CHEMISTRY

September 9, 2013

Agenda

- Brain Teaser
- Collect Atomic Theory Magazine Project
- Grade Atomic Structure Worksheet
- Unit 3
  - Review of Atomic Histories
  - Review of Atomic Structures
  - Isotopes, Bohr Model and Valence Shell
- Homework
  - Isotope Worksheet

Unit 3

Review of Atomic Histories

Isotopes

Bohr Model

Valence Shell

Atomic History

- **Democritus** — Matter is composed of empty space in which atoms move
- **Dalton** — Elements consist of atoms and compounds are collection of atoms
- **JJ Thomson** — "Plum pudding model" : Atoms contain negative particles called electrons
- **Rutherford** — Alpha particles, positive charge with a mass 7500x of electron. Proved the plum pudding model was wrong. Nucleus center (+) and tiny electrons moved in space around it.
- **Chadwick** — Discovered neutrons (slightly more massive than a proton).
- **Bohr** — Electrons are in circular paths depending on their energy levels

Atomic History

- De Broglie
- Schrodinger
- Millikan
- Moseley

- electrons move in waves rather than straight circular paths
- Wave Mechanical Model or Quantum Mechanical Model. Furthered De Broglie's idea of waves by stating that electrons are in clouds but in certain energy region
- Oil drop experiment: discovered that atoms had positive and negative charges and that they equal each other
- Helped to arrange atoms in the periodic table. Atoms were arranged in increasing atomic number using wavelengths and x-rays

Atoms, Isotopes and Ions

How do atoms of different elements differ?

The Modern View of Atomic Structure

- What are the particles that make up an atom and how do they differ from one another?

02m14an1.r

02m14an1

- protonmass = 1 amu charge = +1
- neutronmass = 1amu charge = 0
- electronmass = "0" amu charge = -1
- 1 amu = 1.6726×10^{-27} kg

1/1840

atoms have equal numbers of protons and electrons so they are electrically neutral

Atomic Number

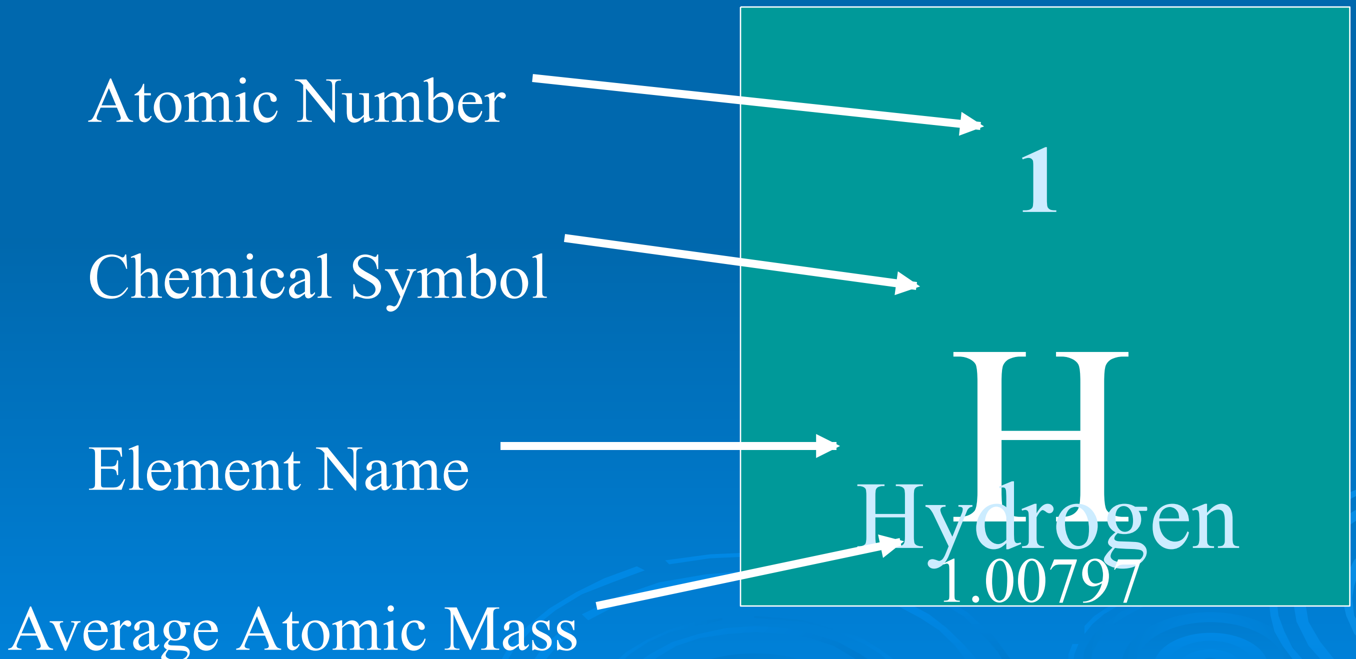
- Atomic number
  - Number of protons in an atom
  - Identifies the element

Atomic Number

- Use the Periodic Table to complete the following.
  1. What element has the atomic number 18?
  2. What element has 35 protons?

How are atoms of one element different from those of another element?

- They have different numbers of these subatomic particles.



Isotopes

- How do we distinguish between atoms?
- Do all atoms of an element have the same composition?

Heavy Water and Water Ice Cube in water

Isotopes


nuclear_particle

- What implication does this have for the masses of atoms?
  - Average atomic mass
- Isotopes differ only in the number of Neutrons
- Difference is shown by their mass numbers
- Notation: superscript for mass number, which is the sum of the number of protons and neutrons
- Notation: subscript for atomic number, which is the number of protons (or electrons)

$^{7}_{3}\mathrm{Li}$ $^{9}_{4}\mathrm{Be}$ $^{11}_{5}\mathrm{B}$

Nuclear Particles

- How many of each particle (protons, neutrons and electrons) are in these atoms?

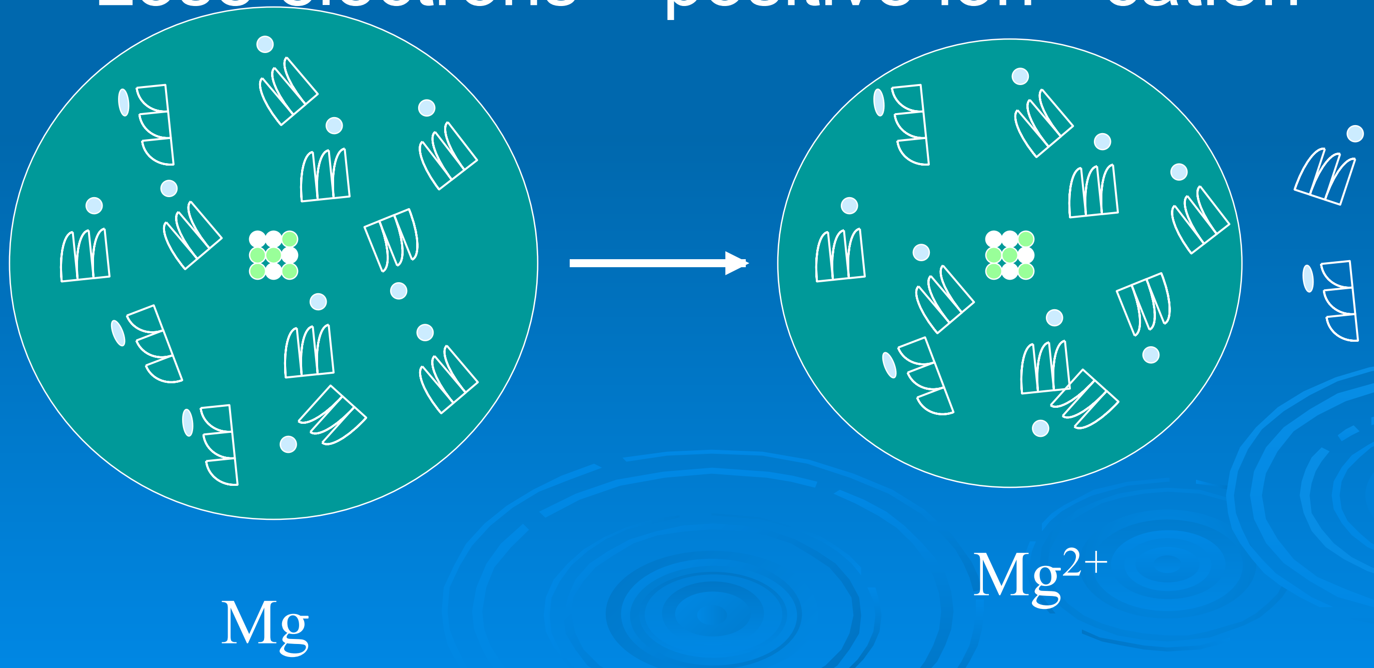
$^{76}_{35}Br$ $^{78}_{35}Br$ $^{80}_{35}Br$

$^{14}_{7}N$ $^{15}_{7}N$

$^{18}_{8}O$ $^{17}_{8}O$ $^{16}_{8}O$ $^{15}_{8}O$

Ions

- When an atom loses or gains electrons and acquires a net electrical charge.
  - Gain electrons – negative ion - anion
  - Lose electrons – positive ion - cation



Ions

Charge of ion = # of protons - # of electrons

How many protons, neutrons and electrons does $^{41}_{20}Ca^{2+}$ have?

How many protons, neutrons and electrons does $^{78}_{35}Br^{-}$ have?

