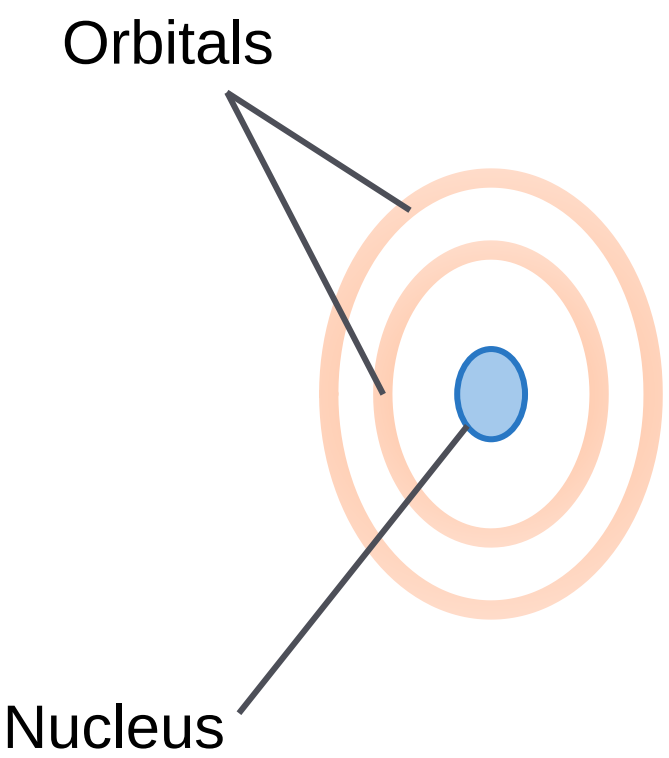
The Atom

Atom is the smallest particle of an element that has the same properties as the element.

The atom can be divided into two parts:

- **Nucleus**: Central portion of the atom
- **Orbitals**: Regions surrounding the nucleus



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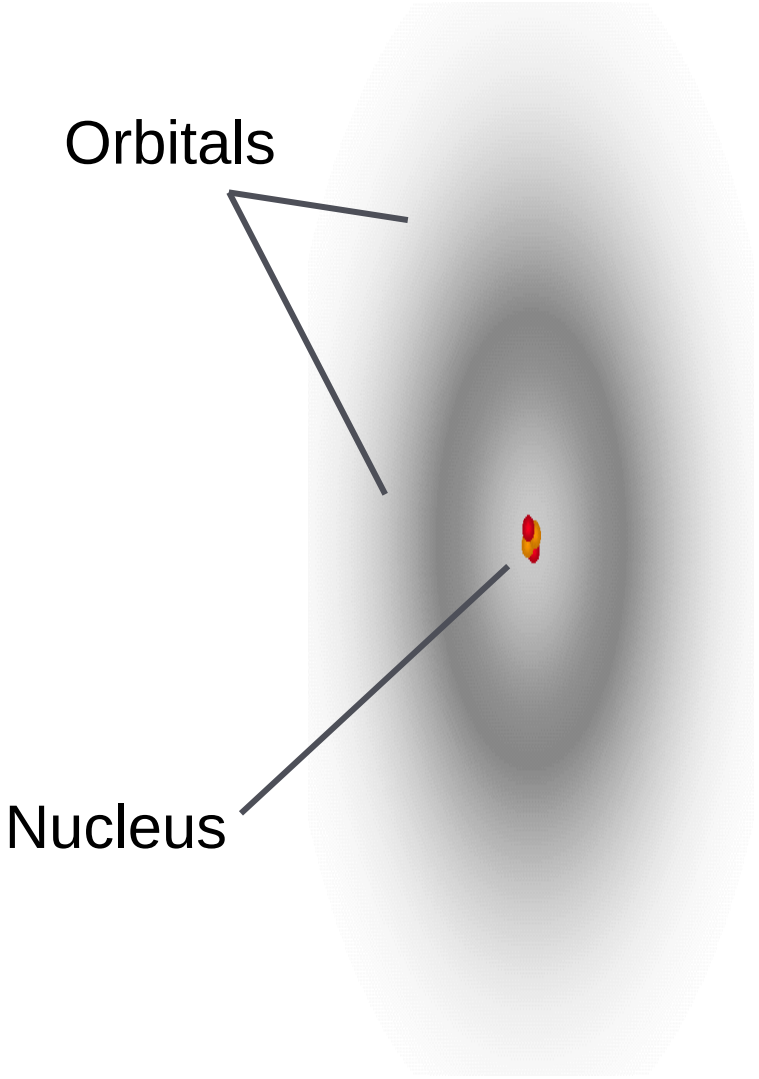
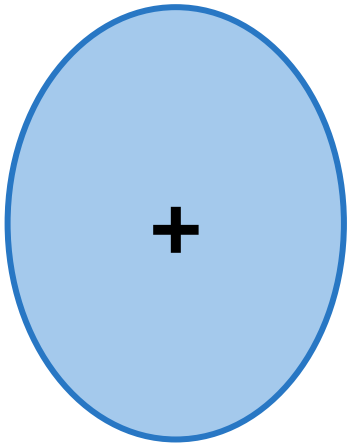
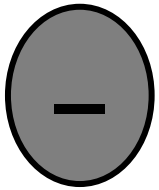
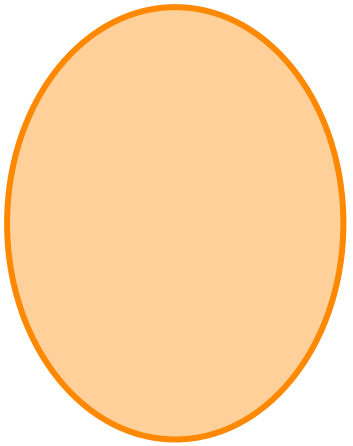


Charged Particles in the Atom

The atom is made of three particles: protons, electrons, and neutrons.



