Unit 3: Atomic Structure Name: ____________________

Basics of the Atom

Particle	**Charge**	**Location in the Atom**	**Mass**

a.m.u.: unit used to measure mass of atoms

atomic number:

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mass number:

To find net charge on an atom, consider ____ and ____.

ion:

anion: a (–) ion

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cation: a (+) ion

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Description	Net Charge	Atomic Number	Mass Number	Ion Symbol
15 p^+ 16 n^0 18 e^-				
38 p^+ 50 n^0 36 e^-				
			128	Te^{2-}
18 e^-	1+		39	

Historical Development of the Atomic Model

- ***Greeks (~400 B.C.E.)***

Greek model of atom →

- ***Hints at the Scientific Atom***

** Antoine Lavoisier: law of conservation of mass

** Joseph Proust (1799): law of definite proportions: every compound has a fixed proportion

e.g., water……………………..

chromium (II) oxide…….

** John Dalton (1803): law of multiple proportions: When two different compounds have same two elements, equal mass of one element results in integer multiple of mass of other.

e.g., water…………………….

hydrogen peroxide…….

e.g., chromium (II) oxide……

chromium (VI) oxide…..

John Dalton's Atomic Theory (1808)

1. Elements are made of indivisible particles called atoms.
2. Atoms of the same element are exactly alike; in particular, they have the same mass.
3. Compounds are formed by the joining of atoms of two or more elements in fixed, whole number ratios.

e.g.,

Dalton's model of atom →

** William Crookes (1870s): Rays causing shadow were emitted from cathode.

- ***The Thomsons (~1900)***

J.J. Thomson discovered that "cathode rays" are…

…deflected by electric and magnetic fields

…

William Thomson (a.k.a., Lord Kelvin): Since atom was known to be electrically neutral, he proposed the <u>plum pudding model</u>.

-- Equal quantities of (+) and (–) charge distributed uniformly in atom.

-- (+) is ~2000X more massive than (–)

Thomson's plum pudding model ←

** James Chadwick discovered neutrons in 1932.

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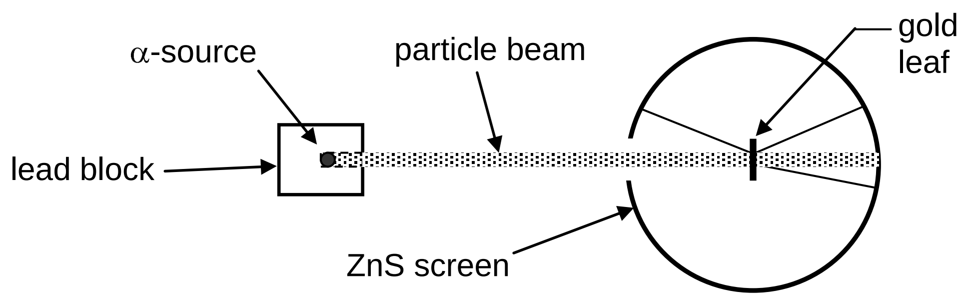
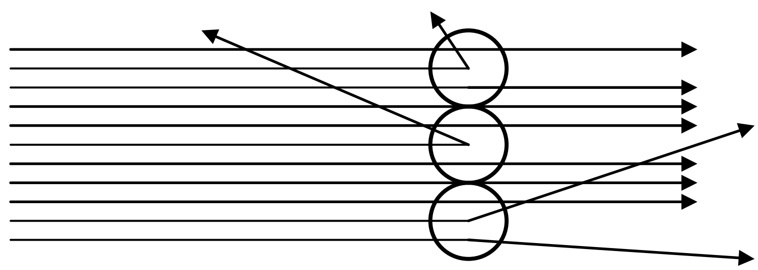
- ***Ernest Rutherford (1909)***: Gold Leaf Experiment

Beam of α-particles (+) directed at gold leaf surrounded by phosphorescent (ZnS) screen.



Most α-particles passed through, some angled slightly, and a tiny fraction bounced back.



Conclusions:

1.

2.

Rutherford's model ←

3.

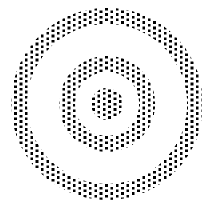
- ***Recent Atomic Models***

<u>Max Planck</u> (1900): proposed that amounts of energy are <u>quantized</u> →

Niels Bohr (1913): e^- can possess only certain amounts of energy, and can therefore be only certain distances from nucleus.

Schrödinger, Pauli, Heisenberg, Dirac (up to 1940): According to the QMM, we never know for certain where the e^- are in an atom, but the equations of the QMM tell us the probability that we will find an electron at a certain distance from the nucleus.

quantum mechanical model
electron cloud model
charge cloud model



- ***Light***

When all e^- are in lowest possible energy state, an atom is in the ____________________.

