Electron Configuration
(Section 5.2)

Dr. Walker

Objectives

- To determine the electron configuration of any of the first 38 elements of the periodic table
- To determine the identity of an element from its electron configuration
- To complete an orbital diagram using arrows to represent electrons

Where are Electrons?

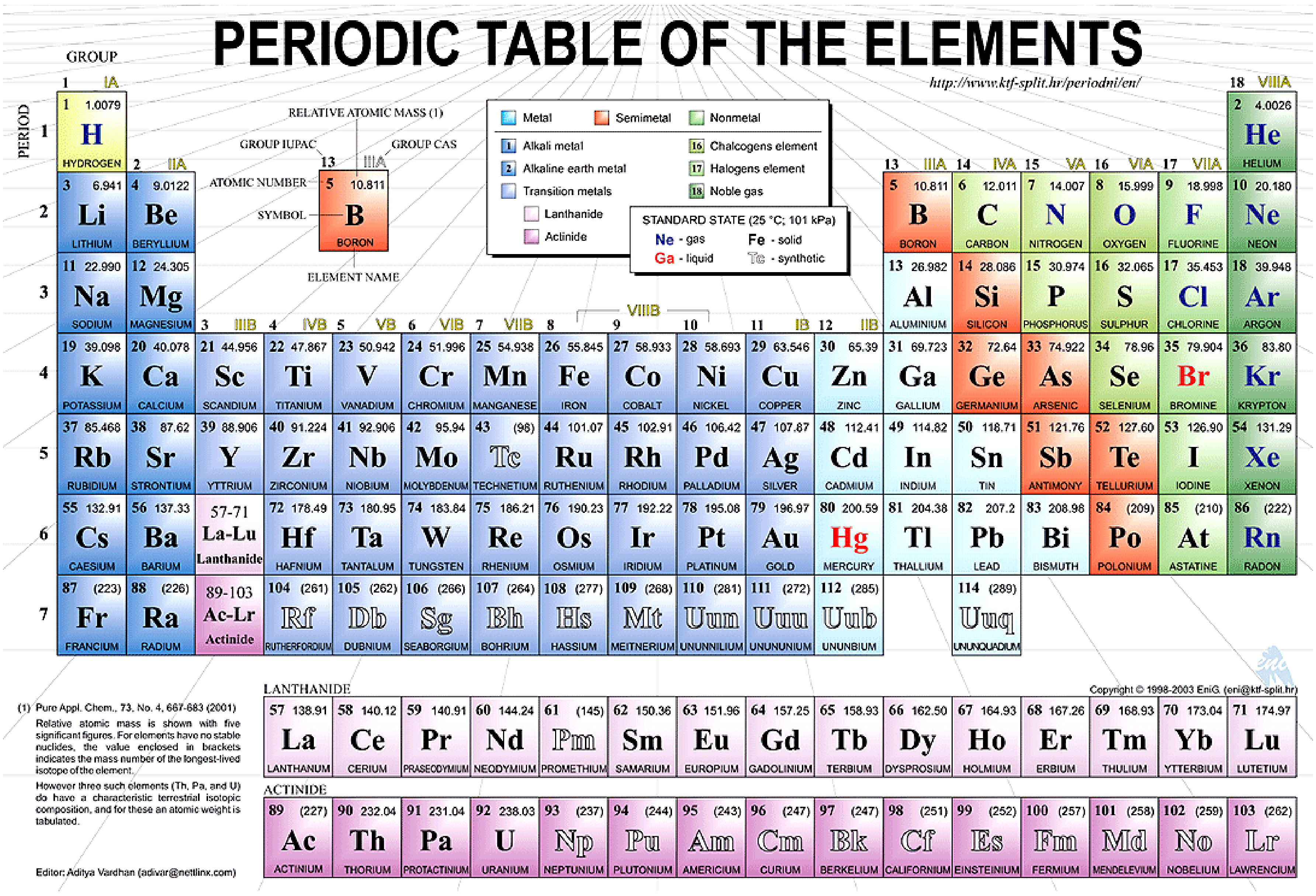
- Electrons exist in different energy levels (previously described as “shells”)
- The energy levels correspond to the horizontal rows on the periodic table

Where are Electrons?

- **Orbitals** are areas within shells where the electrons are located
  - These orbitals may have different shapes
  - There may be different numbers of orbitals within a shell

- We know the electron is somewhere in the orbital, but we can’t know exactly where it is or how fast it is moving
  - Heisenberg’s Uncertainty Principle

- **Each orbital can hold two electrons (Pauli Exclusion Principle)**



PERIODIC TABLE OF THE ELEMENTS

http://www.ktf-split.hr/periodni/en/

RELATIVE ATOMIC MASS (1)
GROUP IUPAC
GROUP CAS
13 IIIA
ATOMIC NUMBER
SYMBOL
5 10.811
B
BORON
ELEMENT NAME

- 🟦 Metal
- 🟥 Semimetal
- 🟩 Nonmetal
- 1 Alkali metal
- 2 Alkaline earth metal
- Transition metals
- Lanthanide
- Actinide
- 16 Chalcogens element
- 17 Halogens element
- 18 Noble gas