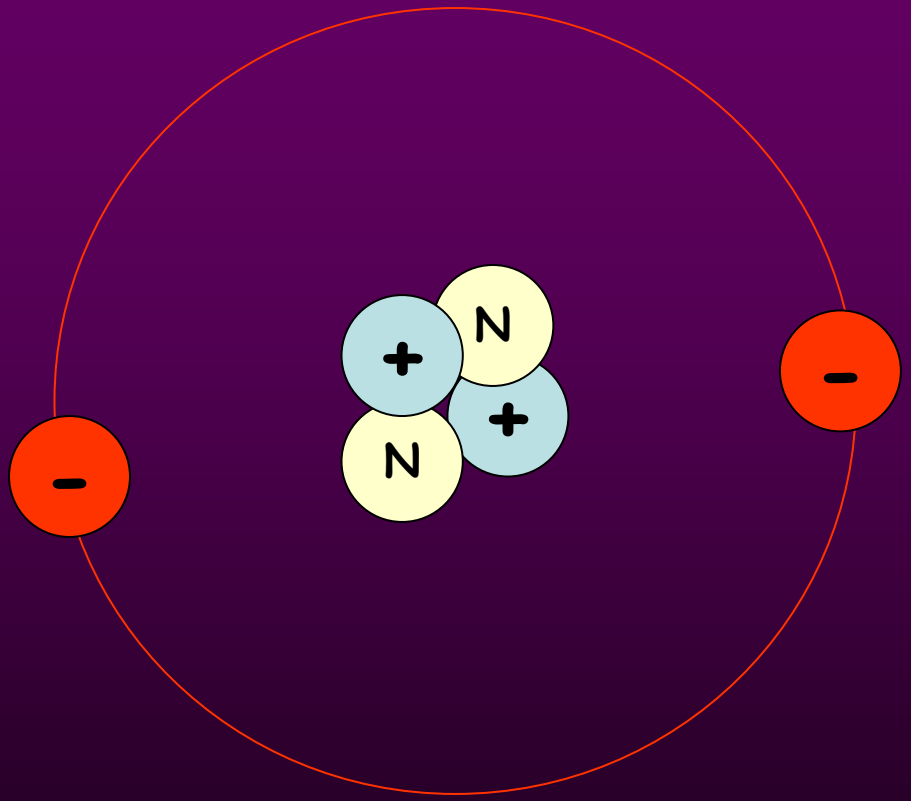




Protons are positively charged.

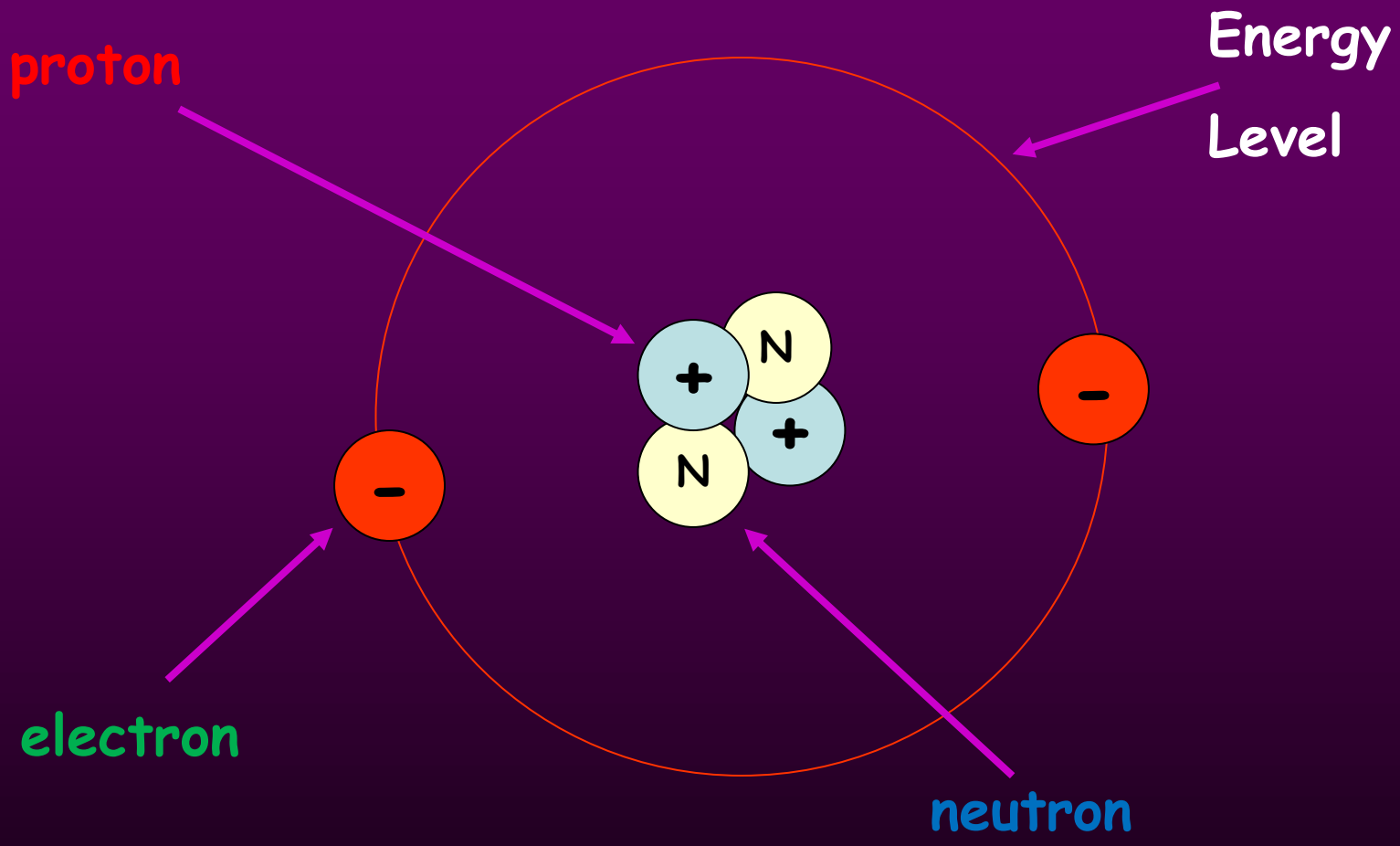
Electrons are negatively charged.

Neutrons are not charged.