Think-Pair-Share

- Basic Atomic Structure Worksheet

Closure

1. How many protons, neutron and electrons does Mg have?

2. How many protons, neutron and electrons does $^{7}_{4}Be^{-2}$ have?

Unit 3
Periodic Table and Trends

I. Periodic Law – Dmitri Mendeleev

- The properties of the elements relates to their **atomic number**
  - The properties of the elements go through a pattern of change as you move across the periodic table
  - Elements of similar properties occur at intervals
  - **Period**- **horizontal** row across the periodic table
    - Refer to the board
  - **Group** (or family)- **vertical** column down the periodic table
    - These elements generally have about the **same** properties
      - Refer to the board

II. Characteristics of different groups

- Elements in the same group have characteristics similar to each other, yet different from the other elements in the periodic table.
  - Similarities occur because elements in the same group have the same number of valence electrons
  - Valence electrons determine many of the properties of an element
- Periodic table is divided into 4 main groups
  - Representative or main-group elements
  - Transition metals
  - Lanthanide series
  - Actinide series

III. Groups or families (Vertical columns)

- Groups 1A – Alkali metals
  - Very reactive
  - Explosive reactions with water
  - One valence electron
  - All metals
- Groups 2A – Alkaline Earth Metals
  - Quite reactive
  - Two valence electrons
  - All metals

Note: Draw the electron-dot diagram for every element in each of the groups

Note: Refer to handout

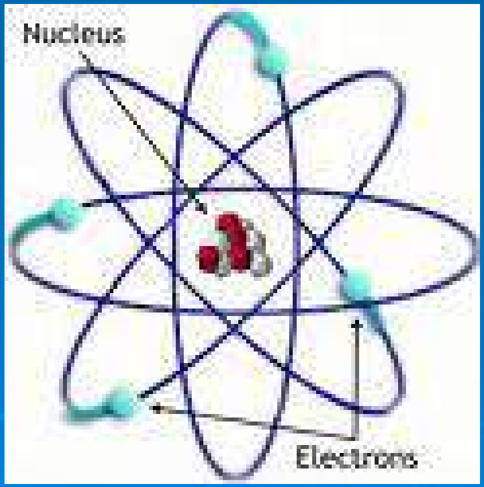
- Groups 3A – Boron Family
  - Varies from semi-metallic to non-metallic in properties
  - Three valence electrons
- Group 4A – Carbon Family
  - Varies from non metallic to metallic in properties
  - Four valence electrons

- Group 5A – Nitrogen Family
  - Varies from non-metallic to metallic properties
  - Five valence electrons
- Groups 6A – Oxygen Family
  - Mostly non-metallic
  - Six valence electrons
- Group 7A – Halogens
  - All are non-metallic and make colorful gases
  - Seven valence electrons

- Group 8A – Noble gases
  - All non metals and highly unreactive
  - Eight valence electrons
- Transition metals
  - All have metallic properties
  - Valence number varies
- Lanthanoids & Actinoids
  - Radioactive, many are non-natural or man-made
  - Valence number varies

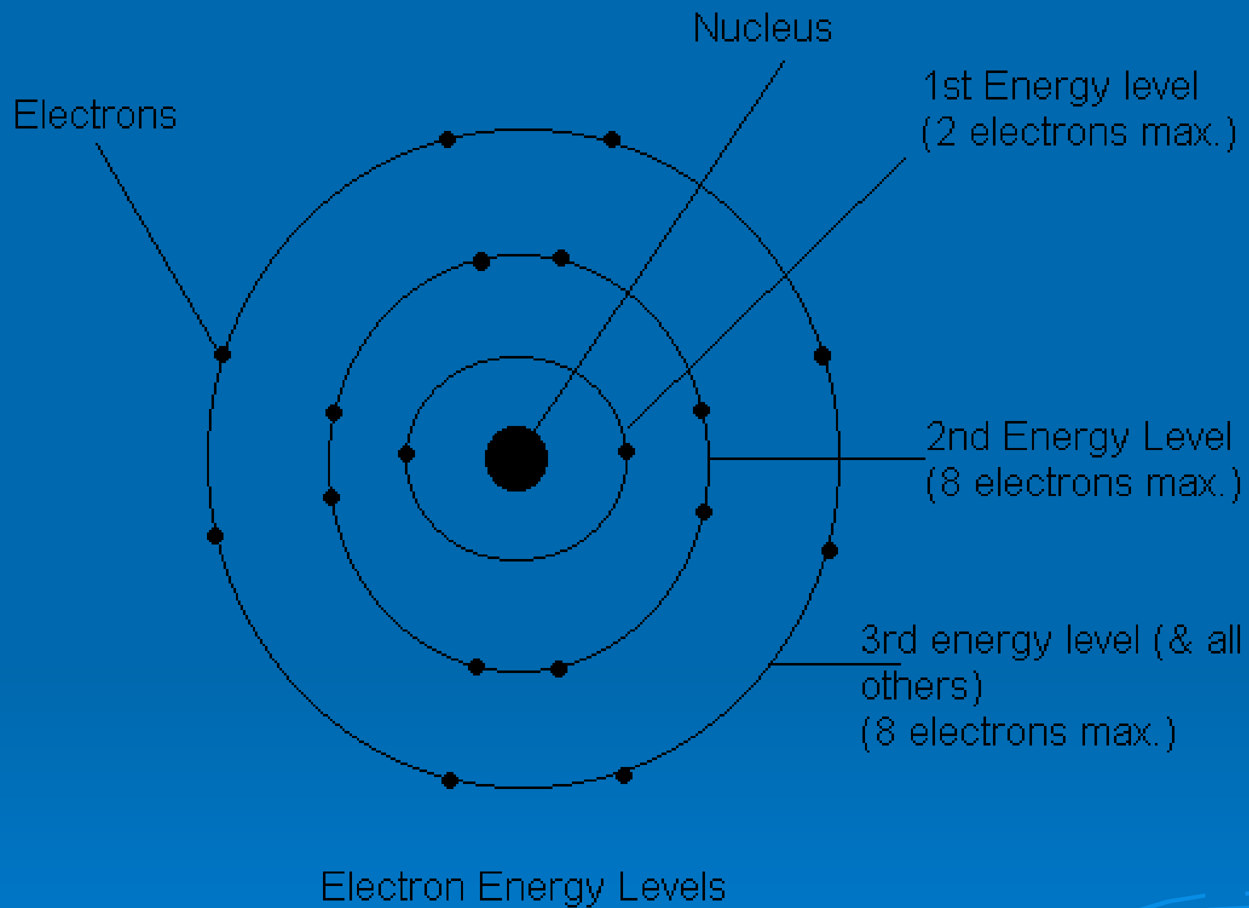
Unit 3
Light and Quantized Energy
Electron Configuration

- Objective:
  - Learn how electrons are arranged in an atom and how that arrangement plays a role in their chemical behavior



III. Bohr Model of the Atom

- Bohr reasoned that electrons can move around the nucleus only at distances that correspond to those amounts of energy.
- These regions of space in which electrons can move about the nucleus of an atom are called energy levels.
- Bohr atomic model assigns quantum numbers (n) to electron orbits.
  - Refer to periodic table



Bohr Movie Clip

Where all of this has led to

- Bohr Model – did some good things but it is not the whole truth.

Practice

- Part 1: Complete Bohr's Diagram Worksheet
  - 10 minutes
- Part 2: Complete Practice Quiz
  - 15 minutes
  - Quiz → This Friday

Review of the Periodic Kingdom

- Read the article on “The Terrain”
- Answer Questions to “Review of the Periodic Kingdom”
  - Write in complete sentences
- Time: 30-45 minutes

Color Coding the Periodic Table

- Objective: Understand how the periodic table is arranged.
- Complete “Family Ties” Worksheet
  - Read and use “Student Information Sheet” to complete worksheet
- Color each group on the table as given in the instructions “Student Worksheet”

Agenda

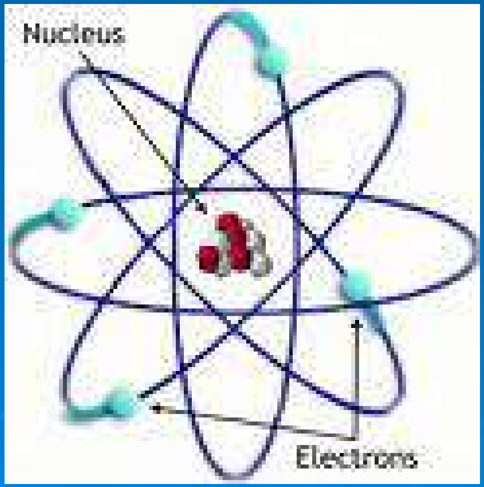
- Brain Teaser
- Unit 3: Quiz Result (?)
- Practice:
  - Draw Electron Dot Structure
- Lecture: Light and Quantized Energy
- Complete “Color coding the Periodic Table”
- Homework:
  - Finish coloring periodic table

Electron Dot Structure

- Draw Lewis Dot Structure
  - Only show the valence electrons
    - Phosphorus
    - Calcium
    - Potassium
- Draw Lewis Dot Structure of the following ions:
  - K^{+1}
  - Ca^{+2}
  - O^{-2}

Unit 3
Light and Quantized Energy
Electron Configuration

- Objective:
  - Learn how electrons are arranged in an atom and how that arrangement plays a role in their chemical behavior



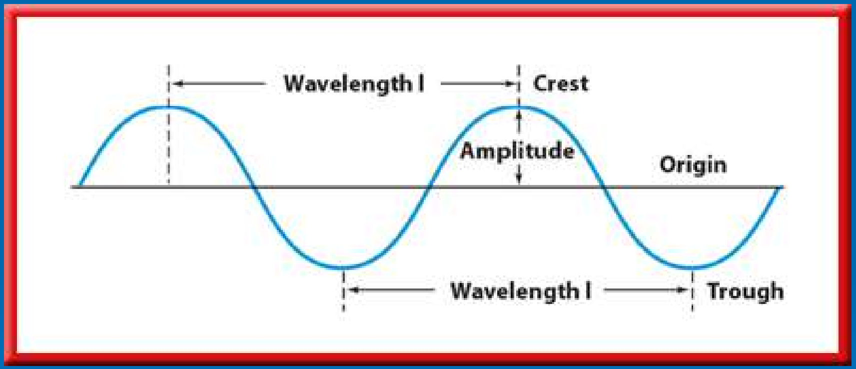
I. Light and Quantized Energy

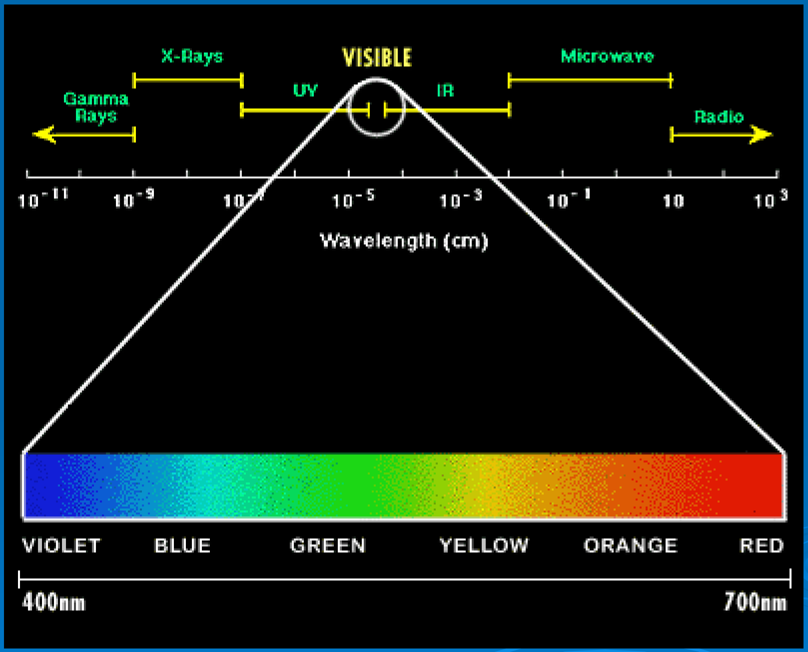
- Certain elements emit visible light when heated in a flame.
- Analysis of the emitted light revealed that an electron behavior is related to arrangement of the electrons in its atoms.

