

Chapter 4 Atoms


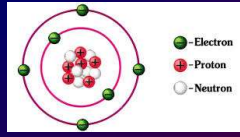

23Na
 11 protons
 12 neutrons
 11 electrons

Joke for the Day

- Why shouldn't you trust an atom?
- They make up everything.

What is in an Atom?

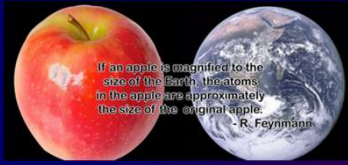
- Atoms are the building blocks of everything.
- Atoms can be divided, but not easily on Earth.
- No overall charge (Neutral)

Nuclear Fission

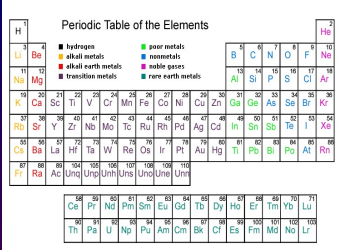
What is in an Atom?

118 different types of Atoms



If an apple is magnified to the size of the earth, the atoms in the apple are approximately the size of the original apple.

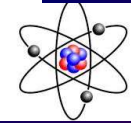
- R. Feynmann



What is in an Atom?



Parts of the Atom

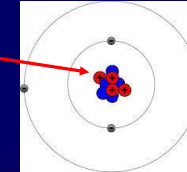
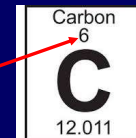


Particle	Charge	Mass (kg)	Location
Proton	+ 1	1.67×10^{-24}	In the nucleus
Neutron	0	1.67×10^{-24}	In the nucleus
Electron	-1	Least mass 9.109×10^{-28}	Outside the nucleus

What is in an Atom?

Protons

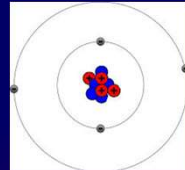
How many protons?



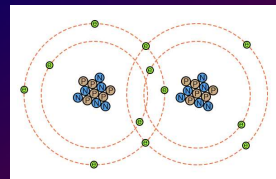
- An element is determined by the number of protons
- Protons determine an atoms Atomic Number
- NO TWO ELEMENTS WILL HAVE THE SAME NUMBER OF PROTONS.
- Positive (+) charge
- Located in the nucleus

What is in an Atom?

Electrons



- Electron have a negative (-) charge
- Located outside the nucleus
- Adding and removing electrons create **ions**.

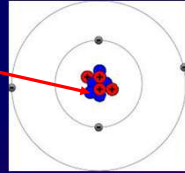


ELECTRON WHEN
PROTON ASKS

"WHY SO NEGATIVE?"

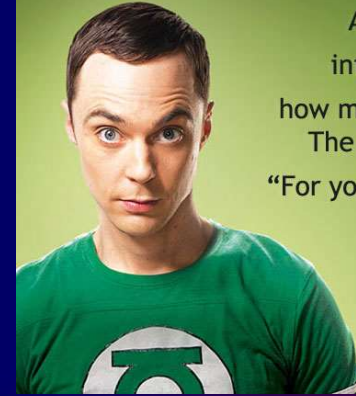
What is in an Atom?

Neutrons



- Neutrons have no charge (0) and are neutral.
- Neutrons contribute to overall atomic mass of the atom.
- Adding and removing neutrons create **isotopes**

A neutron walks
into a bar and asks
how much for a drink.
The bartender replies
"For you, no charge".



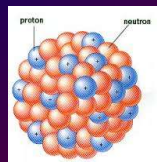
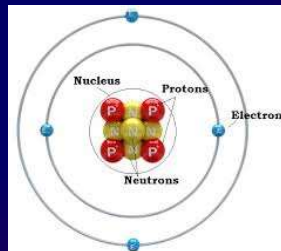
- Dr. Sheldon Cooper
The Big Bang Theory

What is in an Atom?

Nucleus

- Contains the protons and neutrons
- Where most of the mass of the atom is concentrated
- Has an overall positive (+) charge

Why?



Atomic Number

- Atomic number = the number of protons
 - If the atom is neutral, this is also the number of protons.
 - No two elements share the same atomic number or number of protons

What is the atomic number for the atoms below?

