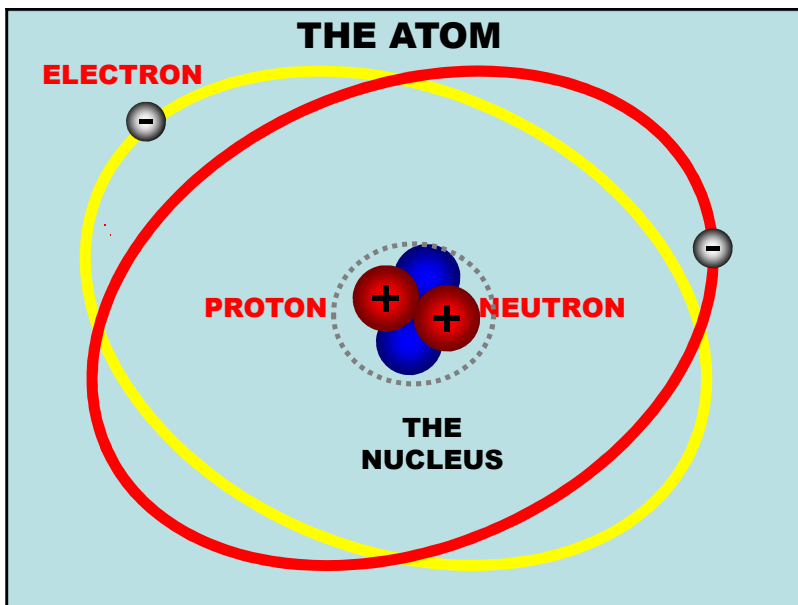


Atomic and Nuclear Theory

Vocabulary

- Atom
- Protons
- Neutrons
- Electrons
- Nucleus
- Ion
- Isotope
- Electron Cloud
- Energy Level
- Atomic Mass
- Atomic Number

2



What is in an Atom?

Parts of the Atom

Particle	Charge	Mass (kg)	Location
Proton	+ 1	1.67×10^{-27}	In the nucleus
Neutron	0	1.67×10^{-27}	In the nucleus
Electron	-1	9.11×10^{-31}	Outside the nucleus

Atomic Number

- Atomic number = the number of protons
 - This is also the number of protons if the atom is neutral.
 - No two elements share the same atomic number or number of protons

Carbon: $Z = \underline{6}$
Hydrogen: $Z = \underline{1}$
Uranium: $Z = \underline{92}$

6	← Atomic number
C	← Symbol
12.011	← Atomic mass

Mass Number

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

Carbon: $A = \underline{12}$
Chlorine: $A = \underline{35}$
Aluminum: $A = \underline{27}$

fluorine
9
F
18.998

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

Finding # of Neutrons

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

Mass number (A)
-Atomic number (Z)
Number of neutrons

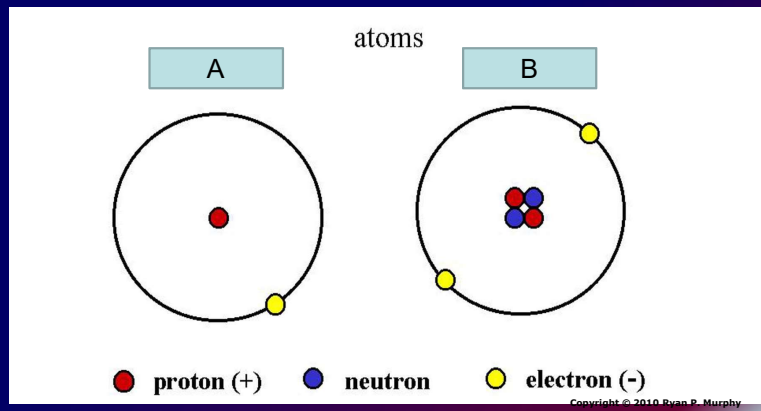
F has 10 neutrons. $19 - 9 = 10$
Al has 14 neutrons $27 - 13 = 14$