II. Wave and Particle Nature of Light

- Wave Nature of Light
  - Wavelength is the shortest distance between equivalent points on a continuous wave.
  - All electromagnetic waves travel at a speed of 3.00×10^8 m/s in a vacuum
  - Electromagnetic waves may have different wavelengths and frequencies

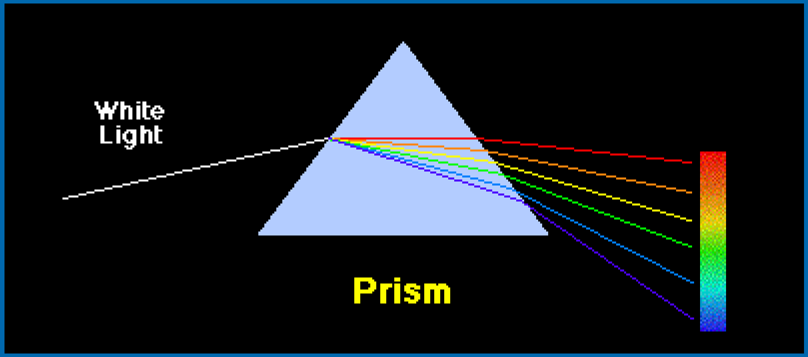
II. Wave and Particle Nature of Light

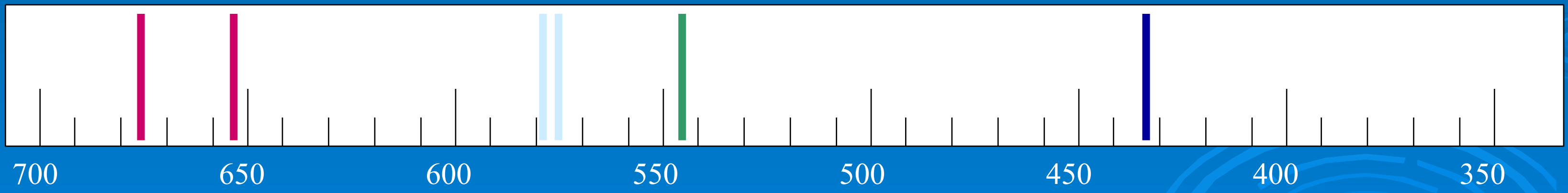




II. Wave and Particle Nature of Light

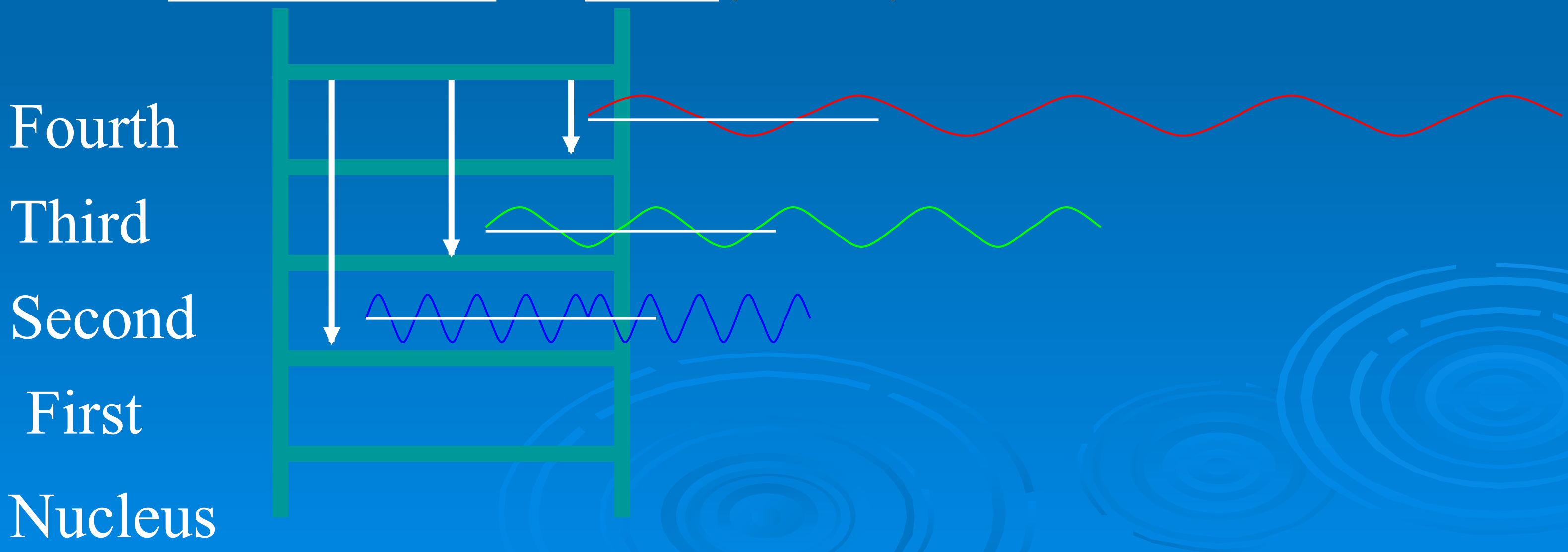
- Light
  - Continuous Spectrum
    - Colors formed when white light passes through a prism and separates into different wavelengths
  - Bright Line Spectra
    - Lines of color produced by light emitted from heating substances and passing them through a prism
    - Fingerprints of elements
    - Researchers can determine values of energy levels in atoms
    - Used to identify different elements


White
Light
Prism


700
650
600
550
500
450
400
350

II. Wave and Particle Nature of Light

- Particle Nature of Light
  - Observation of unique line spectra led to Quantum Theory
    - Quantum is the minimum amount of energy that can be gained or lost by an atom.
    - Helps to explain why heated objects emit only certain frequencies of light (E=hv)



How do fireworks emit light?

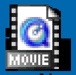
- Demo
  - Sr, K, Li, Cu, Na

Where all of this has led to

- Bohr Model – did some good things but it is not the whole truth.

Some Questions

- Color arises from electrons shifting from one orbital to another of different energy


Na excitatic

- Ground state and excited state
- What shift would give rise to emission of light? to absorption of light?

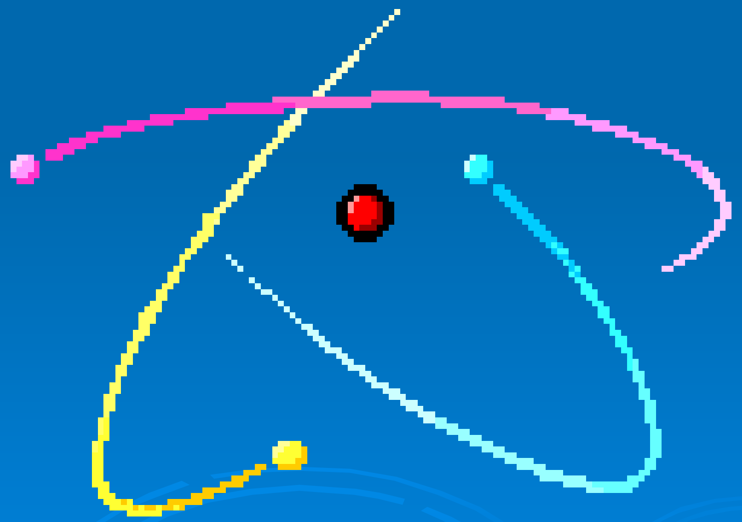

absorb_en

Where all of this has lead to

- Quantum Model

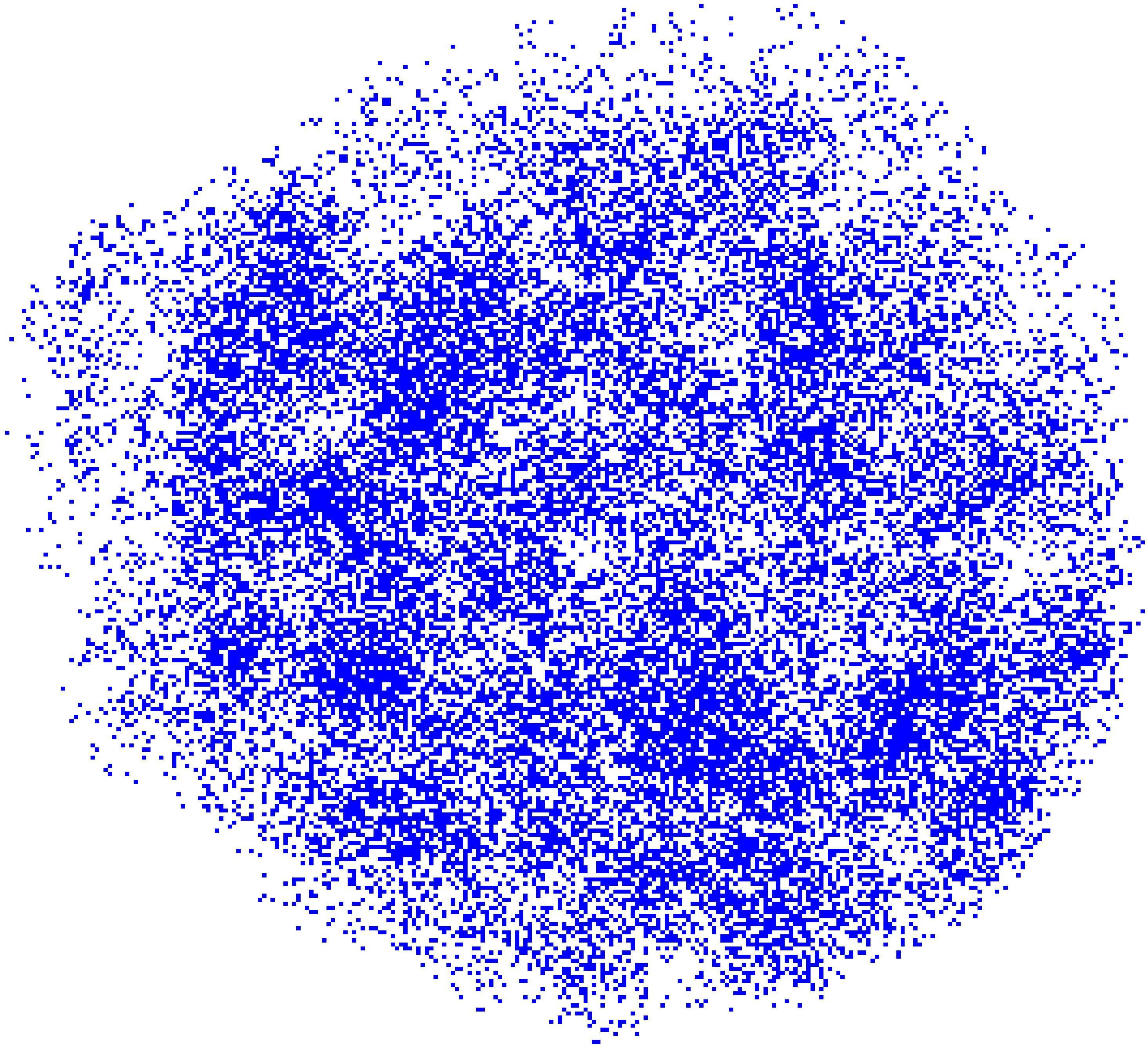
What is the Quantum Mechanical Model?

