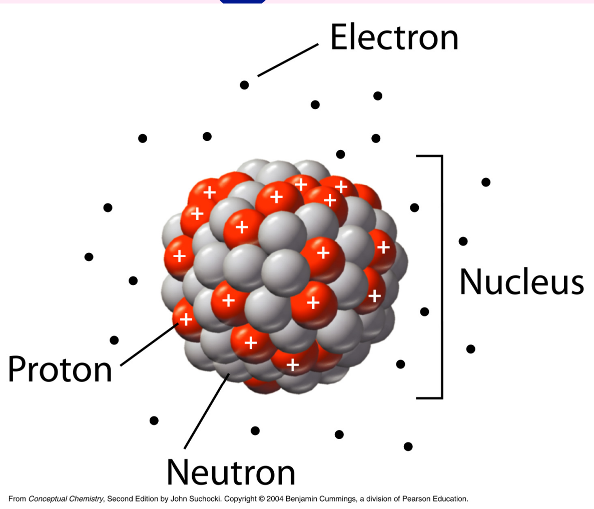
What's Inside the Atom?

This may be review for some of you.

- A neutron goes into a restaurant and asks the waiter…
- The waiter replies…

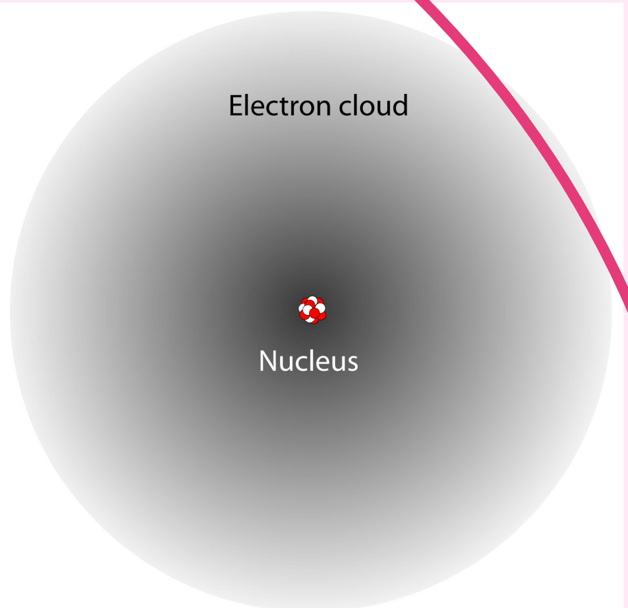
What's wrong with this diagram?



- This diagram is very misleading because it shows the nucleus to be huge and the proton and neutron particles to be huge, and this is NOT true.
- The nucleus is very SMALL SIZE, but very LARGE MASS.
- Sub atomic particles - protons, neutrons, and electrons are SOOOooooo small that most scientists don't ever really worry about their size, although it is generally accepted that protons and neutrons are about 1/3 the size of an electron.
- While the electrons are small themselves, they take up LOTS of SPACE and have very LITTLE MASS.
- For instance, if we expanded an average atom to be the size of the room…

This is Better…

- This diagram is a bit better…
- But the size relationship demonstrated below is even better.



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grow even larger…

- The classroom analogy:
- Place a tiny atom in the center of our classroom and expand the atom − nucleus and electron cloud − proportionately.
- When the electron cloud (the atom) grows to be the size of the room,

nucleus

- the nucleus would be 1 mm in the center of the room.

and still larger…

- continue to proportionately expand this atom beyond the size of our classroom,
- when the electron cloud (the atom) grows to be the size of Fenway Park,
- the nucleus would be a baseball in the center of the stadium

nucleus

What about the Mass of these Particles?

- You certainly do NOT need to know the table below.
- But you should realize that while all three particles are unbelievably lightweight…
- Protons and neutrons are VERY heavy compared to the electrons - approximately 2000 times heavier.

Subatomic Particles

	Particle	Charge	Relative Mass	Actual Mass* (kg)
	Electron	-1	1	9.11×10^{-31} **
Nucleons	Proton	$+1$	1836	1.673×10^{-27}
	Neutron	0	1841	1.675×10^{-27}

In Summary: Size vs Mass

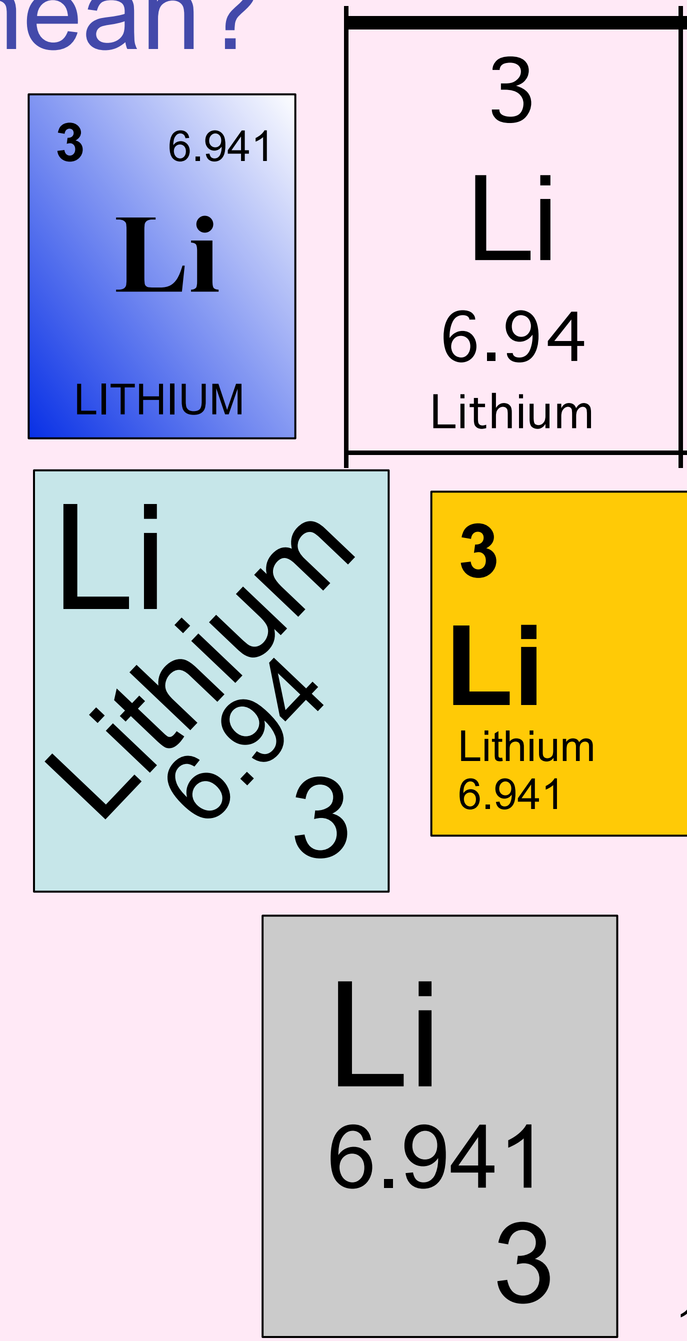
- The protons and neutrons inside the nucleus are very small in size themselves and take up VERY LITTLE SPACE as a group, but they are VERY HEAVY.
- The electrons outside the nucleus are VERY LIGHTWEIGHT, and while they are very small particles individually, together they take up MOST OF THE SPACE within the atom.

Navigating the Periodic Table

Chapter 3

What do the numbers mean?

- **Atomic number (Z)**
  - » number of protons = number of electrons for an atom
- **Atomic mass**
  - » average mass of all the isotopes
- **Mass number (A)**
  - » Atomic mass rounded to the nearest whole number
  - » sum of protons + neutrons



Information in the Periodic Table

- All elements are identified by their atomic number.
  - ✓ For an *atom*, atomic number tells us the # of protons = # of electrons.
- The other number is the average atomic mass.
  - ✓ It is the average mass in grams of a very large bunch of atoms, a *mole* of atoms.
  - ✓ When rounded to the nearest whole number atomic mass becomes the mass number.
  - ✓ The mass # = protons + neutrons.
  - ✓ Thus mass # - atomic # = neutrons.

3
Li
Lithium
6.941

$$\begin{array}{rl} 7 & \\ -\;3 & \mathrm{Li} \\ \hline 4 & \end{array}$$

Atoms vs Ions

- For an ***atom***, atomic number tells us the # of protons = # of electrons.
- Since electrons are on the outside, electrons can come & go forming ***ions***.
- An atom that gains electrons becomes negatively charged, an anion.
  - ✓ Nonmetals gain electrons

F^-

9
F
Fluorine
19.00

- An atom that loses electrons become positively charge, a cation.
  - ✓ Metals lose electrons

Li^+

3
Li
Lithium
6.941

The many ways you can symbolize an element to provide information:

mass number

$$^{A}_{Z}X$$

atomic number

$_3Li$ ^7Li lithium-7

$$\#X^{charge}_{\#}$$

number of unbonded atoms

number of atoms bonded together

Li^+ Li_2 $3Li$

Families and Periods

- What does the word periodic mean?
- Turn to your mate and come up with some “things” that happen periodically.
- Columns aka Groups aka Families *have similar chemical properties*
- Which is why we call this the “Periodic” Chart?

1A	2A	1B	2B	3B	4B	5B	6B	7B	8B	9B	10B	3A	4A	5A	6A	7A	8A
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	71 Lu	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	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Uuu	112 Uub	113 Uut	114 Uuq		116 Uuh		118 Uuo

1C	2C	3C	4C	5C	6C	7C	8C	9C	10C	11C	12C	13C	14C
57 La	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
89 Ac	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

Families and Periods

- Rows aka Periods

1A	2A																8A
1 H																	2 He
												3A	4A	5A	6A	7A	
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	1B	2B	3B	4B	5B	6B	7B	8B	9B	10B	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	71 Lu	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	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Uuu	112 Uub	113 Uut	114 Uuq		116 Uuh		118 Uuo

1C	2C	3C	4C	5C	6C	7C	8C	9C	10C	11C	12C	13C	14C
57 La	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
89 Ac	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

Metals vs Nonmetals

- Metals - the properties of metals
- Nonmetals - properites different from metals

Metals
conduct electricity
are shiny
excellent heat conductors
malleable & ductile

1A	2A	1B	2B	3B	4B	5B	6B	7B	8B	9B	10B	3A	4A	5A	6A	7A	8A
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
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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	71 Lu	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
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1C	2C	3C	4C	5C	6C	7C	8C	9C	10C	11C	12C	13C	14C
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89 Ac	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

Metal families you should be friends with

- Alkali Metals (very, very reactive)
- Alkaline Earth Metals (quite reactive)
- Transition Metals

1A	2A	1B	2B	3B	4B	5B	6B	7B	8B	9B	10B	3A	4A	5A	6A	7A	8A
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	71 Lu	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	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Uuu	112 Uub	113 Uut	114 Uuq		116 Uuh		118 Uuo

1C	2C	3C	4C	5C	6C	7C	8C	9C	10C	11C	12C	13C	14C
57 La	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
89 Ac	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

Nonmetal families you should be friends with

- Halogens
- Noble Gases aka Inert Gases (Unreactive)

1A	2A	1B	2B	3B	4B	5B	6B	7B	8B	9B	10B	3A	4A	5A	6A	7A	8A
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	71 Lu	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
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1C	2C	3C	4C	5C	6C	7C	8C	9C	10C	11C	12C	13C	14C
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89 Ac	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

Protons Neutrons Electrons

What does the periodic table tell us?

Determine the number of protons, electrons, and neutrons in an *atom* of Vanadium. ${}_{23}V$

- protons, neutrons, electrons.

1. 50p, 50n, 23e
2. 23p, 27n, 28e
3. 23p, 51n, 23e
4. 23p, 28n, 23e
5. 23p, 28n, 28e

- protons, neutrons, electrons.

6. 50p, 28n, 23e
7. 50p, 23n, 50e
8. 23p, 28n, 50e
9. 23p, 27.94n, 28e

Determine the number of protons, neutrons, and electrons in an atom of Vanadium. $_{23}V$

4. 23p, 28n, 23e

- Atomic number of V = 23
- Thus the number of protons = 23
- For the most common isotope, use the average mass = 50.94 and round to the nearest whole number for the mass number = 51
- Thus the number of neutrons is 51 - 23 = 28
- Since the symbol represents an atom, and atoms are neutral, the protons = electrons
- The number of electrons = 23

Determine the number of protons, electrons, and neutrons in $^{63}Zn^{2+}$

- protons, neutrons, electrons.

1. 30p, 33n, 30e
2. 30p, 35n, 28e
3. 30p, 35n, 30e
4. 30p, 33n, 28e
5. 30p, 63n, 30e

- protons, neutrons, electrons.

6. 30p, 63n, 28e
7. 30p, 33n, 2e
8. 30p, 33n, 32e
9. 32p, 31n, 30e

Determine the number of protons, neutrons, and electrons in $^{63}Zn^{+2}$

4. 30p, 33n, 28e

- Atomic number of Zn = 30
- Thus protons = 30
- $^{63}Zn^{+2}$ Isotope mass number = 63
- Thus neutrons is 63 - 30 = 33
- $^{63}Zn^{+2}$ +2 indicates a cation which is an atom that has lost 2 electrons
- Thus electrons is 30 - 2 = 28

What element is represented by

$_{4}X \quad (_{4}?)$

1. Xe
2. He
3. Be
4. can not be determined without more info.

What element is represented by

$_{4}Be$

1. Xenon
2. Helium
3. Beryllium - 4 is the atomic number which identifies an element.
4. can not be determined without more info.

What is an ion?

(select all that apply per this course)

1. A different compound
2. An atom that has lost protons
3. An atom that has gained protons
4. An atom that has lost electrons
5. An atom that has gained electrons
6. An atom with a different number of neutrons.
7. A charged particle

What is an ion?

1. A different
2. An atom that has lost protons
3. An atom that has gained protons
4. An atom that has lost electrons
    - lose e−, becoming a + ion, cation
5. An atom that has gained electrons
    - gain e−, becoming a - ion, anion
6. An atom with a different number of neutrons.
7. A charged particle

Determine the number of protons, electrons, and neutrons in an *ion* of chlorine. $_{17}Cl^{-}$ called chloride ion

- protons, neutrons, electrons.

1. 17p, 18.45n, 18e
2. 17p, 18.45n, 17e
3. 35p, 17n, 18e
4. 35p, 17n, 35e
5. 17p, 35n, 18e

- protons, neutrons, electrons.

6. 17p, 35.45n, 18e
7. 17p, 35.45n, 17e
8. 17p, 18n, 18e
9. 17p, 35n, 17e

Determine the number of protons, electrons, and neutrons in an *ion* of chlorine. $_{17}Cl^{-}$ called chloride ion

- protons, neutrons, electrons.
- protons, neutrons, electrons.

1. 17p, 18.45n, 18e
2. 17p, 18.45n, 17e
3. 35p, 17n, 18e
4. 35p, 17n, 35e
5. 17p, 35n, 18e
6. 17p, 35.45n, 18e
7. 17p, 35.45n, 17e
8. 17p, 18n, 18e
9. 17p, 35n, 17e

What element is represented by ^{40}X

1. zirconium
2. argon
3. potassium
4. calcium
5. xenon
6. can not be determined without more info.

What element is represented by ^{40}X

1. zirconium
2. argon
3. potassium
4. calcium
5. can not be determined without more info.

- The mass number (40) can not *definitively* identify an element.
- It can identify the "hood" but not the exact element.

Isotopes

Atomic Siblings

Same Number of Protons/Electrons

Different Number of Neutrons,

thus different masses

Understanding Weighted Averages

In Mr Daudelin’s Physics class, all 33 of the students ended up with only three different test grades: 90, 80, or 70. Determine the class average.

1. 90
2. 85
3. 80
4. 75
5. 70
6. impossible to determine

In Mr Daudelin's Physics class, all 33 of the students ended up with only three different test grades: 90, 80, or 70. Determine the class average.