STANDARD STATE (25 °C; 101 kPa)
Ne - gas
Fe - solid
Ga - liquid
Tc - synthetic

PERIOD / GROUP	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 1.0079 H HYDROGEN																	2 4.0026 He HELIUM
2	3 6.941 Li LITHIUM	4 9.0122 Be BERYLLIUM											5 10.811 B BORON	6 12.011 C CARBON	7 14.007 N NITROGEN	8 15.999 O OXYGEN	9 18.998 F FLUORINE	10 20.180 Ne NEON
3	11 22.990 Na SODIUM	12 24.305 Mg MAGNESIUM											13 26.982 Al ALUMINIUM	14 28.086 Si SILICON	15 30.974 P PHOSPHORUS	16 32.065 S SULPHUR	17 35.453 Cl CHLORINE	18 39.948 Ar ARGON
4	19 39.098 K POTASSIUM	20 40.078 Ca CALCIUM	21 44.956 Sc SCANDIUM	22 47.867 Ti TITANIUM	23 50.942 V VANADIUM	24 51.996 Cr CHROMIUM	25 54.938 Mn MANGANESE	26 55.845 Fe IRON	27 58.933 Co COBALT	28 58.693 Ni NICKEL	29 63.546 Cu COPPER	30 65.39 Zn ZINC	31 69.723 Ga GALLIUM	32 72.64 Ge GERMANIUM	33 74.922 As ARSENIC	34 78.96 Se SELENIUM	35 79.904 Br BROMINE	36 83.80 Kr KRYPTON
5	37 85.468 Rb RUBIDIUM	38 87.62 Sr STRONTIUM	39 88.906 Y YTTRIUM	40 91.224 Zr ZIRCONIUM	41 92.906 Nb NIOBIUM	42 95.94 Mo MOLYBDENUM	43 (98) Tc TECHNETIUM	44 101.07 Ru RUTHENIUM	45 102.91 Rh RHODIUM	46 106.42 Pd PALLADIUM	47 107.87 Ag SILVER	48 112.41 Cd CADMIUM	49 114.82 In INDIUM	50 118.71 Sn TIN	51 121.76 Sb ANTIMONY	52 127.60 Te TELLURIUM	53 126.90 I IODINE	54 131.29 Xe XENON
6	55 132.91 Cs CAESIUM	56 137.33 Ba BARIUM	57-71 La-Lu Lanthanide	72 178.49 Hf HAFNIUM	73 180.95 Ta TANTALUM	74 183.84 W TUNGSTEN	75 186.21 Re RHENIUM	76 190.23 Os OSMIUM	77 192.22 Ir IRIDIUM	78 195.08 Pt PLATINUM	79 196.97 Au GOLD	80 200.59 Hg MERCURY	81 204.38 Tl THALLIUM	82 207.2 Pb LEAD	83 208.98 Bi BISMUTH	84 (209) Po POLONIUM	85 (210) At ASTATINE	86 (222) Rn RADON
7	87 (223) Fr FRANCIUM	88 (226) Ra RADIUM	89-103 Ac-Lr Actinide	104 (261) Rf RUTHERFORDIUM	105 (262) Db DUBNIUM	106 (266) Sg SEABORGIUM	107 (264) Bh BOHRIUM	108 (277) Hs HASSIUM	109 (268) Mt MEITNERIUM	110 (281) Uun UNUNNILIUM	111 (272) Uuu UNUNUNIUM	112 (285) Uub UNUNBIUM		114 (289) Uuq UNUNQUADIUM				

LANTHANIDE

57 138.91 La LANTHANUM	58 140.12 Ce CERIUM	59 140.91 Pr PRASEODYMIUM	60 144.24 Nd NEODYMIUM	61 (145) Pm PROMETHIUM	62 150.36 Sm SAMARIUM	63 151.96 Eu EUROPIUM	64 157.25 Gd GADOLINIUM	65 158.93 Tb TERBIUM	66 162.50 Dy DYSPROSIUM	67 164.93 Ho HOLMIUM	68 167.26 Er ERBIUM	69 168.93 Tm THULIUM	70 173.04 Yb YTTERBIUM	71 174.97 Lu LUTETIUM

ACTINIDE

89 (227) Ac ACTINIUM	90 232.04 Th THORIUM	91 231.04 Pa PROTACTINIUM	92 238.03 U URANIUM	93 (237) Np NEPTUNIUM	94 (244) Pu PLUTONIUM	95 (243) Am AMERICIUM	96 (247) Cm CURIUM	97 (247) Bk BERKELIUM	98 (251) Cf CALIFORNIUM	99 (252) Es EINSTEINIUM	100 (257) Fm FERMIUM	101 (258) Md MENDELEVIUM	102 (259) No NOBELIUM	103 (262) Lr LAWRENCIUM

(1) Pure Appl. Chem., 73, No. 4, 667-683 (2001)
Relative atomic mass is shown with five significant figures. For elements have no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element.

However three such elements (Th, Pa, and U) do have a characteristic terrestrial isotopic composition, and for these an atomic weight is tabulated.

Editor: Aditya Vardhan (adivar@nettlinx.com)

Learning Check

- What are orbitals?

- Where are orbitals?

- How many electrons reside in each orbital?