- It predicts quantized energy levels for electrons, like the Bohr model.



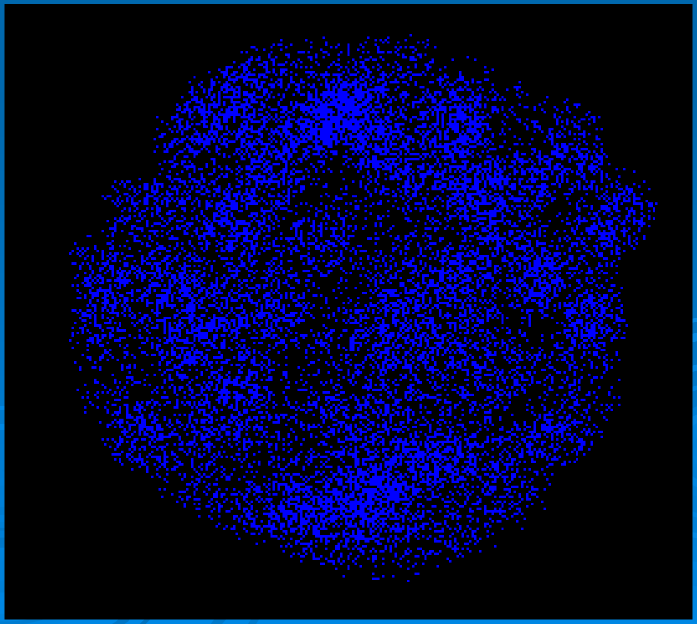
What is Quantum Theory?

- It does not describe the exact path that electrons take around the nucleus of an atom, but is concerned with the probability of an electron being in a certain place.



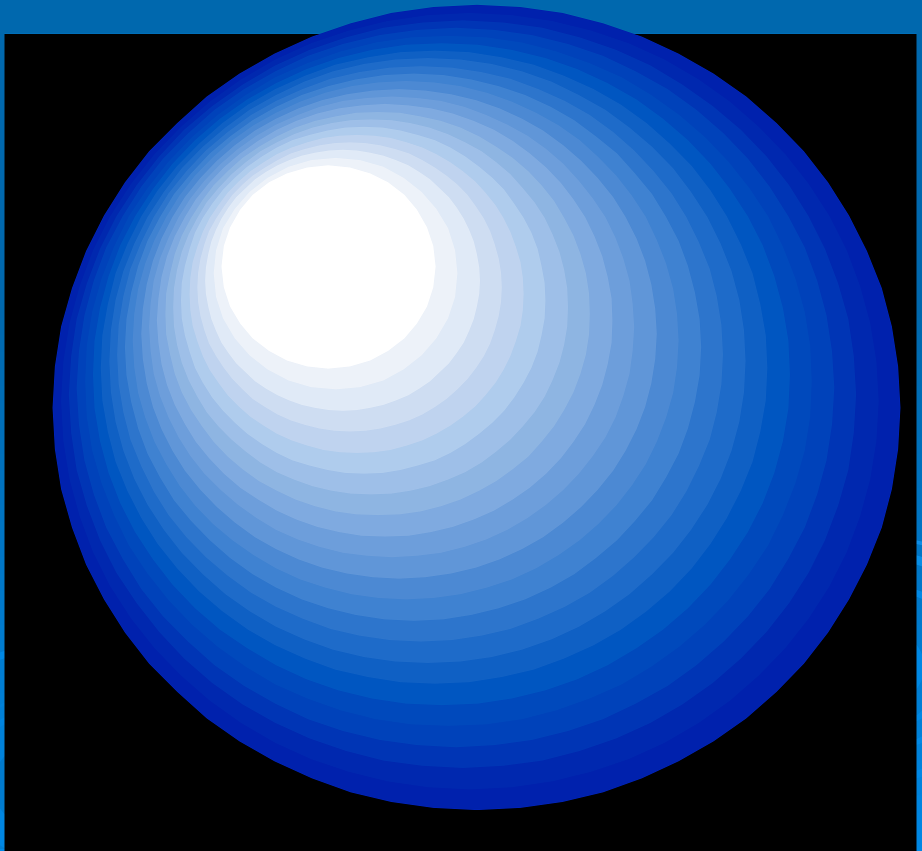
Orbitals

- Areas where an electron can be found
- Can have up to two electrons
- Fuzzy boundaries → "Electron Cloud"



The Closed Sphere Model

- For convenience
- Shows where the electron is 90% of the time



The Heisenberg Uncertainty Principle

- You can never know exactly where an electron is if you know how exactly fast it is moving.
- You can never know exactly how fast an electron is moving if you know exactly where it is.

Video

- Video: Greatest Discoveries with Bill Nye: Physics (atomic physics)
- **Those Pesky Atoms Heisenberg and the Structure of Atoms**
  Video: Particles Waving: The Dual Nature of Light and Matter
- http://www.youtube.com/watch?v=yDCCbxCJLIM
  -

- Color Code the Periodic Table

Agenda

- Brain Teaser
- Notes:
  - Bohr’s Model
  - Orbital Diagrams and Electron Configuration
- Practice Writing electron configuration
- Homework
  - Electron configuration worksheet

Preview of Lesson

- Where are electrons found around the nucleus?
- 4 different shaped orbitals (x-ray diffraction and electron microscopy)
  - s, p, d, f
- Higher energy levels have more shapes
- Each orbital can hold 2 e-
  - Locate an e- 90% of the time
- Orbital is also called Subshells

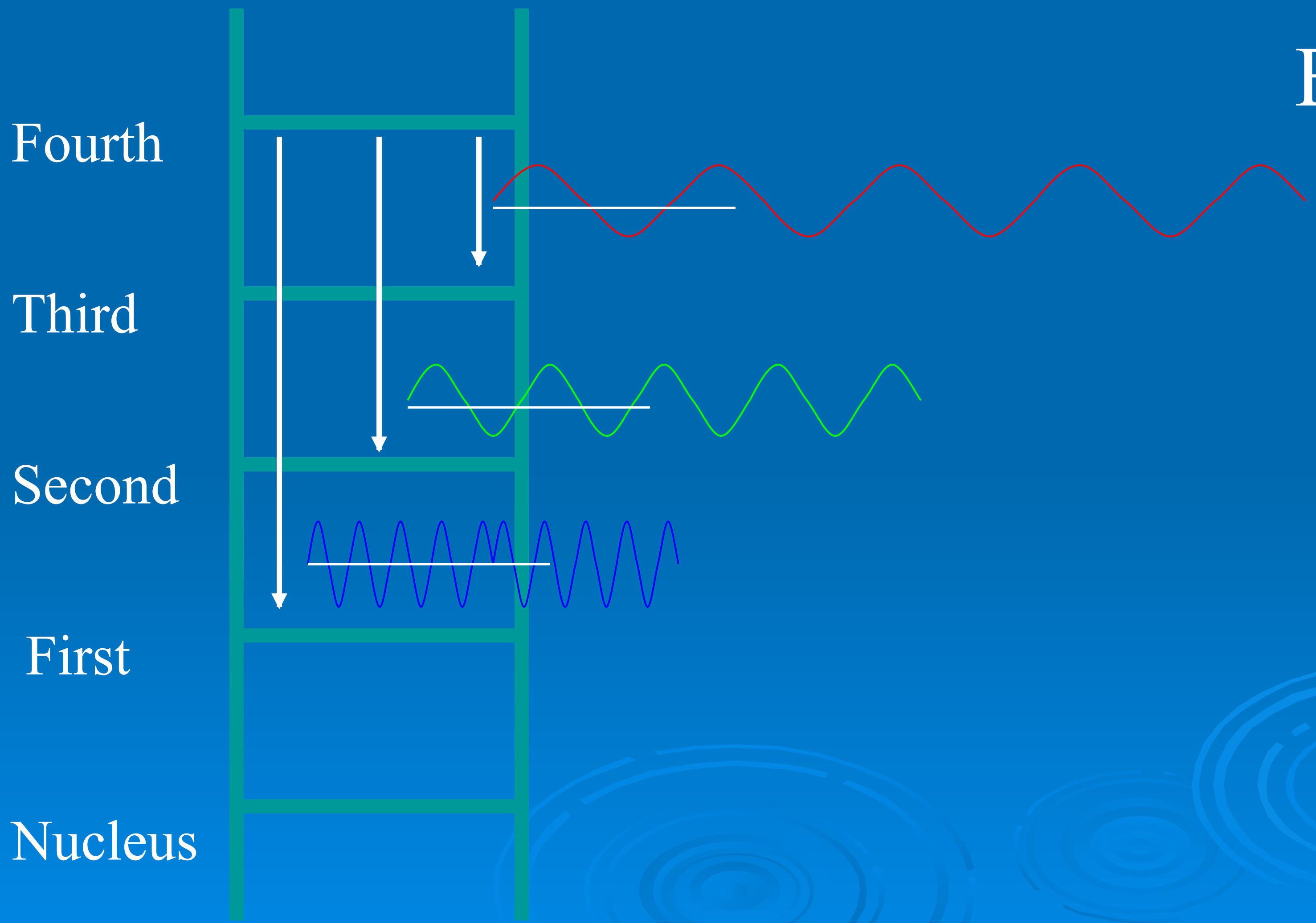
Bohr's Model

- Model of electrons in fixed orbits to explain quantization Figure 6.14
- Transitions between orbits emits or absorbs light

07m07an1.r

07m07an1

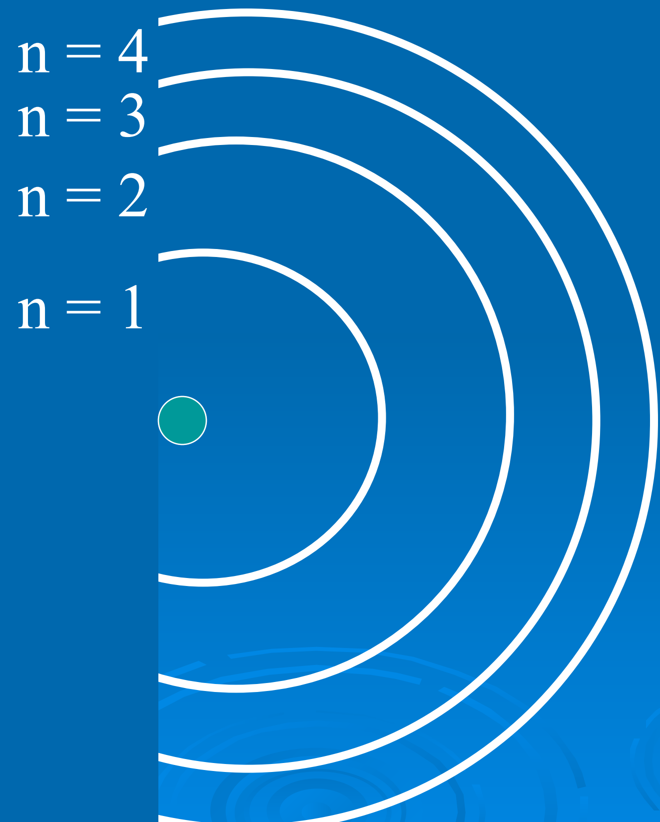
Observation of unique line spectra led to Quantum Theory