1. 90
2. 85
3. 80
4. 75
5. 70
6. impossible to determine

- You would need to know how many students get each grade.

In Ms Hilfinger's Physics class, all 20 of the students ended up with only three different test grades: 90, 80, or 70 as shown in the chart below. Determine the class average.

1. 90
2. 85
3. 80
4. 75
5. 70
6. impossible to determine

grade	# of students receiving grade
90	12
80	6
70	2

In Ms Hilfinger's Physics class, all 20 of the students ended up with only three different test grades: 90, 80, or 70 as shown in the chart below. Determine the class average.

1. 90
2. 85
3. 80
4. 75
5. 70
6. impossible to determine

$$\frac{[(90\times 12)+(80\times 6)+(70\times 2)]}{20}=85$$

$$[(90\times 0.6)+(80\times 0.3)+(70\times 0.1)]=85$$

grade	# of students receiving grade
90	12 (60%)
80	6 (30%)
70	2 (10%)

In Dr Ryan's AP Bio class, all of the students ended up with only three different test grades: 90, 80, or 70 as shown in the chart below. Determine the class average.

1. 90
2. 85
3. 80
4. 75
5. 70
6. impossible to determine

grade	% of students receiving grade
90	10%
80	30%
70	60%

In Dr Ryan's AP Bio class, all of the students ended up with only three different test grades: 90, 80, or 70 as shown in the chart below. Determine the class average.

grade	% of students receiving grade
90	10%
80	30%
70	60%

1. 90
2. 85
3. 80
4. 75
5. 70
6. impossible to determine

$$[(90 \times 0.1) + (80 \times 0.3) + (70 \times 0.6)] = 75$$

In Mr Fontaine's Anatomy class, all of the students ended up with only two different test grades: 90 and 70 as shown in the chart below.

The average is 74.

grade	% of students receiving grade
90	?
70	

Report the % (to nearest whole #) that scored 90

Type in zero if you think this is impossible to determine

In Mr Fontaine's Anatomy class, all of the students ended up with only two different test grades: 90 and 70 as shown in the chart below.
The average is 74.

grade	% of students receiving grade
90	?
70	

- Define either grade 90 as x OR grade 70 as x

$$90x + 70(1 - x) = 74 \qquad 90(1 - x) + 70x = 74$$

$$90x + 70 - 70x = 74 \qquad 90 - 90x + 70x = 74$$

$$20x = 4 \quad x = 0.2 \qquad -20x = -16 \quad x = 0.80$$

- thus 20% of the class scored 90, 80% of the class scored 70

See next slide for the two equation method →

In Mr Fontaine's Anatomy class, all of the students ended up with only two different test grades: 90 and 70 as shown in the chart below. The average is 74.

grade	% of students receiving grade
90	?
70	

$$90x + 70y = 74$$
$$x + y = 1$$

$$90x + 70y = 74$$
$$70x + 70y = 70$$

$$20x = 4$$
$$x = 0.2$$

$$90x + 70y = 74$$
$$x + y = 1$$

$$90x + 70y = 74$$
$$90x + 90y = 90$$

$$-20x = -16$$
$$x = 0.80$$

- thus 20% of the class scored 90, 80% of the class scored 70

Why is the molar mass an *Average* Mass?

- All atoms of a particular element have the same # of protons and electrons.
- However, the number of neutrons can vary from atom to atom of a particular element.
- Atoms of the same element (same number of protons) with different number of neutrons are called isotopes.
- Since neutrons along with protons create most of the mass of the atom, isotopes have different masses.
- The masses of the isotopes of an element are averaged to give the Average Atomic Mass.

Calculating a Weighted Average

- There are two isotopes of Chlorine
- ^{35}Cl and ^{37}Cl (^{35}Cl with 18 n and ^{37}Cl with 20 n)
- You'd think the average would be 36, but actually the average atomic mass is 35.5
- This is because in nature there is 75% ^{35}Cl and only 25% ^{37}Cl and the weighted average reflects these amounts thus ending up closer to the more abundant isotope.
- Here's how to do the math:
- $(35 \times 0.75) + (37 \times 0.25) = 35.5$
  - ✓ 26.25 + 9.25 = 35.5 (Look this up on Per Table)

Calculating Percentages from Isotopes

only for two isotopes

Calculating Percent Abundance

Working with Weighted Averages Backwards

- There are only two isotopes of copper
- ^{65}Cu and ^{63}Cu
- The Periodic Table tells you average atomic mass is 63.55
- You can calculate the % abundance
- name one of the fractions (% divided by 100) as x, the other fraction must be 1−x
- $65x + 63(1-x) = 63.55$
  - ✓ then solve for x = 0.275, thus 27.5% of copper is ^{65}Cu
  - ✓ and 72.5% of copper is ^{63}Cu

Determine the average atomic mass for a recently discovered element, Biggsium, Bg. Its isotopes are found in nature according to the chart below. Calculate the average atomic mass.

- Ignore sig figs right now, and report your answer to the nearest 10ths place.

isotope	% abundance
^{300}Bg	65%
^{303}Bg	30%
^{304}Bg	5%

Determine the average atomic mass for a recently discovered element, Biggsium, Bg. Its isotopes are found in nature according to the chart below. Calculate the average atomic mass.

- Report your answer to the nearest 10^{ths} place.

$$[(300 \times 0.65) + (303 \times 0.3) + (304 \times 0.05)] = 301.1$$

isotope	% abundance
^{300}Bg	65%
^{303}Bg	30%
^{304}Bg	5%

You would like to calculate the % abundance found in nature of the newly discovered element Maxogen, Mx. There are only two naturally occurring isotopes: ^{324}Mx and ^{327}Mx. The average atomic mass is 325.2

- Report the % number to the nearest 10^{ths} place for the isotope that occurs in highest quantity.
- Report just the # no need to put % on the end of number.

You would like to calculate the % abundance found in nature of the newly discovered element Maxogen, Mx. There are only two naturally occurring isotopes: ^{324}Mx and ^{327}Mx. The average atomic mass is 325.2

- Report the % to the nearest 10^{ths} place for the isotope that occurs in highest quantity.

$$324x + 327(1 - x) = 325.2$$

$$324x + 327 - 327x = 325.2$$

$$-3x = -1.8 \qquad x = 0.6$$

- 60% is the ^{324}Mx

Learning about Atoms

Using light (EMR) to poke.

How do you get to know people?

1. Look at them
2. Touch them
3. Listen to them
4. Read about them
5. Talk to them
6. Smell them

How can we get to know atoms?

1. We can’t see individual ones....
2. We can’t touch individual ones....
3. They won’t talk to us...
4. We can’t talk to them….
5. We can’t smell them

- We need to poke them with probes. We often use **light aka electromagnetic radiation**

NoteSheet F3

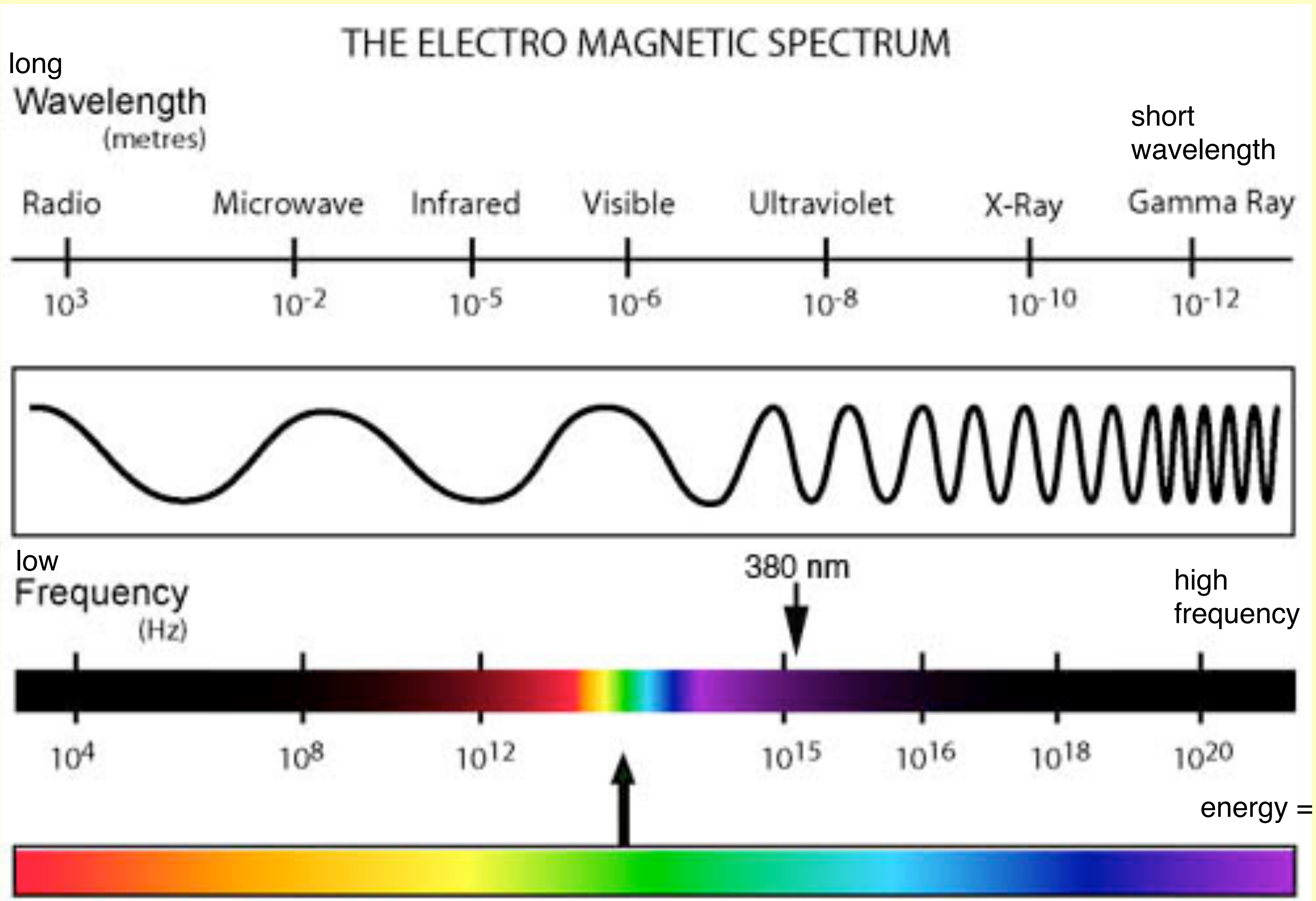
Lets Look at some good examples and some nonexamples of collaboration

Now Let's get into collaborative groups

How do we quantitatively describe light?

$$c = \lambda \nu$$

speed of light = wavelength x frequency



$$E = h\nu$$

energy = Planks constant x frequency

low energy high energy

How do we quantitatively describe light?

- All Electro Magnetic Radiation, EMR travels at the same speed, $c = 3 \times 10^8$ m/sec, 180,000 miles/sec
- Wavelength, λ
  - the distance between crests
- Energy, E
- Frequency, ν
  - The number of times a wave passes a particular point

Having read NoteSheet F3 and worked on Practice F3, Which light has the most energy?

1. Red
2. Orange
3. Yellow
4. Green
5. Blue
6. Purple

Having read NoteSheet F3 and worked on Practice F3, Which light has the most energy?

1. Red
2. Orange
3. Yellow
4. Green
5. Blue
6. Purple - most energy, highest frequency, shortest wavelength.

Which light has the longest wavelength?

1. Red
2. Orange
3. Yellow
4. Green
5. Blue

Which light has the longest wavelength?

1. Red
2. Orange
3. Yellow
4. Green
5. Blue

Which light has the least energy?

1. infrared
2. micro waves
3. green light
4. gamma
5. ultraviolet

Which light has the least energy?

1. infrared
2. micro waves
3. green light
4. gamma
5. ultraviolet

Which light has the highest frequency?

1. Red
2. Orange
3. Yellow
4. Green
5. Blue

Which light has the highest frequency?

1. Red
2. Orange
3. Yellow
4. Green
5. Blue

In a hydrogen atom, an electron undergoing the transition between which energy levels would *emit* the most energy?

1. 1 – 4
2. 3 - 2
3. 5 - 2
4. 1 - 2
5. 4 - 5
6. 4 - 1
7. 2 - 1

In a hydrogen atom, an electron undergoing the transition between which energy levels would emit the most energy?

1. 3 - 2
2. 5 - 2
3. 1 - 2
4. 4 - 5
5. 4 - 1
   - energy is emitted only for transitions from higher to lower energy levels.
   - transitions to the first energy level are always more energy than to other energy levels
6. 2 - 1

In a hydrogen atom, an electron undergoing which transition between energy levels would *emit* red light?

1. 3 - 2
2. 5 - 2
3. 1 - 2
4. 4 - 5
5. 4 - 1
6. 2 - 1
7. 2 - 3

In a hydrogen atom, an electron undergoing which transition between energy levels would emit red light?

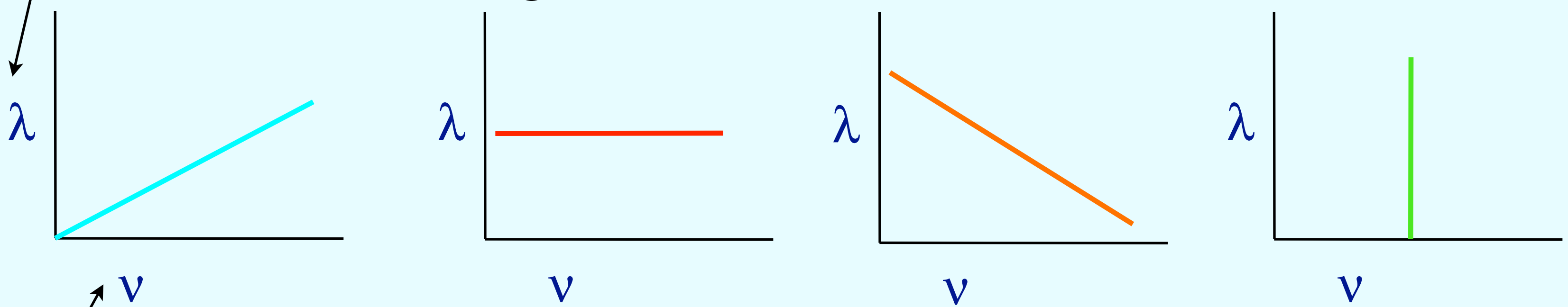
1. 3 - 2 Energy must be put in (absorbed) to excite and electron to a higher energy level, thus energy is emitted when the electron drops back to its ground state. The 3-2 transition is lower energy than the 4-2(teal color light) or 5-2 (violet color light) transition.

- All transitions to the 1st energy level are too high energy, and in the ultraviolet range.

2. 5 - 2
3. 1 - 2
4. 4 - 5
5. 4 - 1
6. 2 - 1

Which graph best represents the relationship between wavelength and frequency for “light” aka EMR (ElectroMagnetic Radiation)?

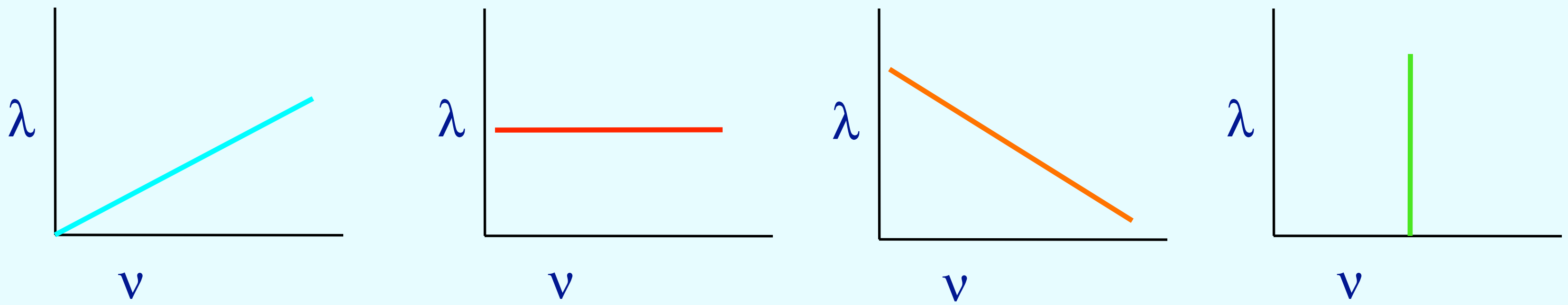
lamda, λ, wavelength



nu, ν, frequency physicists use *f*

1 2 3 4

Which graph best represents the relationship between wavelength and frequency?