Different elements have different particle counts and arrangements

HELIUM ATOM

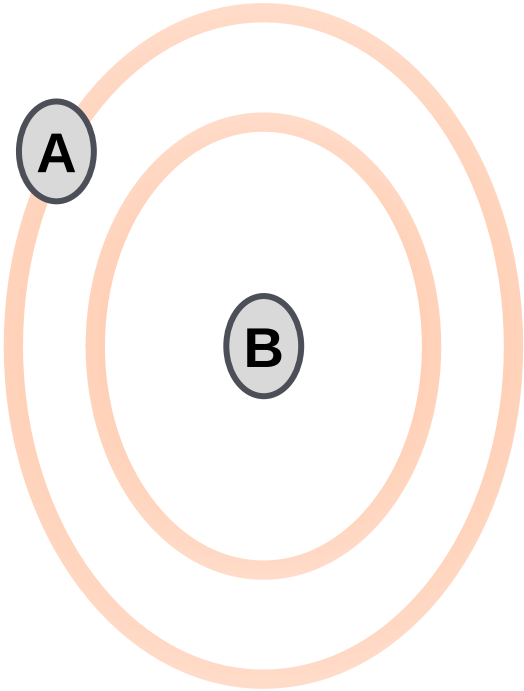


Different elements have different particle counts and arrangements

Determine the Locations of Subatomic Particles

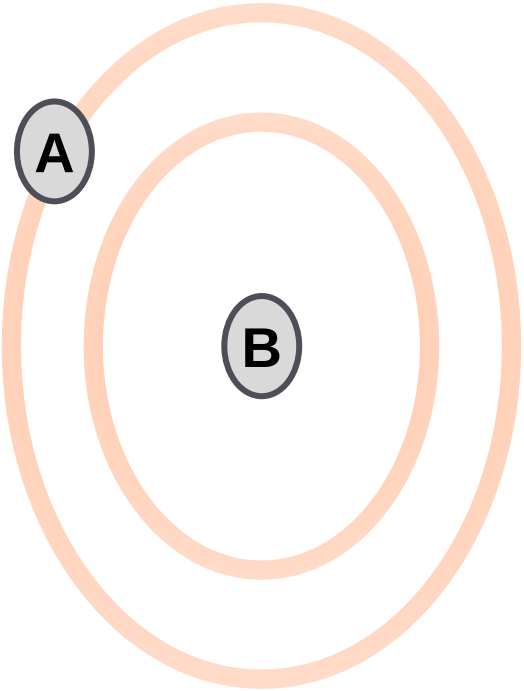
Type the name of the location of each particle.

Particle	Charge	Location	~Mass
?	+1	?	?
?	0	?	?
?	-1	?	?



Determine the Locations of Subatomic Particles

Particle	Charge	Location	Approximate mass (amu)
Proton	+1	Nucleus	1
Neutron	0	Nucleus	1
Electron	−1	Orbitals	0



LESSON QUESTION

What is the structure of the atom?

13	14	15
Al	Si	P
Aluminum	Silicon	Phosphorus
26.98	28.09	30.974

How do we distinguish atoms of different elements?

Atomic number

LESSON QUESTION

Atomic number (*Z*)

- Number of protons in an atom
- Differs for each element

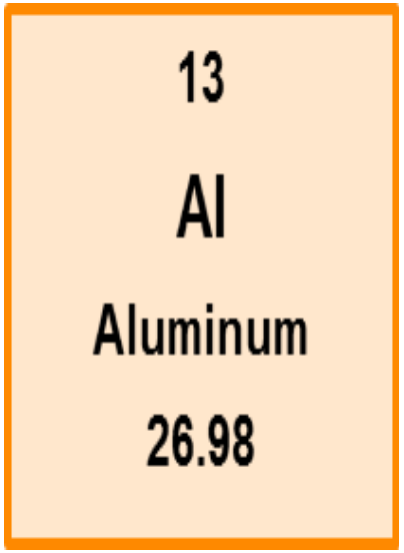
13	14
Al	Si
Aluminum	Silicon
26.98	28.09

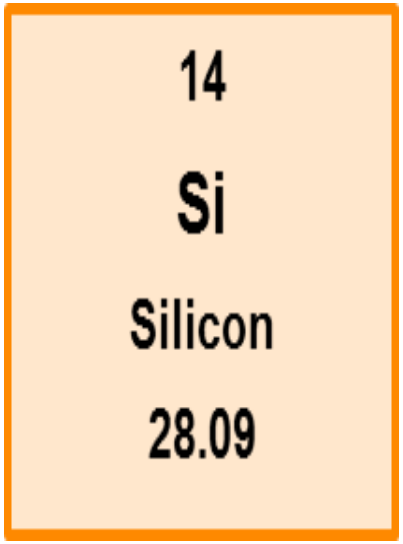
Atomic number

LESSON QUESTION

Atomic number (Z)

- Number of protons in an atom
- Differs for each element



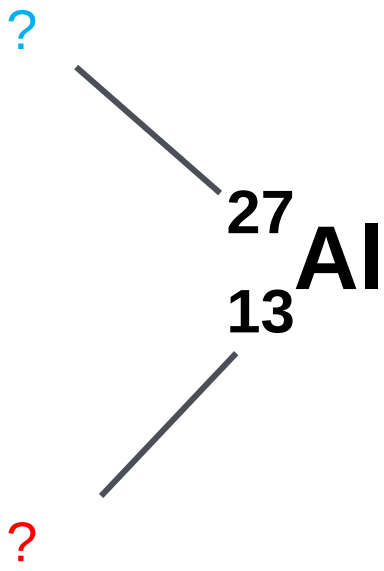


Every atom of a given element has the same atomic number, and atomic number can be used to identify an element.

Mass number (A)

LESSON QUESTION

- Total number of protons + neutrons
- Usually varies from atom to atom



 # neutrons = ?

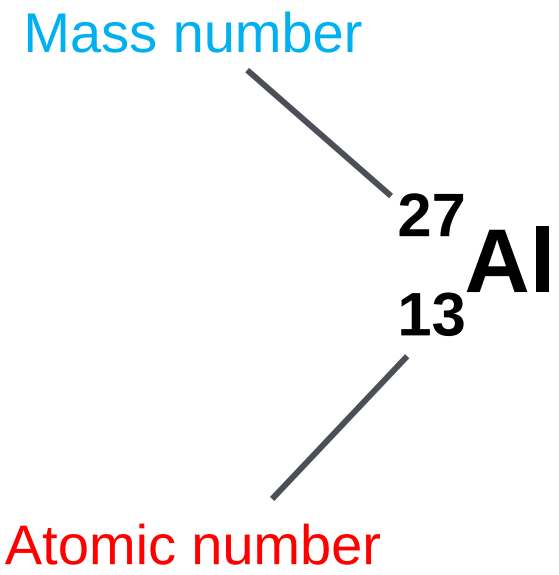
Aluminum-27

- Al-27
- ^{27}Al

Mass number (A)

LESSON QUESTION

- Total number of protons + neutrons
- Usually varies from atom to atom



Aluminum-27

- Al-27
- ^{27}Al

 # neutrons = A – Z

27 – 13 = **14 neutrons**

All atoms of an element have the same atomic number, but atoms of the same element can have different mass numbers.

"Nuclear Symbols"

LESSON QUESTION

Mass number

He

Atomic number

"Nuclear Symbols"

LESSON QUESTION

Mass number

$$^{}_{2}He$$

Atomic number 2

2 protons

"Nuclear Symbols"

LESSON QUESTION

Mass number 4

2 protons &
2 neutrons

$^{4}_{2}He$

Atomic number 2

2 protons

Due to Word Processing

LESSON QUESTION

Mass number

2 protons &
2 neutrons

$^{4}_{2}He$

Atomic number

2 protons

"Nuclear Symbols"

LESSON QUESTION

Mass number 4

2 protons &
2 neutrons

$^{4}_{2}He$

Atomic number 2

2 protons

In a neutral atom

number of electrons = number of protons

QUICK CHECK

Determining the Composition of an Atom

What is the atomic number (Z) and atomic mass (A) for each element? How many protons, electrons, and neutrons are in each atom?