Lithium: 3
Hydrogen: 1
Uranium: 92

6 ← Atomic number
C ← Symbol
12.011 ← Atomic mass

Mass Number

- Mass number= the total number of subatomic particles in the nucleus
 - The sum of the protons and the neutrons.
 - *Example:* A fluorine atom has 9 protons and 10 neutrons, so $A = 19$ for fluorine.

What is the mass number for the atoms below?

Carbon: $\frac{12}{35}$
 Chlorine: $\frac{35}{35}$
 Aluminum: $\frac{27}{13}$

fluorine
9
F
18.998

mass number can be estimated by rounding the average atomic mass.

Atomic Mass is Average Mass

- For example....99% of all the helium atoms in the world have 2 neutrons. However, 3 out of every 1,000 have 3 neutrons instead of 2. Therefore, on the Periodic Table helium has an atomic mass of 4.003 AMU's

Helium	element
2	atomic number
He	symbol
4.003	atomic mass

Finding # of Neutrons

We can find the number of neutrons by subtracting the Atomic Number from the Mass Number.

$$\text{Mass number} - \text{Atomic number} = \text{Number of neutrons}$$

How many neutrons does Sulfur (S) have?

$$32 - 16 = 16 \text{ Neutrons}$$

How many neutrons does Aluminum (Al) have?

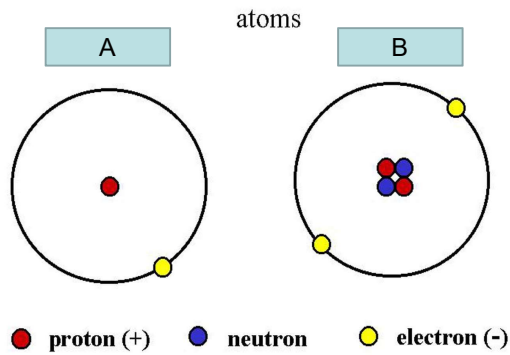
$$27 - 13 = 14 \text{ Neutrons}$$

Try this....

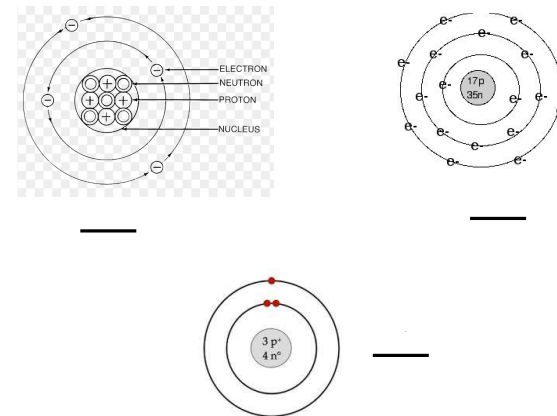
Element	Number of Protons	Number of Neutrons	Number of Electrons	Atomic Mass	Atomic Number
Tantalum Ta	73	108	73	181	73
Radium Ra	88	138	88	226	88

Try This

Identify the following two atoms

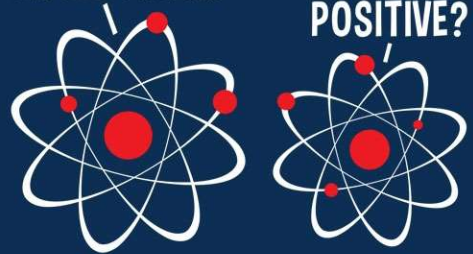


Identify the following atoms based on their Bohr Model



I'VE LOST
AN ELECTRON!

ARE YOU
POSITIVE?

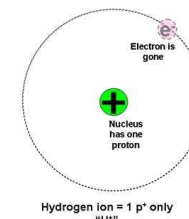
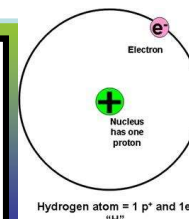


Ion Formation

electrons

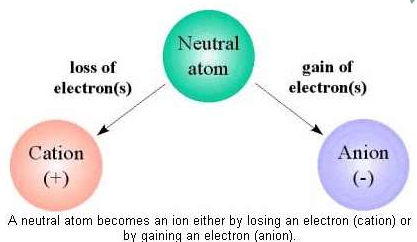
- A neutral atom that becomes charged is called an **ion**.
- Different number of protons and electrons
- Form by adding or removing the number of **electrons ONLY**.
- *Figure out number of electrons as a neutral atom. Then start adding or removing electrons.*

• It happens to atoms that do NOT have their outermost energy levels filled with electrons.



