* Chapter 2: Atoms, Molecules, and Ions

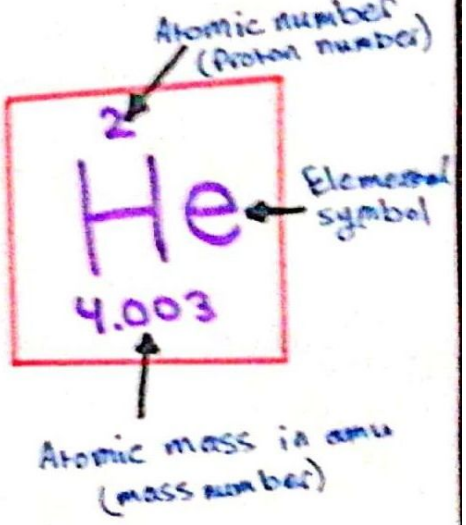
*2.3: Nuclear structure and isotopes (Metal, non metal and metaloids)
*2.4: Atomic Weights

- elements → metals
- elements → non-metals
- elements → metalloids

- **Atom:** is the smallest constituent unit of ordinary matter that has the properties of a chemical element.

- **Molecule:** is an electrically neutral group of <u>two or more</u> atoms held together by chemical bonds.

- Atomic NO. → number of protons in the nucleus (Z)
- Mass NO. → number of protons + neutrons in the nucleus (A)
- in neutral atom → no. of protons = no. of electrons



$N = A - Z$

$Z = P$

$P = e$ → in neutral atom.

- **isotopes:** atoms that have the same atomic NO. but different mass NO..

- important note: atomic NO. is the identity of the atom.

- the difference in the mass NO. caused by difference in neutrons NO.

example: $^{1}_{1}H$, $^{2}_{1}H$, $^{3}_{1}H$ / $^{12}_{6}C$, $^{13}_{6}C$ / $^{235}_{92}U$, $^{238}_{92}U$

Important Page

ex.: How many P, N, e are in the following atoms:

$^{195}_{79}Au$

P = 79

N = 195 - 79 = 116

e = 79

$^{18}_{9}F$

P = 9

N = 9

e = 9

$^{56}_{26}Fe^{+2}$

P = 26

N = 30

e = 26 - 2 = 24

$^{64}_{29}Cu$

P = 29

N = 64 - 29 = 35

e = 29

Ions
- Anions: negative ion because of gaining electrons. $(-)$
- Cations: positive ion because of lossing electrons. $(+)$

- Atomic weights:

* Atomic mass = ~~Atomic~~ mass weight = is the mass of an atom in atomic mass unit (amu)

$$1\,amu = \frac{1}{12}\,(mass\ {}^{12}_{6}C)$$

$$1\ amu = 1.66\times10^{-24}\ g$$

$$1\ gram = 6.022\times10^{23}\ amu$$

$$\text{unit in gram} = \frac{\text{unit in amu}}{N_A}$$

↳ Avogadro's NO. $= 6.022\times10^{23}$

Example: what is the mass in grams of 13.2 amu?

$$g = \frac{amu}{N_A} = \frac{13.2}{6.022\times10^{23}} = 2.19\times10^{-23}\ g$$

* Atomic weight: is the average atomic mass for the naturally occuring isotops (of element) expless Atomic mass unit.

➡ Atomic weight = (percentage of first isotop × mass of the first isotop) + (percentage of second isotop × mass of the second isotop) ...

example: ${}^{35}_{17}Cl$ (34.969 amu), ${}^{37}_{17}Cl$ (36.960 amu) and fractional abundance is 0.7577, 0.2423 respectivley?

Cl :- $(34.969\times0.7577) + (36.960\times0.2423) = 35.45\ amu$

Example:- The atomic mass of $^{7}_{3}Li$ and $^{6}_{3}Li$ are 7.0160 amu and 6.0151 amu respectively, calculate the natural abundance of these two isotopes. The average atomic mass of Li is 6.941 amu ?

$$6.941 = (7.0160 \times X) + (6.0151 \times (1-X))$$

$$6.941 = 7.0160X + 6.0151 - 6.0151X$$

$$0.9259 = 1.0009X$$

$$X = 0.925 \Rightarrow {}^{7}_{3}Li \quad 92.5\ \%$$

$$1-X = 1-0.925$$

$$= 0.0749 \Rightarrow {}^{6}_{3}Li \quad 7.49\ \%$$

100 %

1

X	$1-X$
$^{7}_{3}Li$	$^{6}_{3}Li$

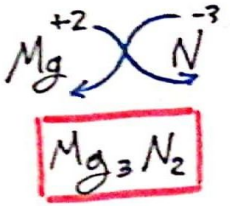
*2.8 : Naming compounds

- Type of the compounds :
  - Ionic compound : due to electrostatic forces between opposite charges | metal (+) + non-metal (-) |
  - Molecular compound : sharing electrons between two atoms | non-metal + non-metal |

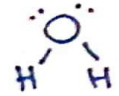
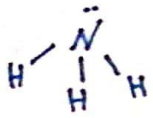
كتابة الصيغة الكيميائية للمركبات الأيونية :