$^{9}_{4}Be$ $^{20}_{10}Ne$ $^{23}_{11}Na$

4. 3 Distinguishing Among Atoms

QUICK CHECK

Determining the Composition of an Atom

How many protons, electrons, and neutrons are in each atom?

$^{9}_{4}\text{Be}$ $^{20}_{10}\text{Ne}$ $^{23}_{11}\text{Na}$

Use the definitions of atomic number and mass number to calculate the numbers of protons, electrons, and neutrons.

Beryllium (Be)	Neon (Ne)	Sodium (Na)
atomic number = 4	atomic number = 10	atomic number = 11
mass number = 9	mass number = 20	mass number = 23

Be has 4 **protons**, 5 **neutrons**, and 4 **electrons**

Ne has 10 **protons**, 10 **neutrons**, and 10 **electrons**

Na has 11 **protons**, 12 **neutrons**, and 11 **electrons**

Nuclear symbols are used by scientist as a standard way to represent elements, showing both the **atomic** and **mass numbers** [***Which is which?***]

$$_{1}H^{1}$$

Hydrogen has ? **proton**, ? **neutrons**, and ? **electron**

Nuclear symbols are used by scientist as a standard way to represent elements, showing both the atomic and mass numbers

mass number

$$ {}_{1}^{1}H $$

atomic #

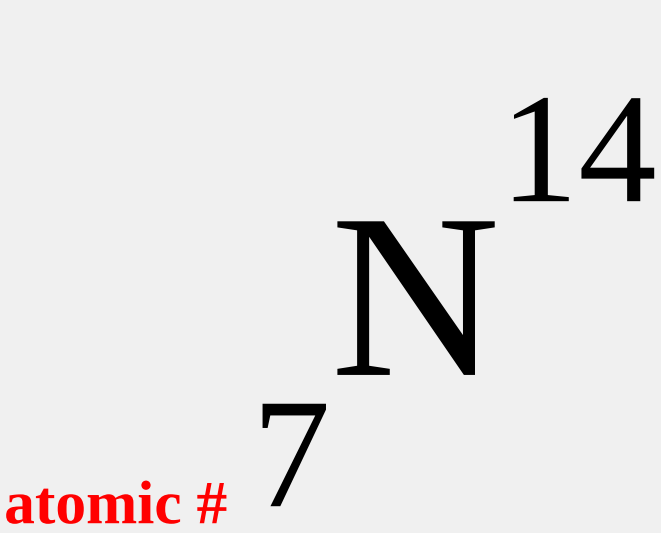
Hydrogen has 1 **proton**, 0 **neutrons**, and 1 **electron**

Nuclear symbols are used by scientist as a standard way to represent elements, showing both the **atomic** and **mass numbers** [***Which is which?***]

$$^{14}_{7}N$$

Nitrogen has ? **protons**, ? **neutrons**, and ? **electrons**

Nuclear symbols are used by scientist as a standard way to represent elements, showing both the atomic and mass numbers



Nitrogen has 7 **protons**, 7 **neutrons**, and 7 **electrons**

Nuclear symbols are used by scientist as a standard way to represent elements, showing both the **atomic** and **mass numbers** **[*Which is which?*]**

$$^{56}_{26}Fe$$

Iron has ? **protons**, ? **neutrons**, and ? **electrons**

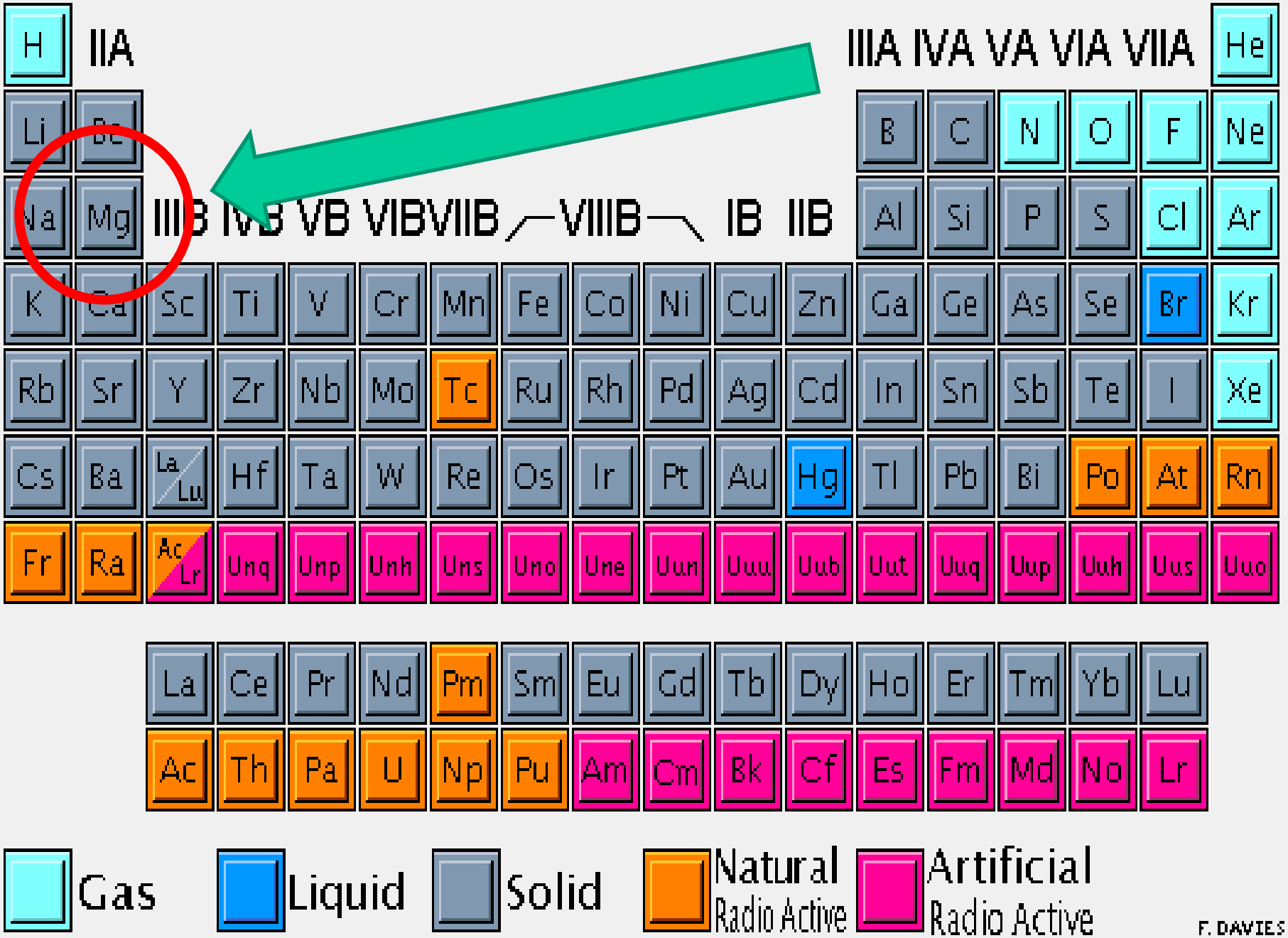
Nuclear symbols are used by scientist as a standard way to represent elements, showing both the atomic and mass numbers

