# Atomic Structure

Vocabulary

1. atomic number
2. isotope
3. anion
4. cation
5. ion
6. charge
7. average atomic mass
8. mass number
9. nuclear(isotope) symbol
10. Bohr diagram
11. Lewis Electron Dot diagram

# Atomic Structure

**Objectives:**

1. I can name, list the charge/location/mass of each subatomic particle.
2. I can draw a Bohr & e-dot model of an element.
3. I can calculate subatomic particles from a Chemical symbol or write a Chemical symbol from subatomic particles.
4. I can define an ion and determine its charge by the subatomic particles.
5. I can define an isotope and determine its atomic mass by the subatomic particles.
6. I am able to determine the number of valence electrons an atom contains using the periodic table or electron configuration.

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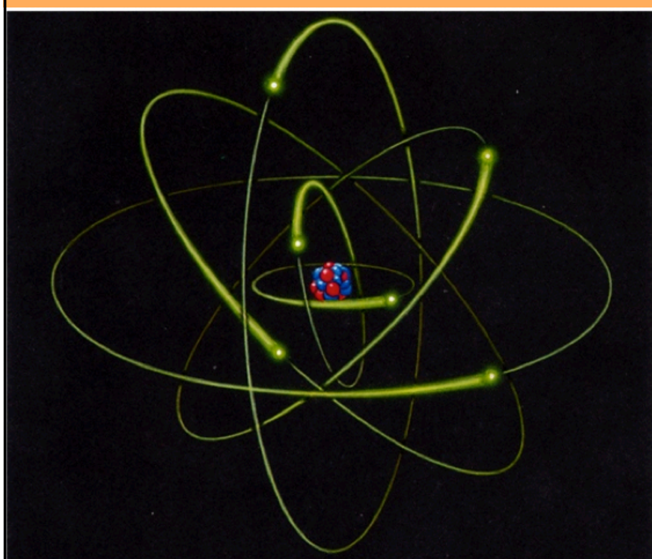
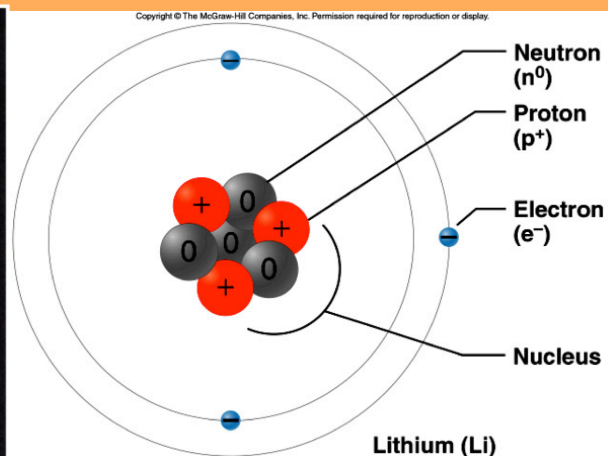
obj: I can name, list the charge/location/mass of each subatomic particle.

# Nucleus:

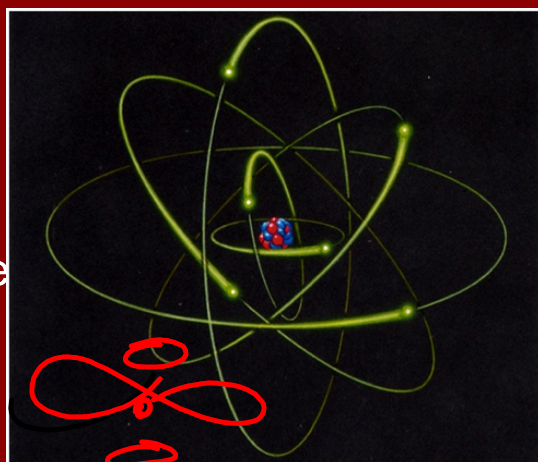
- small area in center of the atom
- contains protons and neutrons
- electrons: located in electron cloud





obj: I can name, list the charge/location/mass of each subatomic particle.

# Truth vs. Myth



**Myth**

- Electrons do not travel around the nucleus like planets.

**Truth**

- Nucleus is located in the center but much smaller
- Electrons have energy levels

http://www.ted.com/talks/just_how_small_is_an_atom.html

obj: I can name, list the charge/location/mass of each subatomic particle.

# Subatomic particles

| Name | charge | mass | location |
|---|---|---|---|
| proton | | | |
| electron | | | |
| neutron | | | |

amu = atomic mass unit

**amu = atomic mass unit**

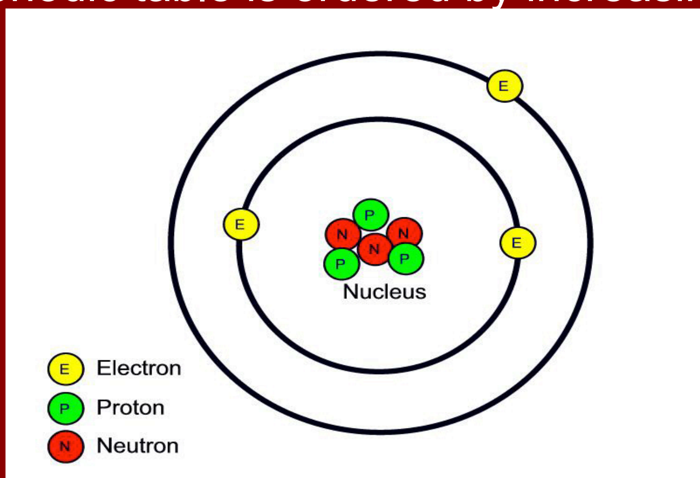
obj: I can name, list the charge/location/mass of each subatomic particle.

Atomic number: number of protons in an atom

Why important?

-The number of protons determines the element.

-The periodic table is ordered by increasing protons.




**The atomic # is the identity of the element**

obj: I can model the properties of all subatomic particles.

# Mass number

*review*

**mass of proton=**
**mass of neutron=**
**mass of electron=**

Mass Number-Describes the mass of an individual atom.