Ion Formation

electrons



Ion Formation

Number of Protons= 11

Number of Neutrons= 12

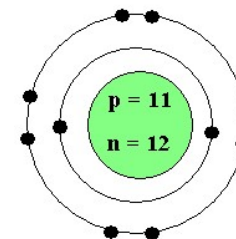
Number of Electrons= 10

Mass Number= 23

Identify the element= Sodium

Is this an Atom or an Ion? Ion

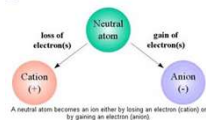
Identify the Ion? Na⁺¹



Ion symbols are written the element symbol with the charge written on the top right.

Ion Practice

Ion	Number of Proton	Number of Electrons	# of Added or removed electrons	Charge	Atom or Ion
Co	27	27	0	0	Atom
Co ⁺²	27	25	Removed 2	+2	Ion
Co ⁺³	27	24	Removed 3	+3	Ion
Cl	17	17	0	0	Atom
Cl ⁻¹	17	18	Added 1	-1	Ion



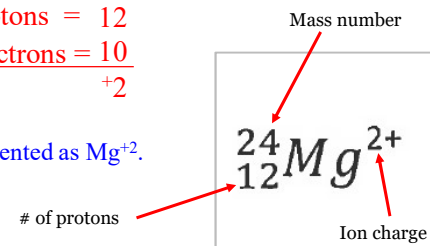
EXAMPLE

A neutral magnesium (Mg) atom has 12 protons and 12 electrons. If the magnesium atom loses 2 Electrons. What is it's net charge?

To find net charge of an ion, subtract the number of electrons from the number of protons.

$$\begin{array}{r}
 \text{Number of protons} = 12 \\
 - \text{Number of electrons} = 10 \\
 \hline
 +2
 \end{array}$$

A magnesium ion is represented as Mg²⁺.



EXAMPLE 1:

1. Sodium (Na) atoms have 11 protons and 11 electrons with a net charge of 0.
2. If the Sodium ion only has 10 electrons, what is the net charge of the ion? $(+11 - 10 = +1)$.
3. What is the chemical symbol for this ion?

Na⁺¹



EXAMPLE 2:

1. Beryllium (Be) atoms have 4 protons and 4 electrons with a net charge of 0.
2. If the Beryllium ion has only 2 electrons, what is the net charge of the ion? $(+4 - 2 = +2)$.
3. What is the chemical symbol for this ion?

Be²⁺

Create the symbol for Beryllium from this example?

Ion Practice Worksheet

Directions: Complete the following table.

Ion Symbol	Element Name	# of Protons	# of Electrons	Charge
S ²⁻				
K ¹⁺				
Ba ²⁺				
Fe ³⁺				
Fe ²⁺				
F ¹⁻				
O ²⁻				
P ³⁻				
Sn ⁴⁺				
Sn ²⁺				

Ion Practice Worksheet

N ³⁻				
Br ¹⁻				
Mg ²⁺				
Cu ¹⁺				
Cu ²⁺				
U ⁶⁺				
Mn ⁵⁺				
Cl ¹⁻				
Se ²⁻				



Learning Check – Counting

State the number of protons, neutrons, and electrons in each of these ions.

	$^{39}_{19}\text{K}^+$	$^{16}_8\text{O}^{-2}$	$^{41}_{20}\text{Ca}^{+2}$
#p ⁺	19	8	20
#n ⁰	20	8	21
#e ⁻	18	10	18

Learning Check

Write the nuclear symbol form for the following atoms or ions:

A. 8 p⁺, 8 n, 8 e⁻ _____

B. 17p⁺, 20n, 17e⁻ _____

C. 47p⁺, 60 n, 46 e⁻ _____

Atoms vs. Ions worksheet

Cations:

- have a positive charge
- have lost electrons

Anions:

- have a negative charge
- have gained electrons

Ion symbol:

To write the ion symbol, you must write the element symbol with the charge written on the top right.
Example: Ca²⁺, Zn²⁺, Ag⁺

		Atom Name:	Ion Name:
		Atomic number:	Atomic number:
		Mass number:	Mass number:
		Protons:	Protons:
		Neutrons:	Neutrons:
		Electrons:	Electrons:
Lithium atom	Lithium ion	Cation/Anion:	Ion symbol:
		Atom Name:	Ion Name:
		Atomic number:	Atomic number:
		Mass number:	Mass number:
		Protons:	Protons:
		Neutrons:	Neutrons:
		Electrons:	Electrons:
Beryllium atom	Beryllium ion	Cation/Anion:	Ion symbol:

		Atom Name:	Ion Name:
		Atomic number:	Atomic number:
		Mass number:	Mass number:
		Protons:	Protons:
		Neutrons:	Neutrons:
		Electrons:	Electrons:
Magnesium atom	Magnesium ion	Cation/Anion:	Ion symbol:
		Atom Name:	Ion Name:
		Atomic number:	Atomic number:
		Mass number:	Mass number:
		Protons:	Protons:
		Neutrons:	Neutrons:
		Electrons:	Electrons:
Aluminum atom	Aluminum ion	Cation/Anion:	Ion symbol:
		Atom Name:	Ion Name:
		Atomic number:	Atomic number:
		Mass number:	Mass number:
		Protons:	Protons:
		Neutrons:	Neutrons:
		Electrons:	Electrons:
Phosphorus atom	Phosphorus ion	Cation/Anion:	Ion symbol:
		Atom Name:	Ion Name:
		Atomic number:	Atomic number:
		Mass number:	Mass number:
		Protons:	Protons:
		Neutrons:	Neutrons:
		Electrons:	Electrons:
Sulfur atom	Sulfur ion	Cation/Anion:	Ion symbol:
		Atom Name:	Ion Name:
		Atomic number:	Atomic number:
		Mass number:	Mass number:
		Protons:	Protons:
		Neutrons:	Neutrons:
		Electrons:	Electrons:
Chlorine atom	Chlorine ion	Cation/Anion:	Ion symbol:

Ion Practice Worksheet

1. Given the information and a periodic table - complete the following.

${}_{9}^{19}\text{F}^{1-}$	${}_{5}^{11}\text{B}$	${}_{5}^{10}\text{B}^{3-}$
element: _____	element: _____	mass #: _____
# protons: _____	atomic #: _____	# protons: _____
# neutrons: _____	# neutrons: _____	# electrons: _____

${}_{13}^{27}\text{Al}^{3+}$	${}_{4}^{9}\text{Be}^{2+}$	${}_{26}^{56}\text{Fe}$
element: _____	element: _____	element: _____
# protons: _____	atomic #: _____	# protons: _____
# neutrons: _____	# electrons: _____	# electrons: _____
# electrons: _____	atomic mass: _____	# neutrons: _____

Ion Practice Worksheet

${}_{11}^{23}\text{Na}^{1+}$	${}_{20}^{40}\text{Ca}^{2+}$	${}_{30}^{65}\text{Zn}$
element: _____	element: _____	element: _____
atomic #: _____	atomic #: _____	# protons: _____
mass #: _____	# electrons: _____	# electrons: _____
# electrons: _____	# neutrons: _____	# neutrons: _____

${}_{18}^{40}\text{Ar}$	${}_{8}^{16}\text{O}^{2-}$	${}_{2}^{4}\text{He}$
element: _____	element: _____	element: _____
# protons: _____	atomic #: _____	# protons: _____
# neutrons: _____	# electrons: _____	# electrons: _____
# electrons: _____	atomic mass: _____	# neutrons: _____

Ion Practice Worksheet

1. Given the information and a periodic table - complete the following.

${}_{17}^{36}\text{Cl}^{1-}$	${}_{31}^{70}\text{Ga}$	${}_{11}^{24}\text{Na}^{1+}$
element: _____	element: _____	mass #: _____
# protons: _____	atomic #: _____	# protons: _____
# neutrons: _____	# neutrons: _____	# electrons: _____
# electrons: _____	# electrons: _____	atomic #: _____

${}_{4}^{9}\text{Be}^{2+}$	${}_{15}^{31}\text{P}^{3-}$	${}_{16}^{36}\text{S}^{2-}$
element: _____	element: _____	element: _____
# protons: _____	atomic #: _____	# protons: _____
# neutrons: _____	# electrons: _____	# electrons: _____
# electrons: _____	atomic mass: _____	# neutrons: _____

Ion Practice Worksheet

${}_{19}^{41}\text{K}^{1+}$	${}_{10}^{21}\text{Ne}$	${}_{55}^{133}\text{Cs}^{1+}$
element: _____	element: _____	element: _____
atomic #: _____	atomic #: _____	# protons: _____
mass #: _____	# electrons: _____	# electrons: _____
# electrons: _____	# neutrons: _____	# neutrons: _____