mass number

$$^{56}_{26}Fe$$

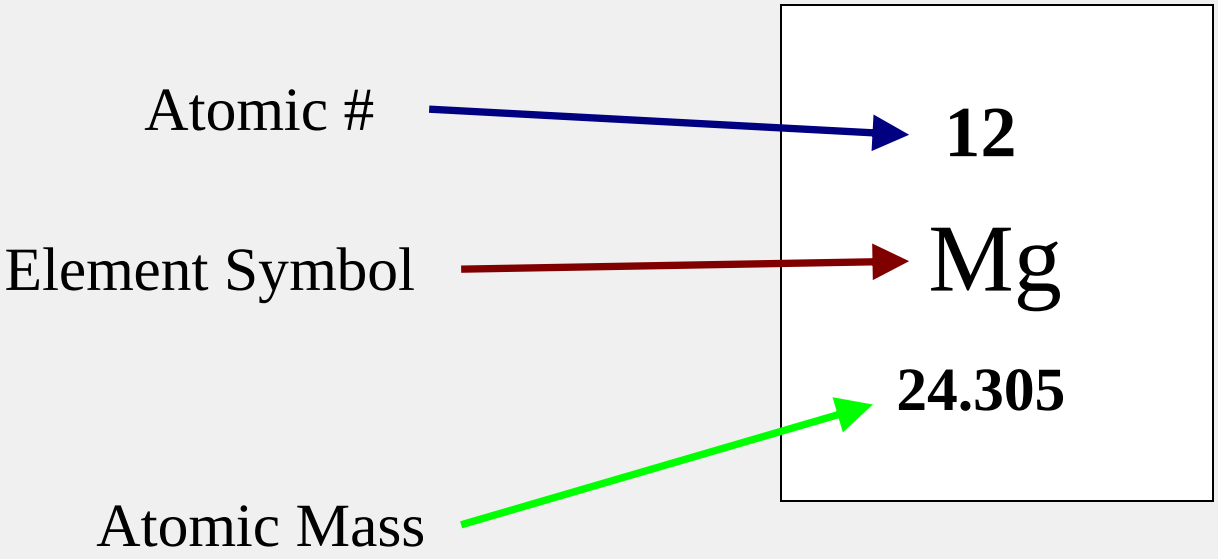
atomic #

Iron has 26 **protons**, 30 **neutrons**, and 26 **electrons**

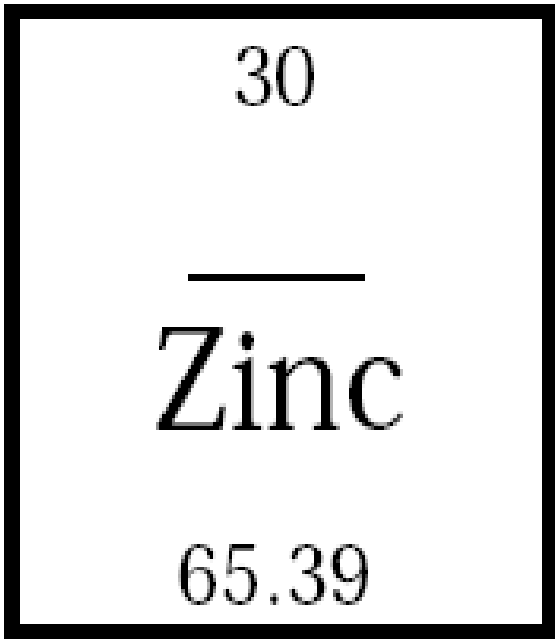

H
IIA
IIIA IVA VA VIA VIIA
He
Li
Be
B
C
N
O
F
Ne
Na
Mg
IIIB IVB VB VIBVIIB
VIIIB
IB IIB
Al
Si
P
S
Cl
Ar
K
Ca
Sc
Ti
V
Cr
Mn
Fe
Co
Ni
Cu
Zn
Ga
Ge
As
Se
Br
Kr
Rb
Sr
Y
Zr
Nb
Mo
Tc
Ru
Rh
Pd
Ag
Cd
In
Sn
Sb
Te
I
Xe
Cs
Ba
La/Lu
Hf
Ta
W
Re
Os
Ir
Pt
Au
Hg
Tl
Pb
Bi
Po
At
Rn
Fr
Ra
Ac/Lr
Unq
Unp
Unh
Uns
Uno
Une
Uun
Uuu
Uub
Uut
Uuq
Uup
Uuh
Uus
Uuo
La
Ce
Pr
Nd
Pm
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
Ac
Th
Pa
U
Np
Pu
Am
Cm
Bk
Cf
Es
Fm
Md
No
Lr
Gas
Liquid
Solid
Natural
Radio Active
Artificial
Radio Active
F. DAVIES

Example: Magnesium

Elements are often represented in the following format in tables or charts



(this is an average mass)



Atomic # = _____

Atomic Mass = _____

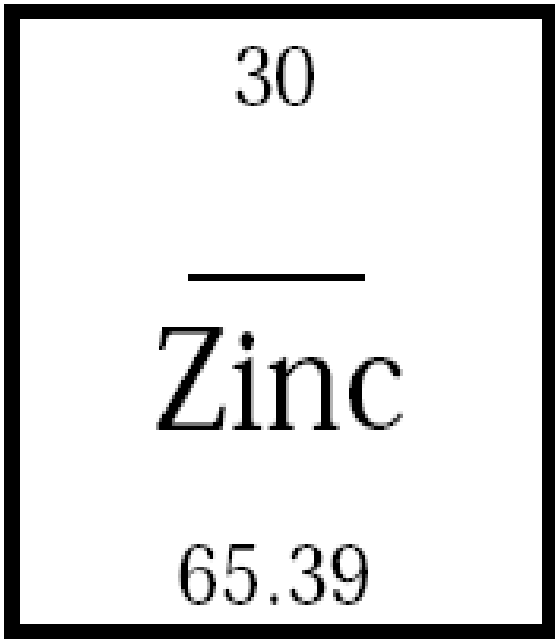
# of Protons = _____

# of Neutrons = _____

# of Electrons = _____

TRY IT

Nuclear symbol?



