CLASSIFICATION OF MATTER

CHEMICAL CLASSIFICATION- On the basis of microscopic observation-

1. PURE SUBSTANCE: Having only one kind of independent particle. These are either **elements** or **compounds.**

Molecule (group of atoms is combined form)

ELEMENT: An element is a molecular or atomic substance which has same atoms. e.g.

oxygen (O_2), iron (Fe), ozone (O_3), hydrogen(H_2), phosphorus (P_4), silver (Ag), etc.

homoatomic molecule

heteroatomic molecule

COMPOUND: A compound is only a molecular substance which consists of different types of atoms in a definite ratio. e.g.

water (H_2O), carbon dioxide (CO_2), ammonia (NH_3), etc.

CLASSIFICATION OF MATTER

- A compound can't be decomposed in to its constituent elements by simple physical methods.
- A compound doesn't possess the properties of its constituent elements. It has its own independent properties.

  e.g.

  in $H_2 + Cl_2 \rightarrow 2HCl$

  H_2 & Cl_2 are elements and are neither acidic nor basic but HCl compound is a well known acid.

Elements → • Metals → which looses electrons
• Non metals → which gains electrons
• Metalloids → which looses / gains electron.

Compound → Nature → Ionic compound (transfer)
Co-valent compound (sharing)

Compound → Origin → organic
Inorganic

"Organic compound are compound are hydrocarbons and their derivatives"

CLASSIFICATION OF MATTER

2.IMPURE SUBSTANCE (MIXTURE): It's a mixture of two or more types of pure substances which retain and don't lose their own identities and properties even after mixing. A mixture can be separated out into its components by simple physical methods like filtration, boiling etc.

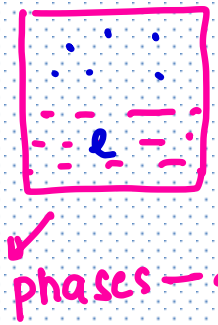
Mixtures are of two types- (i) Homogeneous mixture

(ii) Heterogeneous mixture

CLASSIFICATION OF MATTER

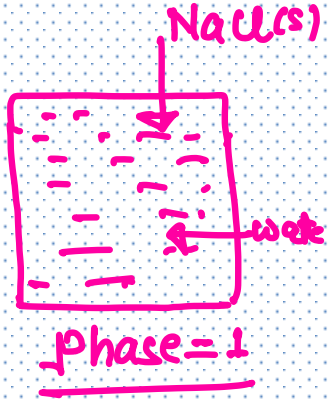
"same phase means uniform density"

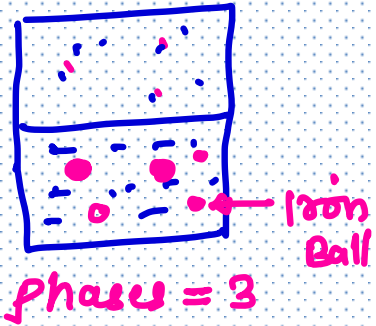
1.Homogeneous mixture: which has no. of phases = 1 i.e. It has uniform composition througout. e.g. Aqueous solution of sugar, aqueous solution of NaCl, air etc.



2. Heterogeneous mixture: which has no. of phases > 1 i.e. It has not uniform composition througout.

e.g. Water + oil, water + sand, milk, storm etc.





$P_4(s)$ (white phosphorous) $\xrightarrow{S_1 \to S_2}$ $P_4(s)$ (Black phosphorous) [Phase transition]

- Element

ATOMIC NUMBER: (Z)

- Designates the **number of protons** in a nucleus of an atom
- Each element has a **characteristic atomic number** (the same atomic # for ALL atoms of the same element)
- The number of electrons **equals the atomic number in a neutral atom**

No of protons = Z

MASS NUMBER: (A)

- Designates the total number of protons + neutrons in an atom

$$A = Z + n$$

- Number of neutrons = mass number - atomic number

$$\Rightarrow \boxed{n = A - Z}$$

- Atoms of the same element can have different mass numbers

Periodic Table Symbol Key:

H

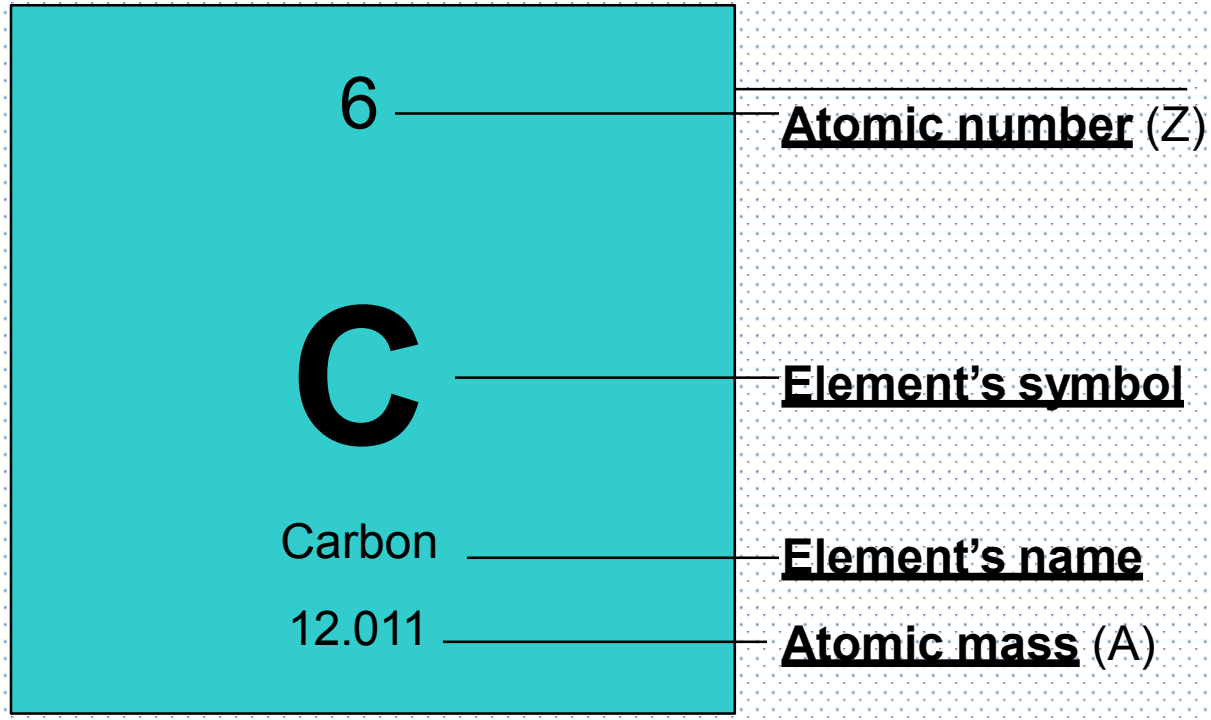
He

N

Ne

C

Ca



# of protons = Z

# of electrons = # of protons (in a neutral atom)

# of neutrons = A - Z

Determining Protons neutrons electrons:

$_{Z}X^{A}$

No of protons = Z

No of Neutrons = A-Z

No of Electrons = Z − [charge on sp.]

$X^{-} \longrightarrow Z+1$

$X^{+2} \longrightarrow Z-2$

Determining Protons neutrons electrons:

Q. Calculat No of Electroons, protons and neutroons in

Na, Mg^{+2}, P^{-3}, CO_2, NH_4^+, SO_4^{-2}

i) Na $[{}_{11}Na^{23}]$

$p = 11$

$n = 23-11 = 12$

$e = 11-0 = 11$

ii) Mg^{+2} $[{}_{12}Mg^{24}]$

protons $= 12$

Neutrons $= 24-12 = 12$

Electroons $= 12-2 = 10$

Determining Protons neutrons electrons:

iii) P^{-3} $[{}_{15}P^{31}]$

$p = 15$

$n = 31 - 15 = 16$

$e = 15 + 3 = 18$

iv) CO_2 $[{}_{6}C^{12}, {}_{8}O^{16}]$

$\hookrightarrow p = 6 \times 1 + 8 \times 2 = 22$

$n = 6 \times 1 + 8 \times 2 = 22$

$e = 6 \times 1 + 8 \times 2 = 22 - 0 = 22$

v) NH_4^+ $[{}_{7}N^{14}, {}_{1}H^{1}]$

$p = 7 \times 1 + 1 \times 4 = 11$

$n = (14-7) \times 1 + (1-1) \times 4$

$= 7$

$e = 7 \times 1 + 1 \times 4 = 11 - 1 = 10$

vi) SO_4^{-2} $[{}_{16}S^{32}, {}_{8}O^{16}]$

$p = 16 + 4 \times 8 = 48$

$n = 16 + 4 \times 8 = 48$

$e = 16 + 4 \times 8 = 48 + 2$

$= 50$

Determining Protons neutrons electrons:

HW find the No of protones, neutrons, electrons for

N^{-3}, Al^{+3}, Cl^-, SO_2, NH_2^-, ClO_4^-, H_2SO_4, NH_3

D_2O [$_1D^2$]

(H^+) → P. = 1, n. = 0, e = 0

$_1H^1$

e = 10 NH_3 —H^+→ $NH_2^\ominus$ e = 10

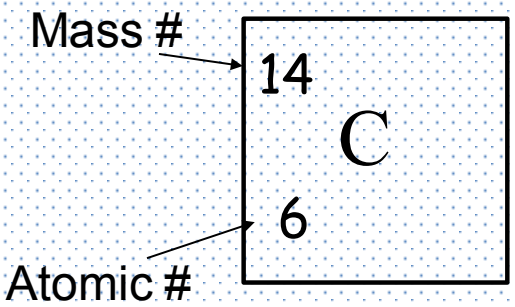
e = 10 NH_3 —H^+→ NH_4^+ e = 10

during this process electrons and neutrons remains constant.

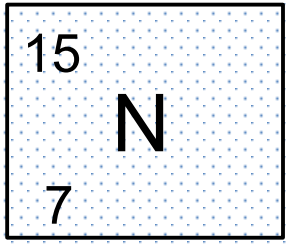
Determining Protons neutrons electrons:

Determining p^+, n, and e^- from chemical symbols:

- Example 1:
  # protons = 6
  # electrons= 6
  # neutrons= 14-6 = 8



- Example 2:
  # protons = 7
  # electrons= 7
  # neutrons= 15-7 = 8



Mole Concept

REPRESENTATION OF ELEMENTS

Mole Concept

REPRESENTATION OF ELEMENTS

Mole Concept

Common Cations, Anions, Acids, Salts Nomenclature

Cations (positive ions)

H+ Hydrogen ion (proton)
NH_4^+ Ammonium ion

Main Group Ions

Li+ Lithium ion
Na+ Sodium ion
K+ Potassium ion
Rb+ Rubidium ion
Cs+ Cesium ion
Be2+ Beryllium ion
Mg2 Magnesium ion
Ca2+ Calcium ion
Sr2+ Strontium ion
Ba2+ Barium ion
Al3+ Aluminum ion
Sn2+ Tin(II) (stannous) ion Sn4+ Tin(IV) (stannic) ion Pb2+ Lead(II) (plumbous) ion Pb4+ Lead(IV) (plumbic) ion
Sb3+ Antimony(III) (antimonous) ion Sb5+ Antimony(V) (antimonic) ion Bi3+ Bismuth(III) (bismuthous) ion Bi5+ Bismuth(V) (bismuthic) ion

Anions (negative ions) (ide)

H– Hydride ion
F– Fluoride ion
Cl– Chloride ion
Br– Bromide ion
I– Iodide ion
O2– Oxide ion
~~OH– Hydroxide ion~~
O_2^{2-} Peroxide ion
S2– Sulfide ion
~~H2S Hydrogen sulfide ion~~ Se2– Selenide Ion
N3– Nitride ion
N_3^- Azide ion
P3– Phosphide ion
As3- Arsinide ion
C4– Carbide ion
CN– Cyanide ion

Oxoanions

ClO^- Hypochlorite ion
ClO_2^- Chlorite ion
ClO_3^- Chlorate ion
ClO_4^- Perchlorate ion
SO_3^{2-} Sulfite ion

hyp_ite
ite
ate
per_ate

REPRESENTATION OF ELEMENTS

Sn^{+2} → stannous = Tin (II)

↳ Stock Notation

Sn2+ Tin(II) (stannous) ion

Sn4+ Tin(IV) (stannic) ion

Pb2+ Lead(II) (plumbous) ion Pb4+ Lead(IV) (plumbic) ion

Sb3+ Antimony(III) (antimonous) ion

Sb5+ Antimony(V) (antimonic) ion

Bi3+ Bismuth(III) (bismuthous) ion

Bi5+ Bismuth(V) (bismuthic) ion

Oxoanions

ClO_1^- Hypochlorite ion.....