A B C D

Wavelength (λ) and frequency (ν) are inversely related.

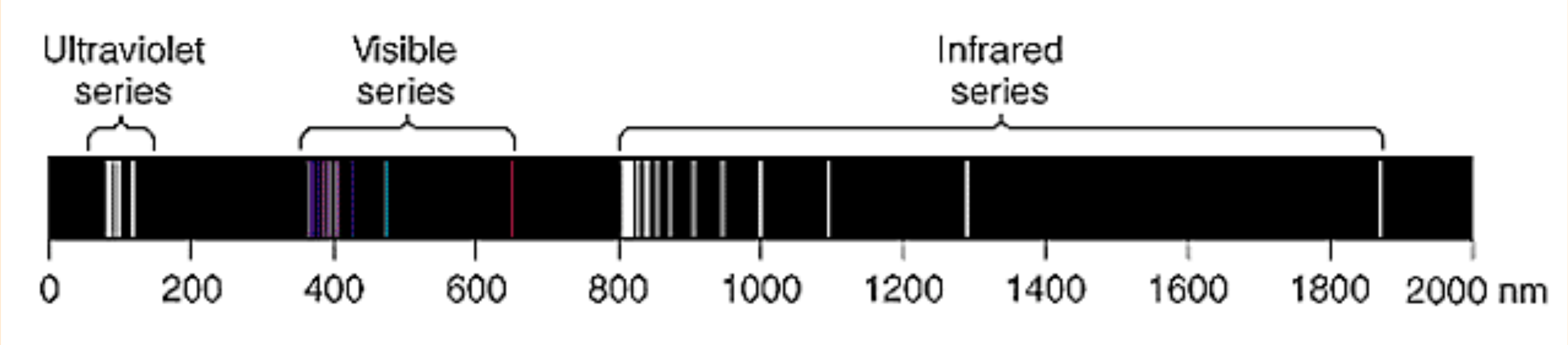
Niels Bohr’s model could not describe atoms bigger than helium.

Enter…

Schrodinger & Dirac with a new wave model.

1913 - Niels Bohr

- Hydrogen atoms were known to emit specific wavelengths of light after being excited.



- Focusing on the particle properties of electrons, Bohr constructed a quantum model to explain this emission phenomenon.
- He proposed that electrons orbited the nucleus at specific radii, also called energy levels.

You will not be tested on this background info.

Problems with the Bohr Model

- Electrons require specific (quantized) amounts of energy to move from one lower energy level to higher, then emitt specific quantity of energy when returning the ground-state energy levels.
- Bohr’s model predicted that electrons were more tightly bound when they were closer to the nucleus, and that atoms emitted energy when electrons dropped energy levels, energy would be released.
- With a lot of assumptions and adjustments, the Bohr Model fit the one-electron hydrogen atom pretty well, but failed for all other atoms.
- It was soon recognized that it was fundamentally wrong, and a new approach was needed.

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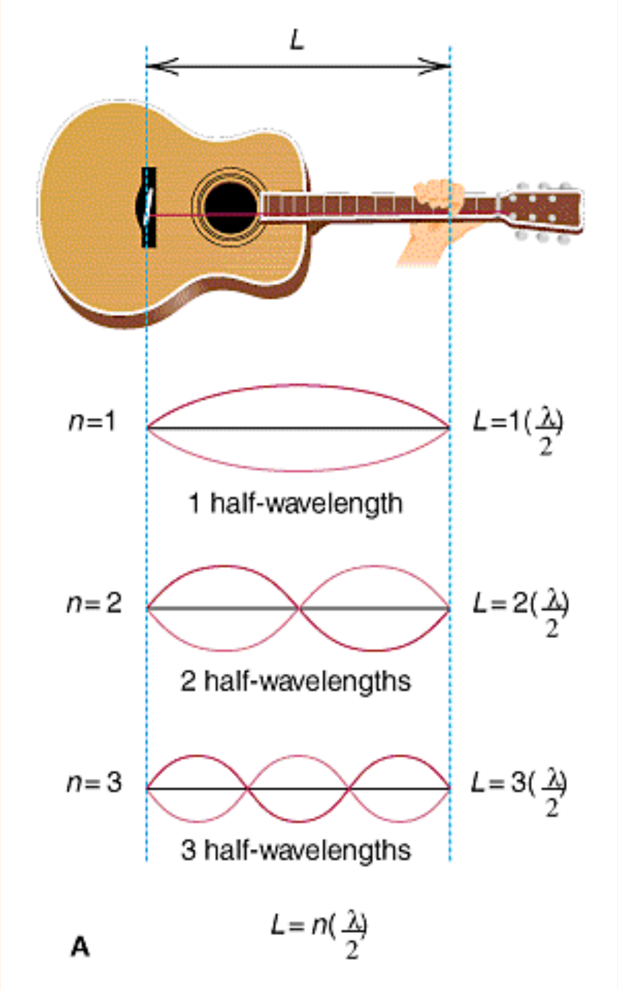
Wave Properties of Electrons

- In the mid-1920s, Erwin Schrodinger, building on the dual nature of matter, began focusing on the wave-like properties of the electron.
- By visualizing electrons as standing waves (like guitar strings) instead of "orbiting" particles, the distinct energy levels observed by experiments could be explained.



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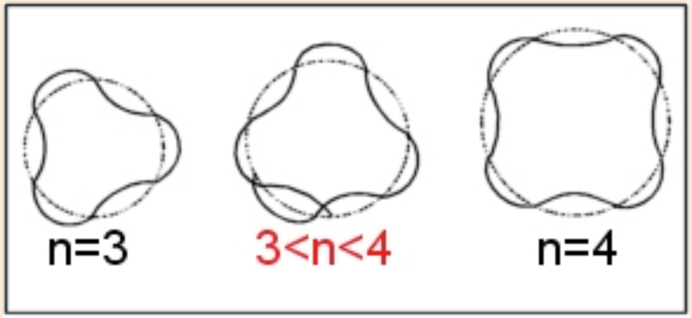
Wave Properties of Electrons

- If electrons are waves, then the wavelength of the electron must “fit” into any orbit that it makes around the nucleus in an atom.
- All orbits that do not “fit” are not possible, because wave interference will rapidly destroy the wave amplitude and the electron (wave) wouldn't exist.



The standing wave diagram above is a visualization of why (if electrons have wave-like properties like wavelength) only certain orbitals are allowed. It is **not** meant to say that electrons move in wavy orbits around the nucleus.

- This leads to discrete (quantized) energy levels and the discrete “bright line” emission spectrum of the hydrogen atom:

You will not be tested on this background info.

The Wave Equation

$$i\hbar\frac{\partial}{\partial t}\Psi(\mathbf{r},\,t) = -\frac{\hbar^2}{2m}\nabla^2\Psi(\mathbf{r},\,t) + V(\mathbf{r})\Psi(\mathbf{r},\,t)$$

This is just one of many different forms the equation can take.

- Schrödinger developed a mathematical model based on wave mathematics to describe the position of electrons in an atom.
- For a given atom, Schrödinger's Equation has many solutions, and these different solutions are called orbitals.
- These orbitals do not describe actual orbits like Bohr's model, but, instead, describe *areas of probability* of where an electron might be found.

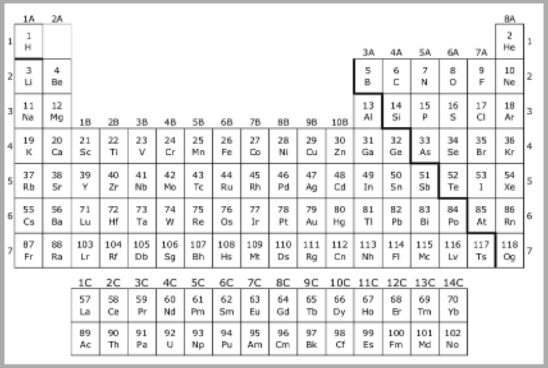
You will not be tested on this background info.

Electron Configuration

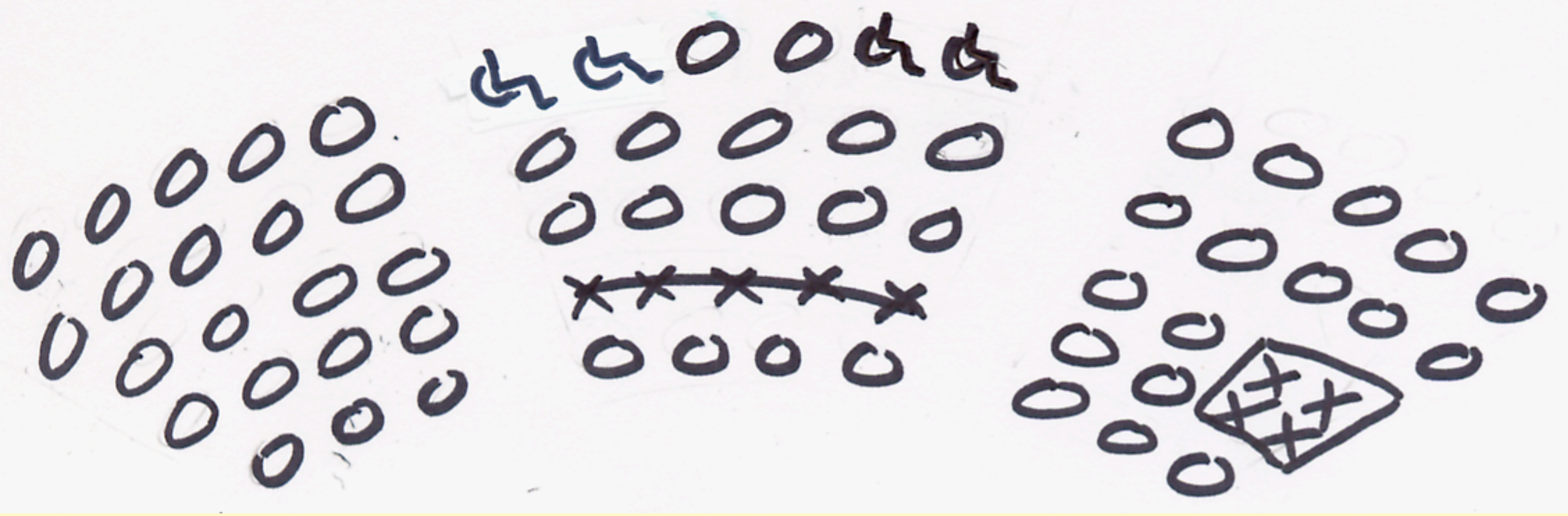
Modern Atomic Theory

Just how are those electrons arranged?

Break out your paper Periodic Table



Suppose you needed to communicate the seating in the auditorium by email without the use of the picture with just letters and/or numbers. You might symbolize the seats in the following manner:



- Section Letter
- Rows
- Seat numbers
- etc

- In Chemistry we will use a system to keep track of electrons in atoms

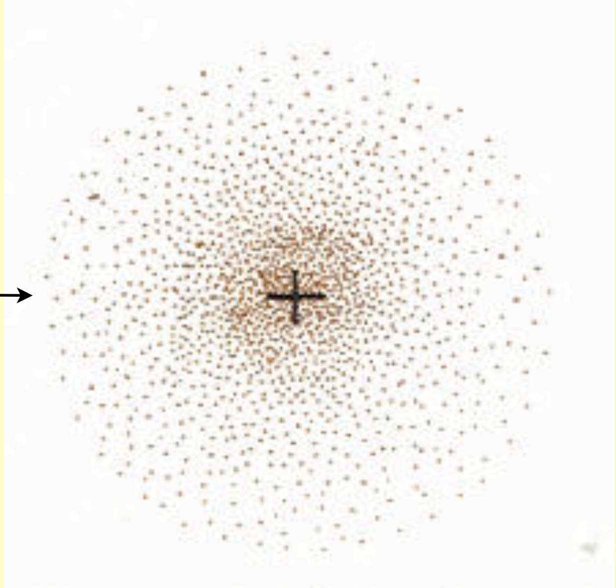
First Row - Electron Configuration

- H: $1s^1$

1 electron

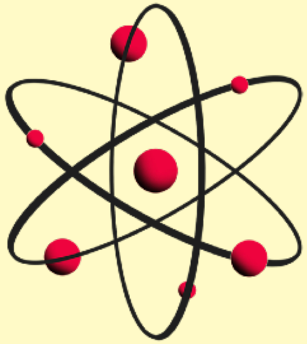
first energy level

"s" orbital

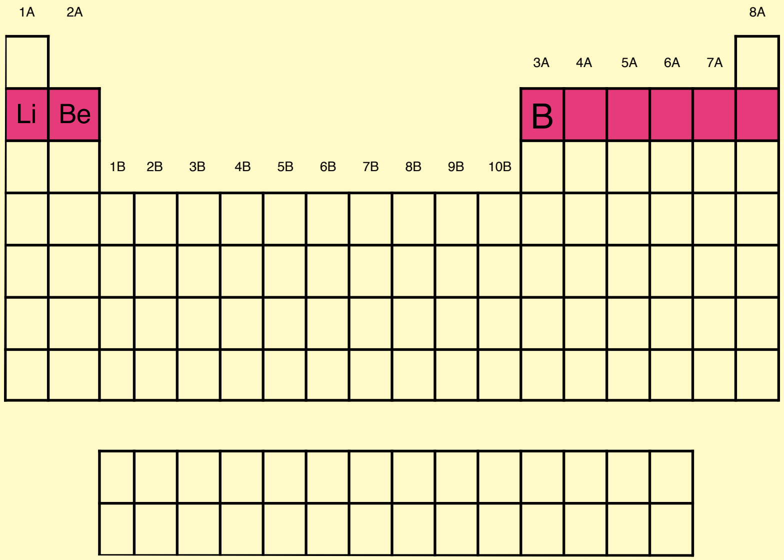


- s orbitals are sphere-shaped and there is one s orbital on each and every energy level.