Atomic # = 30

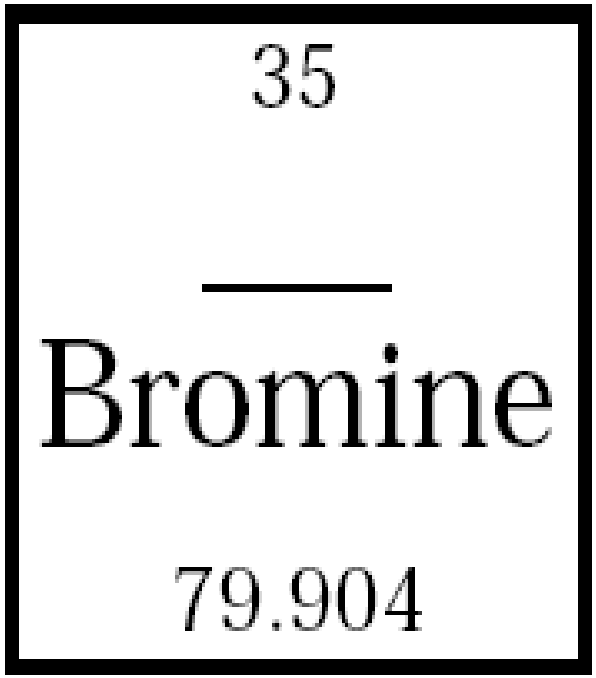
Atomic Mass = 65

# of Protons = 30

# of Neutrons = 35

# of Electrons = 30

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



Atomic # = _____

Atomic Mass = _____

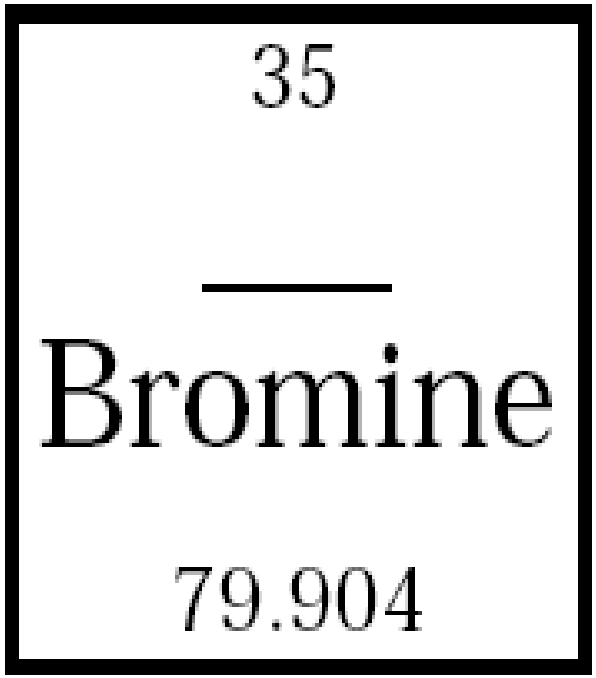
# of Protons = _____

# of Neutrons = _____

# of Electrons = _____

TRY IT

Nuclear symbol?



$^{80}_{35}Br$

Atomic # = 35

Atomic Mass = 80

# of Protons = 35

# of Neutrons = 45

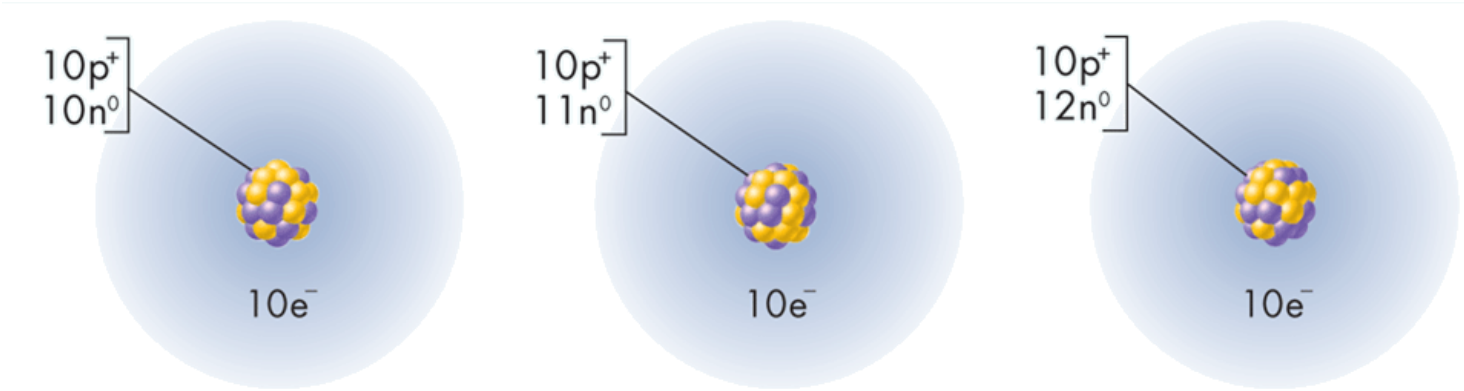
# of Electrons = 35

Isotopes

LESSON QUESTION

Isotopes are atoms that have the same number of protons but different numbers of neutrons. *Therefore, they have the same chemical properties.*

Neon-20, neon-21, and neon 22 are isotopes of neon.