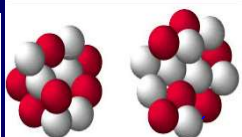
${}_{12}^{24}\text{Mg}^{2+}$	${}_{12}^{25}\text{Mg}$	${}_{12}^{26}\text{Mg}^{2+}$
element: _____	element: _____	mass #: _____
# protons: _____	atomic #: _____	# protons: _____
# neutrons: _____	# electrons: _____	# electrons: _____
# electrons: _____	atomic mass: _____	# neutrons: _____

What is the term used to describe these last examples? _____

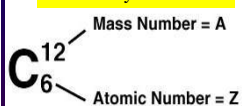
What do all three have in common? _____

Isotopes

- An isotope is an atom that has the same number of protons but a different number of neutrons (relative to other atoms of the element).
- Same number of electrons
- They vary in mass and mass number.



How many Neutrons?



Atomic number stays the same.
Why?

Same number protons

Complete Nuclear Symbols

Isotopes should be written using the complete nuclear symbol or by using a hyphen symbol. A charge should be indicated if the atom is not neutral.

EXAMPLE: Chlorine - 37 ← mass number

EXAMPLE: Chlorine - 35 ← mass number



What is different about the two symbols above?

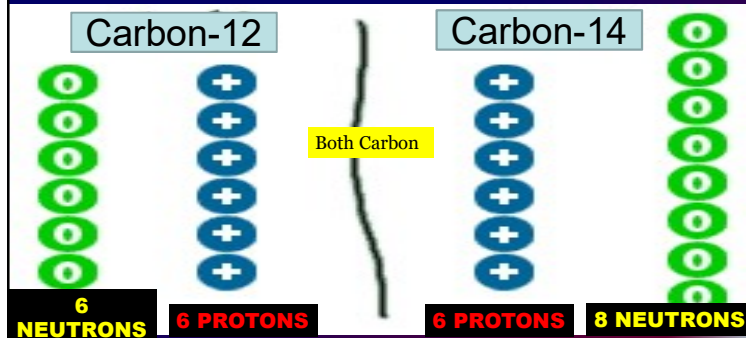
What do they have in common?

What are Isotopes?

All atoms of an element have the same atomic number and the same number of protons. However, atoms do not necessarily have the same number of neutrons. Atoms with the same number of electrons and protons, but different numbers of neutrons, are called isotopes. Different isotopes belong to the same element because they have the same number of electrons, which means that they all behave almost the same in chemical reactions.

Isotopes

Same element, but different mass due to different number of neutrons.



Isotopes

CHANGE IN WEIGHT, BUT NOT CHARGE

TWO ISOTOPES OF HYDROGEN.

ON THE LEFT, ONE NEUTRON
ON THE RIGHT, THERE ARE TWO

Isotopes

- Boron-10 (^{10}B) has 5 p and 5 n
- Boron-11 (^{11}B) has 5 p and 6 n

Atoms are same element but have different mass numbers making them isotopes.

Isotopes of Hydrogen

Hydrogen

Hydrogen - 1

Protons = 1
Electrons = 1
Neutrons = 0

Deuterium

Hydrogen - 2

Protons = 1
Electrons = 1
Neutrons = 1

Tritium

Hydrogen - 3

Protons = 1
Electrons = 1
Neutrons = 2

Figure 3

Isotopes?

Which of the following represent isotopes of the same element?
Which element?

① $\frac{234}{92} \text{X}$	② $\frac{234}{93} \text{X}$	③ $\frac{235}{92} \text{X}$	④ $\frac{238}{92} \text{X}$
Isotope	Neptunium	Isotope	Uranium



Learning Check – Counting

Naturally occurring carbon consists of three isotopes, ^{12}C , ^{13}C , and ^{14}C . State the number of protons, neutrons, and electrons in each of these carbon atoms.

	^{12}C	^{13}C	^{14}C
	6	6	6
#p ⁺	6	6	6
#n ^o	6	7	8
#e ⁻	6	6	6

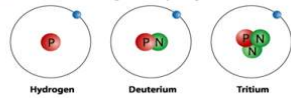
Learning Check

An atom has 14 protons and 20 neutrons.