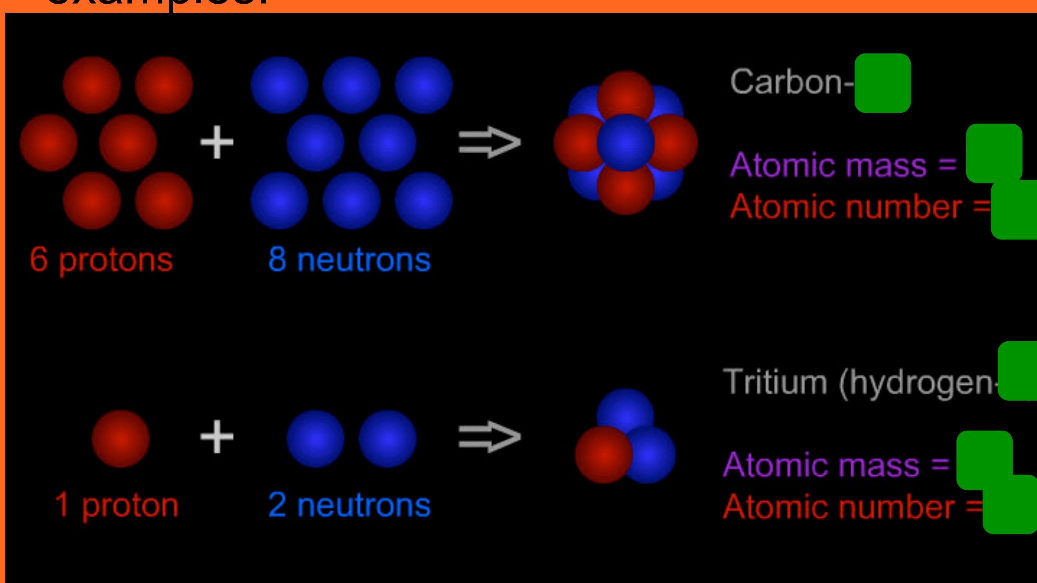
1. Since only Protons and Neutrons have mass all the **mass** is located in the **nucleus.**

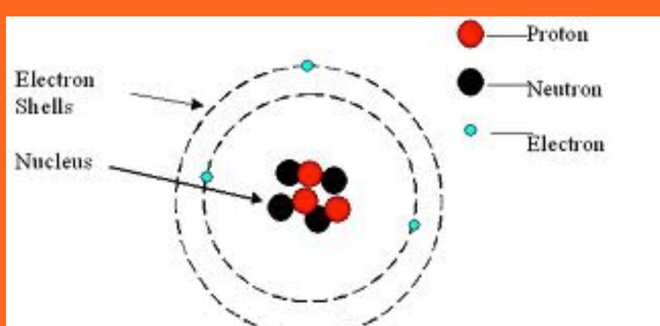
2. Each neutron and proton has a mass of 1 amu so...

Mass number = protons + neutrons

Mass # = $p^{+}$ + $n^{0}$

examples:




atomic number:

element:

mass number:

Obj: I can draw a Bohr & e-dot model of an element.

# Bohr Diagrams: (for #1 -20)

need

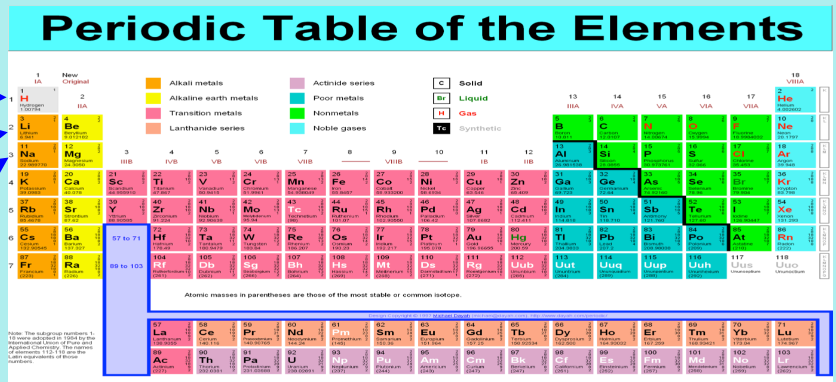
1. # energy shells = period #
2. # of valence $e^-$ = group in s and p block

## 1. # energy shells

period 1 has 1 shell

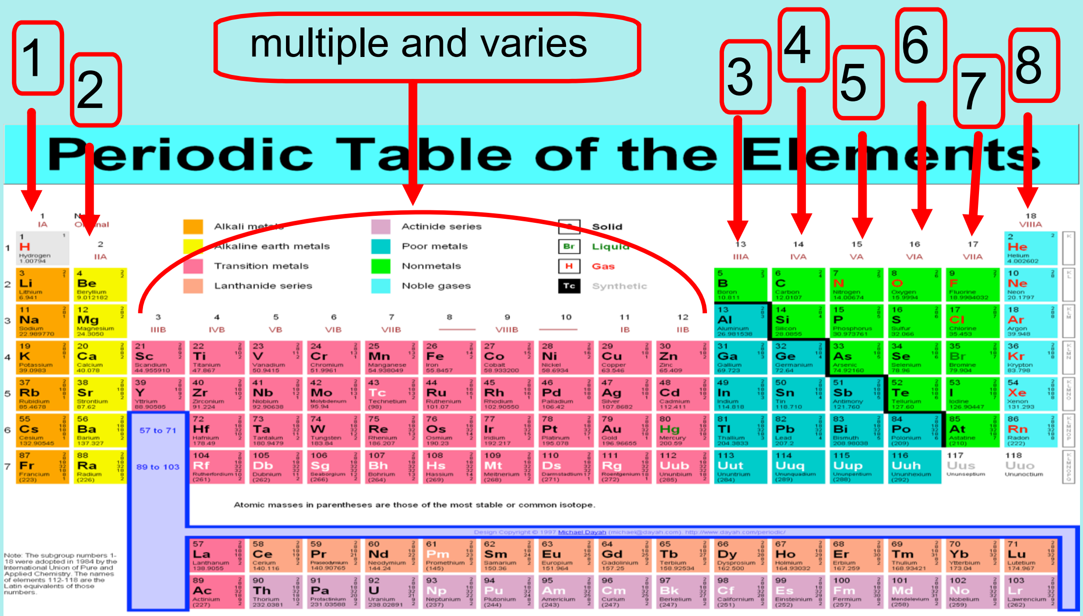
period 2 has 2 shells

period 3 has 3 shells




## 2. valence electrons: electrons in the outermost shell

How many valence electrons? Look at group.