$E = h\nu$

Orbital Diagrams and Electron Configurations

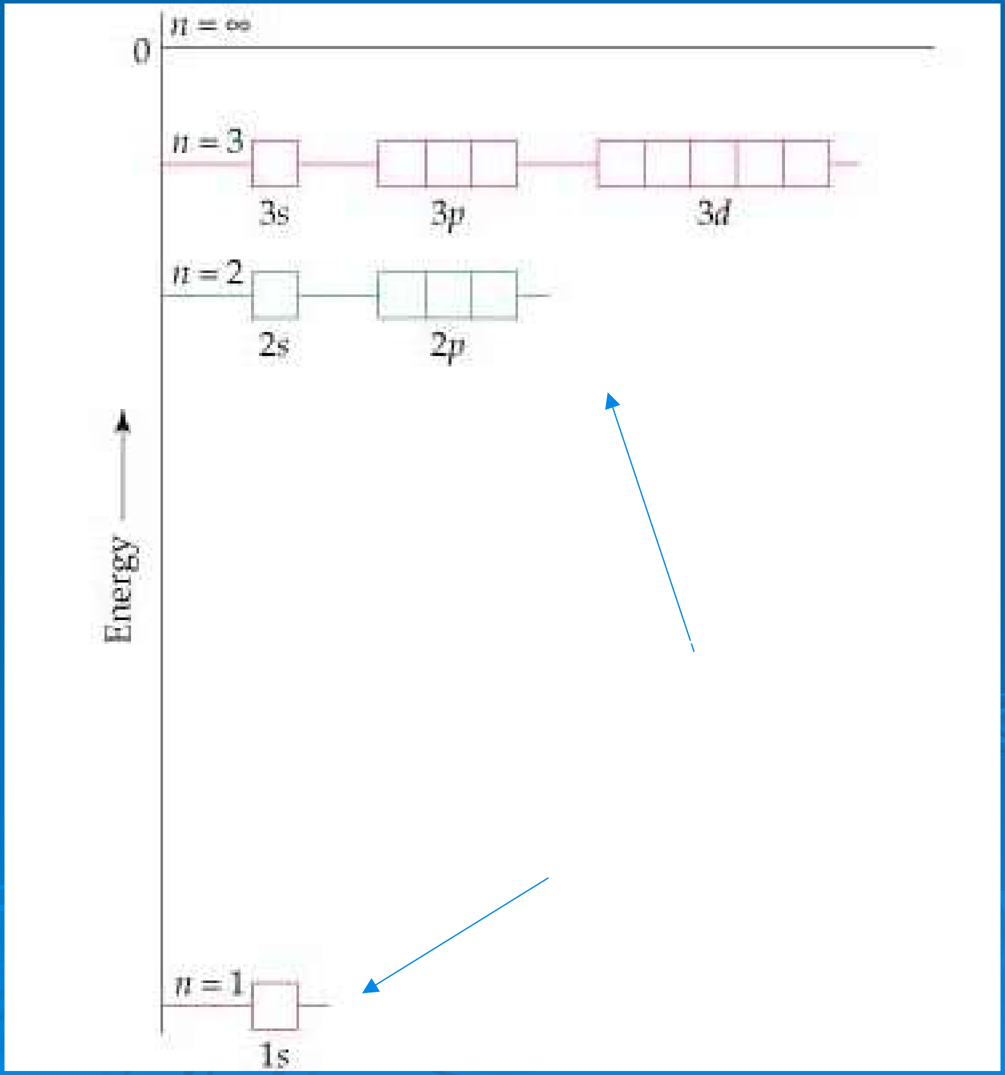
- n = Principle quantum number
- Describes the energy level the electron occupies



Orbital Energy Levels

- Shape of orbital designated by the letters

s, p, d, f

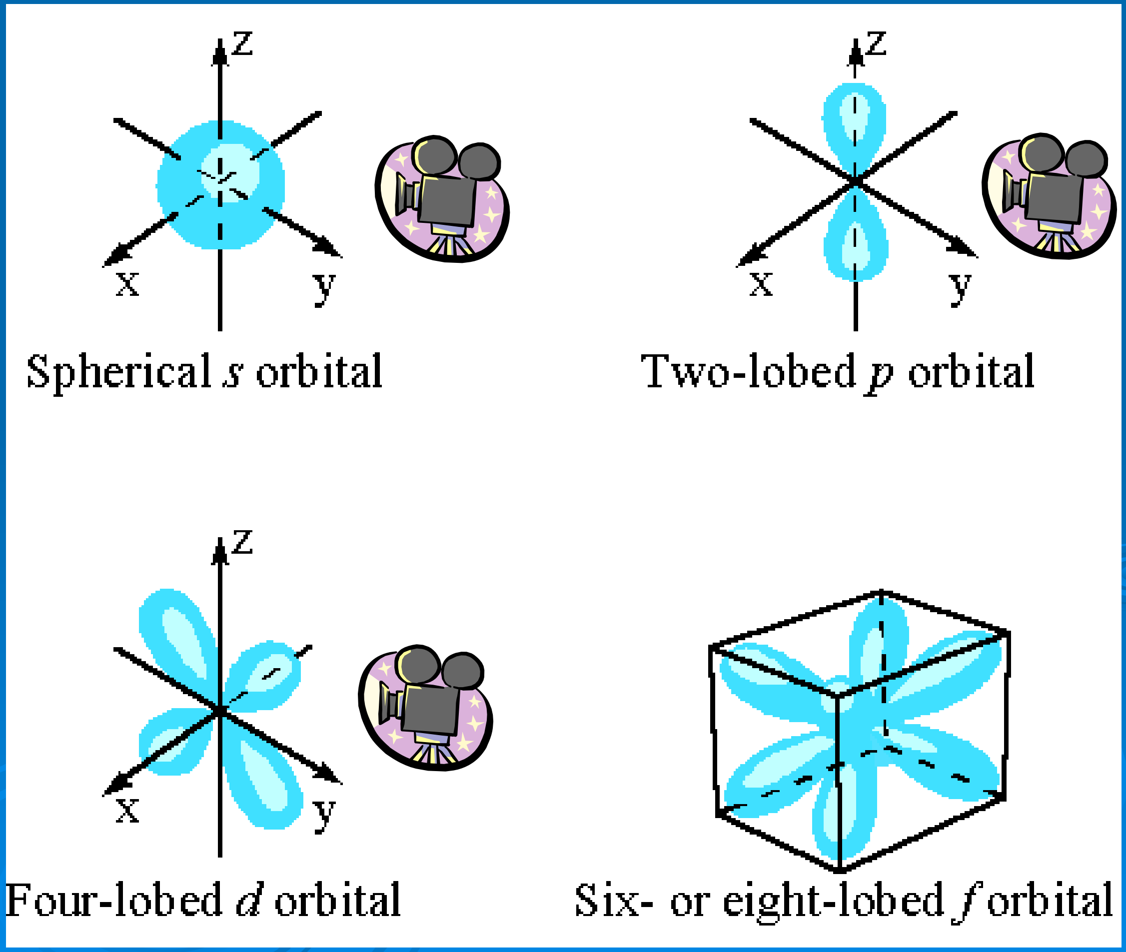


Shapes of Orbitals

- Shape of orbital designated by the letters

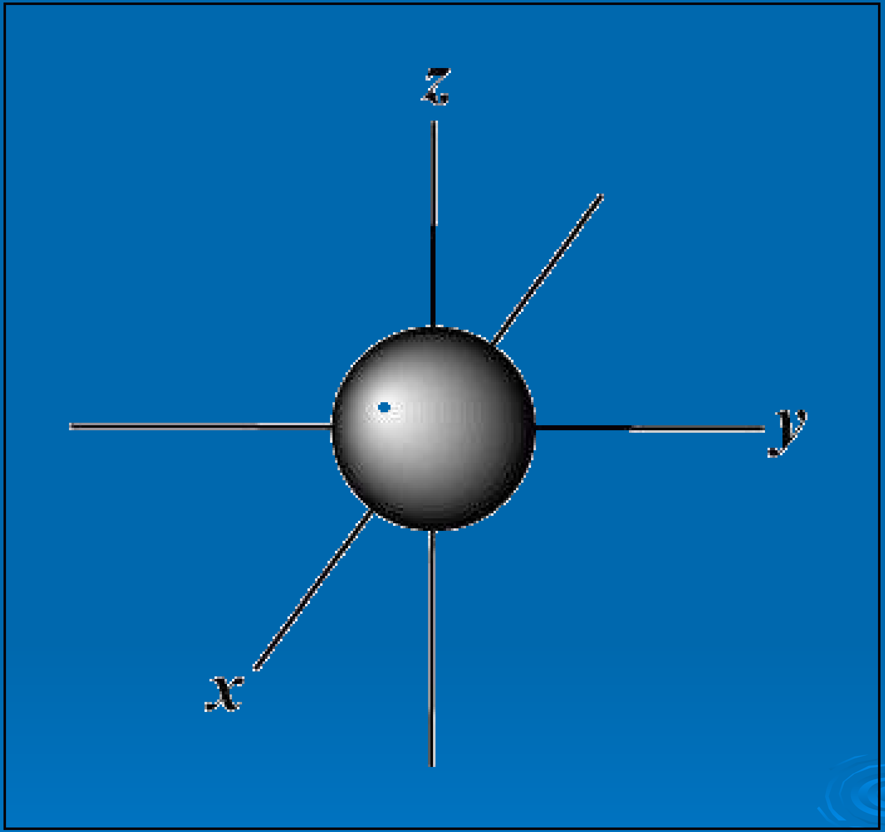
  s, p, d, f

- Orbitals have different shapes

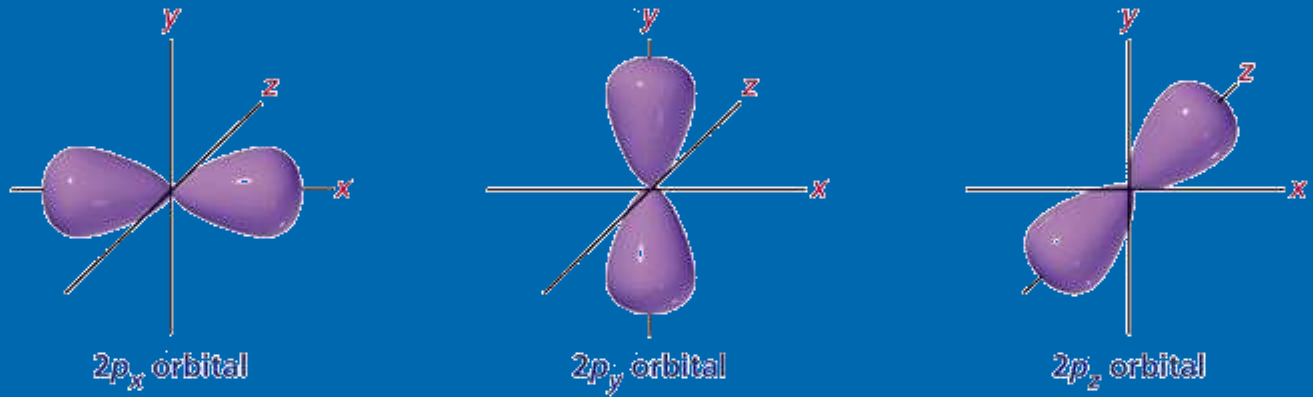


s Orbital shape

The s orbital has a spherical shape centered around the origin of the three axes in space.