- A. Its atomic number is
 1) 14 2) 16 3) 34
- B. Its mass number is
 1) 14 2) 16 3) 34
- C. The element is
 1) Si 2) Ca 3) Se
- D. Another isotope of this element is
 1) $^{34}\text{X}_{16}$ 2) $^{34}\text{X}_{14}$ 3) $^{36}\text{X}_{14}$

Isotope Practice

There are three isotopes of Hydrogen



1. Fill in the chart for the three isotopes of hydrogen:

Isotope	^1_1H	^2_1H	^3_1H
# protons			
# neutrons			
# electrons			

Here are three isotopes of an element: $^{12}_6\text{C}$ $^{13}_6\text{C}$ $^{14}_6\text{C}$

- The element is: _____
- The number 6 refers to the _____
- The numbers 12, 13, and 14 refer to the _____
- How many protons and neutrons are in the first isotope? _____
- How many protons and neutrons are in the second isotope? _____
- How many protons and neutrons are in the third isotope? _____

2. What structural characteristics do all three hydrogen atom isotopes have in common?

3. How does one isotope of hydrogen differ from another isotope of hydrogen?

4. What does the mass number tell you?

5. What does the atomic number tell you?

6. Define the term isotope.

Complete the following chart:

Isotope name	atomic #	mass #	# of protons	# of neutrons	# of electrons
Potassium-37					
Oxygen-17					
uranium-235					
uranium-238					
boron-10					
boron-11					

3. How can you tell isotopes apart?

For each of the following isotopes, write the number of protons, neutrons, and electrons.

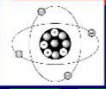
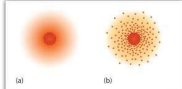
	Chromium-58	Chromium-63		Carbon-12	Carbon-16
# of protons			# of protons		
# of neutrons			# of neutrons		
# of electrons			# of electrons		

	Nitrogen-15	Nitrogen-20		Sulfur-23	Sulfur-25
# of protons			# of protons		
# of neutrons			# of neutrons		
# of electrons			# of electrons		

Fill in the isotope names and any missing information, including isotope numbers from the chart. Use your periodic table and the information provided.

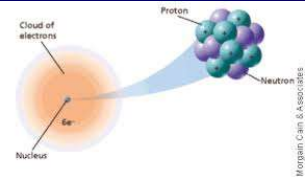
	Iodine-	Iodine-		Iron-	Iron-
# of protons			# of protons		
# of neutrons	32	35	# of neutrons	27	30
# of electrons			# of electrons		

Modern Atomic Theory

- Electrons can be found only in certain energy levels, not between levels.
- Electron location (not precise) is limited to energy levels.

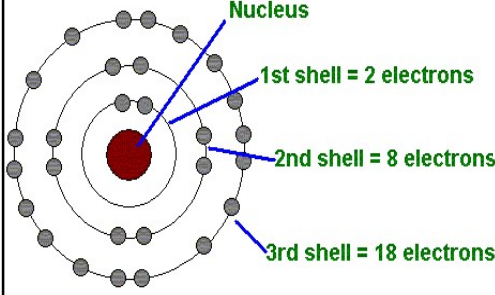
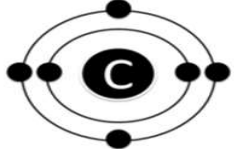
- Electrons act like waves.
- The whole shaded region is called an **electron cloud**.



Bohr Model

Bohr models show every electrons on each energy level of an atom.

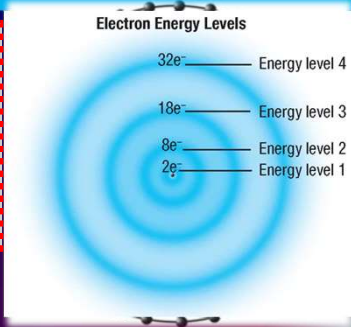
- Since you have 2 electrons already drawn, you need to add 4 more.
- These go in the 2nd shell.
- Add one at a time - starting on the right side and going counter clock-wise.

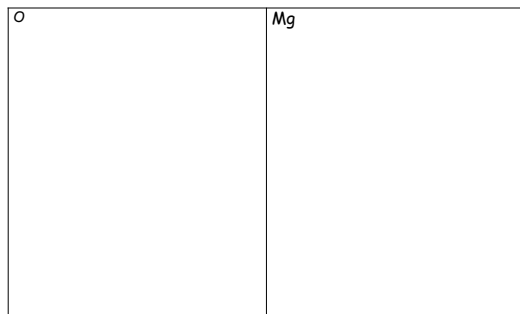
Energy Level

- Describe the path the electron takes around the nucleus
- They have different amounts of energy

- Energy levels closest to the nucleus have the least energy.
- Electrons are arranged in a predictable pattern from inner to outer levels.