- He: $1s^2$

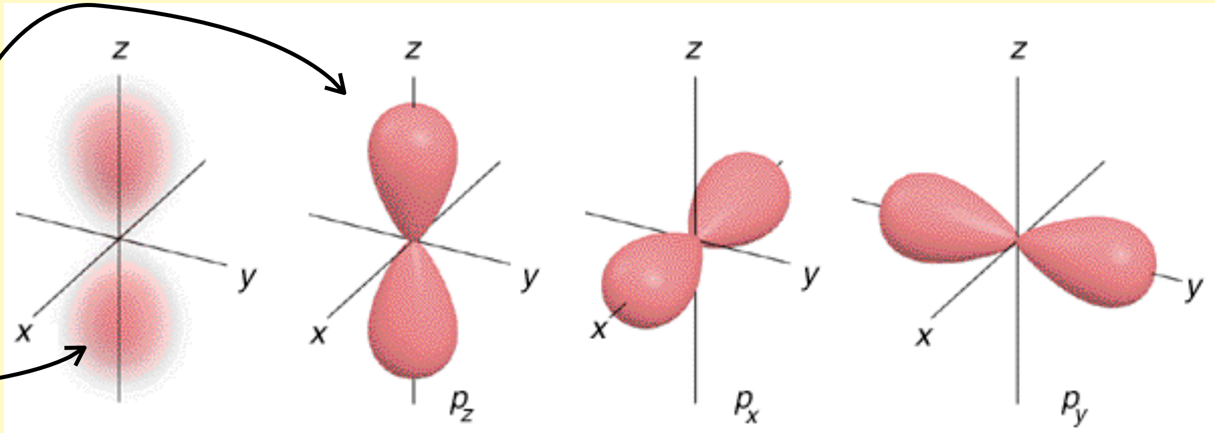


Second Row - Electron Configuration



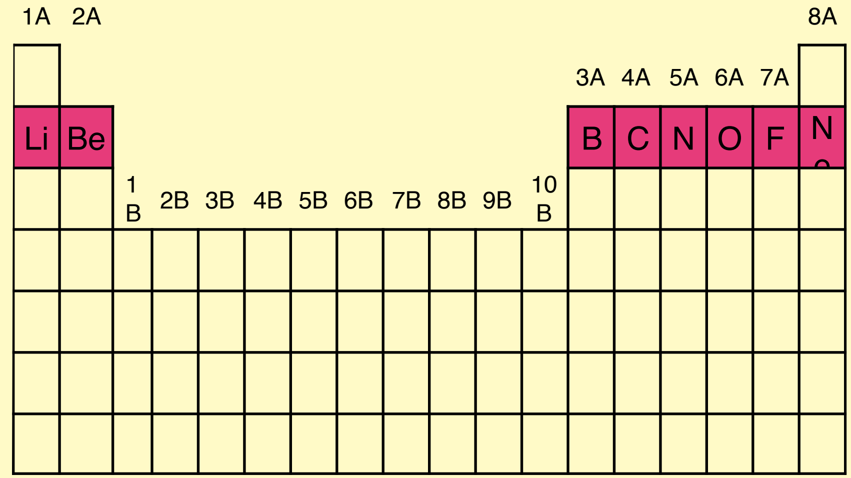
- Li: $1s^2\ 2s^1$
- Be: $1s^2\ 2s^2$
- B: $1s^2\ 2s^2\ 2p^1$
- There are three "p" orbitals on any given energy level (none on level 1).
- They are lobe-shaped, oriented in the x, y, z planes.

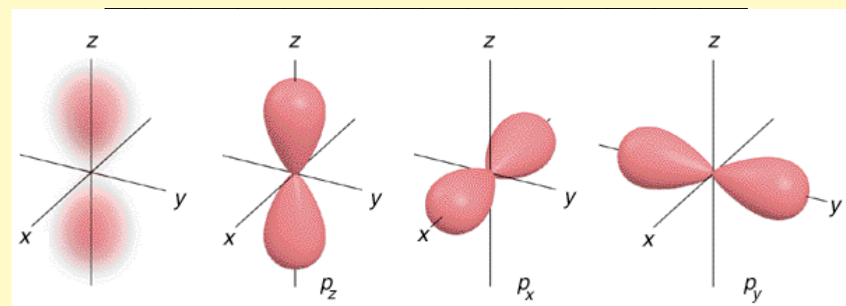
We sketch them like this but really they are "fuzzy" probability locations, not hard shells.



Second Row, continued....

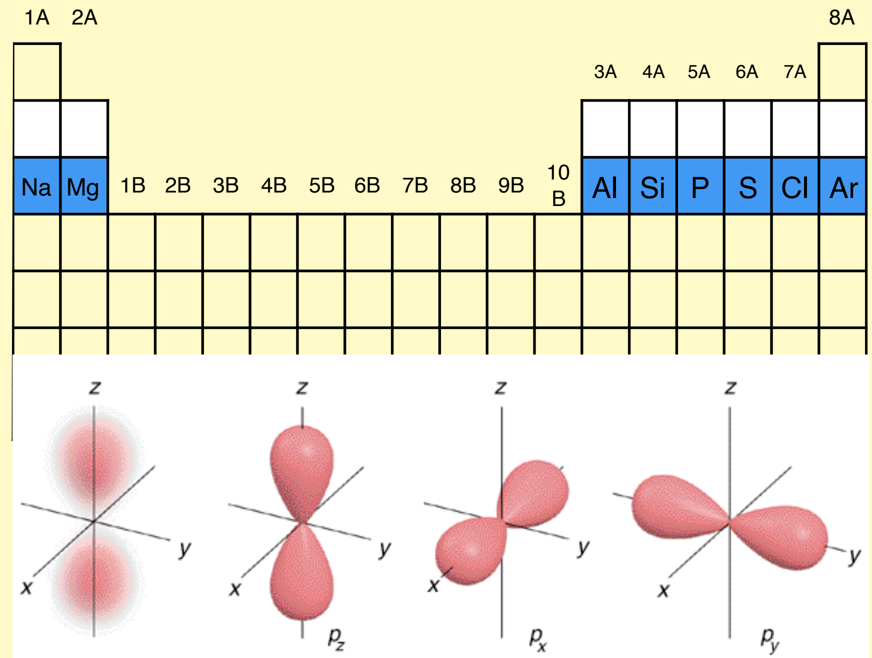
- Li: $1s^2\ 2s^1$
- Be: $1s^2\ 2s^2$
- B: $1s^2\ 2s^2\ 2p^1$
- C: $1s^2\ 2s^2\ 2p^2$ $(p_x^1\ p_y^1\ p_z)$
- N: $1s^2\ 2s^2\ 2p^3$ $(p_x^1\ p_y^1\ p_z^1)$
- O: $1s^2\ 2s^2\ 2p^4$ $(p_x^1\ p_y^2\ p_z^1)$
- F: $1s^2\ 2s^2\ 2p^5$ $(p_x^2\ p_y^1\ p_z^2)$
- Ne: $1s^2\ 2s^2\ 2p^6$ $(p_x^2\ p_y^2\ p_z^2)$





Third Row - Electron Configuration

- Na: $1s^2\ \ 2s^2\, 2p^6\ \ 3s^1$
- Mg: $1s^2\ \ 2s^2\, 2p^6\ \ 3s^2$
- Al: $1s^2\ \ 2s^2\, 2p^6\ \ 3s^2\, 3p^1$
- Si: $1s^2\ \ 2s^2\, 2p^6\ \ 3s^2\, 3p^2$
- P: $1s^2\ \ 2s^2\, 2p^6\ \ 3s^2\, 3p^3$
- S: $1s^2\ \ 2s^2\, 2p^6\ \ 3s^2\, 3p^4$
- Cl: $1s^2\ \ 2s^2\, 2p^6\ \ 3s^2\, 3p^5$
- Ar: $1s^2\ \ 2s^2\, 2p^6\ \ 3s^2\, 3p^6$

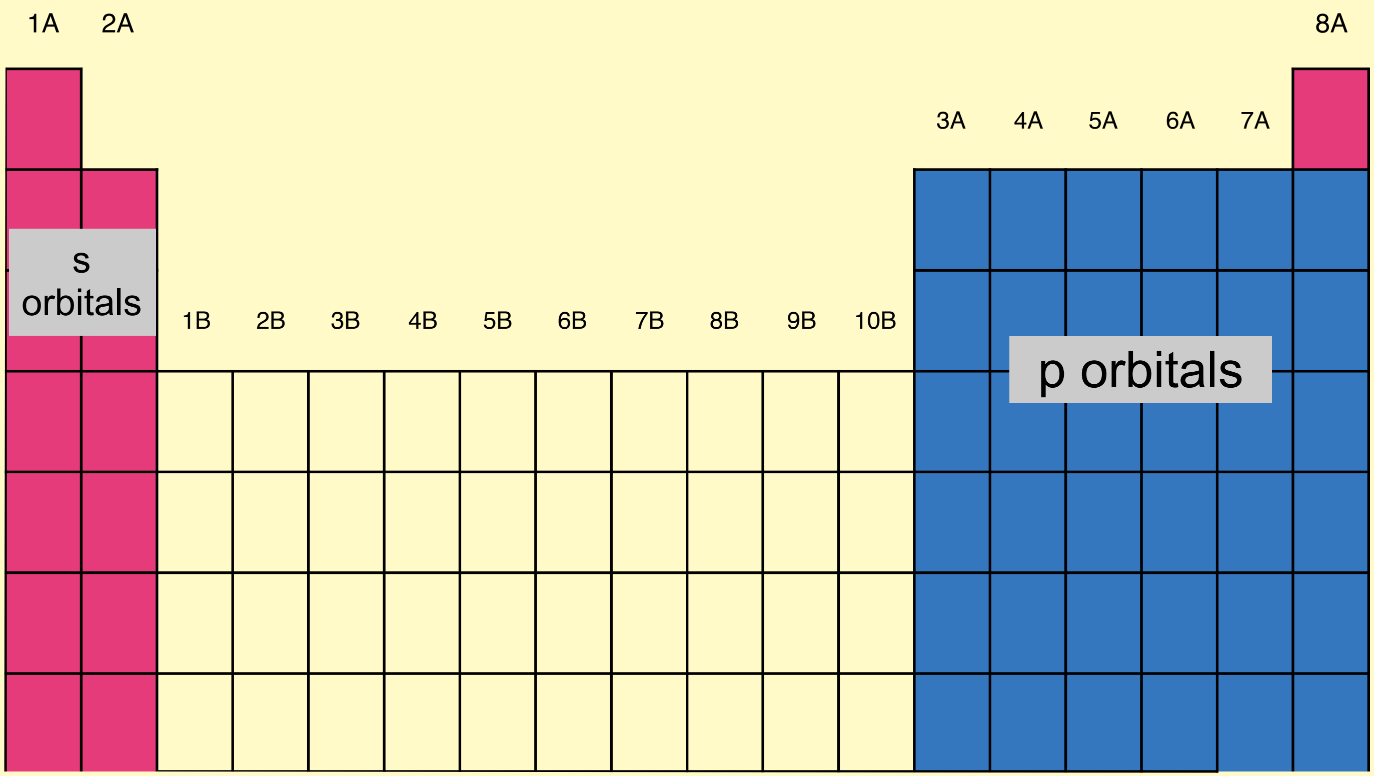


and *Orbital Notation*

Useful to help count the number of paired vs unpaired electrons

The Periodic Table is Shaped to Help You

- s - two columns, 2 electrons maximum, 1 orbital
- p - six columns, 6 electrons maximum, 3 orbitals



Fourth Row

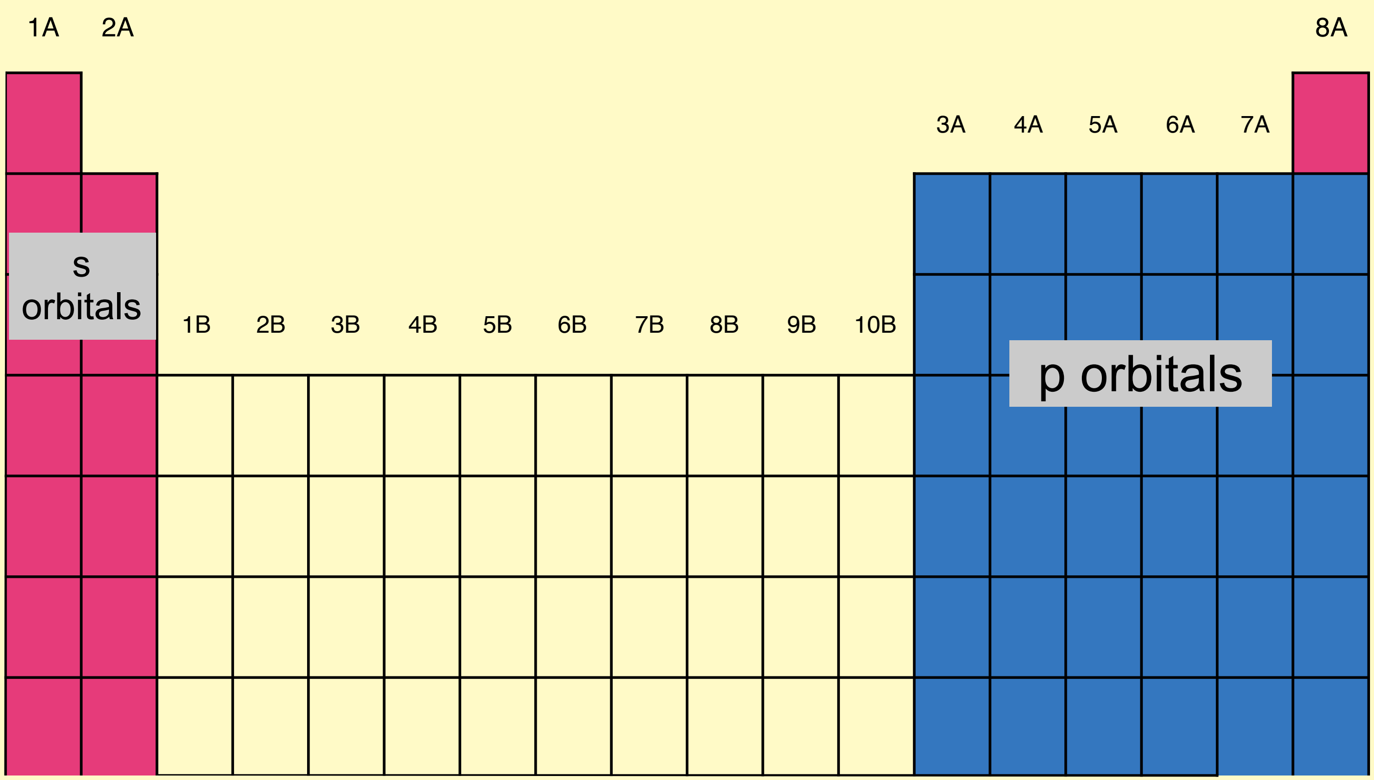
- K: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
- Ca: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
- Sc: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^1$

Why is it 3d not 4d?

- When you are in the 4th row of the table, you are actually filling the 3d orbitals (3rd level).
- 21 protons is enough + attraction to pull the electrons closer to the nucleus to the 3rd energy level.

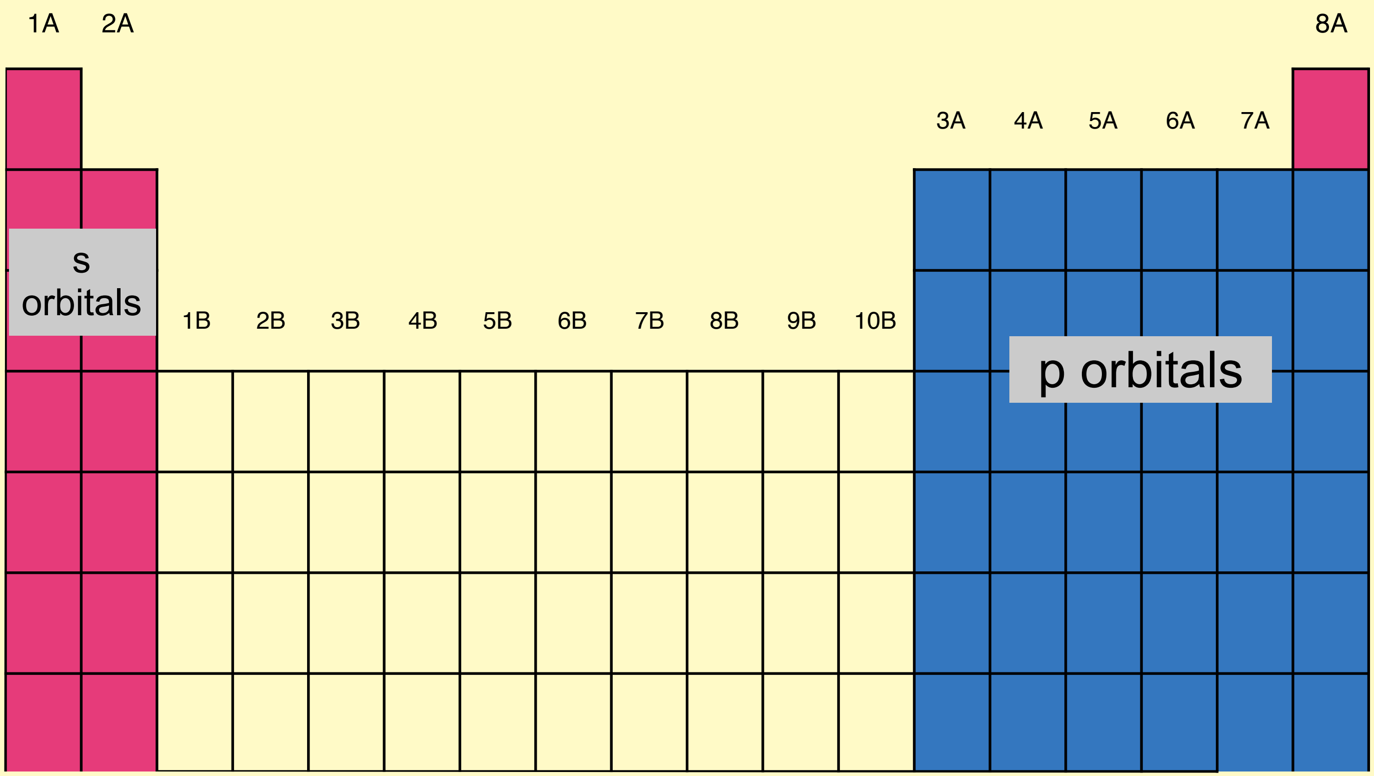
The Periodic Table is Shaped to Help You

- Looking at the periodic table, can you tell how many "d" electrons are found on any given EL on which "d" electrons exist?