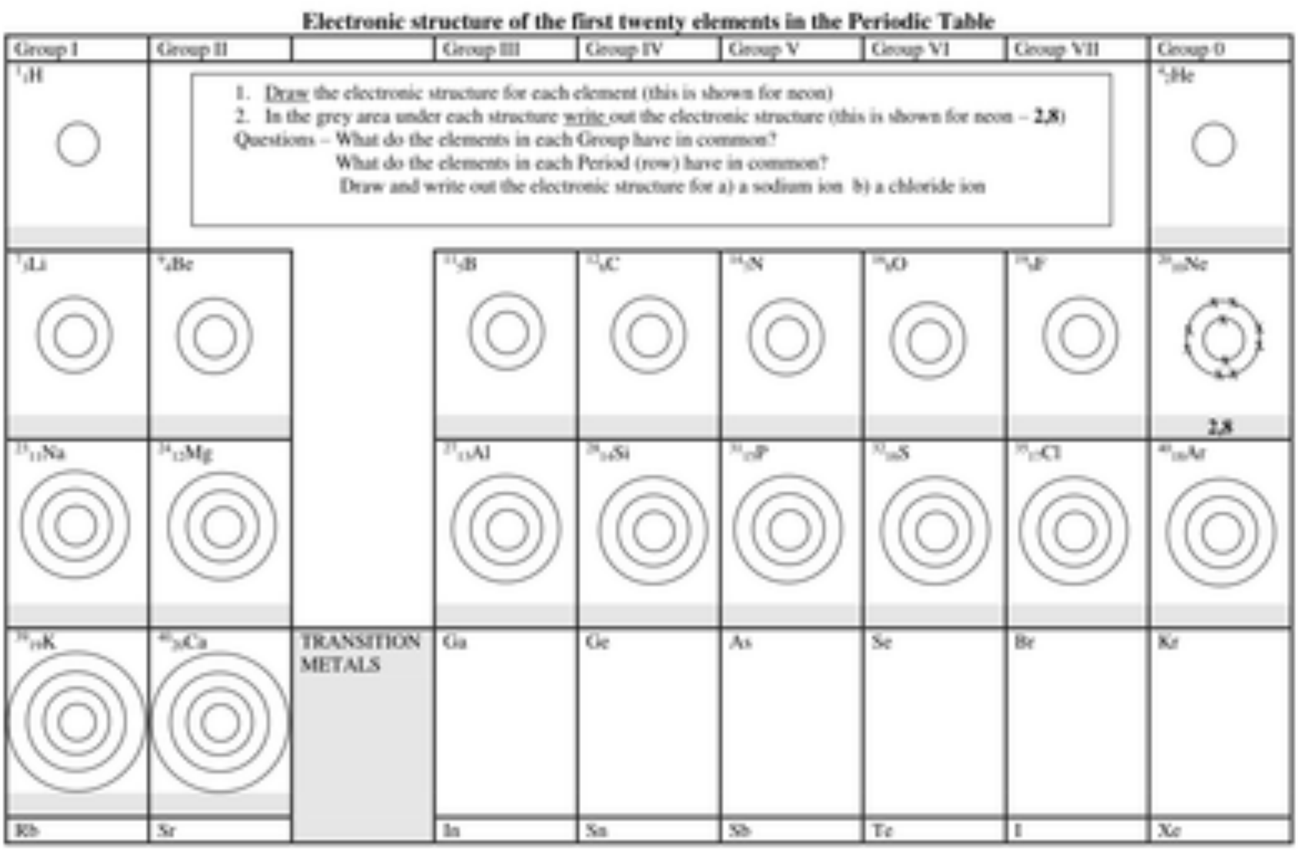


Obj: I can draw a Bohr & e-dot model of an element.

## Bohr Diagrams: (for #1 -20)

need

- # energy shells = period #
- # of valence $e^-$ = group in s and p block
- include $p^+$ and $n^0$ in center



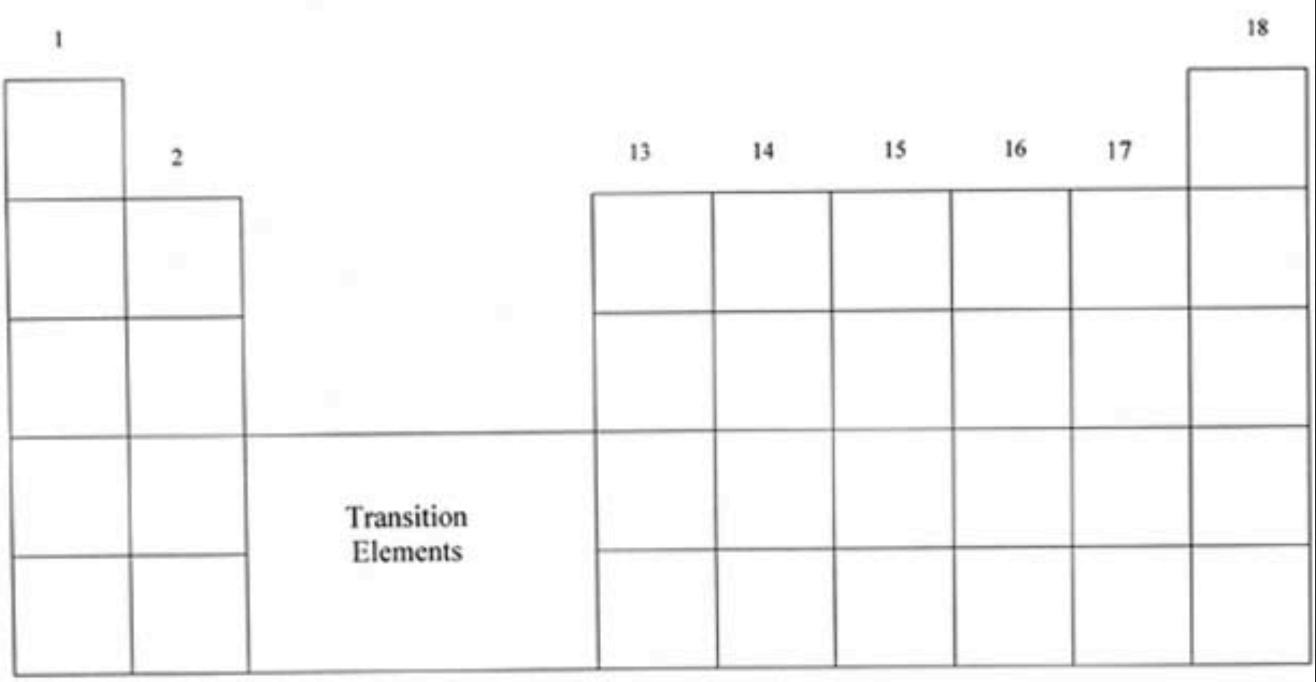
Obj: I can draw a Bohr & e-dot model of an element.