ClO_2^- Chlorite ion..... ...

ClO_3^- Chlorate ion..... ...

ClO_4^- Perchlorate ion ....

SO_3^{2-} Sulfite ion..... ...

SO_4^{-2} sulphate

SO_5^{-2} - per sulphate

REPRESENTATION OF ELEMENTS

PO_2^{-3} → hypophosphite

PO_3^{3-} Phosphite ion……

PO_4^{3-} Phosphate ion……

CO_3^{2-} Carbonate ion……

HCO_3^- Hydrogen carbonate ion (bicarbonate ion)

$C_2O_4^{2-}$ Oxalate ion ……

CrO_4^{2-} Chromate ion ……

$Cr_2O_7^{2-}$ Dichromate ion ……

MnO_4^- Permanganate ion

Cr2+Chromium(II) (chromous) ion

Cr3+Chromium(III) (chromic) ion

Mn2+ Manganese(II) (manganous) ion

Mn3+ Manganese(III) (manganic) ion

Fe2+ Iron(II) (ferrous) ion

Fe3+ Iron(III) (ferric) ion

Co2+ Cobalt(II) (cobaltous) ion

Co3+ Cobalt(III) (cobaltic) ion

Ni2+Nickel(II) (nickelous) ion Ni3+ Nickel(III) (nickelic) ion Cu+ Copper(I) (cuprous) ion

Cu2+ Copper(II) (cupric) ion

Ag+ Silver(I) ion

Au+ Gold(I) (aurous) ion

Au3+ Gold(III) (auric) io n Zn2+ Zinc ion

Cd2+ Cadmium ion

Hg_2^{2+} Mercury(I) (mercurous) ion

Hg2+ Mercury(II) (mercuric) ion

O_2^{-2} → peroxide

O_2^- → superoxide

$[Fe(CN)_6]^{-4}$ → Ferrocyanide

CN^- → cyanide

REPRESENTATION OF ELEMENTS

ate → ic acid

CO_3^{-2} —(H^+)→ HCO_3^- —(H^+)→ H_2CO_3

Carbonate — Hydrogen carbonate — Carbonic acid

NO_3^- —(H^+)→ HNO_3

Nitrate — Nitric acid

ClO_3^- → $HClO_3$

Chlorate — Chloric acid

REPRESENTATION OF ELEMENTS

PO_4^{-3} $\xrightarrow{H^+}$ HPO_4^{-2} $\xrightarrow{H^+}$ $H_2PO_4^-$ $\xrightarrow{H^+}$ H_3PO_4

phosphate — Hydrogen phosphate — di hydrogen phosphate — phosphoric acid

SO_4^{-2} $\xrightarrow{H^+}$ HSO_4^- $\xrightarrow{H^+}$ H_2SO_4

Sulphate — hydrogen sulphate — Sulphuric acid

REPRESENTATION OF ELEMENTS

HW 50 name

- Naming of Compound :

Cation + Anion

Cacium Carbonate

$1 \times (Ca^{+2})\ (CO_3^{-2}) \times 1$

$CaCO_3$

- Magnisium phosphate

$3 \times (Mg^{+2})\ (PO_4^{-3}) \times 2$

$Mg_3(PO_4)_2$

- Ammonium dichromate

$2 \times (NH_4^{+})\ (Cr_2O_7^{-2}) \times 1$

$(NH_4)_2Cr_2O_7$

Mole Concept

DEFINITIONS

10^9	10^6	10^3	10^2	10	1	10^{-1}	10^{-2}	10^{-3}	10^{-6}	10^{-9}	10^{-10}	10^{-12}	10^{-15}
G	M	Km	Hm	Dm	m	dm	cm	mm	μ	n	A°	P	f