Neon-20
10 protons
10 neutrons
10 electrons

Neon-21
10 protons
11 neutrons
10 electrons

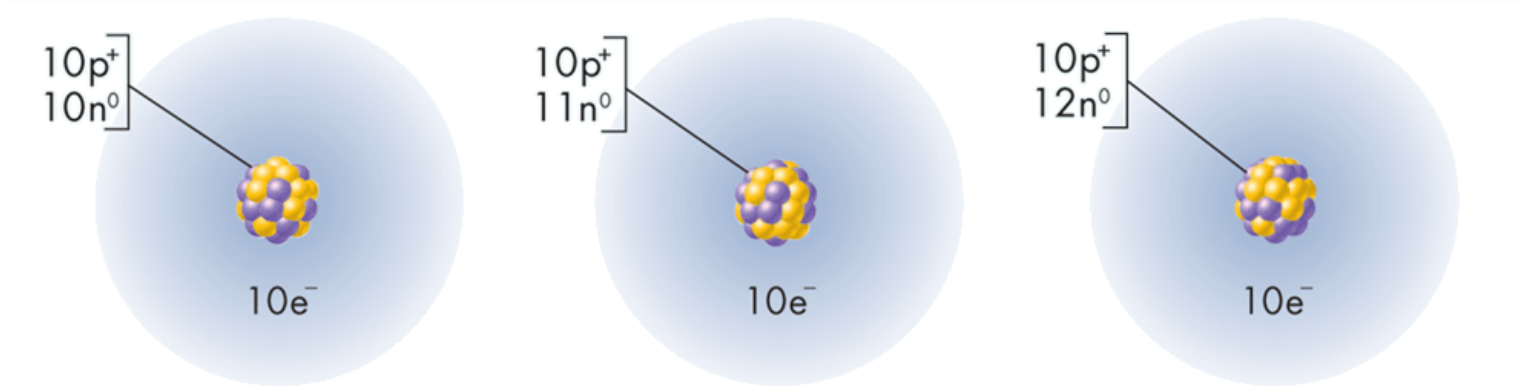
Neon-22
10 protons
12 neutrons
10 electrons

Isotopes

LESSON QUESTION

Isotopes are atoms that have the same number of protons but different numbers of neutrons. *Therefore, they have the same chemical properties.*

Neon-20, neon-21, and neon 22 are isotopes of neon.



Neon-20	Neon-21	Neon-22
10 protons	10 protons	10 protons
10 neutrons	11 neutrons	12 neutrons
10 electrons	10 electrons	10 electrons

Isotopes of Neutral Atoms

- Atoms of the same element with different mass numbers.
  - Number of protons are the same
  - Number of electrons are the same
  - Number of neutrons are different

Isotope	*Z*	*n*	*A*
Sn-112	50	62	112
Sn-114	50	64	114
Sn-115	50	65	115
Sn-116	50	66	116
Sn-117	50	67	117
Sn-118	50	68	118
Sn-119	50	69	119

Atomic Mass

An **atomic mass unit (amu)** is defined as one-twelfth of the mass of a carbon-12 atom.

This isotope of carbon has been assigned a mass of exactly 12 atomic mass units.

In nature, most elements occur as a mixture of two or more isotopes.

Each isotope of an element has a fixed mass and a **natural percent abundance**.

Atomic Mass

An **atomic mass unit (amu)** is defined as one-twelfth of the mass of a carbon-12 atom.

This isotope of carbon has been assigned a mass of exactly 12 atomic mass units.

$$_{6}C^{12}$$

In nature, most elements occur as a mixture of two or more isotopes.

Each isotope of an element has a fixed mass and a **natural percent abundance**.

4.3 Distinguishing Among Atoms

Atomic Mass

Natural Percent Abundance of Stable Isotopes of Some Elements				
Name	**Symbol**	**Natural percent abundance**	**Mass (amu)**	**Atomic mass**
Hydrogen	$^{1}_{1}H$ $^{2}_{1}H$ $^{3}_{1}H$	99.985 0.015 negligible	1.0078 2.0141 3.0160	1.0079
Helium	$^{3}_{2}He$ $^{4}_{2}He$	0.0001 99.9999	3.0160 4.0026	4.0026
Carbon	$^{12}_{6}C$ $^{13}_{6}C$	98.89 1.11	12.000 13.003	12.011
Oxygen	$^{16}_{8}O$ $^{17}_{8}O$ $^{18}_{8}O$	99.759 0.037 0.204	15.995 16.995 17.999	15.999
Chlorine	$^{35}_{17}Cl$ $^{37}_{17}Cl$	75.77 24.23	34.969 36.966	35.453

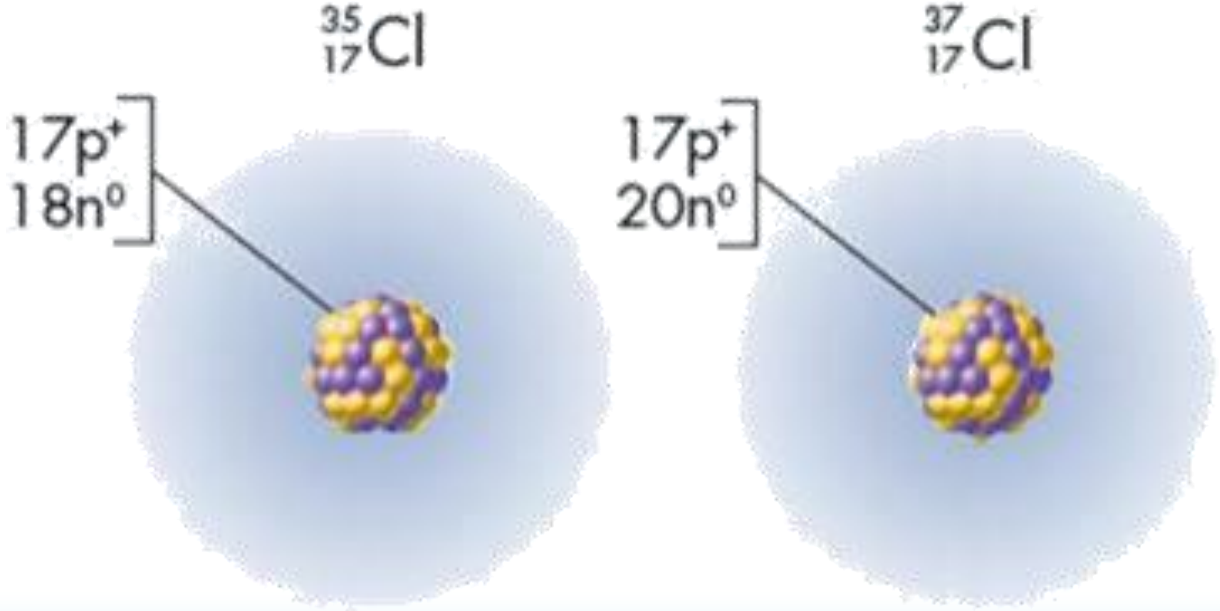
Atomic Mass

THINK ABOUT IT

Chlorine exists as chlorine-35 and chlorine-37.