Learning Check

- What are orbitals? A place where electrons can be found

- Where are orbitals? Outside the nucleus

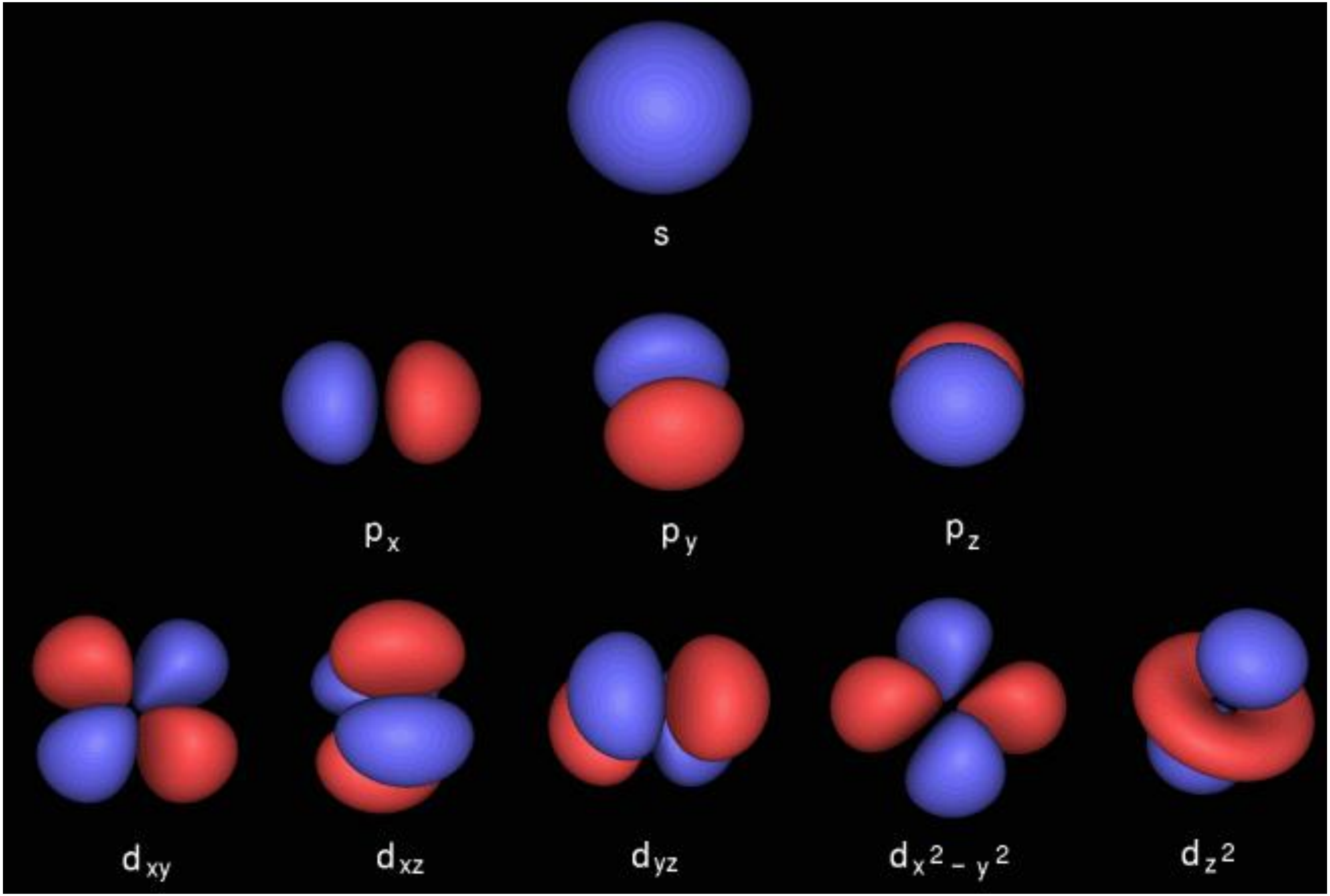
- How many electrons reside in each orbital? 2

Types of Orbitals (subshells)

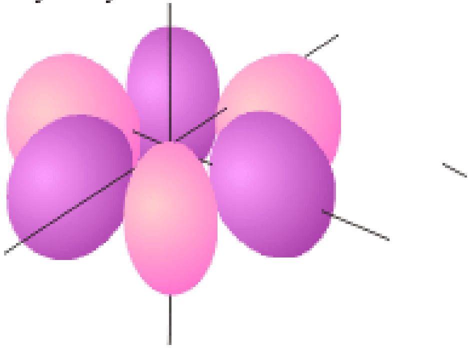
- S orbitals – 1 orbital per shell – holds ___ electrons total
- P orbitals – 3 orbitals per shell – holds ___ electrons total
- D orbitals – 5 orbitals per shell – holds ___ electrons total
- F orbitals – 7 orbitals per shell – holds ___ electrons total

Types of Orbitals (subshells)

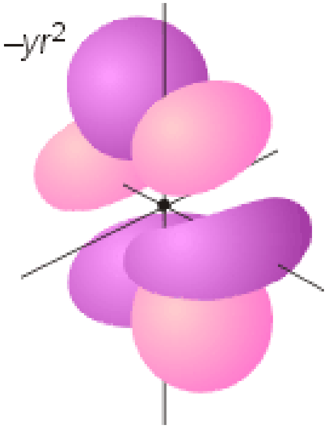
- S orbitals – 1 orbital per shell – holds **2** electrons total
- P orbitals – 3 orbitals per shell – holds **6** electrons total
- D orbitals – 5 orbitals per shell – holds **10** electrons total
- F orbitals – 7 orbitals per shell – holds **14** electrons total