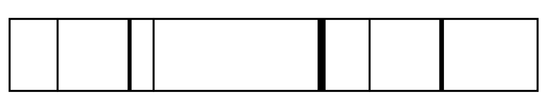
e.g.,

If "right" amount of energy is absorbed by an e^-, it can "jump" to a higher energy level. This is an unstable, momentary condition called the _____________________.

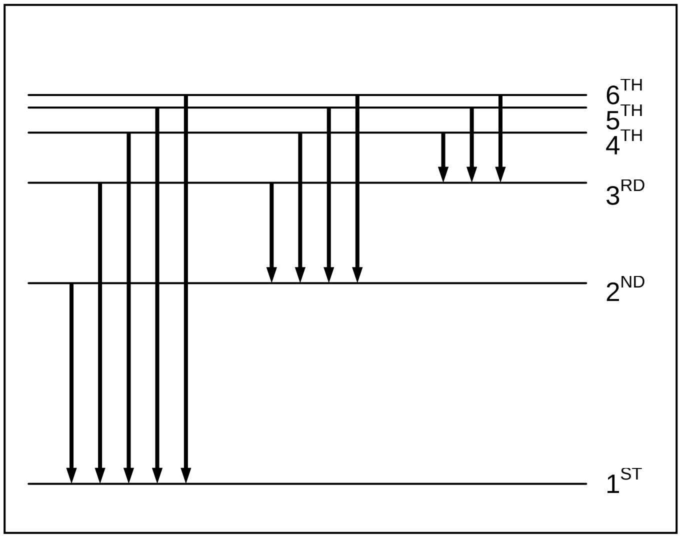
e.g.,

When e^- falls back to a lower-energy, more stable orbital (it might be the orbital it started out in, but it might not), atom releases the "right" amount of energy as light.

Any-old-value of energy to be absorbed or released is NOT OK. This explains the lines of color in an emission spectrum.



- ***Emission Spectrum for a Hydrogen Atom***



Lyman series:

Balmer series:

Paschen series:

Isotopes different varieties of an element's atoms

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Isotope	Mass	p^+	n^0	Common Name
H–1				
H–2				
H–3				

C–12 atoms C–14 atoms

Radioactive Isotopes:

Nucleus attempts to attain a lower energy state by releasing extra energy as ___________.

e.g.,

half-life: the time needed for ½ of a radioactive sample to decay into stable matter

e.g., C–14: → half-life is 5,730 years; decays into stable N–14

Say that a 120 g sample of C-14 is found today.

Years from now	g of C–14 present	g of N–14 present
0		
5,730		
11,460		
17,190		
22,920		

- ***Complete Atomic Designation***

  …gives precise info about an atomic particle

$$^{125}_{53}\mathrm{I}^{1-}$$

mass # charge (if any)
element symbol
atomic #

Protons	Neutrons	Electrons	Complete Atomic Designation
92	146	92	
11	12	10	
34	45	36	
			$^{59}_{27}Co^{3+}$
			$^{37}_{17}Cl^{1-}$
			$^{55}Mn^{7+}$

- ***Average Atomic Mass (Atomic Mass, AAM)***

  This is the weighted average mass of all atoms of an element, measured in a.m.u.

  For an element with isotopes A, B, etc.:

Lithium has two isotopes. Li-6 atoms have mass 6.015 amu; Li-7 atoms have mass 7.016 amu. Li-6 makes up 7.5% of all Li atoms. Find AAM of Li.

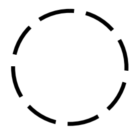
** Decimal number on Table refers to…

Isotope	Mass	% abundance

Si-28	27.98 amu	92.23%
Si-29	28.98 amu	4.67%
Si-30		

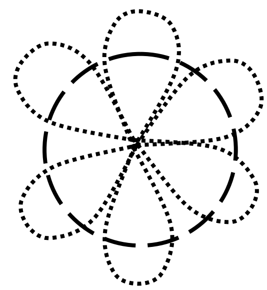
Electron Configurations

- ***"e⁻ Jogging" Rules***



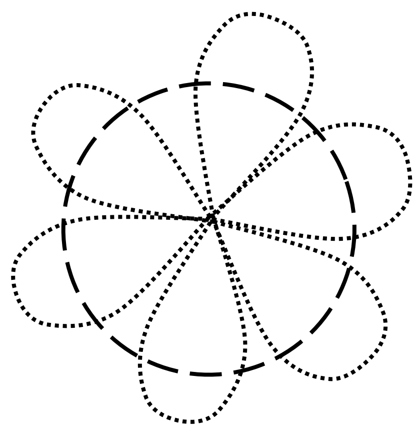
1. Max. of two e⁻ per jogging track (i.e., orbital).
2. Easier orbitals fill up first.

s orbital
(level)