## Lewis/Electron Dot Diagram (for #1 -20)

need

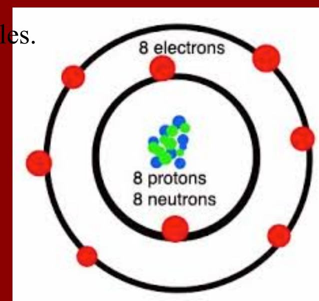
- element symbol
- # of valence $e^-$ = group in s and p block

  show in dots around symbol



Obj: I can define an ion and determine its charge by the subatomic particles.
Obj: I can define an isotope and determine its atomic mass by the subatomic particles.

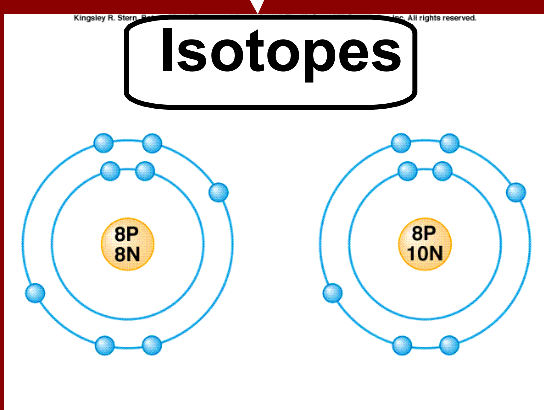
# Atomic number



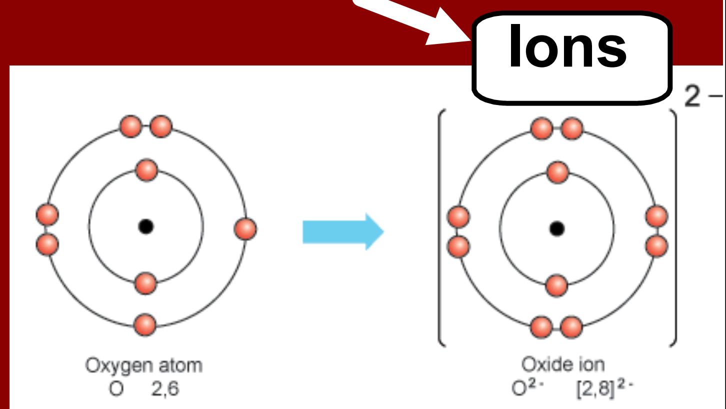

**Example:**
Oxygen has 8 protons (cannot change)

The number of neutrons and electrons can and will vary.

**<u>Altering the neutrons</u>** will change the overall mass.




**<u>Altering the electrons</u>** will change the charge.



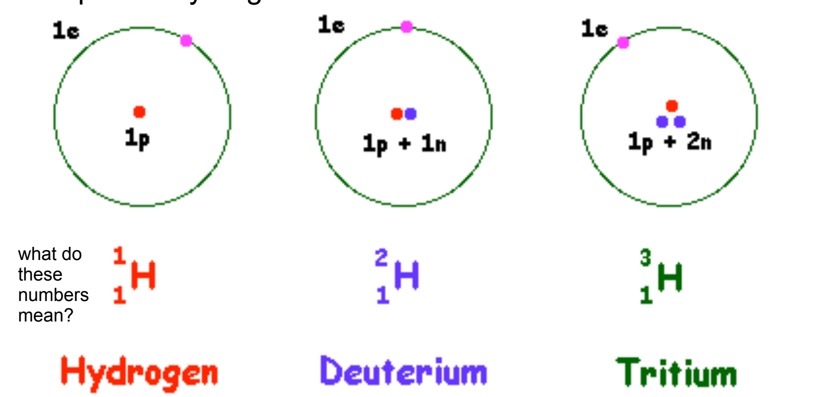
Obj: I can define an isotope and determine its atomic mass by the subatomic particles.

# Isotopes

**2 atoms with the same number of protons but different number of neutrons**

**Atoms of a single element can vary in mass.**
**Protons must stay constant. (locked)**
**Neutrons can vary.**

Isotopes of Hydrogen




Hydrogen
Atomic Mass = 1
Atomic Number = 1

Hydrogen (Deuterium)
Atomic Mass = 2
Atomic Number = 1

Hydrogen (Tritium)
Atomic Mass = 3
Atomic Number = 1

## Isotope --Notation

mass number
**X**
atomic number

mass number = protons + neutrons
atomic number = protons
$^{3}_{1}H$ symbol of element

three ways to write:

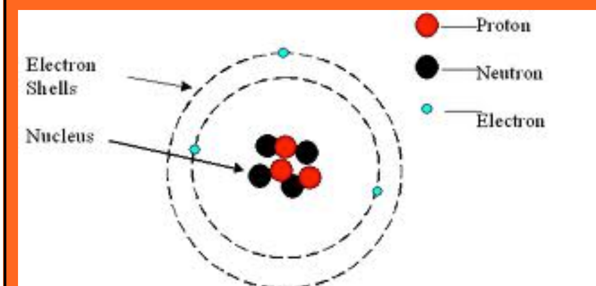
$^{12}_{6}C$ ↔ C-12 Carbon-12

$^{13}_{6}C$ ↔ C-13 Carbon-13

$^{14}_{6}C$ ↔ C-14 Carbon-14

obj: I can model the properties of all subatomic particles.