s
p_x
p_y
p_z
d_{xy}
d_{xz}
d_{yz}
$d_{x^2-y^2}$
d_{z^2}

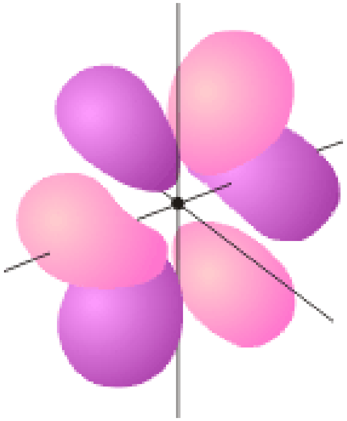
$4f_{y^3-3yx^2}$



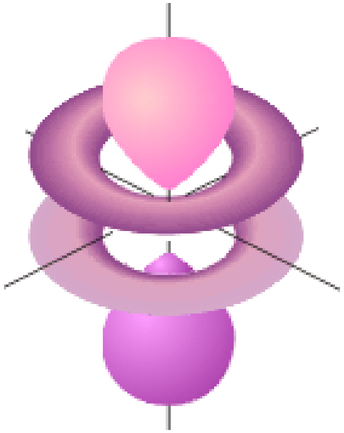
$4f_{5yz^2-yr^2}$



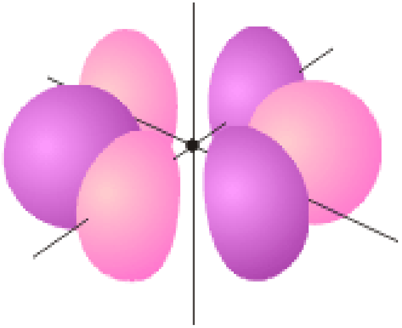
$4f_{5xz^2-3xr^2}$



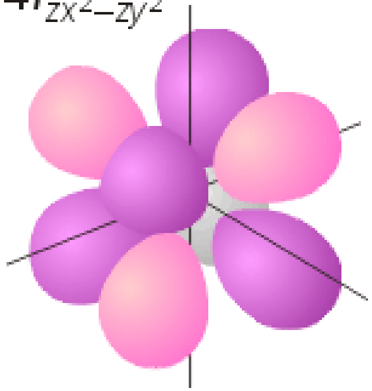
$4f_{5z^3-3zr^2}$



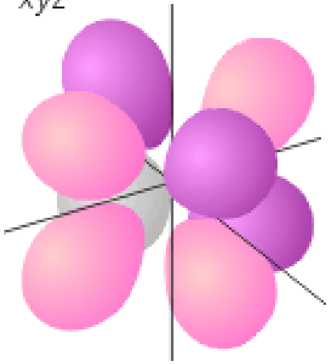
$4f_{x^3-3xy^2}$



$4f_{zx^2-zy^2}$



$4f_{xyz}$



Electron Configuration

- Defined
  - – Electron configuration is the arrangement of electrons around the nucleus of an atom based on their energy level.

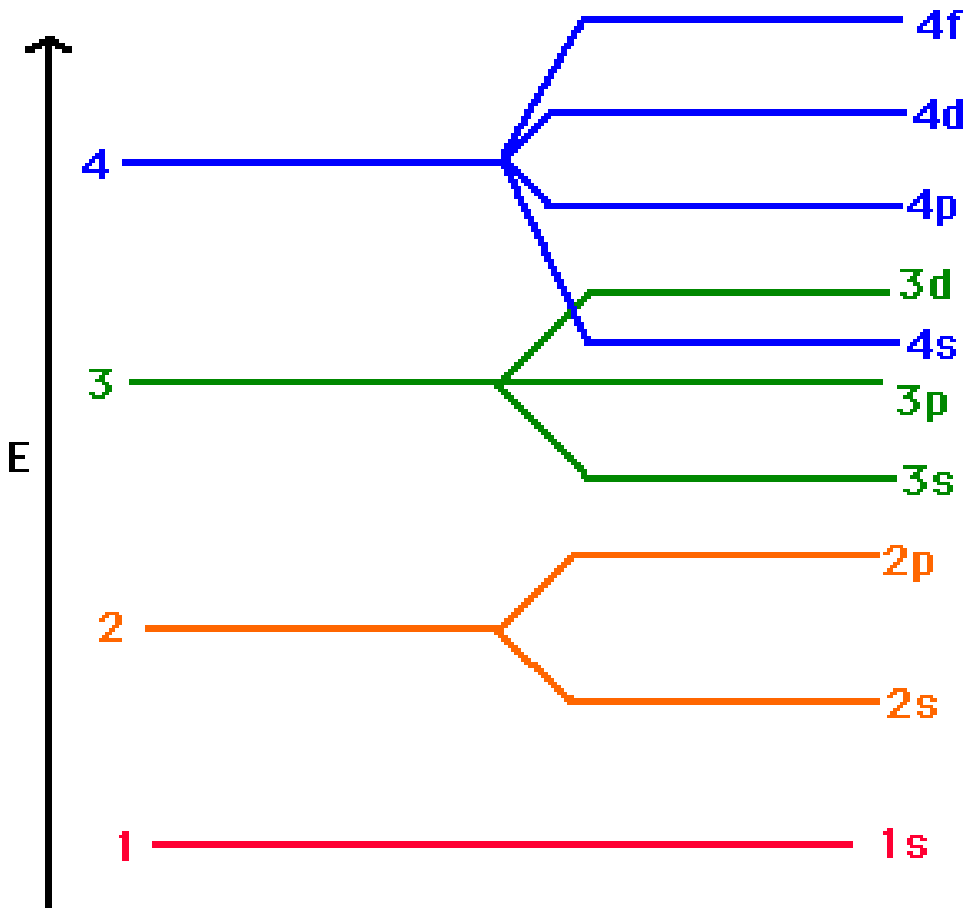
Actual Electron Configurations

- Total electrons = atomic number
- Electrons are added one at a time to the lowest energy levels first (Aufbau principle)
- Fill energy levels with electrons until you run out
- A superscript states how many electrons are in each level

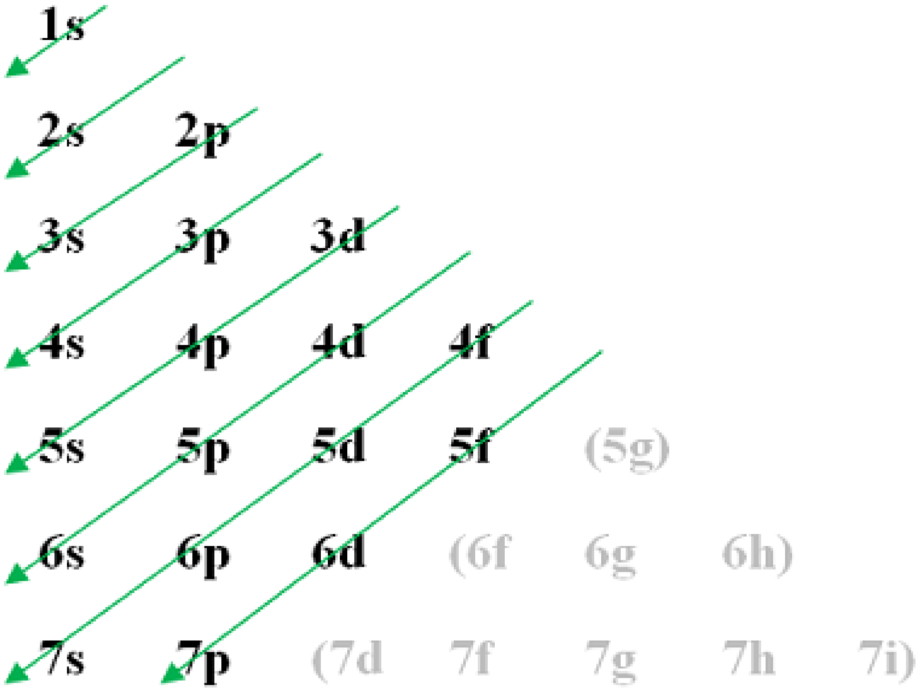
Order of Orbitals

- Low Energy to High Energy (# of electrons)
  - 1s (2)
  - 2s (2)
  - 2p (6)
  - 3s (2)
  - 3p (6)
  - 4s (2)
  - 3d (10)
  - 4 p (6)
  - 5s (2)
  - Continues for the whole periodic table
  - You’re expected to know through here