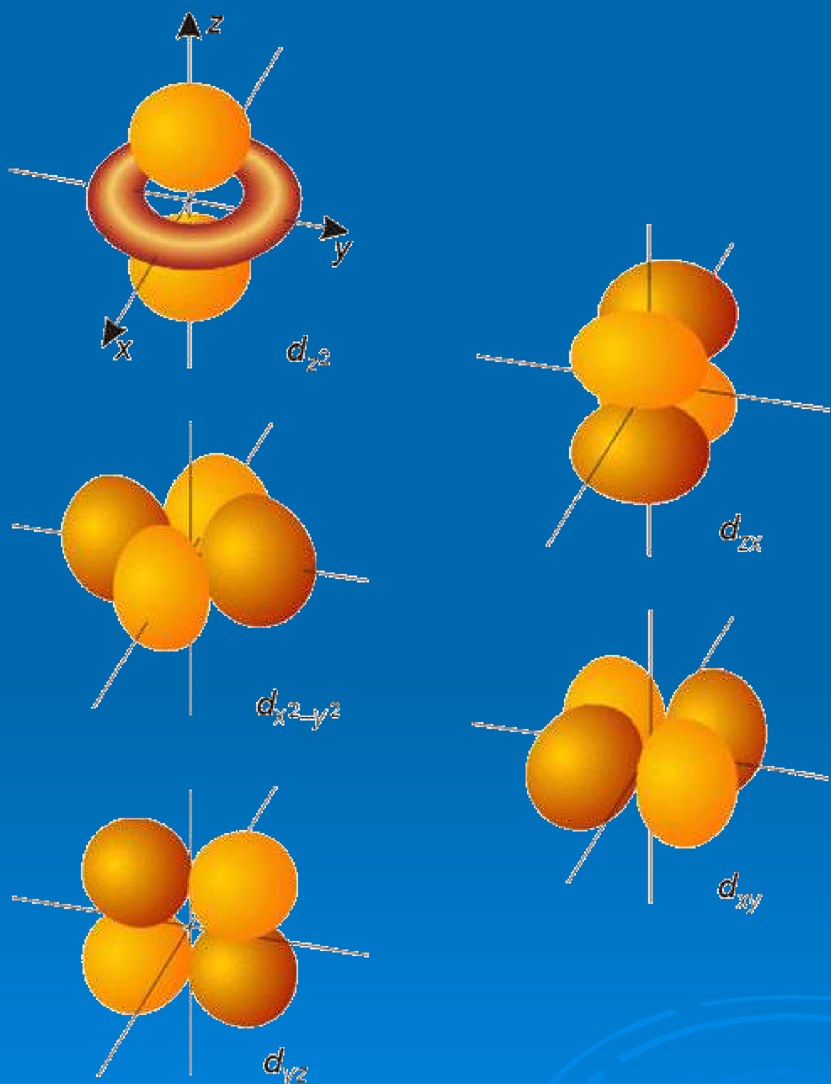


p orbital shape



There are three dumbbell-shaped p orbitals in each energy level above n = 1, each assigned to its own axis (x, y and z) in space.

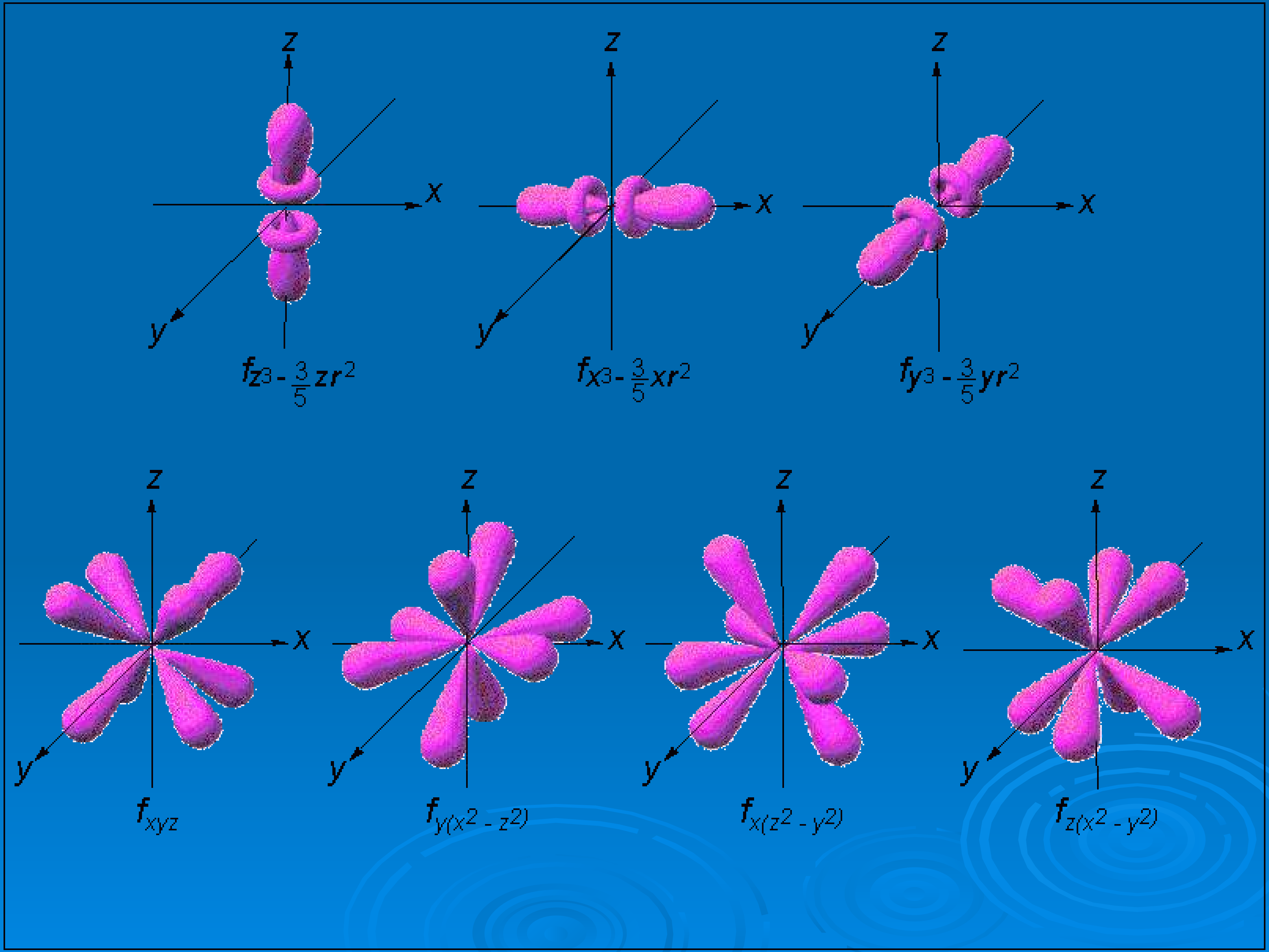
d orbital shapes



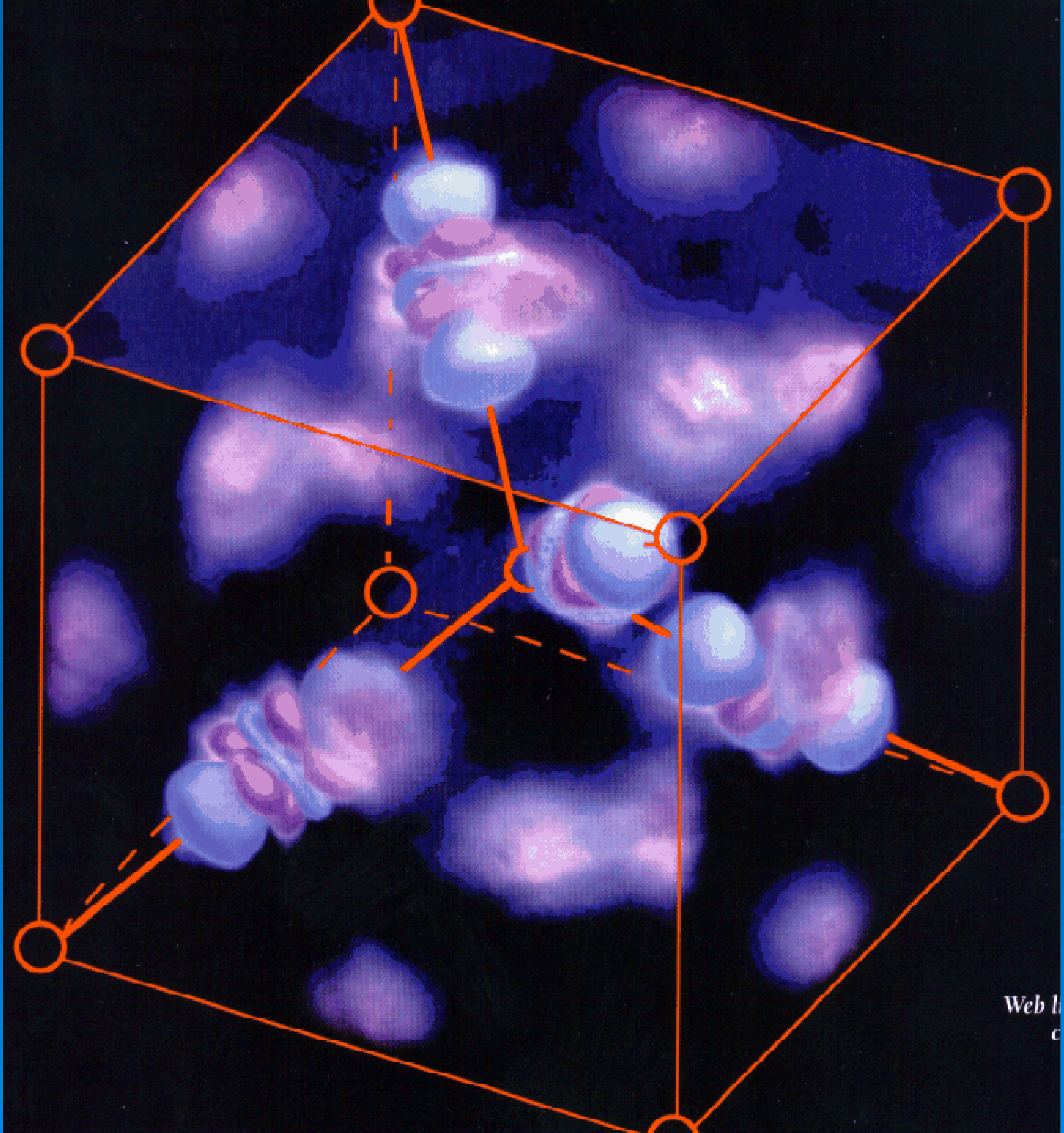
Things get a bit more complicated with the five d orbitals that are found in the d sublevels beginning with n = 3. To remember the shapes, think of "double dumbells"

…and a "dumbell with a donut"!