The Periodic Table is Shaped to Help You

- Look at the periodic table, can you tell how many “d” electrons are found on any given EL on which “d” electrons exist?
- 10….how many orbital is this?



Fourth Row

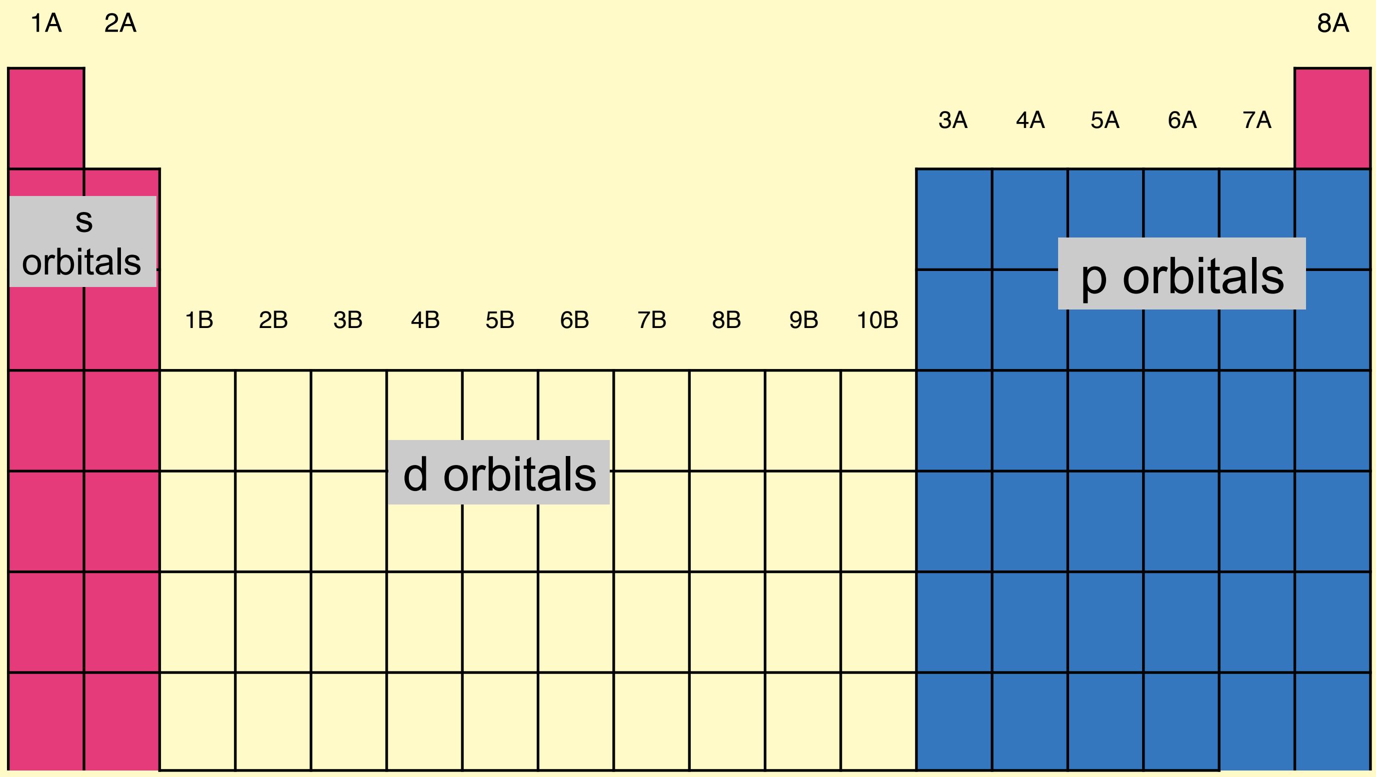
- K: $1s^2\ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^1$
- Ca: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ \ 4s^2$
- Sc: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^1$
- Ti: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^2$
- V: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^3$
- Cr: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^4$
- Mn: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ 4s^2\ 3d^5$
- Fe: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^6$
- Co: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^7$
- Ni: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^8$
- Cu: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^9$
- Zn: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^{10}$

finish the Fourth Row s (d) & p

- K: $1s^2\ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^1$
- Ca: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ \ 4s^2$
- *(…Transition Metals - "d" group*
  Zn: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^{10}$)
- *Continue on to the "p" block*
- Ga: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^{10}\ 4p^1$
- Ge: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^{10}\ 4p^2$
- As: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^{10}\ 4p^3$
- Se: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^{10}\ 4p^4$
- Br: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^{10}\ 4p^5$
- Kr: $1s^2\ \ 2s^2\ 2p^6\ \ 3s^2\ 3p^6\ \ 4s^2\ 3d^{10}\ 4p^6$

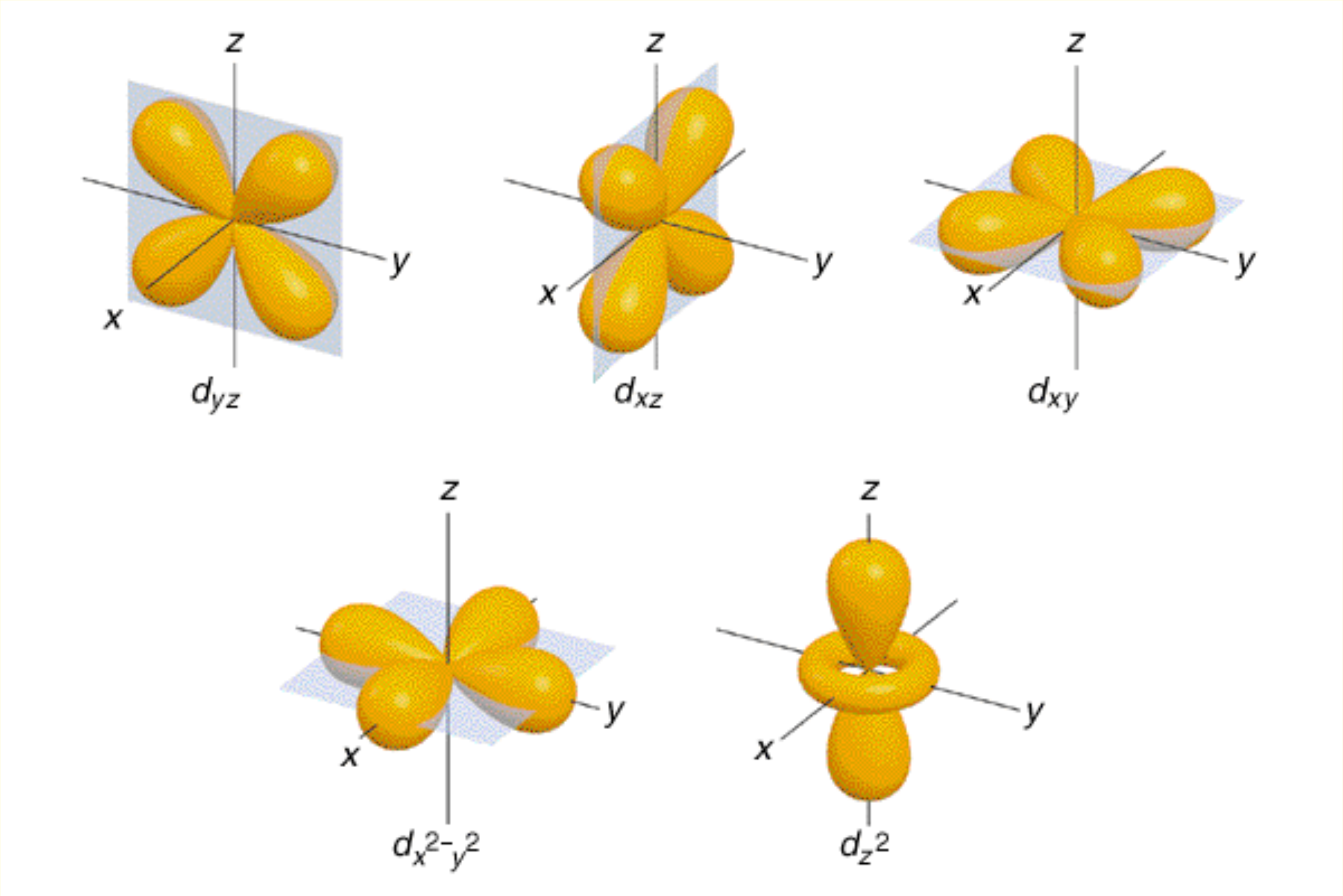
The Periodic Table is Shaped to Help You

- s - two columns, 2 electrons maximum, 1 orbital
- p - six columns, 6 electrons maximum, 3 orbitals
- d - ten columns, 10 electrons maximum, 5 orbitals



What are the shape of "d" orbitals?

- Yikes ! You do NOT need to know these shapes.



Fifth Row s & d

- Rb: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^1$
- Sr: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$
- Y: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^1$
- Zr: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^2$
- Nb: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^3$
- Mo: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^4$
- Tc: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^5$
- Ru: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^6$
- Rh: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^7$
- Rd: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^8$
- Ag: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^9$
- Cd: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$

Fifth Row Representative Elements s (d) & p

- Rb: $1s^2$ $2s^1$ $3s^2$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^1$
- Sr: $1s^2$ $2s^2$ $3s^2$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$
- *Finish the transition Metals - "d" group*
  Cd: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$
- In: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^1$
- This is sooooo tedius, we often write "condensed" electron configurations
- Sn: [Kr] $5s^2$ $4d^{10}$ $5p^2$
- Sb: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^3$
- Te: [Kr] $5s^2$ $4d^{10}$ $5p^4$
- I: [Kr] $5s^2$ $4d^{10}$ $5p^5$
- Xe: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$

Sixth Row

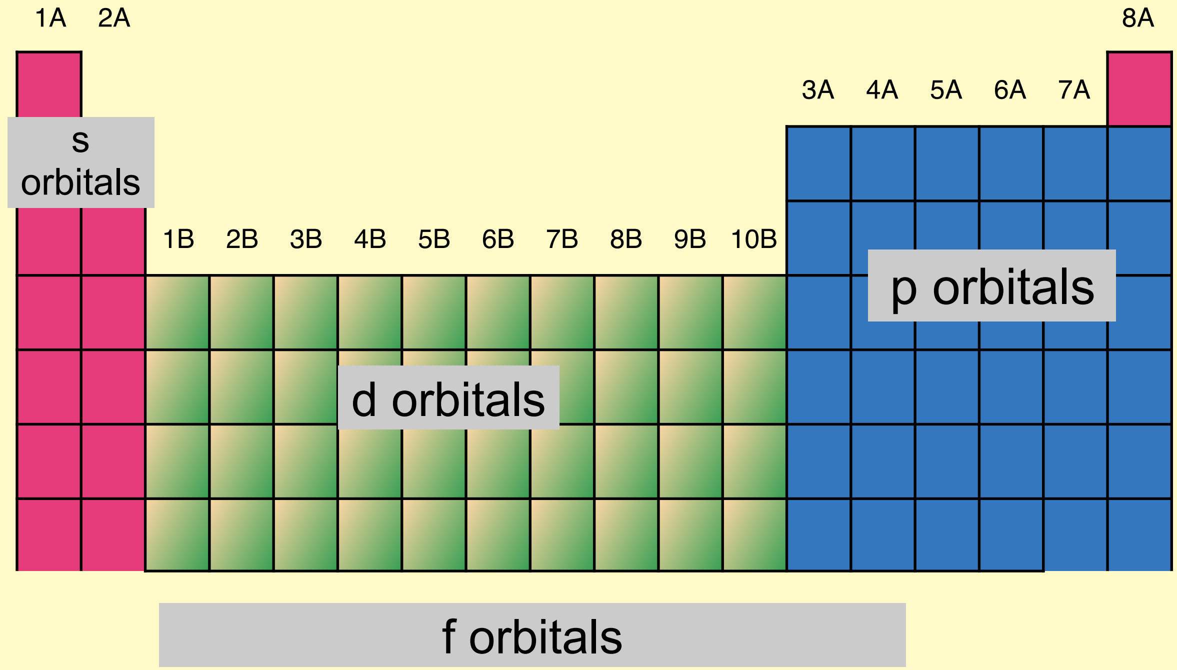
- Cs: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $6s^1$
- Ba: [Xe] $6s^2$
- *so pause to note where we are in the periodic table*
- *clearly we need a new orbital type as we are headed into a new "block" on the table.*
- *This type of orbital is called "f"*
- La: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $6s^2$ $4f^1$
- Ce: [Xe] $6s^2$ $4f^2$
- Pr: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $6s^2$ $4f^3$
- Nd: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $6s^2$ $4f^4$
- We could even represent the next element by just writing the "last orbital" filled, assuming all lower energy orbitals filled up.
- Pm: $4f^5$
- Sm: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $6s^2$ $4f^6$
- Etc, etc, etc through
- Yb: $4f^{14}$

Sixth Row continued.....