The mass number is not located on the periodic table. Why?




Lithium mass number: 7

**<u>Mass number</u> describes a SINGLE atom and**
**<u>ave. atomic mass</u> (periodic table) describes MANY atoms**


average atomic mass:
some Li-6 and
mostly Li-7

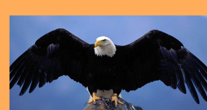
# Protons and Neutrons

**Instructions**

Below you will practice figuring out the different protons, electrons, and neutrons for the table. I have left some open to help you out, but once you have an answer click on the cell shade to reveal the answers. If you need the periodic table click on the animal below to go to the periodic table.

| Isotope | Number of $p^+$ | Number of $e^-$ | Number of $n^o$ | Nuclear Symbol |
|---|---|---|---|---|
| Hydrogen-2 | | | 1 | |
| Helium-3 | 2 | | | |
| Lithium-7 | | | | $^{7}_{3}Li$ |
| Beryllium-9 | | 4 | | |
| Boron-11 | | | | |

Previous



Next

1.What is the mass of a proton? Neutron? Electron?

2.A neutral atom has 14 protons and 18 neutrons. Write the correct nuclear (isotope) symbol.

3.Which of the following pairs show two atoms with the same number of neutrons?

$^{37}_{17}Cl$ and $^{38}_{18}Ar$ $^{59}_{27}Co$ and $^{61}_{27}Co$

$^{32}_{15}P$ and $^{32}_{16}S$ $^{65}_{30}Zn$ and $^{67}_{30}Zn$

4.There are 3 stable isotopes of Argon: Argon-36, Argon-38 and Argon-40.
What would the atoms of these isotopes have in common?
What would be different about their atoms?

1. What is the mass of a proton? Neutron? Electron?

1 amu 1 amu 0 amu

2. A neutral atom has 14 protons and 18 neutrons. Write the correct nuclear (isotope) symbol. $^{32}_{14}Si$

3. Which of the following pairs show two atoms with the same number of neutrons?

$^{37}_{17}Cl$ and $^{38}_{18}Ar$ — both have 20 neutrons

$^{59}_{27}Co$ and $^{61}_{27}Co$

$^{32}_{15}P$ and $^{32}_{16}S$

$^{65}_{30}Zn$ and $^{67}_{30}Zn$

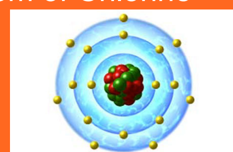
4. There are 3 stable isotopes of Argon:
Argon-36, Argon-38 and Argon-40.
What would the atoms of these isotopes have in common?
same # $p^+$ and $e^-$
What would be different about their atoms? different # $n^0$

obj: I can model how and why different atoms of the same element have different masses.

# Average atomic mass

The Atomic mass of Chlorine is 35.453.


Q: Is there actually an atom of Chlorine with a mass of 35.453?



Chlorine: How many Protons? 17

How many Neutrons?

If the mass number = 35

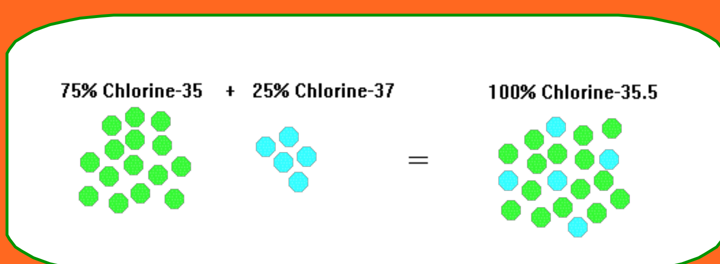
Neutrons = **18**

If the mass number = 37

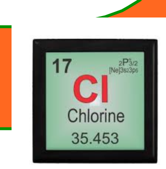
Neutrons = **20**

No-- only **35** and **37.** So why the decimal?

Average atomic mass is the average mass in relation to its relative abundance of its isotopes.




The periodic table shows the **average atomic mass** of all atoms




$$\frac{(15 \times 35) + (5 \times 37)}{20} = 35.5 \text{ amu}$$

$$(0.75 \times 35) + (0.25 \times 37) = 35.5 \text{ amu}$$

obj: I can model how and why different atoms of the same element have different masses.

## Example with averages:

A student receives a 84.6%
This is a B but the student never actually scored a B on any assignments.

How is this possible?

The student is scored on many assignments.
Some where higher then a B and others where lower then a B.

| assignment | grade |
|---|---|
| 1 | 100%/A+ |
| 2 | 50%/F |
| 3 | 75%/C |
| 4 | 98%/A |
| 5 | 100%/A+ |
| average | 84.6/B |

obj: I can model how and why different atoms of the same element have different masses.

Find the element Rf on the periodic table.
Atomic #104
What is different about this element as opposed to other elements?

(261)

**see the key:**
this element has no stable isotope,
the mass number of the isotope with the longest half-life is in parenthesis.

obj: I can model how and why different atoms of the same element have different masses.

# Average atomic masses

1st – When we mass out a sample,
we are getting a mixture of different isotopes.
Some heavier… some lighter

2nd – Scientists have actually measured the abundance of different isotopes and determined the **average mass** for Cl is 35.47.

| Isotope | Half Life |
|---|---|
| Cl-35 | Stable |
| Cl-36 | 301000 years |
| Cl-37 | Stable |
| Cl-38 | 37.2 minutes |

Obj: I can define an ion and determine its charge by the subatomic particles.