Making Sense of the Order



Another option



- Draw the orbitals in this format, use diagonal lines to determine order of orbitals to fill

Actual Electron Configurations

- Total electrons = atomic number
- Fill energy levels with electrons until you run out
- A superscript states how many electrons are in each level
  - **Hydrogen – $1s^1$ – 1 electron total**
  - **Helium – $1s^2$ – 2 electrons total**
  - **Lithium – $1s^2 2s^1$ – 3 electrons total**
  - **Beryllium – $1s^2 2s^2$ – 4 electrons total**

Write all

Actual Electron Configurations

- Bigger Elements
  - Fill the energy levels until you run out of electrons
  - Oxygen
  - Sodium
  - Titanium

Actual Electron Configurations

- Bigger Elements
  - Fill the energy levels until you run out of electrons

  - Oxygen
    - $1s^2 2s^2 2p^4$
  - Sodium
    - $1s^2 2s^2 2p^6 3s^1$
  - Titanium
    - $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$

Practice

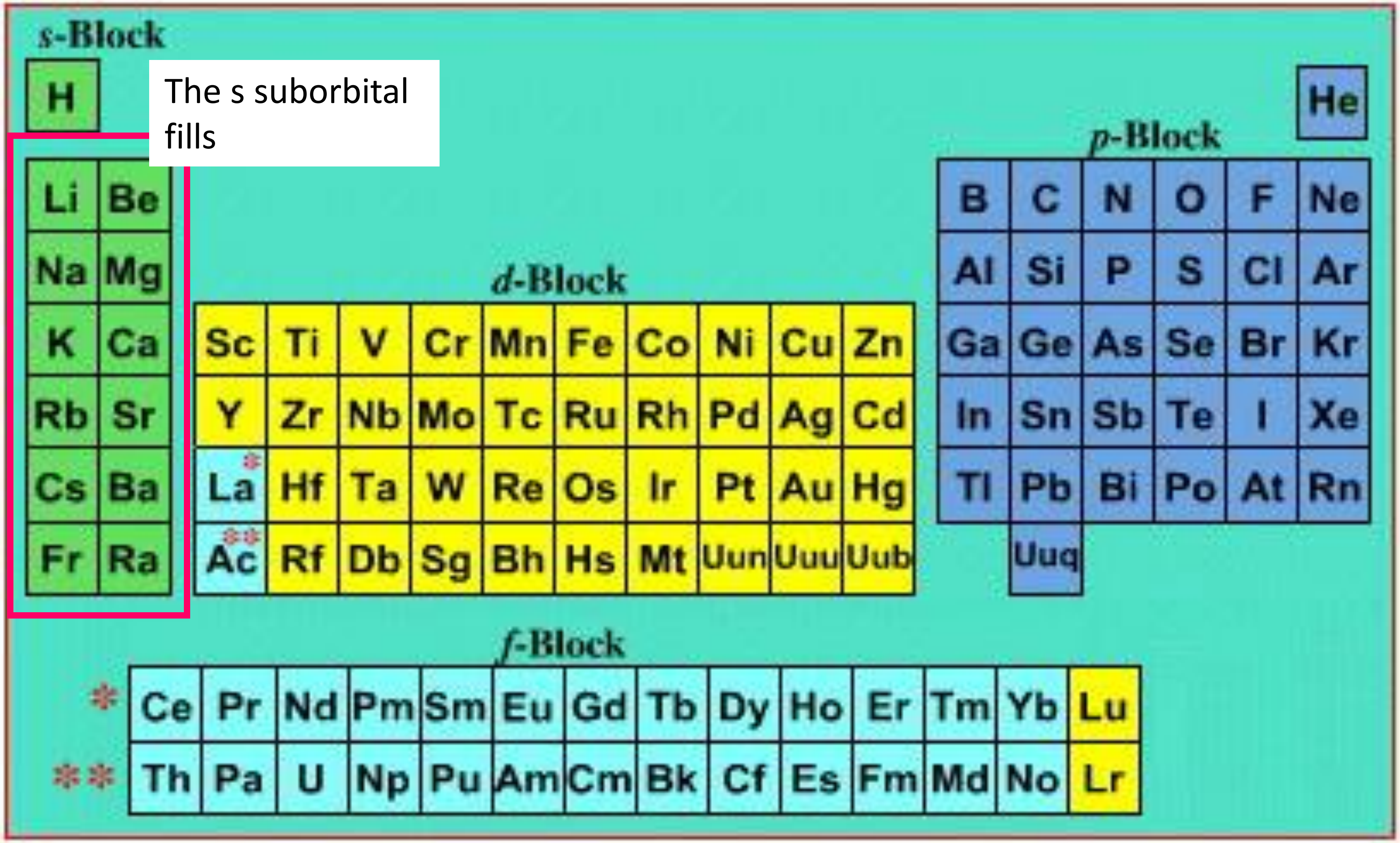
- Potassium

Practice

- Potassium
  - Atomic Number = 19
  - $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