$10\ cm \longrightarrow x\ Km$

$$x = \frac{10 \times 10^{-2}}{10^3} = 10^{-4}\ Km$$

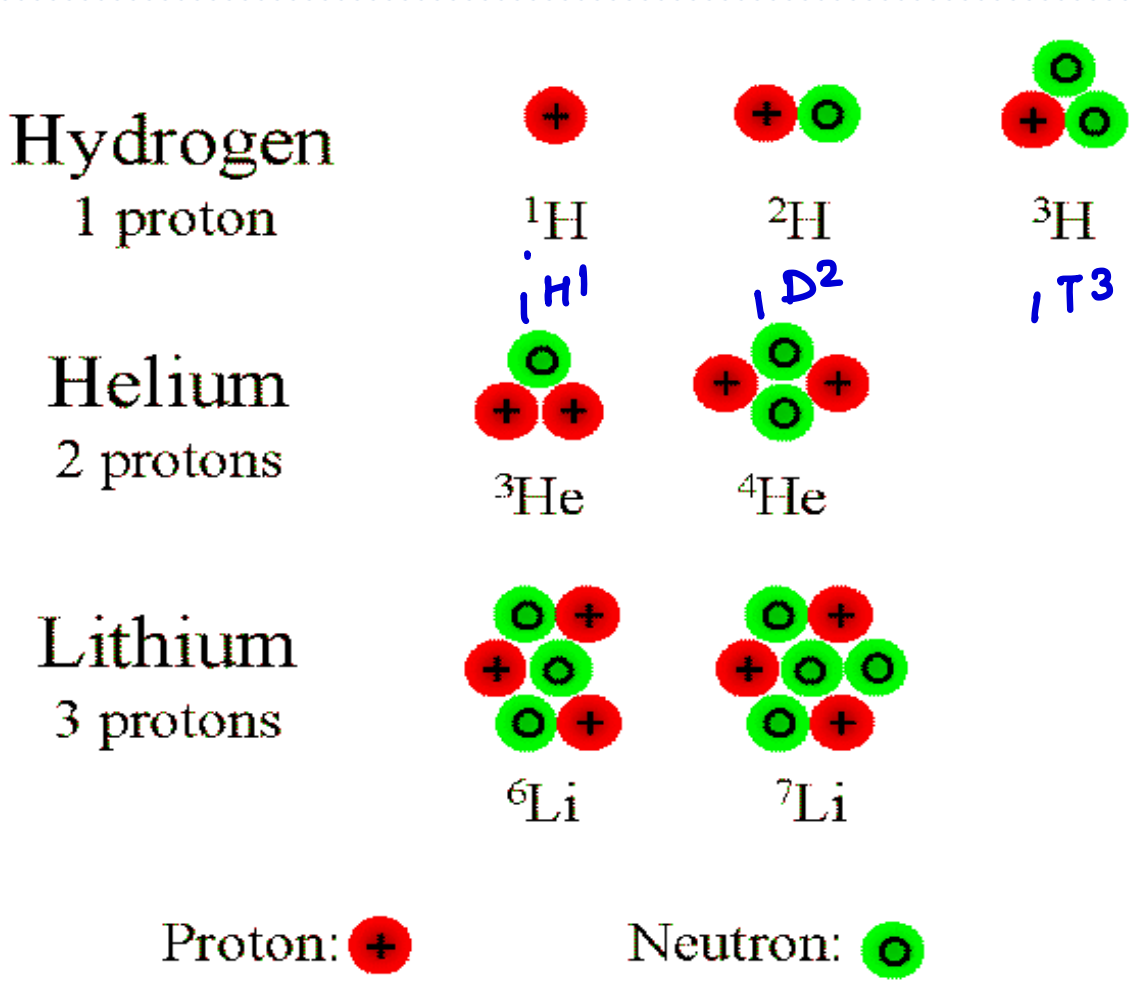
$12\ A^\circ \longrightarrow x\ cm$

$$x = \frac{12 \times 10^{-10}}{10^{-2}} = 12 \times 10^{-8}\ cm$$

ISOTOPES:

- Atoms with the same number of protons (Z), but **different numbers of neutrons** (n)
- Isotopes of an element have the same atomic number, but different mass numbers
- **Nuclear Symbol** or isotopic symbol
  – shows number of protons, neutrons and electrons in an atom

$_{Z}X^{A_1}$ and $_{Z}X^{A_2}$ are called isotopes


Hydrogen
1 proton
^{1}H
^{2}H
^{3}H
$_1H^1$
$_1D^2$
$_1T^3$
Helium
2 protons
^{3}He
^{4}He
Lithium
3 protons
^{6}Li
^{7}Li
Proton:
Neutron:

ISOTOPE CHART:

Element	Isotope symbol	# pro.	# elec.	# neu.
Boro n- 10	^{10}B	5	5	5
Boro n- 11	^{11}B	5	5	6
Chlorine - 35	^{35}Cl	17	17	18
Chlorine - 37	^{37}Cl	17	17	20

- Isotopes have same chemical properties.