# Determining the charge on an atom

What are the charges on subatomic particles?

Protons = ☐

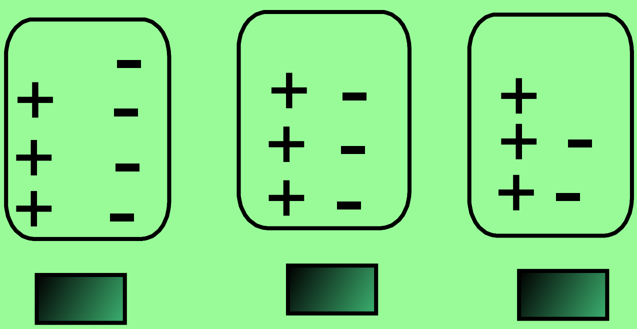
Electrons = ☐

Neutrons = ☐

If protons = electrons then the charge is 0

**Each + cancels out a −**

Ask: What do you have more of, + or - ?
How many more?



An atom of oxygen has 10 electrons.
What is the charge?

Oxygen:

Protons ☐

Electrons ☐

One more $e^-$ than $p^+$, so the charge is ☐

# <u>Ions:</u> **charged particles**

If an atom ...
acquires a negative charge it _________ electrons

acquires a positive charge it _________ electrons

Two types:

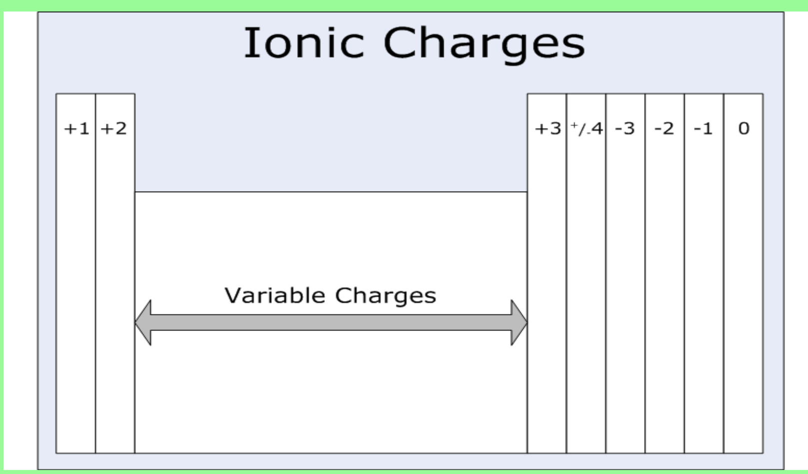
**Anion: negatively charged particle**

**aN**ion = **N**egative ion

**Cation: Positivly charged particle.**

Ca**+**ion
Pronounced: “cat + ion”

*They are always "Paws"ative*



Obj: I can define an ion and determine its charge by the subatomic particles.

# Behavior of protons and electrons

Very important:

Atoms can ***easily*** lose or gain electrons

↓

alter the charge

Atoms can ***NOT easily*** gain or lose protons.

↓

this would be a nuclear reaction.

If an atom ...

acquires a negative charge it [redacted] electrons

acquires a positive charge it [redacted] electrons

Protons NEVER move!
Any change is relative to the number of electrons moving.

$Zn^o$ becomes $Zn^{2+}$

What happened? Zn "lost" 2 electrons

$Zn^o \rightarrow Zn^{2+} +$ _____

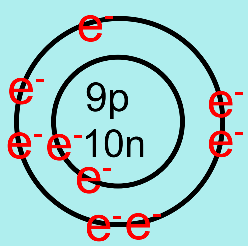
O becomes $O^{-2}$

What happened here? O "gained" 2 electrons

O + ____ $\rightarrow O^{-2}$

## Non-Metals Form Anions (Negative Ions)

Nearest noble gas?___




F $9p^+$ $9e^-$

0 charge

$F^{-1}$

Octet achieved by ____________

Draw a Lewis dot diagram of a phosphorus(P, #15) **atom** and **ion**.

P P

Nearest noble gas?

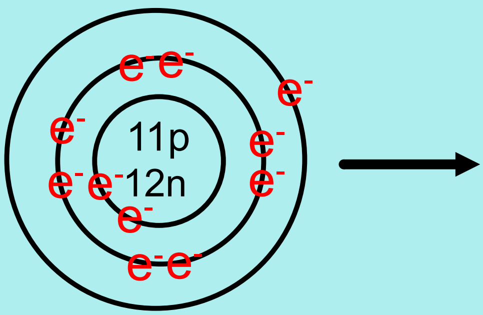
What is the charge on the P ion?

What is the symbol for the P ion?

Octet achieved by ____________

# Metals Form Cations, (Positive Ions)

Nearest noble gas to Na is _____




Na 11p⁺ 11e⁻ Na$^{+1}$

0 charge

Octet achieved by ___________

Draw a Lewis dot diagram of a calcium(Ca, #20) **atom** and **ion**.

Ca Ca

Nearest noble gas to Ca?____

What is the charge on the Ca ion?

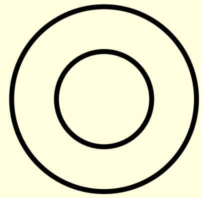
What is the symbol for the Ca ion?