- Yb: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $6s^2$ $4f^{14}$
- So where do we go from here?
- on to the "d" orbitals
- Lu: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $6s^2$ $4f^{14}$ $5d^1$
- Hf: (condensed version) [Xe] $5d^2$
- Ta: (single highest orbital) $5d^3$
- Etc, etc, etc through
- Hg: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $6s^2$ $4f^{14}$ $5d^{10}$
- Tl: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $6s^2$ $4f^{14}$ $5d^{10}$ $6p^1$
- Pb: (condensed version) [Xe] $6p^2$
- Bi: $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $4s^2$ $3d^{10}$ $4p^6$ $5s^2$ $4d^{10}$ $5p^6$ $6s^2$ $4f^{14}$ $5d^{10}$ $6p^3$
- Po: (single highest orbital) $6p^4$
- At: (condensed version) [Xe] $6p^5$
- Rn: (single highest orbital) $6p^6$

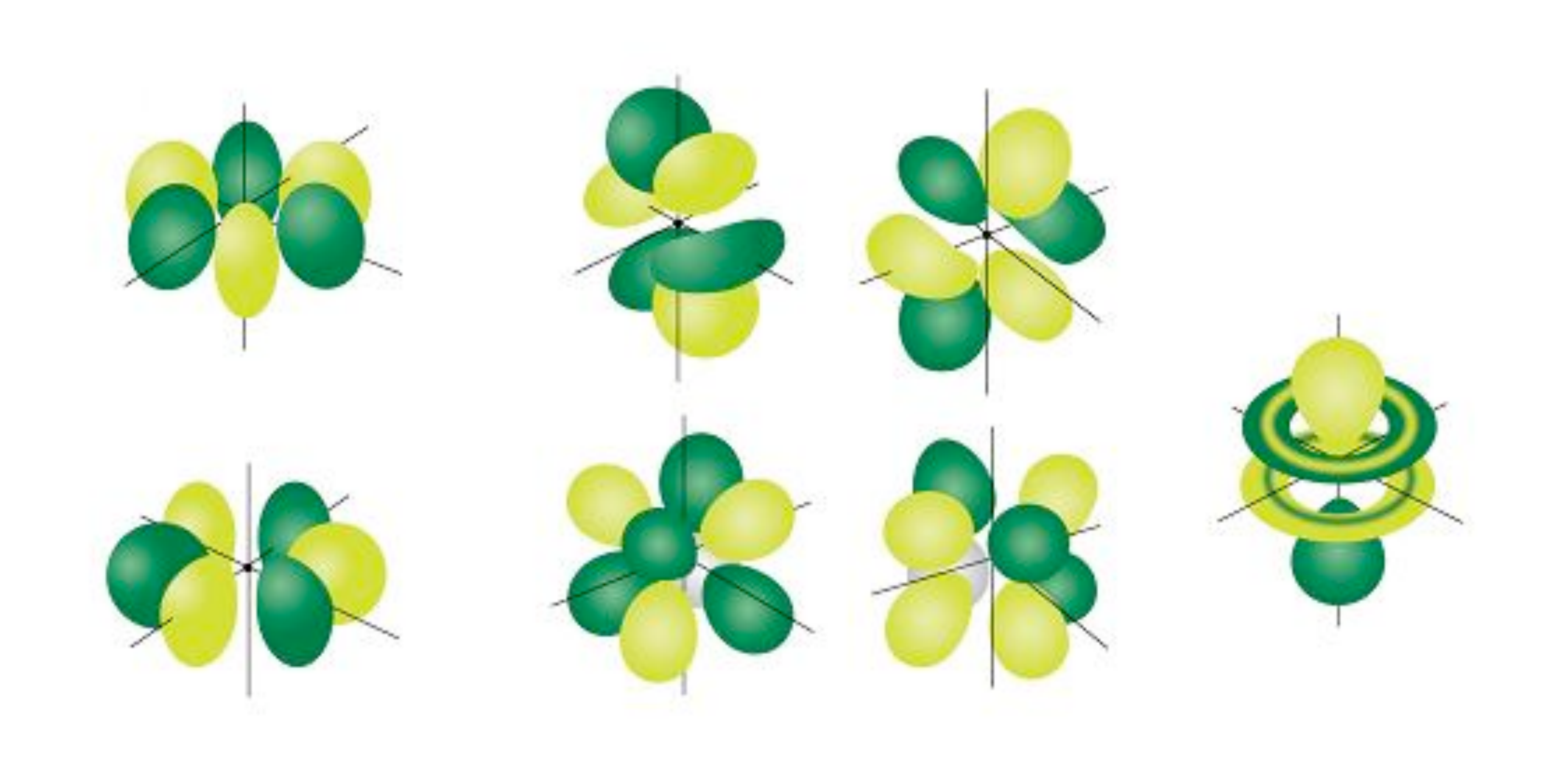
The Periodic Table is Shaped to Help You

- s - two columns, 2 electrons maximum, 1 orbital
- p - six columns, 6 electrons maximum, 3 orbitals
- d - ten columns, 10 electrons maximum, 5 orbitals
- f - fourteen columns, 14 electrons maximum, 7 orbitals



So what shape are "f" orbitals?

- 7 different orbitals, each of which is 4-lobed
- you so do NOT need to know these shapes



Electron Configuration

Modern Atomic Theory

Just how are those electrons arranged?

Break out a Personal WhiteBoard

Write the entire electron configuration

- $_{16}S$

- $_{28}Ni$

- $_{60}Nd$

Write the entire electron configuration

- ${}_{16}S$
  - » $1s^2 2s^2 2p^6 3s^2 3p^4$
- ${}_{28}Ni$
  - » $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$
- ${}_{60}Nd$
  - » $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^4$

Turn these *entire* e.c. into the condensed version of e.c.

Turn these entire e.c. into the condensed version of e.c.

- $_{16}S$
  - » $1s^2 2s^2 2p^6 3s^2 3p^4$
  - » [Ne] $3s^2 3p^4$
- $_{28}Ni$
  - » $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^8$
  - » [Ar] $4s^2 3d^8$
- $_{60}Nd$
  - » $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^4$
  - » [Xe] $6s^2 4f^4$

Write the **orbital notation** for these condensed electron configurations and report the number of unpaired electrons.

Write the orbital notation for these condensed electron configurations and report the number of unpaired electrons.

- $_{16}$S
  - » [Ne] $3s^2 3p^4$
  - » ⊗ ⊗⦸⦸ *two unpaired electrons*
- $_{28}$Ni
  - » [Ar] $4s^2 3d^8$
  - » ⊗ ⊗⊗⊗⦸⦸ *two unpaired electrons*
- $_{60}$Nd
  - » [Xe] $6s^2 4f^4$
  - » ⊗ ⦸⦸⦸⦸○○○ *four unpaired electrons*

Name the element described by the condensed version of e.c.

- [Ne] $3s^2\ 3p^3$
- [Ar] $4s^2\ 3d^{10}\ 4p^5$
- [Xe] $6s^2\ 4f^{14}\ 5d^3$
- [Rn] $7s^2\ 5f^8$

Name the element described by the condensed version of e.c.

- [Ne] $3s^2\ 3p^3$
  - » $_{15}P$
- [Ar] $4s^2\ 3d^{10}\ 4p^5$
  - » $_{35}Br$
- [Xe] $6s^2\ 4f^{14}\ 5d^3$
  - » $_{73}Ta$
- [Rn] $7s^2\ 5f^8$
  - » $_{96}Cm$

Name the element in the ground state described by the single highest energy orbital. (Assume all lower orbitals are filled.)

- $2p^1$
- $4d^2$
- $6p^5$
- $5f^2$
- $4p^8$

Name the element in the ground state described by the single highest energy orbital. (Assume all lower orbitals are filled.)

- $2p^1$
  - » $_5B$
- $4d^2$
  - » $_{40}Zr$
- $6p^5$
  - » $_{85}At$
- $5f^2$
  - » $_{90}Th$
- $4p^8$
  - » No such element

Write the single highest energy orbital to describe the element.
(Assume all lower orbitals are filled.)

- ${}_{12}Mg$
- ${}_{43}Tc$
- ${}_{65}Tb$
- ${}_{82}Pb$

Write the single highest energy orbital to describe the element.
(Assume all lower orbitals are filled.)

- $_{12}Mg$
  - » $3s^2$
- $_{43}Tc$
  - » $4d^5$
- $_{65}Tb$
  - » $4f^9$
- $_{82}Pb$
  - » $6p^2$

In summary…how will you be asked questions about electron configuration?

In both directions

1. Name the element described by an entire e.c.
   - Write the entire e.c. for some atom or ion.

2. Name the element described by the condensed version of e.c.
   - Write the condensed version of e.c. for some atom or ion

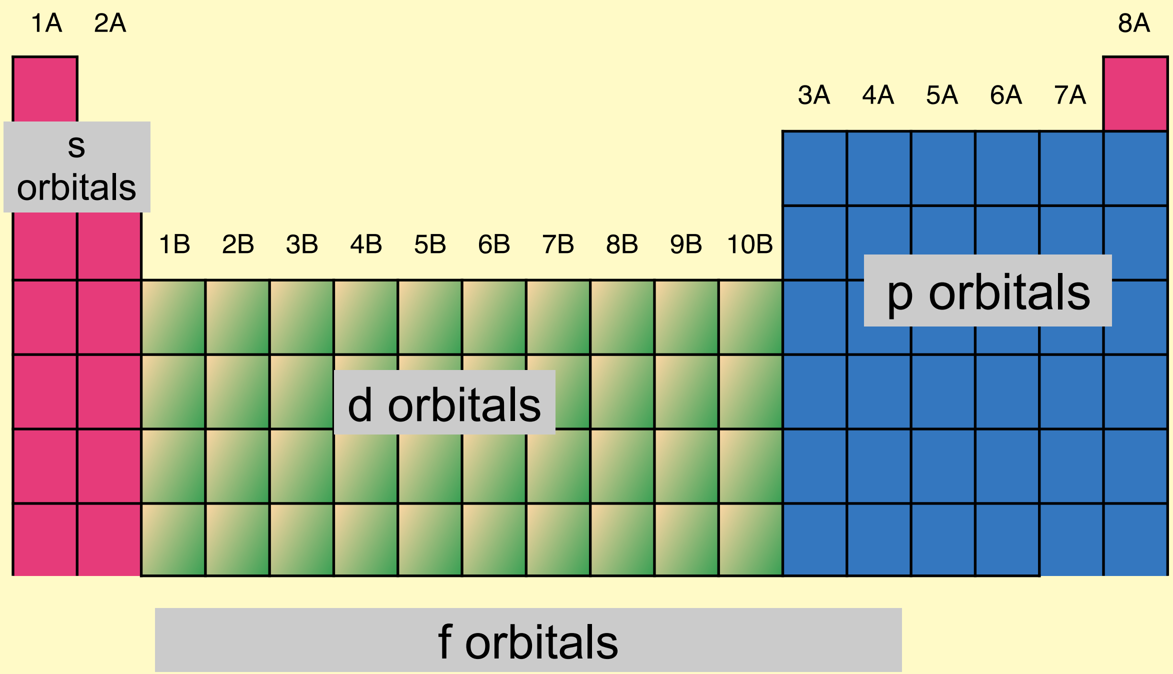
3. Name the element described by the single highest energy orbital. (Assume all lower orbitals are filled.)
   - Write the single highest energy orbital for and atom or ion (Assume all lower orbitals are filled.)

ec

more practice

The Periodic Table is Shaped to Help You

- s - two columns, 2 electrons maximum, 1 orbital
- p - six columns, 6 electrons maximum, 3 orbitals
- d - ten columns, 10 electrons maximum, 5 orbitals
- f - fourteen columns, 14 electrons maximum, 7 orbitals



The element represented by $[Ar]\ 4s^2 3d^{10} 4p^2$ is

1. ${}_{20}Ca$
2. ${}_{22}Ti$
3. ${}_{32}Ge$
4. ${}_{50}Sn$
5. ${}_{35}Br$

The element represented by $[Ar]\ 4s^2 3d^{10} 4p^2$ is

1. $_{20}Ca$
2. $_{22}Ti$
3. $_{32}Ge$

- All that you really need to look at is the $4p^2$ to be able to identify.

4. $_{50}Sn$
5. $_{35}Br$

The element represented by [Kr] $5s^2 4d^9$ is

1. $_{29}Cu$
2. $_{27}Co$
3. $_{79}Au$
4. $_{47}Ag$
5. $_{45}Rh$

The element represented by $[Kr]\ 5s^2 4d^9$ is

1. $_{29}Cu$
2. $_{27}Co$
3. $_{79}Au$
4. $_{47}Ag$
5. $_{45}Rh$

The element represented by $5p^3$ is (assuming all lower energy orbitals are filled, aka ground state)

1. $_{39}Y$
2. $_{51}Sb$
3. $_{33}As$
4. $_{21}Sc$
5. $_{83}Bi$

The element represented by $5p^3$ is

1. $_{39}Y$
2. $_{51}Sb$
3. $_{33}As$
4. $_{21}Sc$
5. $_{83}Bi$

Give highest energy orbital to describe $_{74}W$

1. $6d^6$
2. $7d^6$
3. $6p^4$
4. $6d^4$
5. $5d^4$

Give highest energy orbital to describe $_{74}W$

1. $6d^6$
2. $7d^6$
3. $6p^4$
4. $6d^4$
5. $5d^4$

Write the entire electron configuration for Cl

Write the electron configuration for Cl

- Cl $1s^2\ 2s^2 2p^6\ 3s^2 3p^5$

Write the electron configuration for Cl^-, the chloride ion

- Cl $1s^2\ 2s^2 2p^6\ 3s^2 3p^5$

Write the electron configuration for Cl^-, the chloride ion

- Cl $1s^2\ 2s^2 2p^6\ 3s^2 3p^5$

- Cl^- $1s^2\ 2s^2 2p^6\ 3s^2 3p^6$

Write the entire electron configuration for Mg

Write the electron configuration for Mg

- Mg $1s^2\ 2s^2 2p^6\ 3s^2$

Write the electron configuration for Mg^{2+}, the magnesium ion

- Mg atom $1s^2\ 2s^2 2p^6\ 3s^2$

Write the electron configuration for Mg^{2+}, the magnesium ion

- Mg ion $1s^2\ 2s^2 2p^6\ 3s^0$
- or just: $1s^2\ 2s^2 2p^6$

Write the condensed electron configuration for Fe

Write the electron configuration for Fe

- [Ar] $4s^2 3d^6$

Write the electron configuration for Fe^{3+}

- Fe: [Ar] $4s^2\ 3d^6$

Write the electron configuration for Fe^{3+}

- Fe^{3+}: $1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 4s^0\ 3d^5$
- The outermost electrons, aka *valence electrons* will be lost first.
- Fe: $1s^2\ 2s^2 2p^6\ 3s^2 3p^6\ 4s^2\ 3d^6$

How many *valence* electrons in $_{15}P$

1. 15
2. 8
3. 3
4. 4
5. 5
6. I don’t know what the word *valence* means.

How many *valence* electrons in ${}_{15}P$

1. 15
2. 8
3. 3
4. 4
5. 5
6. I don’t know what the word *valence* means.

- Valence means outermost electrons - the “s” and “p” electrons in the last energy level.

When atoms turn into a positive ion

1. Protons are gained.
2. Protons are lost.
3. Electrons are gained
4. Electrons are lost.
5. Either protons are gained or electrons are lost.

When atoms turn into a positive ion

1. Protons are gained.
2. Protons are lost.
3. Electrons are gained
4. Electrons are lost. = cation
5. Either protons are gained or electrons are lost.

Which orbital notation model below best represents the valence electrons for oxygen?

1. ⊗ ⊗ ⊗⊗○
2. ⊗ ⊗ ⊗⊘⊘
3. ⊗ ⊗⊗○
4. ⊗⊗○
5. ⊗ ⊗⊘⊘
6. ⊘⊘⊘
7. ⊗⊘
8. ⊘⊘⊘⊘
9. ⊗⊘⊘⊘⊘

Which model below best represents the valence electrons for oxygen?

1. ⊗ ⊗ ⊗⊗○
2. ⊗ ⊗ ⊗⊘⊘
3. ⊗ ⊗⊗○
4. ⊗⊗○
5. ⊗ ⊗⊘⊘
6. ⊘⊘⊘
7. ⊗⊘
8. ⊘⊘⊘⊘
9. ⊗⊘⊘⊘⊘

Which represents the (generic) valence electron configuration of the halogens?

1. ns^1
2. ns^2
3. ns^2np^1
4. ns^2np^4
5. ns^2np^5
6. ns^2np^6
7. Without knowing which halogen, an answer can not be given.

n represents the energy level

Which represents the (generic) valence electron configuration of the halogens?

1. ns^1
2. ns^2
3. ns^2p^1
4. ns^2p^4
5. ns^2p^5
6. ns^2p^6
7. Without knowing which halogen, an answer can not be given.

n represents the energy level

How many p orbitals are occupied in $_{6}C$?

1. 1
2. 2
3. 3
4. 4
5. none

How many p orbitals are occupied in $_6C$?

1. 1
2. 2 both are half full, 1 e- each
3. 3
4. 4
5. none

How many p orbitals are occupied in $_{16}S$?

1. 2
2. 3
3. 4
4. 5
5. 6
6. 10
7. none

How many p orbitals are occupied in $_{16}S$?

1. 1
2. 2
3. 3
4. 4
5. 5
6. 6 $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$

- ⊗ ⊗ ⊗⊗⊗ ⊗ ⊗⊘⊘

7. 10
8. none

How many unpaired electrons in $_{16}S$?

1. 1
2. 2
3. 3
4. 4
5. 5
6. 6

How many unpaired electrons in $_{16}S$?