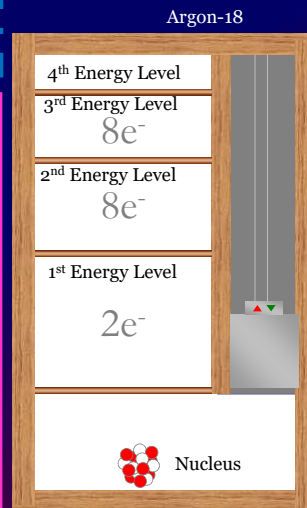


Bohr's Model



Energy Levels

- ❖ Like an elevator
- ❖ it can only be on certain floors
- ❖ **Never in between**
- ❖ **Energy levels get closer together the higher you go**
- ❖ Each has room for a certain number of electrons



BOHR MODELS

1									2
3	4	5	6	7	8	9	10		
11	12	13	14	15	16	17	18		

Mystery Isotope Activity Instructions

Student Instructions for "Mystery Isotope Activity" :

- Each group will create a model of their given isotope on a piece of construction paper. Use the following information:
 1. Title the construction paper: "**Mystery Isotope # ____**" based on the number on their strip. **DO NOT** write the name of the isotope.
 2. Figure out the number of protons, neutrons, and electrons in the isotope.
 3. On your own data sheet, record your information.
 4. Use the stickers to create a Bohr model of the isotope on the construction paper.
 5. Be sure to assign each subatomic particle a color and create a key. You need 3 different colors, one for each subatomic particle.

Practice Problems

Atom 1	Atom 2	Relationship between atom 1 and atom 2
${}^{12}_6\text{C}$	${}^{13}_6\text{C}$	<input type="checkbox"/> Isotopes <input type="checkbox"/> Same Atom, Not Isotopes of Each Other <input type="checkbox"/> Different Element
Carbon-12	${}^{12}_6\text{C}$	<input type="checkbox"/> Isotopes <input type="checkbox"/> Same Atom, Not Isotopes of Each Other <input type="checkbox"/> Different Element
Argon-40	Argon-41	<input type="checkbox"/> Isotopes <input type="checkbox"/> Same Atom, Not Isotopes of Each Other <input type="checkbox"/> Different Element
${}^{11}_5\text{B}$	Boron-10	<input type="checkbox"/> Isotopes <input type="checkbox"/> Same Atom, Not Isotopes of Each Other <input type="checkbox"/> Different Element
An atom with 13 protons and 13 neutrons	An atom with 14 protons and 13 neutrons	<input type="checkbox"/> Isotopes <input type="checkbox"/> Same Atom, Not Isotopes of Each Other <input type="checkbox"/> Different Element

Practice Problem

Name	Symbol	Atomic number	Mass Number	Number of neutrons	Number of Electrons	Charge
hydrogen -2	${}^2\text{H}$	1	2	1	1	0
	${}^3\text{H}$					
sodium-22	${}^{22}\text{Na}^+$				10	
		12	24		12	
		12	25		13	
	${}^{46}\text{Ti}^{-2}$					
	${}^{107}\text{Ag}$					

Practice Problems

Element	Atomic Number	Mass Number	Protons	Neutrons	Electrons
Carbon	6	14			
Oxygen	8			10	
Potassium	19		19	20	
Gold	79	197			
Tin	50			68	
Zinc		64	30		

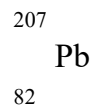
Practice Problem

In addition to atomic symbol, we can represent atoms by name and mass number.

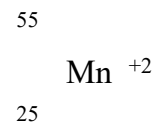
Symbol	Name
${}^{12}_6\text{C}^{+1}$	Carbon-12
${}^{18}_9\text{F}$	
${}^{11}_5\text{B}$	

Practice Problems

1. List out the number of protons, electrons, and neutrons of



2. List out the number of protons, electrons, and neutrons of



3. Atoms of a certain isotope have 73 neutrons and a mass of 123.

- a. What is the atomic number?
- b. How many electrons are there?
- c. What is the name of the element?
- d. Write the chemical symbol for this isotope.