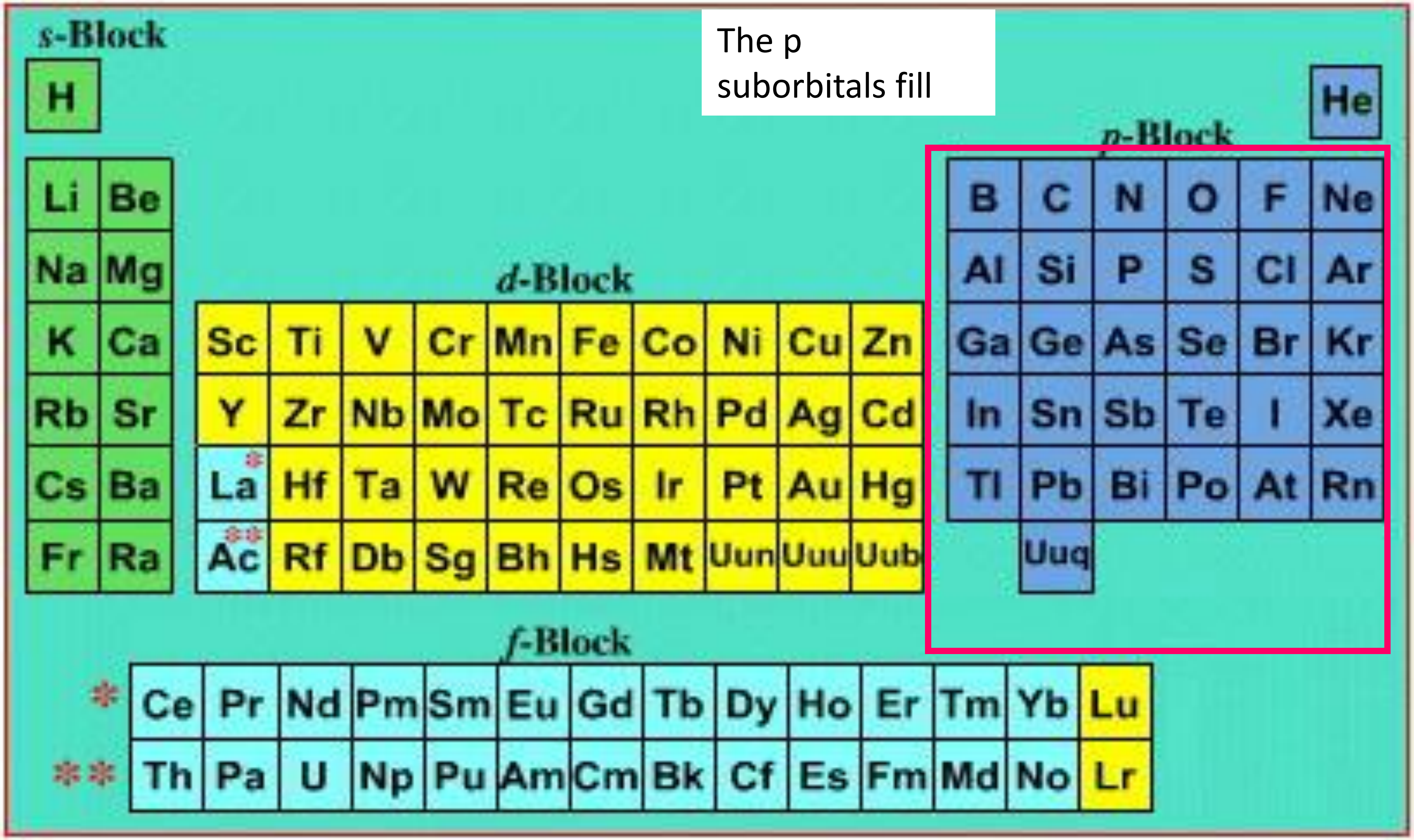
  - Superscripts add up to atomic number