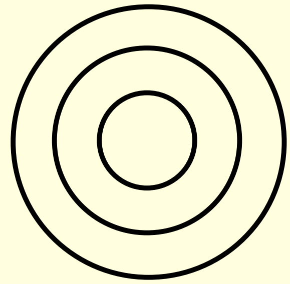
Octet achieved by ___________

# Drawing Bohr models:

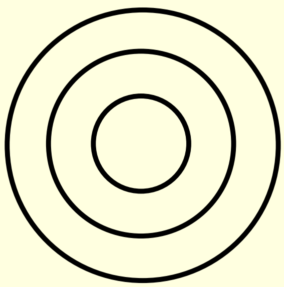
Number of electrons in each shell:

1st shell:
2nd shell:
3rd shell:

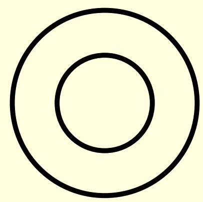




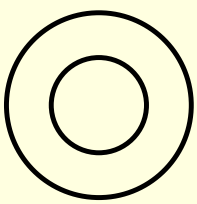
Na



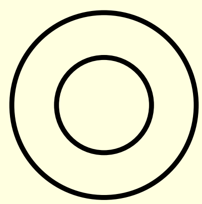
$Na^{+1}$



F



$F^{-1}$



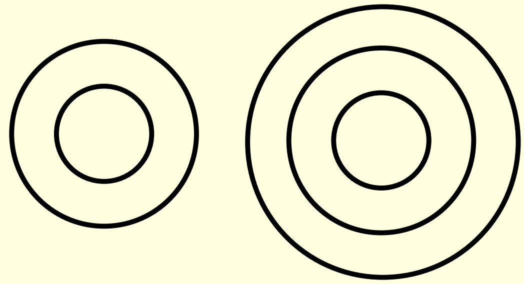
N

$N^{-3}$

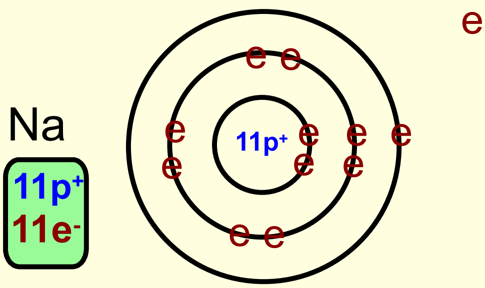
# Drawing Bohr models:

Number of electrons in each shell:

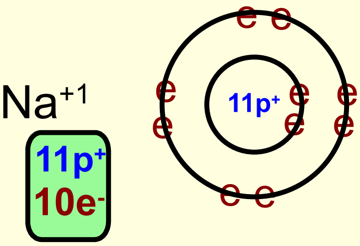
- 1st shell: 2
- 2nd shell: 8
- 3rd shell: 8



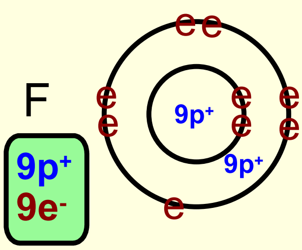
Na



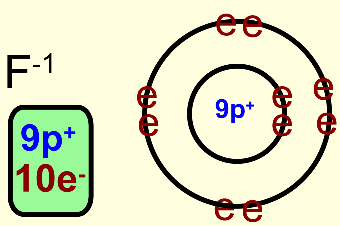

$Na^{+1}$




F



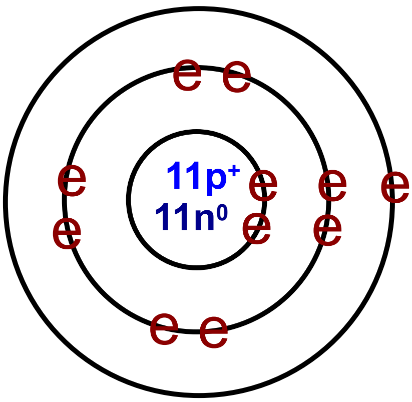

$F^{-1}$



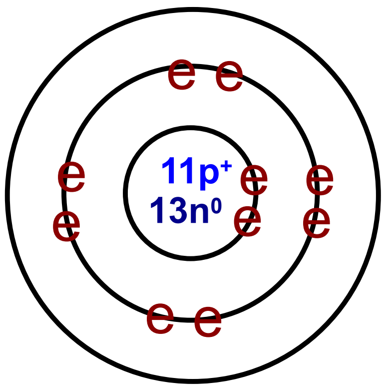

N

$N^{-3}$

# Practice




element?
isotope symbol?
mass number?
charge?




element?
isotope symbol?
mass number?
charge?

What do we call both of these when the mass numbers are different?

Which is the atom?
Which is the ion?

Obj: I am able to determine the number of valence electrons an atom contains using the periodic table or electron configuration.

# How many protons and electrons are in the following atoms/ions?

**(hint: always find proton number first)**

| | Protons | Electrons |
|---|---|---|
| $Na^{+1}$ | | |
| $F^{-1}$ | | |
| Ar | | |
| $Be^{+2}$ | | |
| $N^{-3}$ | | |

Obj: I am able to determine the number of valence electrons an atom contains using the periodic table or electron configuration.

## How many protons and electrons are in the following atoms/ions?

(hint: always find proton number first)

| | Protons | Electrons |
|---|---|---|
| $Na^{+1}$ | +11 | -10 |
| $F^{-1}$ | +9 | -10 |
| Ar | +18 | -18 |
| $Be^{+2}$ | +4 | -2 |
| $N^{-3}$ | +7 | -10 |

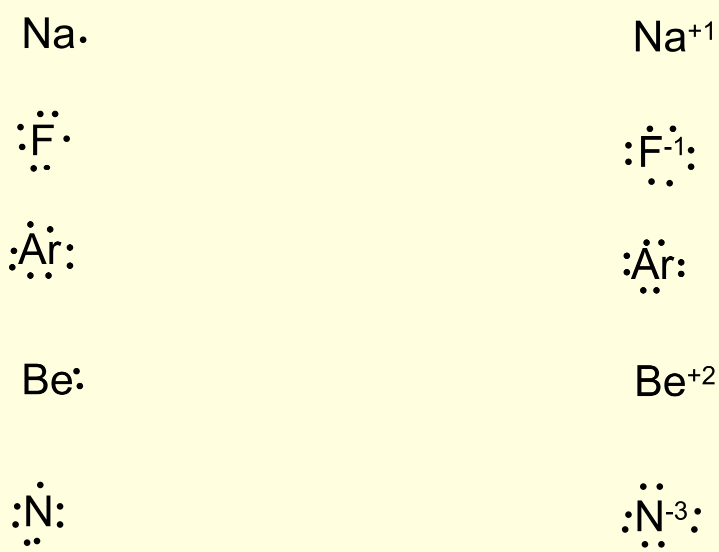
Obj: I am able to determine the number of valence electrons an atom contains using the periodic table or electron configuration.