Fill in this chart

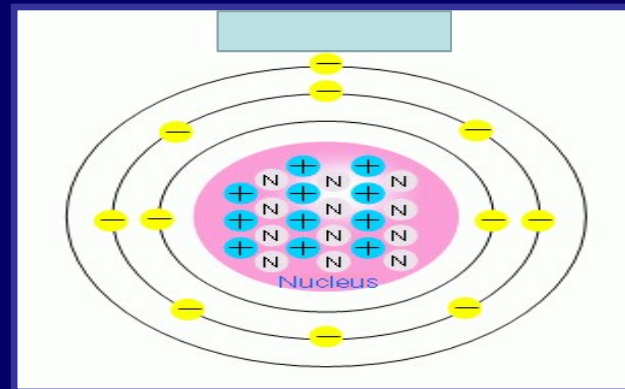
Element	Number of Protons	Number of Neutrons	Number of Electrons	Atomic Mass	Atomic Number
Tantalum	73	108	73	181	73
Radium	88	138	88	226	88

Try This

Identify the following two atoms



Try This

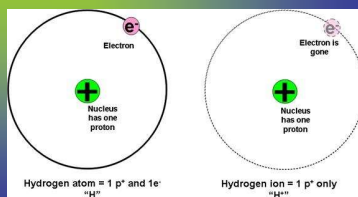
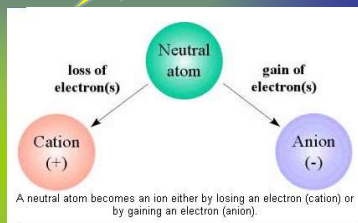


Ion Formation

electrons

- Atoms with a charge(+) or (-)
- Form by changing the number of **electrons** **ONLY**
- Different number of protons and electrons

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



EXAMPLE

A neutral magnesium (Mg) atom has 12 protons and 12 electrons. If the magnesium atom loses 2 electrons, it will have a net electrical charge of +2.

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

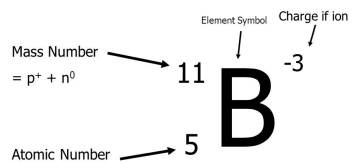
$$\begin{array}{r}
 \text{Number of protons} = 12 \\
 - \text{Number of electrons} = 10 \\
 \hline
 +2
 \end{array}$$

A magnesium ion is represented as Mg⁺².

Complete Nuclear Symbols

EXAMPLE: (hyphen symbol) Chlorine - 37 ← mass number
 Complete nuclear symbol for an element is written like this

mass number → 37
 Cl^{+2} → element symbol and charge
 atomic number → 17

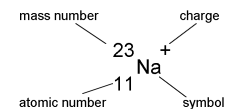


How many electrons does it have?

EXAMPLE 1:

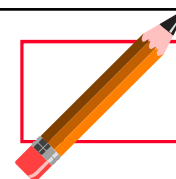
- Sodium (Na) atoms have 11 protons and 11 electrons with a net charge of 0.
- If the Sodium ion only has 10 electrons, what is the net charge of the ion? (+11 -10 = +1).
- What is the chemical symbol for this ion?

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⁺



Learning Check – Ions

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

	³⁹ K ⁺	¹⁶ O ⁻²	⁴¹ Ca ⁺²
	19	8	20
#p ⁺	<u>19</u>	<u>8</u>	<u>20</u>
#n ^o	<u>20</u>	<u>8</u>	<u>21</u>
#e ⁻	<u>18</u>	<u>10</u>	<u>18</u>

Learning Check

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

A. 8 p⁺, 8 n, 8 e⁻

O

B. 17p⁺, 20n, 17e⁻

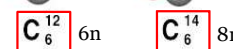
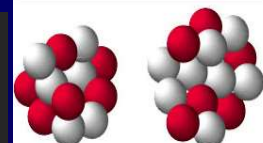
Cl

C. 47p⁺, 60 n, 46 e⁻

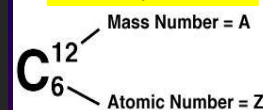
Ag⁺

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
- Mass number changes



How many Neutrons?