1. 1
2. 2
   - [Ne] $3s^2$ $3p^4$
   - ⊗ ⊗⊘⊘
3. 3
4. 4
5. 5
6. 6

Periodic Trends

Atomic Size (Radius)
Ionization Energy

Slide view

Comment on what you think would be the periodic trend for atomic radii (size of atoms) in any one column (such as Ca and Ba).

1. The size of atoms *increases* down the chart.
2. The size of atoms *decreases* down the chart.
3. The size of atoms *stays the same* down to the chart.
4. No trend, random sizing

Comment on what you think would be the periodic trend for atomic radii (size of atoms) in any one column (such as Ca and Ba).

1. The size of atoms *increases* down the chart.
   - This is because there are more electrons in more occupied energy levels
2. The size of atoms *decreases* down the chart.
3. The size of atoms *stays the same* down to the chart.

Select what you think would be the periodic trend for atomic radii (size of atoms) from left to right across the chart. (such as As and Br)

1. The size of atoms increases (L→R) across the chart.
2. The size of atoms decreases (L→R) across the chart.
3. The size of atoms stays the same (L→R) across to the chart.

Comment on what you think would be the periodic trend for atomic radii (size of atoms) from left to right across the chart.

1. The size of atoms increases (L→R) across the chart.
2. The size of atoms decreases (L→R) across the chart.
   - this is because the *effective* nuclear charge increases as we move across the chart. There are more protons pulling on electrons that are the no further away (in the same energy level.)
3. The size of atoms stays the same (L→R) across to the chart.

Slide show next

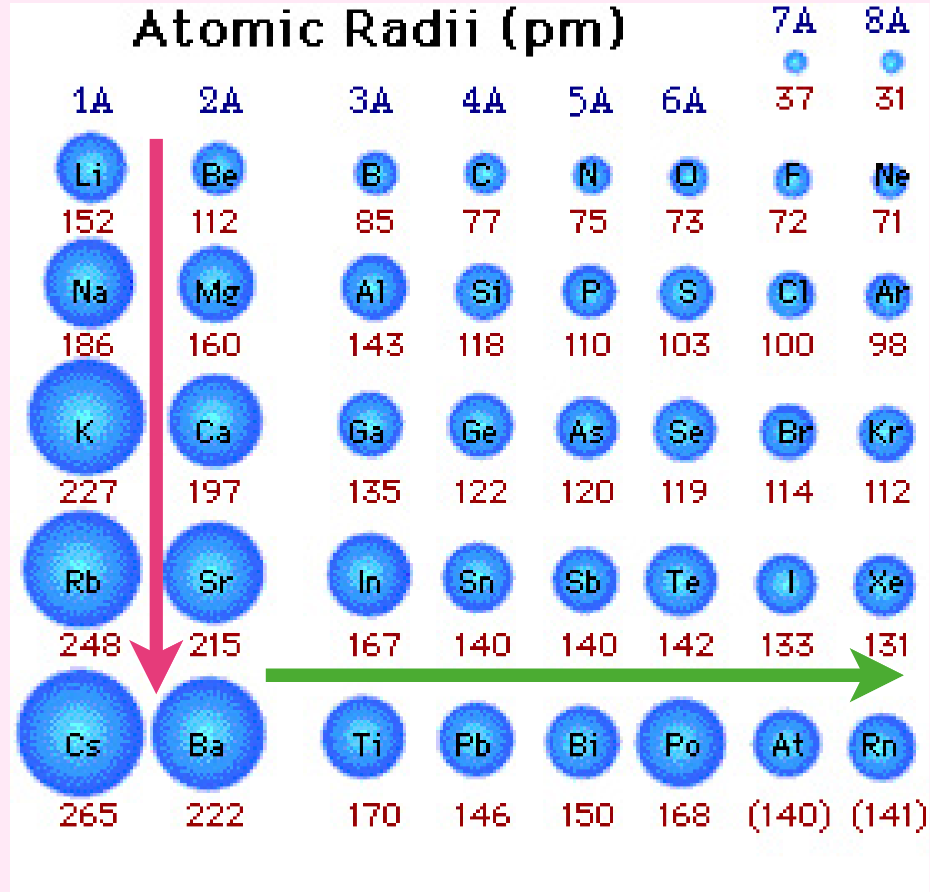
Coulombs Law

of electrostatic forces

$$F = k\frac{Q^{+}Q^{-}}{d^{2}}$$

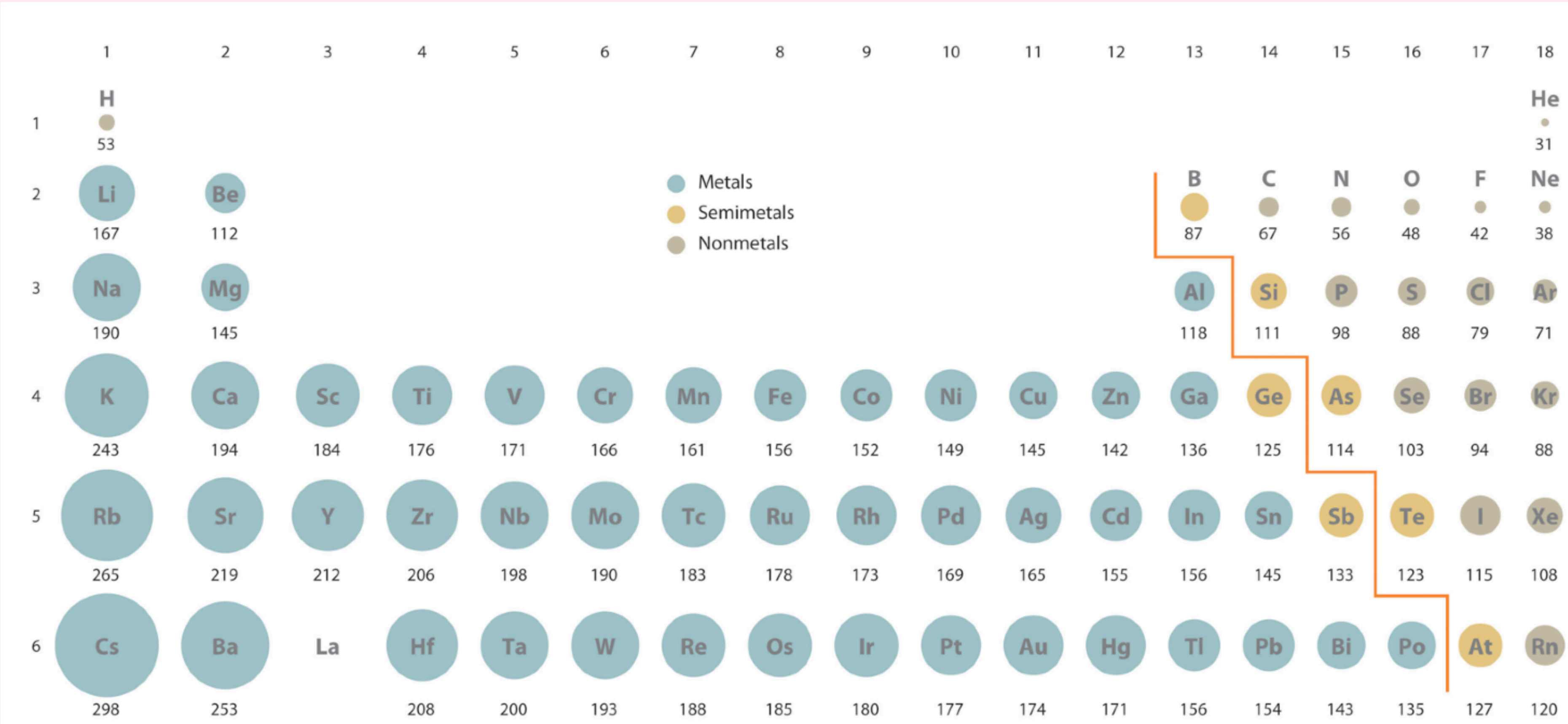
- The force of attraction between opposite charges (protons & a valence electron) is affected by
  - ✓ Q^{+}, the magnitude of the nuclear charge (1+, 2+, 3-, etc)
  - ✓ d, the distance between the nucleus and the electron of interest.
- We will invoke coulombs law to justify the strength of the attractive forces between the nucleus and the electron.
  - ✓ *You will never need to put numbers in this equation, just use it to explain the effects the magnitude of Q & d and the resulting effect on periodic properties.*

The Size of Atoms



- The size of atoms increases down a group.
  - ✓ due to more occupied energy levels
- The size of atoms decreases across to the right on the chart.
  - ✓ due to increased # of protons (attractive force) on the outermost electrons
  - ✓ electrons that are no further away from the nucleus.

The Size of Atoms



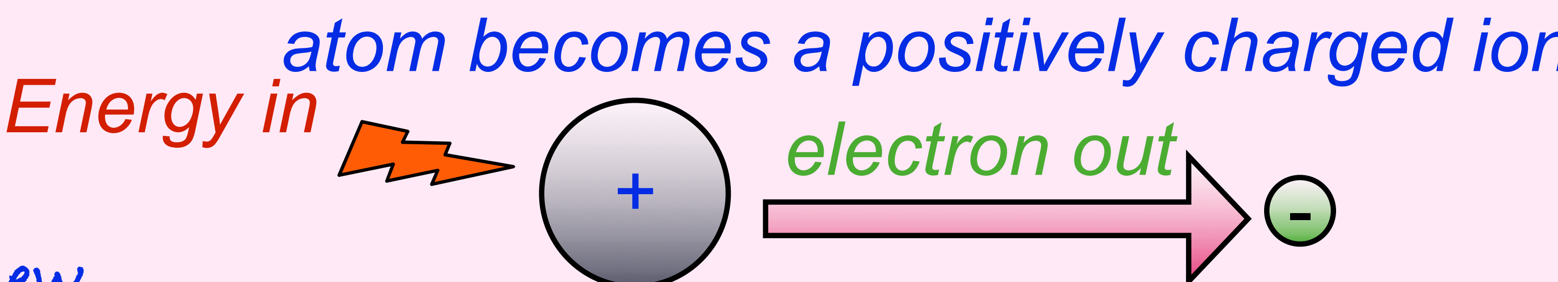
- You are not likely to see questions about the side of “d” atoms.
- Though they do follow the same general trend

How to Learn about Atoms?

- We can’t see individual atoms
- We can’t talk to them
- So we poke them with
  - ✓ heat
  - ✓ light – (not just visible light)
  - ✓ electricity

Ionization Energy

- Ionization Energy
  - ✓ The amount of energy required to forcibly remove an electron from an atom.
- Energy added as heat, light, or electricity
  - ✓ Equation: $X + IE \rightarrow X^{+} + e^{-}$
  - ✓ If an atom's IE is high, we will interpret that as an atom with a stable (and therefore favorable) electron configuration. (in which e- are held tightly)



Slide view

Select what you think would be the periodic trend for ionization energy in any one column.

1. Ionization energy *increases* within a column down the chart.
2. Ionization energy *decreases* within a column down the chart.
3. Ionization energy *stays the same* within a column down the chart.

Select what you think would be the periodic trend for ionization energy in any one column.

1. Ionization energy *increases* within a column down the chart.
2. Ionization energy *decreases* within a column down the chart.
   - this is because size increases as we move down the chart, since the electron removed will be further from the nucleus that is holding it, the electron can be removed more easily.
   - IE is *inversely proportional* to atom size
3. Ionization energy *stays the same* within a column down the chart.

Select what you think would be the periodic trend for ionization energy in any one row.

1. Ionization energy increases (L→R) within a row across the chart.
2. Ionization energy decreases (L→R) within a row across the chart.
3. Ionization energy stays the same (L→R) within a row across to the chart.

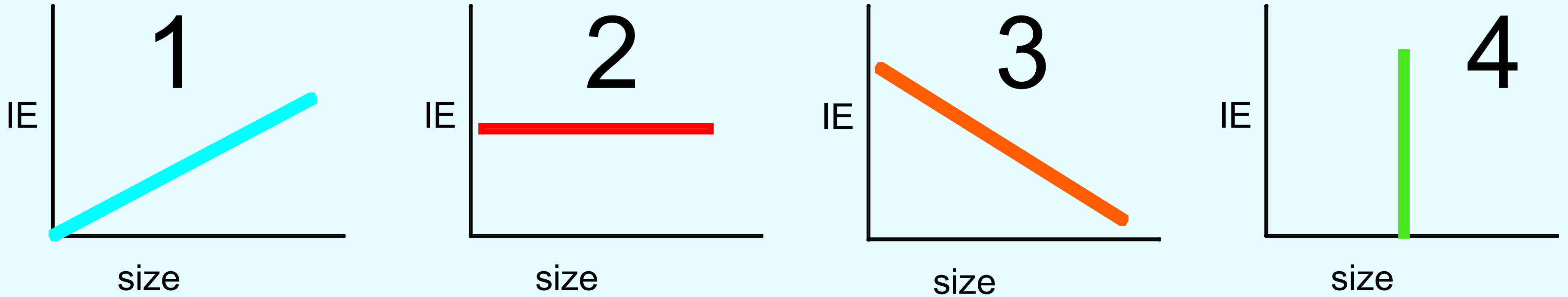
Select what you think would be the periodic trend for ionization energy in any one row.

1. Ionization energy increases (L→R) within a row across the chart.
   - this is because effective nuclear charge increased as we move across the chart (protons increase), since the electron removed will be closer to the nucleus that is holding it, the electron is harder to remove.
   - IE is inversely proportional to atom size
2. Ionization energy decreases (L→R) within a row across the chart.
3. Ionization energy stays the same (L→R) within a row across to the chart.

Slide show

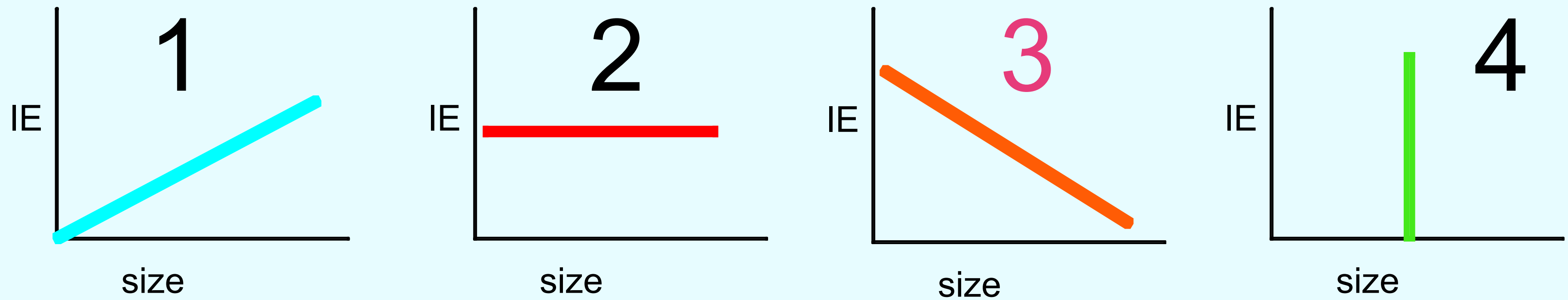
The Relationship between IE & Size

Which graph below would best represent the relationship between IE and size of atoms?



The Relationship between IE & Size

Which graph below would best represent the relationship between IE and size of atoms?



Smaller atoms are more difficult to remove an electron from because the electron is closer to the force that is holding it in place. An *inverse* relationship

Slide show

First Ionization Energy

(The energy required to remove only one electron from an atom.)

- IE decreases down the chart.
  - ✓ Larger size of atom (∴ e- further from protons) makes it easier to remove a valence electron.
- IE increases across to the right on the chart.
  - ✓ The smaller size and the increased *effective* nuclear charge of the atom makes it harder to remove an electron.