## Drawing Lewis electron dot Structures:
only showing valence (outer shell) electrons

| | |
|---|---|
| Na | $Na^{+1}$ |
| F | $F^{-1}$ |
| Ar | Ar |
| Be | $Be^{+2}$ |
| N | $N^{-3}$ |

Obj: I am able to determine the number of valence electrons an atom contains using the periodic table or electron configuration.

## Drawing Lewis electron dot Structures:
## only showing valence (outer shell) electrons



Obj: I can define an ion and determine its charge by the subatomic particles.

# Atomic Structure Practice

**Same value**

**Mass number = $p^+ + n^0$**

**Charge = $p^+ - e^-$**

| Symbol (nuclear) | atomic # | Mass # | p | n | e | Charge | Avg. atomic mass |
|---|---|---|---|---|---|---|---|
| O | | | | 8 | | 0 | |
| | 12 | 22 | | | 13 | | |
| | | | 5 | 4 | | -2 | |
| | | | | | | | |

# Atomic Structure Practice

**Same value**

**Mass number = $p^+ + n^0$**

**Charge = $p^+ - e^-$**

| Symbol (nuclear) | atomic # | Mass # p+n | p | n | e | Charge | Avg. atomic on periodic table |
|---|---|---|---|---|---|---|---|
| $^{16}_{8}O$ | 8 | 16 | 8 | 8 | 8 | 0 | 16.0 |
| $^{22}_{12}Mg$ | 12 | 22 | 12 | 10 | 13 | -1 | 24.3 |
| $^{9}_{5}B$ | 5 | 9 | 5 | 4 | 7 | -2 | 10.8 |

# Practice

if not written as isotope, use
mass number closest to the average
atomic mass

| Element/ Ion | Atomic Number | Average Atomic Mass | Mass Number | Protons | Neutrons | Electrons |
|---|---|---|---|---|---|---|
| H | | | | | | |
| $H^+$ | | | | | | |
| $^{12}_{6}C$ | | | | | | |
| $^{7}_{3}Li^+$ | | | | | | |

# Practice

if not written as isotope, use mass number closest to the average atomic mass

| Element/ Ion | Atomic Number | Average Atomic Mass | Mass Number | Protons | Neutrons | Electrons |
|---|---|---|---|---|---|---|
| H | 1 | 1.00794 | 1 | 1 | 0 | 1 |
| $H^+$ | 1 | 1.00794 | 1 | 1 | 0 | 0 |
| $^{12}_{6}C$ | 6 | 12.0107 | 12 | 6 | 6 | 6 |
| $^{7}_{3}Li^+$ | 3 | 6.941 | 7 | 3 | 4 | 2 |

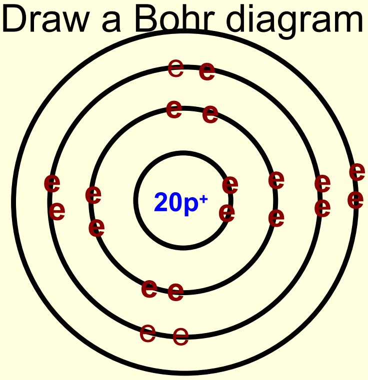
| SYMBOL nuclear | ATOMIC NUMBER | MASS NUMBER | $^{0}{}_{1}n$ | $e^-$ | Charg e | $P^+$ |
|---|---|---|---|---|---|---|
| O | | | 8 | 8 | | 8 |
| | 9 | 18 | | | 0 | |
| | | | 8 | | -1 | 16 |
| U | | | 80 | | +1 | |
| | | 209 | | | 0 | 95 |

Draw a Bohr diagram of Calcium

Draw a Lewis structure of Calcium

| SYMBOL nuclear | ATOMIC NUMBER | MASS NUMBER | ${}^{0}{}_{1}n$ | $e^-$ | Charge | $P^+$ |
|---|---|---|---|---|---|---|
| ${}^{16}_{8}O$ | 16 | 16 | 8 | 8 | 0 | 8 |
| ${}^{18}_{9}F$ | 9 | 18 | 9 | 9 | 0 | 9 |
| ${}^{16}_{24}S$ | 16 | 24 | 8 | 17 | -1 | 16 |
| ${}^{172}_{92}U$ | 92 | 172 | 80 | 91 | +1 | 92 |
| ${}^{209}_{95}Am$ | 95 | 209 | 114 | 95 | 0 | 95 |

Draw a Bohr diagram of Calcium




Draw a Lewis structure of Calcium

Ca:

| Element/ Ion | Atomic Number | Ave Atomic Mass | Mass Number | Protons | Neutrons | Electrons |
|---|---|---|---|---|---|---|
| H | 1 | 1.0 | 1 | 1 | 0 | 1 |
| $H^+$ | 1 | 1.0 | 1 | 1 | 0 | 0 |
| ${}^{12}_{6}C$ | 6 | 12.0 | 12 | 6 | 6 | 6 |
| ${}^{7}_{3}Li^+$ | 3 | 6.9 | 7 | 3 | 4 | 2 |
| ${}^{35}_{17}Cl^-$ | 17 | 35.5 | 35 | 17 | 18 | 18 |
| ${}^{39}_{19}K$ | 19 | 39.1 | 39 | 19 | 20 | 19 |
| ${}^{24}_{12}Mg^{2+}$ | 12 | 24.3 | 24 | 12 | 12 | 10 |
| $As^{3-}$ | 33 | 74.9 | 75 | 33 | 42 | 36 |
| Ag | 47 | 107.9 | 108 | 47 | 61 | 47 |
| $Ag^{+1}$ | 47 | 107.9 | 108 | 47 | 61 | 46 |
| $S^{-2}$ | 16 | 32.1 | 32 | 16 | 16 | 18 |
| U | 92 | 238.0 | 238 | 92 | 146 | 92 |