Chlorine's atomic mass on the Periodic Table is 35.453 amu. (*Notice is it not exactly in-between.*)

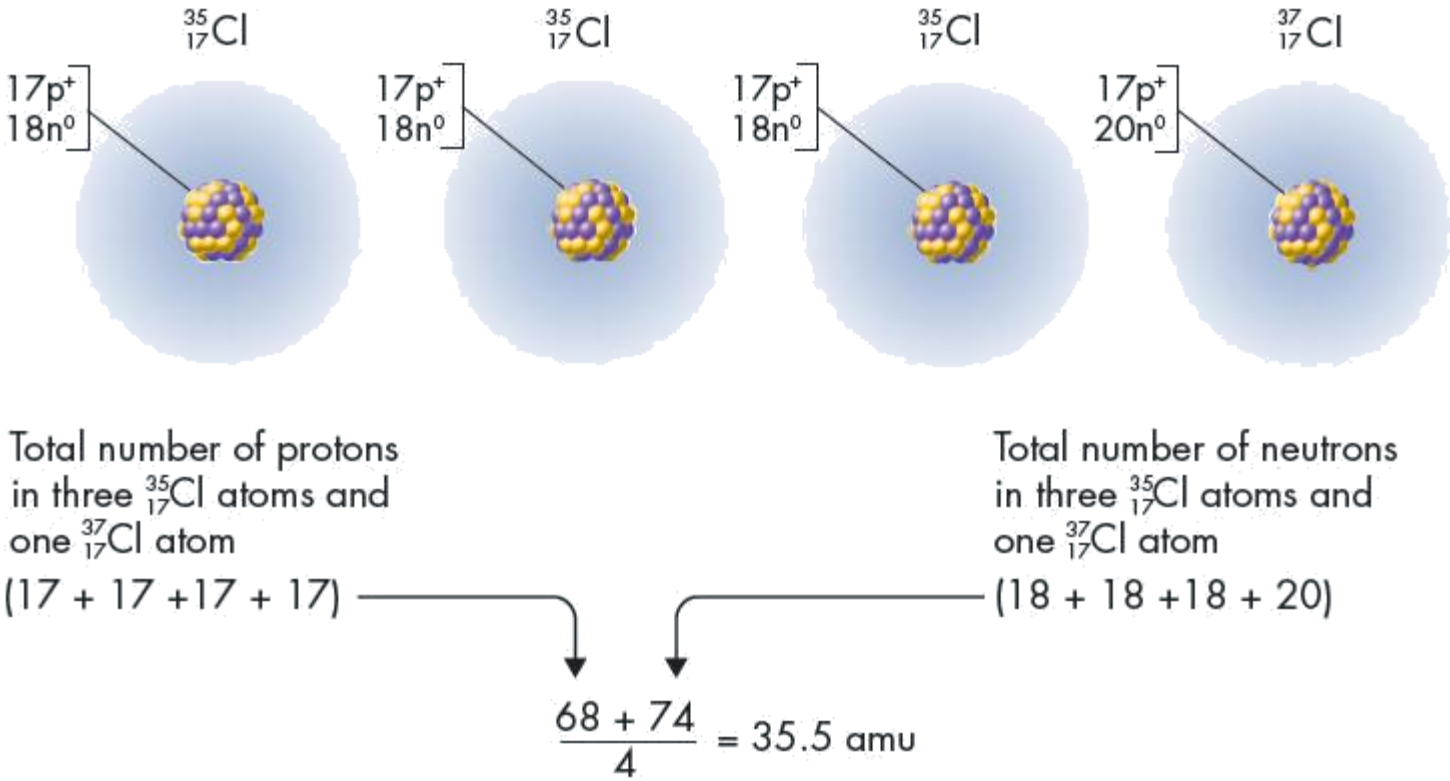
Which isotope is more abundant?



4.3 Distinguishing Among Atoms

Atomic Mass

In nature there is 76% Cl-35 than 24% Cl-37, therefore, the atomic mass of chlorine, 35.453 amu, is closer to 35 than to 37.



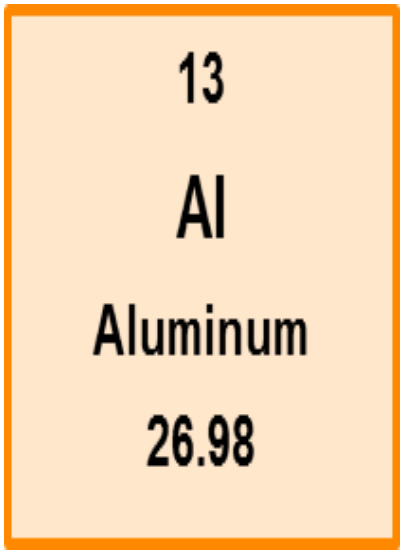
Calculating Average Atomic Mass

LESSON QUESTION

The **average atomic mass** is the weighted average mass of all isotopes of an element.

Abundance of aluminum isotopes:

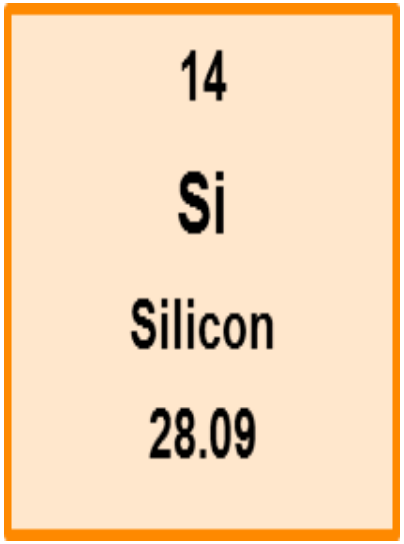
- 100% is from Al-27
- Therefore, no isotopes
- Al-26 is radioactive (not natural)



Average Atomic Mass

Abundance of silicon isotopes:

- 92.2297% is from Si-28
- 4.6832% is from Si-29
- 3.0872% is from Si-30



How do you arrive at a mass of 28.09?

Atomic Mass

The **weighted average mass** reflects both the **mass** and the **relative abundance (%)** of the isotopes as they occur in nature.

- Multiply the mass of each isotope by its natural abundance and add the products.

92.2297% (28) + 4.6832% (29) + 3.0872% (30) =

OR

0.9223(28) + 0.0468(29) + 0.03087(30) = **28.09**

25.82 + 1.36 + 0.93

14
Si
Silicon
28.09

Carbon has two stable isotopes: carbon-12, natural abundance 98.89%, and carbon-13, natural abundance 1.11%.

What is the Average Atomic Mass of C-12?

Atomic Mass

TRY IT

Carbon has two stable isotopes: carbon-12, natural abundance 98.89%, and carbon-13, natural abundance 1.11%.

The mass of carbon-12 is 12.000 amu;

The mass of carbon-13 is 13.003 amu.

The atomic mass of carbon is calculated as follows:

= (12.000 amu x 0.9889) + 13.003 amu x 0.0111)

= (11.867 amu) + (0.144 amu)

= 12.011 amu