Shape of f orbitals

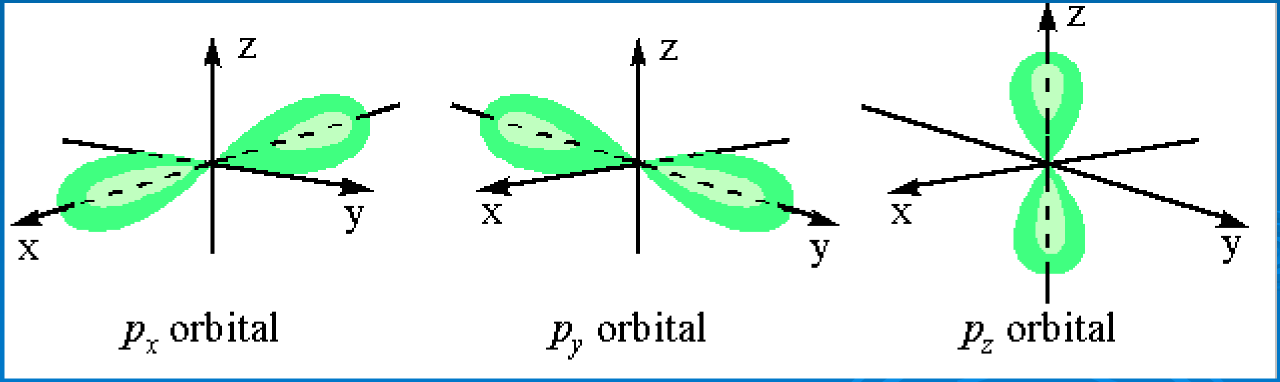


Combination of electron microscopy and x-ray diffraction produced image of orbitals



Sets of Orbitals (Subshells)

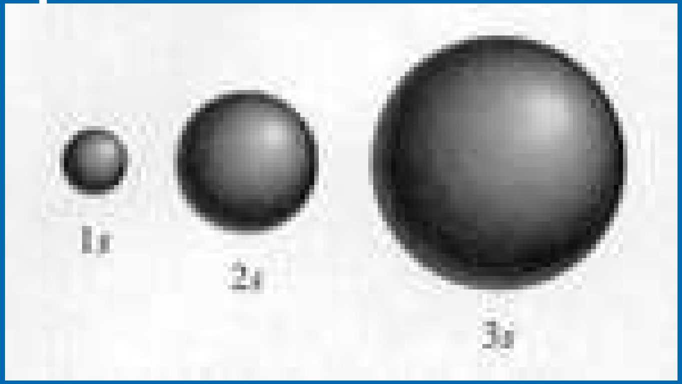
- Depending on the type of orbital, we find that they occur in **sets differing in their orientation** in space
  - Label periodic table
- s - set of 1
- p - set of 3
- d - set of 5
- f - set of 7



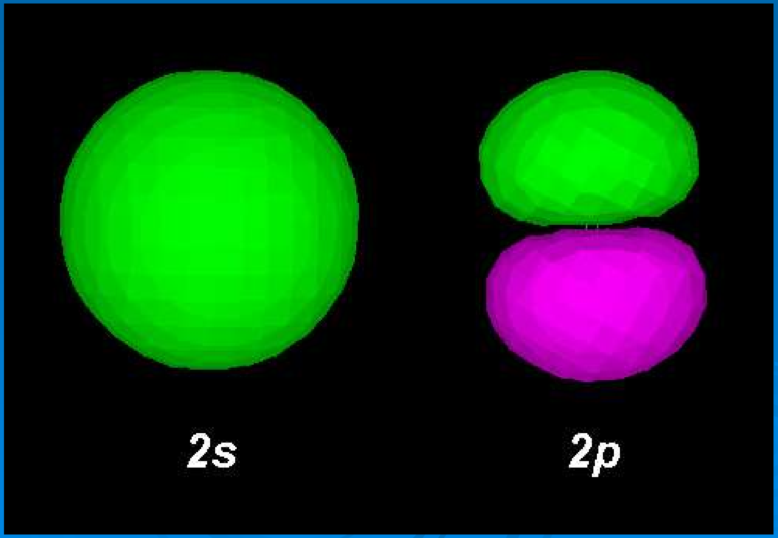
Orbitals.e

Sizes of orbitals

- **Size** depends on the **value of *n***



- Orbitals with the same *n* are about the same size



Check for understanding

- What are the subshells?
- How many sets of electrons are found in each subshell?
- What is the principal quantum number for Ar?

Electron Configurations of Some Atoms

- The first ten elements

Element	Orbitals 1*s*	2*s*	$2p_x$	$2p_y$	$2p_z$	Electronic Configuration
H	↑					$1s^1$
He	↑↓					$1s^2$
Li	↑↓	↑				$1s^2\ 2s^1$
Be	↑↓	↑↓				$1s^2\ 2s^2$
B	↑↓	↑↓	↑			$1s^2\ 2s^2\ 2p^1$
C	↑↓	↑↓	↑	↑		$1s^2\ 2s^2\ 2p^2$
N	↑↓	↑↓	↑	↑	↑	$1s^2\ 2s^2\ 2p^3$
O	↑↓	↑↓	↑↓	↑	↑	$1s^2\ 2s^2\ 2p^4$
F	↑↓	↑↓	↑↓	↑↓	↑	$1s^2\ 2s^2\ 2p^5$
Ne	↑↓	↑↓	↑↓	↑↓	↑↓	$1s^2\ 2s^2\ 2p^6$

Practice

- Write the electron configuration for the 1st 5 elements on the periodic table

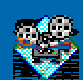
Shorthand Notation for Orbitals

- Combinations of first two quantum numbers; number of orbital types equals the shell number (n).
- 1s
- 2s, 2p
- 3s, 3p, 3d
- 4s, 4p, 4d, 4f
- 5s, 5p, 5d, 5f, (5g)
- 6s, 6p, 6d, 6f, (6g, 6h)

Refer to Electron Configuration Worksheet

Aufbau Principle

- Aufbau Principle: start with the nucleus and empty orbitals, then "build" up the electron configuration using orbitals of increasing energy



Aufbau

Electron Configurations

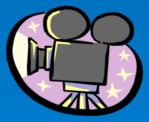
- Electron Spin and Pauli Exclusion Principle:
  - Only two electrons can occupy a single orbital and they must have opposite spins

Electron Configurations

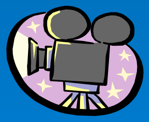
- Hund's Rule:
  - When filling a subshell, such as the set of 3 p orbitals, place 1 electron in each before pairing up electrons in a single orbital

Electron Configurations

- Arrangement of electrons in the orbitals is called the electron configuration of the atom
- The ground state configuration can be predicted, using the Aufbau Principle, the Pauli Exclusion Principle, and Hund's Rule.



Electron configurations



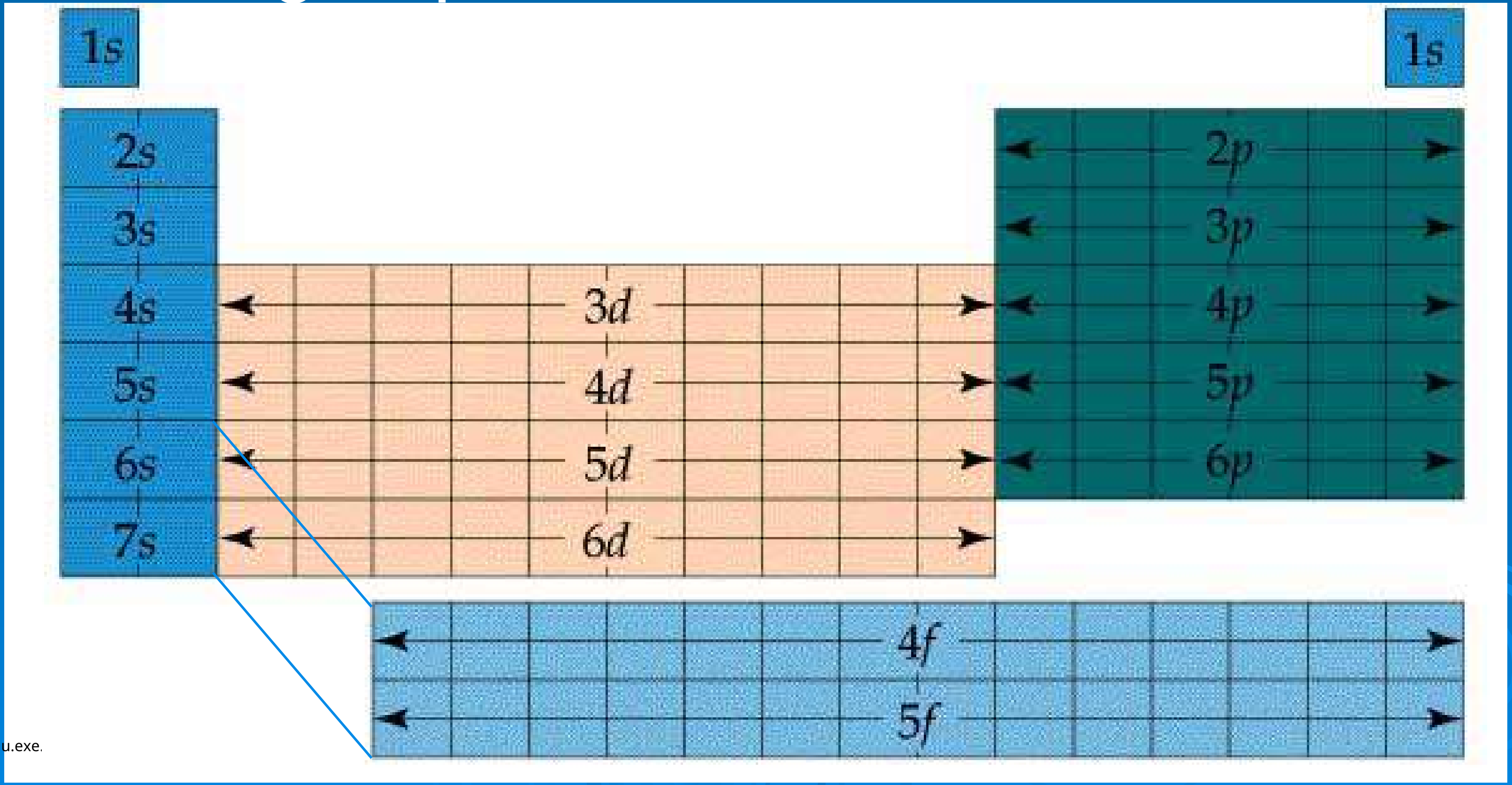
Filling _ rules.exe

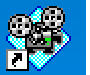
How do we know what the filling order is?