The orbitals and the periodic table



The s suborbital fills

The orbitals and the periodic table

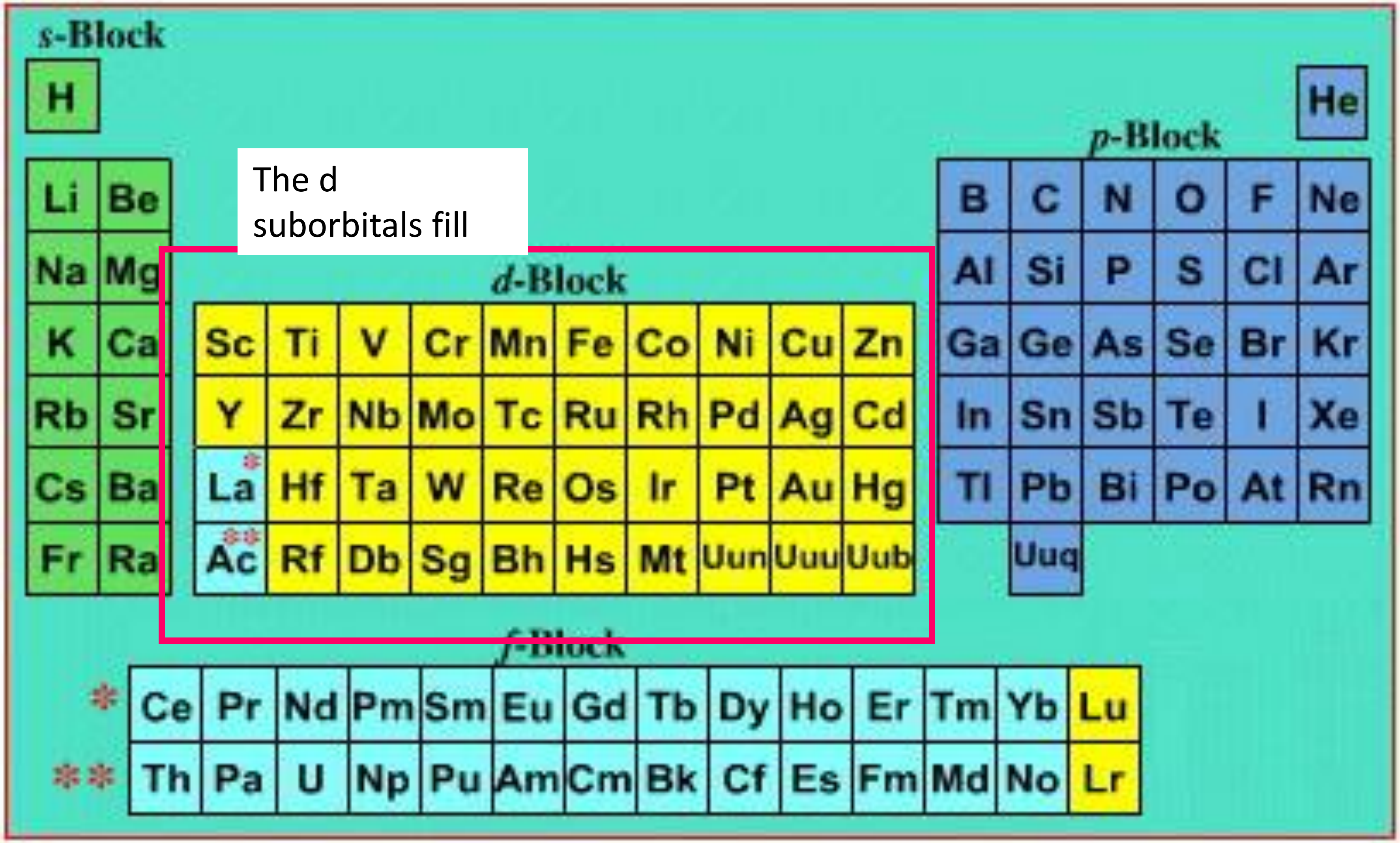


The p suborbitals fill

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La *	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac **	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub		Uuq				

*	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
**	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

The orbitals and the periodic table

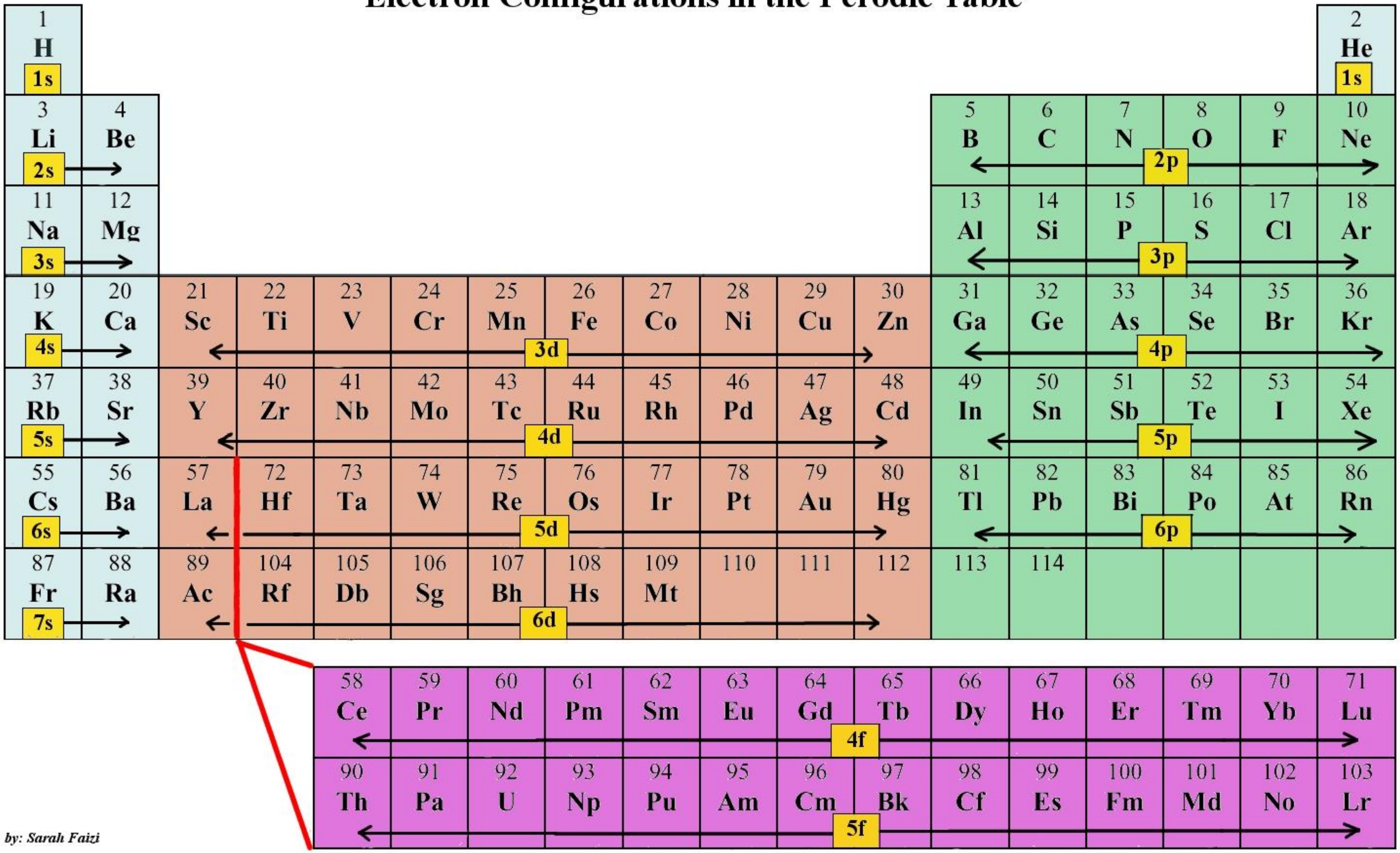


The d suborbitals fill

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac**	Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub		Uuq				

*	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
**	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Electron Configurations in the Perodic Table