First Ionization Energies (kJ/mole)

1	H 1311							He 2370	1
2	Li 521	Be 899	B 799	C 1087	N 1404	O 1314	F 1682	Ne 2080	2
3	Na 496	Mg 737	Al 576	Si 786	P 1052	S 1000	Cl 1245	Ar 1521	3
4	K 419	Ca 590	Ga 579	Ge 762	As 944	Se 941	Br 1140	Kr 1351	4
5	Rb 403	Sr 550	In 558	Sn 709	Sb 832	Te 869	I 1009	Xe 1170	5
6	Cs 376	Ba 503	Tl 589	Pb 716	Bi 703	Po 812	At	Rn 1037	6
7	Fr	Ra							7

IE decreases down

IE increases across

Slide show

Ionization Energy

Scientists learned lots from knocking of one electron….guess what they decided to do?

Slide view

Successive Ionization Energy

- ✓ The amount of energy required to repeatedly remove electrons.
- ✓ Energy could be added in the form of heat, light, or electricity.
- ✓ First: $X + IE \rightarrow X^{+} + e^{-}$
- ✓ Second: $X^{+} + IE \rightarrow X^{2+} + e^{-}$
- ✓ Third: $X^{2+} + IE \rightarrow X^{3+} + e^{-}$
- ✓ Etc, etc, etc.

Which choice below would you suspect would best describe a successive ionization energy values (the energy to remove a second electron)?

1. the same as the previous IE
2. more than the previous IE
3. less than the previous IE
4. sometimes more, sometimes less, depending on which electron is being removed

Which choice below would you suspect would best describe successive ionization energy values?

1. the same as the previous IE
2. more than the previous IE
   - less electrons in the outer shell allows those remaining e− to "skootch" in closer to the nucleus and "feel" more force.
3. less than the previous IE
4. sometimes more, sometimes less, depending on which electron is being removed

Successive Ionization Energy

- ✓ Always more than the previous
  - The remaining electrons may “skootch” in a bit closer because the remaining e− repel each other a little bit less, thus the remaining electrons “feel” greater force since they are closer to the protons
- ✓ removing certain electrons may be extra difficult to remove

So What Does this Tell Us?

- A very high IE indicates that taking an electron away is very difficult implying that the number of e− present before trying to take the e− away was a stable electron configuration.
- The very high IE increase always occurs when knocking off from the next energy level **closer** to the nucleus.
- Taking away one more electron than the number of valence electrons is *very difficult*.
- A very high increase always occurs for the removal of one electron more than the number of valence electrons in the atom.

What are the periodic trends for successive IE values as you move across the chart?

Successive Ionization Energies kJ/mole

across chart

	1st	2nd	3rd	4th	5th	6th	7th	8th
H	1311							
He	2370	5220						
Li	521	*7304*	11752					
Be	899	1756	*14849*	20899				
B	799	2422	3657	*25019*	32660			
C	1087	2393	4622	6223	*37822*	46988		
N	1404	2856	4573	7468	9446	*53250*	63970	
O	1314	3396	5297	7468	10990	13325	*71312*	83652
F	1682	3367	6050	8423	11028	15167	17869	*91950*
Ne	2080	3946	6165	9301	12138	15148	19972	22963
Na	496	*4564*	6918	9542	13373	16644	20175	25501
Mg	737	1447	*7738*	10546	13624	18033	21767	25742
Al	576	1814	2750	*11578*	14820	18361	23465	27575
Si	786	1582	3232	4361	*16007*	19693	23658	29110
P	1052	1901	2914	4959	6272	*21516*	25858	30489
S	1000	2258	3387	4544	6947	8500	*27112*	31734
Cl	1245	2287	3850	5162	6542	9359	11028	*33442*
Ar	1521	2653	3927	5886	7526	8587	11964	13778

across chart

Anomalies in the Ionization Energy Trends

- Notice the anomalies in column 3 and 6
- There are reasons for these anomalies that we will not discuss in first year chem.
- Come to AP chem for more detail.

First Ionization Energies (kJ/mole)

	1	2	3	4	5	6	7	8	
1	H 1311							He 2370	1
2	Li 521	Be 899	B 799	C 1087	N 1404	O 1314	F 1682	Ne 2080	2
3	Na 496	Mg 737	Al 576	Si 786	P 1052	S 1000	Cl 1245	Ar 1521	3
4	K 419	Ca 590	Ga 579	Ge 762	As 944	Se 941	Br 1140	Kr 1351	4
5	Rb 403	Sr 550	In 558	Sn 709	Sb 832	Te 869	I 1009	Xe 1170	5
6	Cs 376	Ba 503	Tl 589	Pb 716	Bi 703	Po 812	At 900	Rn 1037	6
7	Fr	Ra							7

Periodicity Review

Modern Atomic Theory

Coulombs Law

Select the largest diameter atom from the group: ${}_{3}Li$, ${}_{11}Na$, ${}_{37}Rb$, ${}_{53}I$

Be ready to explain your choice.

1. ${}_{3}Li$
2. ${}_{11}Na$
3. ${}_{37}Rb$
4. ${}_{53}I$
5. Cannot be determined since they are in different *families* and different *periods*

Select the largest atom from the group: $_{3}Li$, $_{11}Na$, $_{38}Sr$, $_{53}I$

1. $_{3}Li$
2. $_{11}Na$
3. $_{37}Rb$
   - *Two extra energy levels* in Rb and I, yet Rb has a lower *effective nuclear charge*, so the force felt by the valence e^- is smaller, resulting Rb's larger size.
4. $_{53}I$
5. Cannot be determined since they are in different *families* and different *periods*

$$F = \frac{\downarrow Q_1^+ Q_2^-}{d^2}$$

Select the *largest* radius particle from the group: $_{54}Xe$, $_{53}I^{-}$, $_{56}Ba^{2+}$, $_{52}Te^{2-}$

Be ready to explain your choice.

1. $_{54}Xe$
2. $_{53}I^{-}$
3. $_{56}Ba^{2+}$
4. $_{52}Te^{2-}$
5. They are all the same size because they are *isoelectronic*.
6. I can't choose because I don't know what isoelectronic means and I don't know about the size of charged particles.

Select the largest particle from the group: ${}_{54}Xe$, ${}_{53}I^{-1}$, ${}_{56}Ba^{+2}$, ${}_{52}Te^{-2}$

1. ${}_{54}Xe$
2. ${}_{53}I^{-1}$
3. ${}_{56}Ba^{+2}$
4. ${}_{52}Te^{-2}$ This ion has less protons, only 52 to hold the 54 electrons, thus the e- repel each other and cause larger size
5. They are all the same size because they are isoelectronic.
6. I can’t choose because I don’t know what isoelectronic means and I don’t know about the size of charged particles.

${}_{16}S$ is smaller than ${}_{11}Na$ because

Select all that apply.

1. ${}_{16}S$ has more protons and more electrons.
2. ${}_{16}S$ has more electrons.
3. ${}_{16}S$ has more protons pulling on electrons in the same energy level.
4. ${}_{16}S$ has fewer energy levels.
5. ${}_{16}S$ has more neutrons to allow the atom to squeeze in more.
6. No explanation since S is *bigger* than Na, not smaller.

$_{16}S$ is smaller than $_{11}Na$ because

1. $_{16}S$ has more protons and more electrons.
2. $_{16}S$ has more electrons.
3. $_{16}S$ has more protons pulling on electrons in the same energy level.
   (S has a greater effective nuclear charge)
4. $_{16}S$ has fewer energy levels.
5. $_{16}S$ has more neutrons to allow the atom to squeeze in more.

Select the atom below with the lowest first ionization energy.

Be ready to explain your choice.

1. $_{11}Na$
2. $_{12}Mg$
3. $_{13}Al$
4. $_{14}Si$

Select the atom below with the lowest first ionization energy.

1. $_{11}Na$ because it is largest in size
2. $_{12}Mg$
3. $_{13}Al$
4. $_{14}Si$

The atom that has a *really* large increase for its 3rd ionization energy would be

1. $_{11}Na$
2. $_{12}Mg$
3. $_{13}Al$
4. $_{14}Si$
5. $_{15}P$

The atom with the largest increase for its 3rd ionization energy would be

1. $_{11}Na$ *(for Na it would be the 2nd IE)*

2. $_{12}Mg$ because it has 2 valence electrons and stealing the third electron comes from a full energy level.

3. $_{13}Al$ *(for Al it would be the 4th IE)*

4. $_{14}Si$ *(for Si it would be the 5th IE)*

5. $_{15}P$ *(for P it would be the 6th IE)*

   - All successive IE are larger than the previous, however,the really large increase occurs for the electron that is one more than the number of valence electrons.

In which set of elements would all the atoms have very similar *chemical* properties?

1. ${}_{11}Na$, ${}_{12}Mg$, ${}_{13}Al$
2. ${}_{14}Si$, ${}_{32}Ge$, ${}_{50}Sn$
3. ${}_{26}Fe$, ${}_{27}Co$, ${}_{28}Ni$
4. ${}_{8}O$, ${}_{16}S$, ${}_{34}Se$
5. I have no idea how to even begin to answer this question.
   (Hint: chemical families…)

In which set of elements would all the atoms have very similar *chemical* properties?

1. ${}_{11}Na$, ${}_{12}Mg$, ${}_{13}Al$
2. ${}_{14}Si$, ${}_{32}Ge$, ${}_{50}Sn$ this family crosses the metal nonmetal barrier and thus would have different chemical properties
3. ${}_{26}Fe$, ${}_{27}Co$, ${}_{28}Ni$
4. ${}_{8}O$, ${}_{16}S$, ${}_{34}Se$ These elements are all in the same chemical family which all have the same number of valence electrons.
5. I have no idea how to even begin to answer this question.

When rubidium ($_{37}Rb$) turns into its most common ion by losing an electron, *(Select all that apply.)*

1. It is isoelectronic with $_{35}Br^{-1}$
2. It becomes positively charged
3. It turns into Kr
4. The resulting ion will be smaller than the atom it came from
5. Its electrons will be the same as the strontium ion's electrons ($_{38}Sr^{+2}$)
6. turns into a +1 cation

When rubidium ($_{37}Rb$) turns into its most common ion by losing an electron,

1. It is isoelectronic with $_{35}Br^{-1}$
   » *The bromide ion has gained one e- making 36 electrons*
2. It becomes positively charged
   » *because it lost one electron: 37+ and 36-*
3. It turns into Kr
   » *(Of course the Rb^{+1} ion does not become Kr because it still only has 37 protons, not 36 like Kr)*
4. The resulting ion will be smaller than the atom it came from
   » *Cations (+ ions) are always smaller than their parent atom.*
5. Its electrons will be the same as the strontium ion's electrons ($_{38}Sr^{+2}$)
   » *The electrons for both of these ions will be the same as Kr's electrons: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6$*

Which is more reactive?

1. $_{3}Li$
2. $_{11}Na$
3. $_{19}K$
4. $_{37}Rb$
5. They are equally reactive because they are in the same chemical family.
6. I have no knowledge of how I might even decide this.

Which is more reactive?

1. $_{3}Li$
2. $_{11}Na$
3. $_{19}Na$
4. $_{37}Rb$ rubidium would be most reactive because the alkali metals are **losing** an electron, and the e^- will be lost most vigorously when the electron being lost is **furthest** from the + pull of the nucleus.
5. They are equally reactive because they are in the same chemical family.
6. I have no knowledge of how I might even decide this.

Which is more reactive?

1. $_{9}F$
2. $_{17}Cl$
3. $_{35}Br$
4. $_{53}I$
5. They are equally reactive because they are in the same chemical family.
6. I have no knowledge of how I might even decide this.

Which is more reactive?

1. $_{9}F$ Halogens most commonly gain electrons. A **smaller** halogen **gains e^{-}'s** more vigorously because the **protons** pulling in the electron that is being gained are **closer** to the valence shell, and the closer the incoming e^{-} comes to the nucleus, the more vigorously that electron will be grabbed.
2. $_{17}Cl$
3. $_{35}Br$
4. $_{53}I$
5. They are equally reactive because they are in the same chemical family.
6. I have no knowledge of how I might even decide this.

Which is more reactive?

1. $_{8}O$
2. $_{16}S$
3. $_{34}Se$
4. $_{52}Te$
5. They are equally reactive because they are in the same chemical family.

Which is more reactive?

1. $_{8}O$ Like the halogens, these atoms also **gain electrons** and a smaller atom does that more vigorously because the protons are closer to the valence shell and pull in the electrons to be gained more vigorously.
2. $_{16}S$
3. $_{34}Se$
4. $_{52}Te$
5. They are equally reactive because they are in the same chemical family.

Which will normally form a negative ion? *(Select as many as apply.)*

1. $1s^2\,2s^2 2p^6\,3s^2$
2. $1s^2\,2s^2 2p^6\,3s^1$
3. $1s^2\,2s^2 2p^6$
4. $1s^2\,2s^2 2p^4$
5. $1s^2\,2s^2 2p^3$
6. $1s^2\,2s^2 2p^6\,3s^2 3p^1$

Which will normally form a negative ion? *(Select as many as apply.)*

1. $1s^2\,2s^2 2p^6\,3s^2$
2. $1s^2\,2s^2 2p^6\,3s^1$
3. $1s^2\,2s^2 2p^6$
4. $1s^2\,2s^2 2p^4$
5. $1s^2\,2s^2 2p^3$
6. $1s^2\,2s^2 2p^6\,3s^2 3p^1$

Which will normally form a negative ion? *Select as many as apply.*

1. [Ar] $4s^1$
2. [Ar] $4s^2$
3. [Ar] $4s^2 3d^{10} 4p^6$
4. [Ar] $4s^2 3d^{10} 4p^5$
5. [Ar] $4s^2 3d^{10} 4p^2$
6. [Ar] $4s^2 3d^6$

Which will normally form a negative ion? *Select as many as apply.*

1. [Ar] $4s^1$
2. [Ar] $4s^2$
3. [Ar] $4s^2 3d^{10} 4p^6$
4. [Ar] $4s^2 3d^{10} 4p^5$
5. [Ar] $4s^2 3d^{10} 4p^2$
6. [Ar] $4s^2 3d^6$

Which will have the lowest ionization energy?

1. $1s^2\ 2s^2\ 2p^6\ 3s^2$
2. $1s^2\ 2s^2\ 2p^6\ 3s^1$
3. $1s^2\ 2s^2\ 2p^6$
4. $1s^2\ 2s^2\ 2p^4$
5. $1s^2\ 2s^2\ 2p^3$
6. $1s^2\ 2s^2\ 2p^1$

Which will have the lowest ionization energy?

1. $1s^2\ 2s^2\ 2p^6\ 3s^2$
2. $1s^2\ 2s^2\ 2p^6\ 3s^1$
3. $1s^2\ 2s^2\ 2p^6$
4. $1s^2\ 2s^2\ 2p^4$
5. $1s^2\ 2s^2\ 2p^3$
6. $1s^2\ 2s^2\ 2p^1$

Which *metal* would combine with oxygen in a one to one ratio.

Select as many as apply.

1. $1s^2\ 2s^2\ 2p^6\ 3s^2$
2. $1s^2\ 2s^2\ 2p^6\ 3s^1$
3. $1s^2\ 2s^2\ 2p^6$
4. $1s^2\ 2s^2\ 2p^4$
5. $1s^2\ 2s^2\ 2p^3$
6. $1s^2\ 2s^2\ 2p^1$

Which metal would combine with oxygen in a one to one ratio.

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1. $1s^2\ 2s^2\ 2p^6\ 3s^2$
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3. $1s^2\ 2s^2\ 2p^6$
4. $1s^2\ 2s^2\ 2p^4$
5. $1s^2\ 2s^2\ 2p^3$
6. $1s^2\ 2s^2\ 2p^1$

A certain nonmetallic element forms a compound with gallium having the general formula GaX_3. Element X must be a member of which group?

1. 1A
2. 2A
3. 3A
4. 4A
5. 5A
6. 6A
7. 7A

A certain nonmetallic element forms a compound with gallium having the general formula GaX_3. Element X must be a member of which group?

1. 1A
2. 2A
3. 3A
4. 4A
5. 5A
6. 6A
7. 7A

That’s all for now