2$

Energy level diagram



Lyman = MOST energy = UV, n = 1

Balmer = visible n = 2

Paschen = LEAST energy = IR, n =3

if absorbs photon = starts at that orbital

if releases photon =ends at that orbital

Electrons orbital energy

Bohr Atom...would self destruct but..

$F_c = F_e$

$\frac{mv^2}{r} = \frac{kZe^2}{r^2}$

$mv^2 = \frac{kZe^2}{r^2}$

Total E = KE + EPE

Total E = $1/2mv^2$ + EPE

$E = \frac{(1/2)(kZe^2)}{r} - \frac{kZe^2}{r} = -\frac{kZe^2}{2r}$

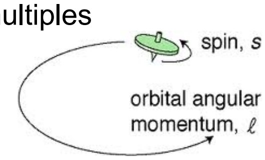
Angular Momentum of an electron in Bohr Atom

$L = I\omega = mr^2(v/r) = mvr$

Bohr said integer multiples

of h....

$L_n = \frac{nh}{2\pi} = mvr_n$



Orbital Radius and E of Bohr Atom

$r_n = (5.29 \times 10^{-11}\ m)n^2/Z$ r in meters

$E_{(of\ atom)} = -kZe^2/2r$ E in Joules

$E_n = -(2.18 \times 10^{-18}\ J)Z^2/n^2$ E in Joules

$E_n = -(13.6\ eV)Z^2/n^2$ E in eV

remember eV = energy to increase e^- by 1 J/C so 1 eV = 1.6×10^{-19} J

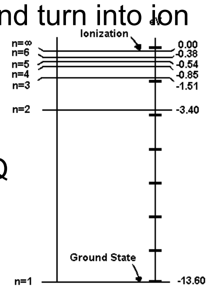
** note as n ⇒ ∞....E ⇒ 0 since electron escapes pull of nucleus**

Ionization energy = energy needed to "pull" electron from atom and turn into ion

$E_{ionization} = E_\infty - E_o$

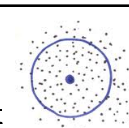
= energy of photon

**same as Rydberg EQ



Energy levels for the hydrogen atom

Quantum Mechanics



**electrons do NOT stay in orbit

** electrons can't be assigned ONE orbital number (like n that Bohr uses)

**instead there are FOUR quantum numbers to describe electrons position and motion in an atom

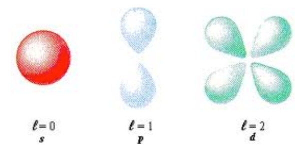
4 Quantum Numbers:

1) n

- principle quantum #
- = 1, 2, ...
- = shell

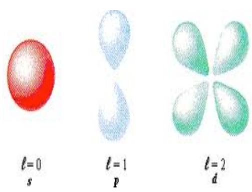
2) Orbital quantum #

- ℓ
- 0, 1,.... , n-1
- = subshell (s, p, d, f, g, h)



3) Magnetic quantum #

- m_ℓ
- $-\ell$...0....$+\ell$
- "spot" in subshell

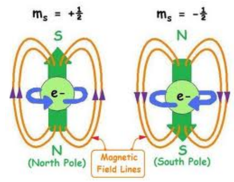


# of Electrons

Value of n → $1s^1$ ← Orbital type

(Orally say 1 s 1)

- spins up or down

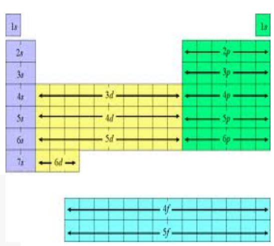


Electron configuration notation:

# of Electrons

Value of n → $1s^1$ ← Orbital type

(Orally say 1 s 1)



Example	electron notation	orbital notation
hydrogen	$1s^1$	↑
helium	$1s^2$	↑↓
lithium	$1s^2 2s^1$	↑↓ ↑ _ _ _
beryllium	$1s^2 2s^2$	↑↓ ↑↓ _ _ _
boron	$1s^2 2s^2 2p^1$	↑↓ ↑↓ ↑ _ _

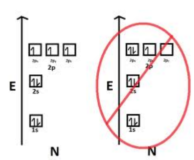
Pauli Exclusion Principle

No two electrons in the same atom can have ALL four quantum numbers the same

EX....do these combinations work??

$n = 2, \ell = 1, m_\ell = 0, m_s = +1/2$

$n = 4, \ell = 1, m_\ell = 2, m_s = -1/2$



Angular Momentum in Quantum world

$$L = \left(\sqrt{\ell(\ell+1)}\right)(h/2\pi)$$

This means when $\ell = 0$, L = 0 no matter what n is!!!

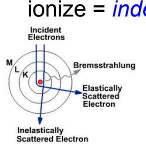
Number of electrons in an atom

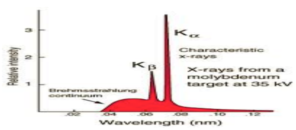
$\#e = 2(2\ell + 1)$

Bohr	Quantum
$L = nh/2\pi \neq 0$	$L = \sqrt{l(l+1)}\,(h/2\pi)$ can = 0
L = same for every orbit n	L can be different for same n
orbits = circles	orbits = probability clouds = various shapes

Bremsstrahlung = X-ray spectrums

- used to identify metals
- electrons ionized from K-shell of atom produce X-rays
- **peaks** show unique electrons for element = *characteristic X-rays*
- **cutoff** = minimum energy needed to make electrons ionize = *independent of material*





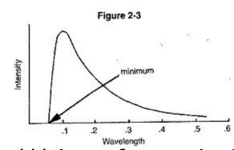
Bombard target material with high energy electrons....(electrons moved with high V)

$hf_o = KE = eV$

$f_o = eV/h$

$c/\lambda_o = eV/h$

$\lambda_o = eV/hc$



therefore min λ only depends on bombarding electrons NOT material

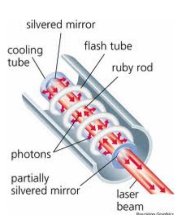
LASERS

Light **A**mplification, **S**timulated **E**mission of **R**adiation

One Color/monochromatic

In Phase/coherent

High Intensity



Number of electrons in an atom

$\#e = 2(2\ell + 1)$

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