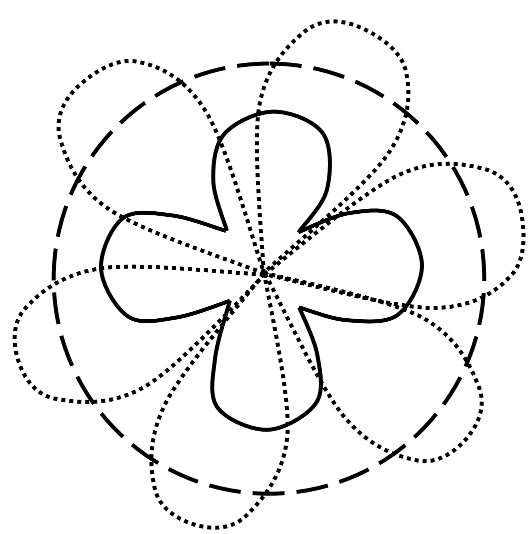


p orbital
(rolling hills)

d orbital
(steep hills)



3. e⁻ must go 100X around.
4. All orbitals of equal difficulty must have one e⁻ before any doubling up.



5. e⁻ on same orbital must go opposite ways.

- ***Writing Electron Configurations***: Where are the e^-? (probably)

H

He

Li

N

Al

Ti

As

Xe

- ***Three Principles about Electrons***

<u>Aufbau Principle</u>: e^- will take lowest-energy orbital available

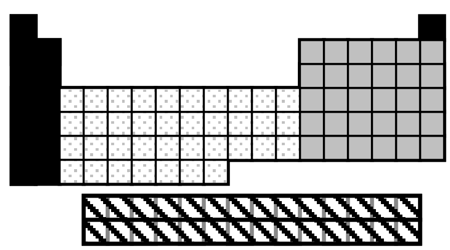
<u>Hund's Rule</u>: for equal-energy orbitals, each must have one e^- before any take a second

<u>Pauli Exclusion Principle</u>: two e^- in same orbital have different spins

- ***Orbital Diagrams:*** …show spins of e^- and which orbital each is in

O	☐	☐	☐	☐	☐	☐	☐	☐	☐
	1s	2s		2p		3s		3p	
P	☐	☐	☐	☐	☐	☐	☐	☐	☐
	1s	2s		2p		3s		3p	

- ***Sections of Periodic Table to Know:***



- ***Shorthand Electron Configuration*** (S.E.C.)

To write S.E.C. for an element:

1. Put symbol of noble gas that precedes element in brackets.
2. Continue writing e^- config. from

S

Co

In

Cl

that point. Rb

- ***The Importance of Electrons***

In "jogging tracks" analogy, the tracks represent

orbitals:

In a generic e^- config (e.g., $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$…):

coefficient →

superscript →

In general, as energy level # increases, e–…

HAVE MORE ENERGY	AND	ARE FARTHER FROM NUCLEUS

kernel electrons:

valence electrons:

He = $1s^2$

Ne = [He] $2s^2\ 2p^6$

Ar = [Ne] $3s^2\ 3p^6$

Kr = [Ar] $4s^2\ 3d^{10}\ 4p^6$

octet rule:

Noble gas atoms have full valence shells. They are stable, low-energy, and unreactive.

Other atoms "want" to be like noble gas atoms.

fluorine atom, F
$9\ p^+,\ 9\ e^-$

chlorine atom, Cl
$17\ p^+,\ 17\ e^-$

lithium atom, Li
$3\ p^+,\ 3\ e^-$

sodium atom, Na
$11\ p^+,\ 11\ e^-$

Know charges on these columns of Table:

Group 1:

Group 2:

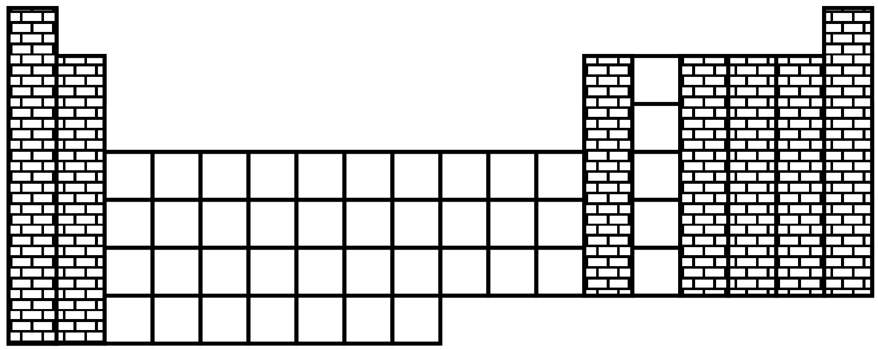
Group 13:

Group 15:

Group 16:

Group 17:

Group 18:



Naming Ions

Cations → use element name and then say "ion"

e.g., Ca^{2+}

Cs^{1+}

Al^{3+}

Anions → change ending of element name to "ide" and then say "ion"

e.g., S^{2-}

P^{3-}

N^{3-}

O^{2-}

Cl^{1-}