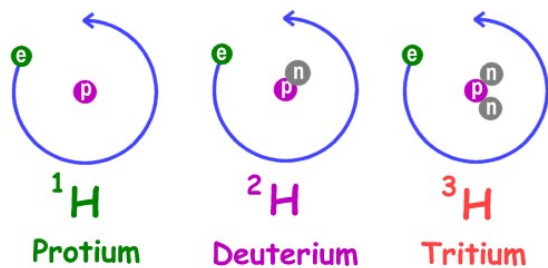
Atomic number stays the same.

Why?

Same number protons

What are Isotopes?

Three Isotopes of Hydrogen



What do all the isotopes have in common?

What is different between them?

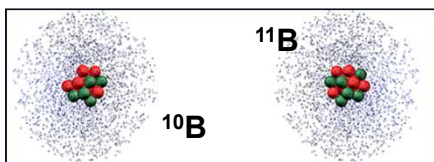
Isotopes

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

Carbon-12	Both Carbon	Carbon-14	
6 NEUTRONS	6 PROTONS	6 PROTONS	8 NEUTRONS

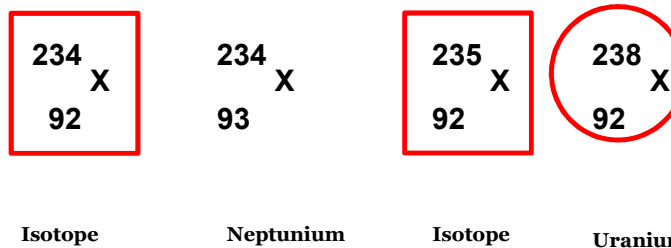
Isotopes

- Atoms of the same element but different mass number
- Boron-10 (^{10}B) has 5 p and 5 n
- Boron-11 (^{11}B) has 5 p and 6 n



Isotopes?

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





Learning Check – Isotopes

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.

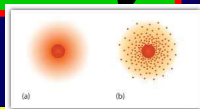
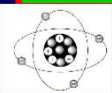
	^{12}C	^{13}C	^{14}C
	6	6	6
#p ⁺	6	6	6
#n ^o	6	7	8
#e ⁻	6	6	6

Learning Check

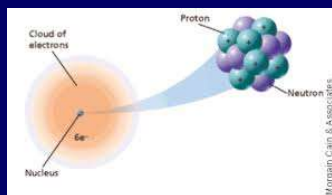
An atom has 14 protons and 20 neutrons.

- 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) $^{34}_{16}\text{X}$ 2) $^{34}_{14}\text{X}$ 3) $^{36}_{14}\text{X}$

Modern Atomic Theory



- Electrons can be found only in certain energy levels, not between levels.



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

Energy Level

- Describe the path the electron takes around the nucleus
- Farther from nucleus is more energy

Electron Energy Levels

32e⁻ ——— Energy level 4
18e⁻ ——— Energy level 3
8e⁻ ——— Energy level 2
2e⁻ ——— Energy level 1

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

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

Argon-18

4th Energy Level

3rd Energy Level

$8e^-$

2nd Energy Level

$8e^-$

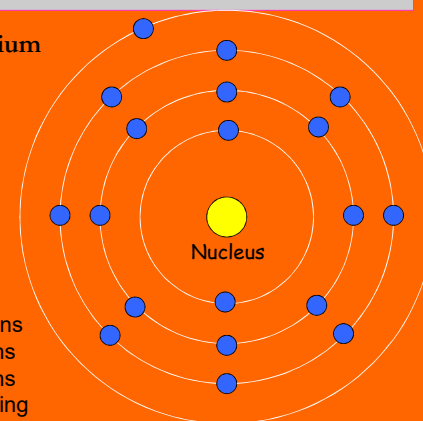
1st Energy Level

$2e^-$



Electron structure

Consider an atom of Potassium



- The inner shell has ___ electrons
- The next shell has ___ electrons
- The next shell has ___ electrons
- The next shell has the remaining ___ electron

Electron structure
= 2,8,8,1

Practice Problems

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

Practice Problems

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

207

Pb

82

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

55

Mn ⁺²

25

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

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

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