Statistic

Student	Mark
5	50
10	40
15	60

$$\text{Mark} = \frac{5 \times 50 + 10 \times 40 + 15 \times 60}{5 + 10 + 15} = 51.6$$

Cl^{35} ⟶ 10 atom

Cl^{37} ⟶ 30 atom

$$A_{avg} = \frac{10 \times 35 + 30 \times 37}{10 + 30} = 36.5$$

$$ {}^{A_1}_{Z}X \qquad {}^{A_2}_{Z}X \qquad {}^{A_3}_{Z}X $$

abundancy a b c

$$\text{Avg} = \frac{a A_1 + A_2 \cdot b + A_3 \cdot c}{a + b + c}$$

given abundancy is %

$$\underline{a + b + c = 100}$$

Q- Chlorine has two isotopes Cl^{35}, Cl^{37}. If their abundancy are in ratio of 3:1 find Avg mass number.

Cl^{35}		Cl^{37}
3	:	1

$$\text{Avg} = \frac{35 \times 3 + 37 \times 1}{3+1} = 35.5$$

Q. Neon has two isotopes Ne^{20} and Ne^{21} if % abundance of Ne^{21} is 10% then find Avg mass Number

Ne^{20}	Ne^{21}
90%	10%

$$\text{Avg} = \frac{20 \times 90 + 21 \times 10}{100}$$

Q- Boron has two isotopes B^{10}, and B^{11} if avg mass number is 10.81 find % abundance of lighter isotopes

	B^{10}	B^{11}
% abundance	x %	(100-x) %

$$10.81 = \frac{10 \cdot x + 11(100-x)}{100}$$

$$1081 = 10x + 1100 - 11x$$

$$x = 19\ \%$$

Q- Oxygen has 3 isotopes O^{15} O^{16}, O^{17} if sum of abundancy of O^{15} and O^{17} is 20% and avg mass Number is 15.9 find % abundancy of each isotopes.

O^{15}	O^{16}	O^{17}
x	80%	(20 − x)

$$15.9 = \frac{15.x + 16 \times 80 + 17 \times (20 - x)}{100}$$

$x = 15\%$, $\quad 5\%$

AVERAGE ATOMIC MASS
(= Atomic Weight)

- the weighted average of the masses of the atoms (isotopes) in a naturally occurring sample of an element
- masses are based off of the atomic mass unit (amu) defined as one twelfth the mass of a carbon-12 atom
- these values can be fractions

Average Atomic Mass Example

- In nature carbon is composed of 98.890% ^{12}C atoms and 1.1100% ^{13}C atoms. ^{12}C has a mass of 12.000 amu and ^{13}C has a mass of 13.0034 amu. What is the average atomic mass of carbon?

Ave. mass = (.98890)(12.000)
+ (.011100)(13.0034)

= 12.011 amu

Example: There are 3 isotopes of magnesium that occur in nature. Their abundances and masses are listed below:

Isotope	% Abundance	Mass (amu)
^{24} Mg	78.99%	23.98504
^{25} Mg	10.00%	24.98584
^{26} Mg	11.01%	25.98259

What is the atomic weight of magnesium?

Atomic weight =

(.7899)(23.98504)

\+ (.1000)(24.98584)

\+ (.1101)(25.98259)

= **24.31 a.m.u.**

Carbon-12 and carbon-14 are

a) isomers
b) isotopes
c) radioactive elements
d) different elements

Isotopes are atoms of the same element with different numbers of neutrons, and therefore different atomic masses.

While carbon-14 is used in radioactive dating, carbon-12 has a more stable nucleus and therefore is not used in this capacity.

How many protons, electrons and neutrons are in one atom of oxygen-17?

a) 17 p, 17 e, 17 n

b) 17 p, 17 e, 1 n

c) 8 p, 8 e, 8 n

d) 8 p, 8 e, 9 n

While most oxygen atoms have a mass of 16 g/mol, oxygen-17 is an isotope with a mass of 17 g/mol.

The number of protons in an element is the same for every atom of that element.

electrons = # protons if element has no charge.