- What chemistry tool might we rely on?

Electron Configurations and the Periodic Table

- Valence electron configurations repeat down a group

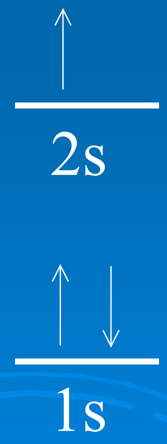




aufbau.exe

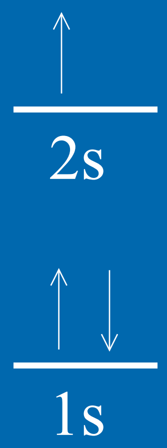
Ground state electron configurations

- Example: Li
  - atomic number = 3
  - nucleus has 3 protons
  - neutral atom has 3 electrons
    - 2 electrons in 1*s* orbital, 1 electron in 2*s* orbital

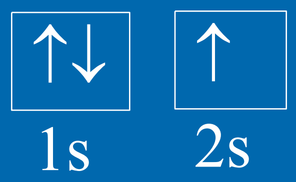


Different ways to show electron configuration

Energy level diagram



Box notation



Spectroscopic notation

Li $1s^2\ 2s^1$

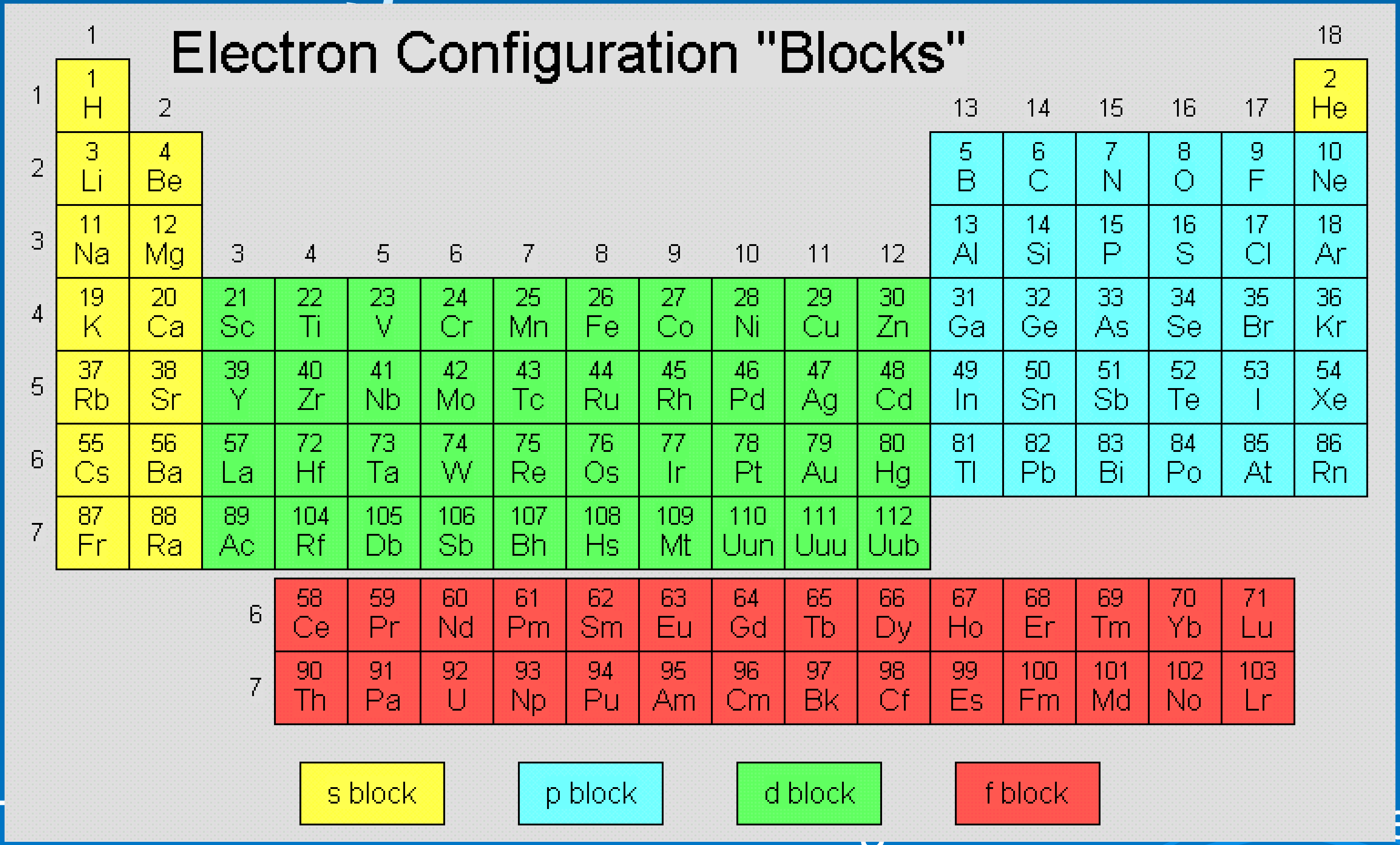
Read this "one s two" not "one s squared"

Write the superscript 1. Don't leave it blank

Practice

- Review
  - Refer to 3-3 Practice Worksheet
- Electron configuration worksheet

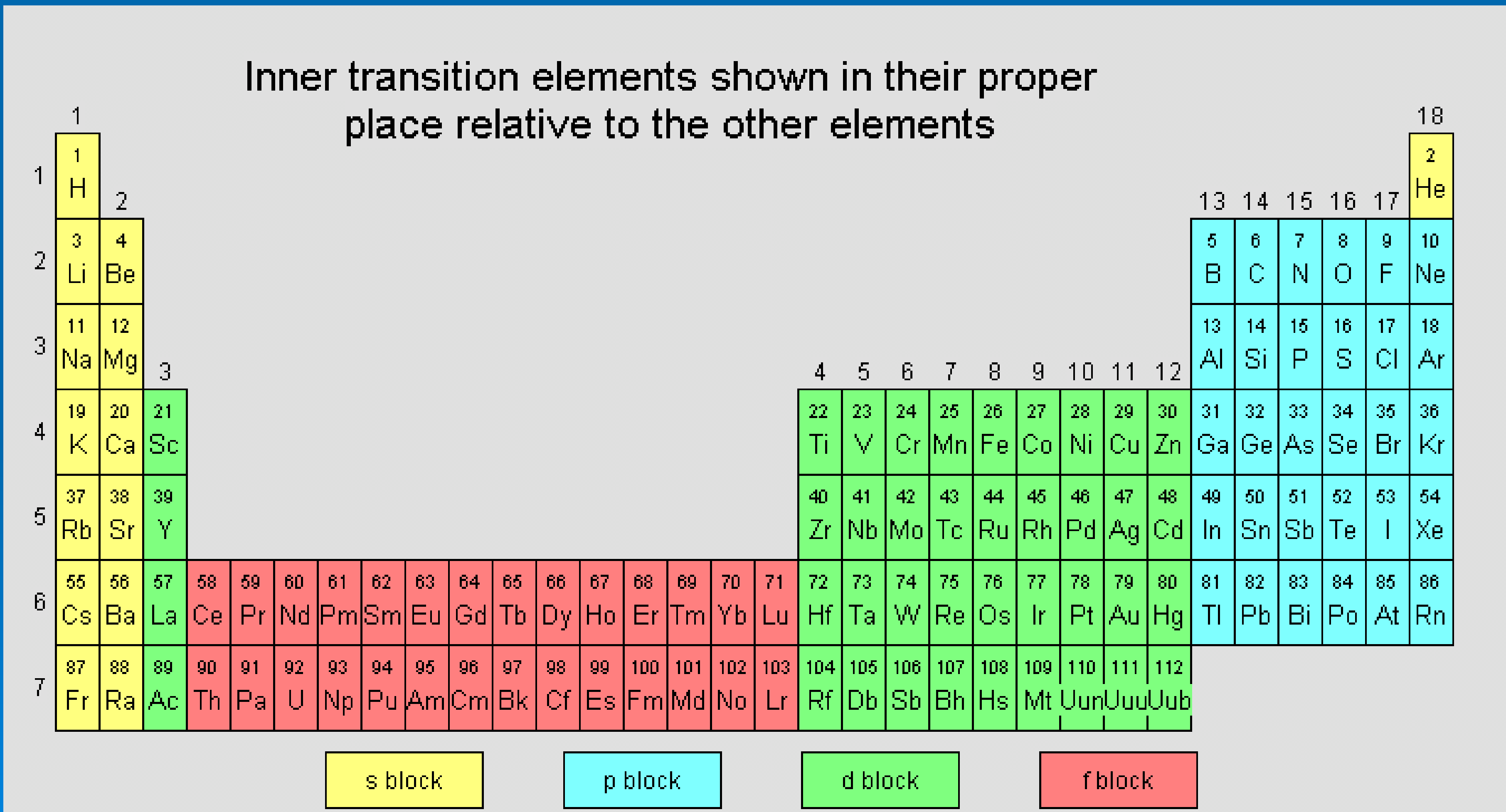
Using the Periodic Table



(row #) s(row # – 1) d

(row #) p(row # – 2) f

The f-block is inserted into to the d-block



Electron configuration of O

- Atomic number of O = 8 so neutral atom has 8 e^-

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sb	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub						
			58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
			90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

Electron configuration of Co

- Atomic number of Co = 27 so neutral atom has 27 e⁻

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sb	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub						
			58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu	
			90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr	

Closure

- Write the electron configuration:
  - Aluminum
  - Copper