1 H 1s																	2 He 1s
3 Li 2s	4 Be											5 B	6 C	7 N 2p	8 O	9 F	10 Ne
11 Na 3s	12 Mg											13 Al	14 Si	15 P 3p	16 S	17 Cl	18 Ar
19 K 4s	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn 3d	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As 4p	34 Se	35 Br	36 Kr
37 Rb 5s	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc 4d	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb 5p	52 Te	53 I	54 Xe
55 Cs 6s	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re 5d	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi 6p	84 Po	85 At	86 Rn
87 Fr 7s	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh 6d	108 Hs	109 Mt	110	111	112	113	114				
				58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd 4f	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 5f	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

by: Sarah Faizi

Shorthand

- Shorter form of electron configuration

- [Ne] = $1s^2 2s^2 2p^6$
- [Ar] = $1s^2 2s^2 2p^6 3s^2 3p^6$

- Potassium
  - Atomic Number = 19
  - $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
  - [Ar]$4s^1$

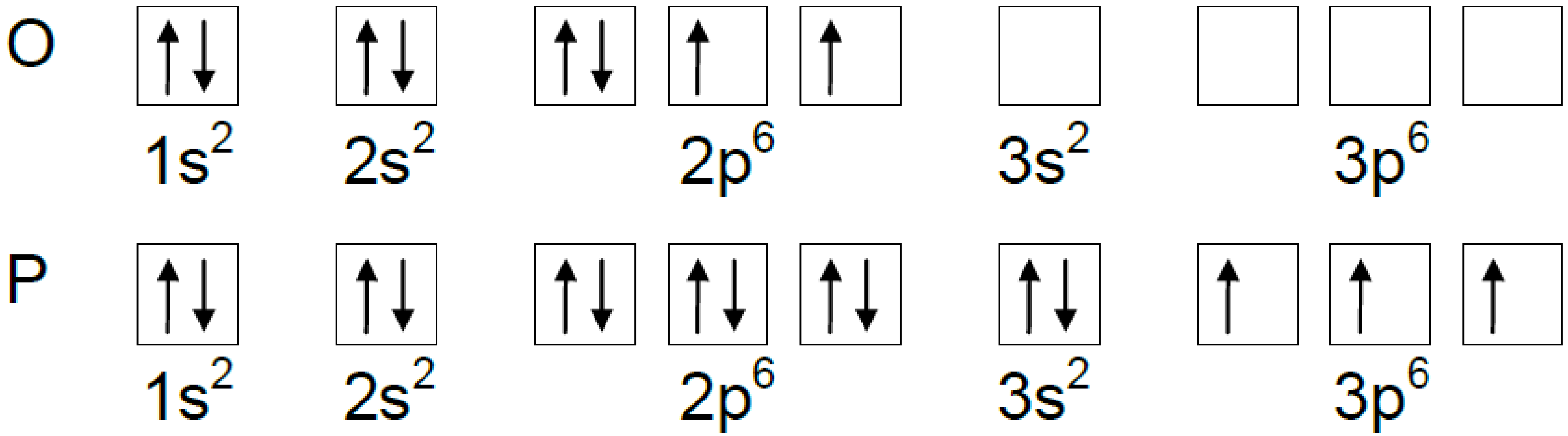
Pauli Exclusion Principle

- Two electrons in same orbital have different spins

Orbital Diagrams

❑ ***Orbital Diagrams***

…show spins of e^- and which orbital each is in



-Each electron is an arrow

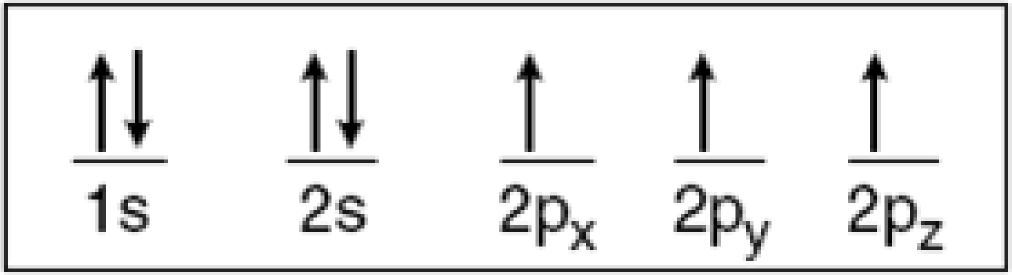
-They have opposing “spins” – think of two bar magnets together

-Orbital diagrams are visual representations of electron configuration

Hund's Rule

- When electrons are filling orbitals of the same energy, they prefer to enter empty orbitals first. These electrons all have the same spin

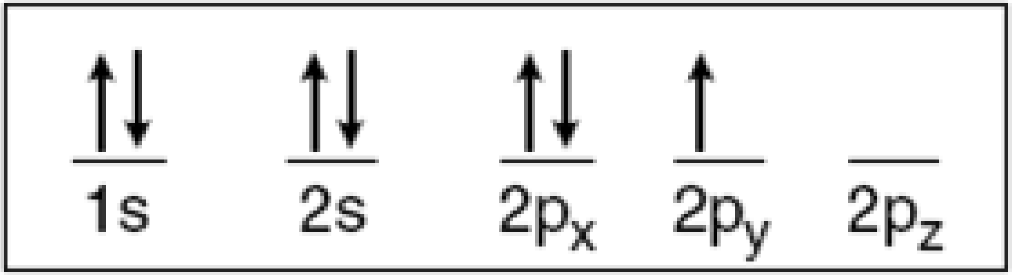
- A diagram of nitrogen is shown below (7 total electrons)



Benchmark Alert!!

Hund’s Rule

- The orbital diagram below violates Hund’s rule because the third electron does not enter the empty 2p orbital



Benchmark Alert!!!

Terms to Know & Skills to Master

- Terms
  - Orbitals
  - Hund’s Rule
  - Aufbau principle
  - Pauli Exclusion principle
- Skills
  - Determining electron configuration from number of electrons
  - Determining the identity of an element from its electron configuration
  - Completing orbital diagrams using arrows to represent electrons