1 نكتب الأيون الموجب ثم السالب

2 عدد شحنة الأيون هو عدد ذرات الأيون المقابل



المجموعة	الأولى	الثانية	الثالثة	الرابعة	الخامسة	السادسة	السابعة	الثامنة
الرمز	I	II	III	IV	V	VI	VII	VIII
الشحنة	+1	+2	+3	×	-3	-2	-1	×

Emperical formula	→	Molecular formula	→	structurd
CH_2O	→	$C_6H_{12}O_6$	→	
H_2O	→	H_2O	→	
NH_3	→	NH_3	→	

*Note: ions are: ① mono atomic ion ⇒ one element: Na^+, F^-

② poly atomic ion ⇒ two elements or more: OH^-, CN^-

*Naming compounds:-

- Ionic compounds:

1 If the metal is from group A in periodic table:

يسمى الفلز كما هو ونتبع اللافلز بـ ide .

example: $NaCl$ → sodium chloride

Li_2O → Lethium oxide

2 If the metal is from group B in periodic table:

يسمى الفلز كما هو + محتة بالأعداد اليونانية ونتبع اللافلز بـ ide .

example: Mn_2O_3 → Manganese (III) Oxide

$CuCl_2$ → copper (II) chloride

*يمكننا العلم باختصارات لبعض العناصر الإنتقالية وخصوصاً التي قد ينتج منها أكثر من أيون كما التالي :

$FeCl_2$ → Iron(II) ... → Ferrous ...

$FeCl_3$ → Iron(III) ... → Ferric ...

"ous" → lower charge

"ic" → higher charge

Ion → name → shortcut

Cr^{+3} → Chromium (III) → chromic

Co^{+2} → Cobalt (II) → cobaltous

Cu^{+} → Copper (I) → Cuprous

Cu^{+2} → Copper (II) → Cupric

Fe^{+2} → Iron (II) → Ferrous

Fe^{+3} → Iron (III) → Ferric

Pd^{+2} → Lead (II) → plumpous

Mn^{+2} → Manganese (II) → Manganous

Hg_2^{+2} → Mercury (I) → Mercurous

Hg^{+2} → Mercury (II) → Mercuric

Sn^{+2} → Tin (II) → stannous

3 If one of mole sides of the compound are polyatomic ions:

• هي مجموعة أيونية تتكون من عنصرين أو أكثر ولها شحنة إما موجبة أو سالبة.

* يسمى المركب الذي يحتوي مجموعة أيونية بنفس الطريقة السابقة والمجموعة تعامل معاملة أيون عادي ويكتب اسم المجموعة.

* Oxyanion:- is polyatomic ions involving one or more oxygen atoms and non-metal atoms.

general form is (A_xO_y)

-propably including atom from group (V II A), and we name them as in the following table:

FO^-: Hypofluorite	ClO^-: Hypochlorite	BrO^-: Hypobromite	IO^-: Hypoiodite
FO_2^-: fluorite	ClO_2^-: chlorite	BrO_2^-: bromite	IO_2^-: iodite
FO_3^-: fluorate	ClO_3^-: chlorate	BrO_3^-: bromate	IO_3^-: iodate
FO_4^-: perfluorate	ClO_4^-: perchlorate	BrO_4^-: perbromate	IO_4^-: periodate

example: a) $CuCO_3$ → Copper(II) carbonate
charge of Cu is +2

b) $KClO$ → Potassium hypochlorite

c) NH_4FO_3 → Ammonium fluorate

d) $KHSO_4$ → Potassium bisulfate

Formula	Name
NH_4^+	Ammonium
NO_2^-	Nitrite
SO_3^{-2}	sulfite
PO_3^{-3}	Phosphite
CrO_4^{-2}	Chromate
MnO_4^-	Permanganate
CN^-	Cyanide
H_3O^+	Hydronium
$S_2O_3^{-2}$	Thiosulfate
H^-	Hydride
HPO_4^{-2}	Hydrogen Phosphate
$C_2O_4^{-2}$	oxalate
HSO_4^-	Hydrogen Sulfate or bisulfate

Formula	Name
$CH_3CO_2^-$	Acetate
NO_3^-	Nitrate
SO_4^{-2}	Sulfate
PO_4^{-3}	Phosphate
$Cr_2O_7^{-2}$	Dichromate
MnO_4^{-2}	Manganate
SCN^-	Thiocyanate
OH^-	Hydroxide
CO_3^{-2}	Carbonate
O_2^{-2}	Peroxide
$H_2PO_4^-$	dihydrogen Phosphate
HCO_3^-	Hydrogen Carbonate or bicarbonate

- **Molecular compound:**

* if the compound is molecular (non-metal + non-metal) then we use the following phrases to indicate number of atoms.

The phrases (greek numbers)	mono	di	tri	tetra	Penta	hexa	hept	octa
	1	2	3	4	5	6	7	8

mona	dica
9	10

* في حالة كان العنصر الأول ذرة واحدة فإننا لا نتبعه بـ mono ونفهم ضمناً.
* شبه الفلزات تعتبر كاللافلزات في طريقة التسمية

example:- ⓐ P_2S_5: diphosphorous pentasulfide
ⓑ B_2O_3: diboron tri oxide
ⓒ Cl_2O_7: dichlorine heptoxide

* لكن يوجد بعض المركبات التساهمية لها أسماء شائعة لا تتبع طريقة التسمية يجب علينا حفظها:-

B_2H_6 → diborane
CH_4 → Methane
SiH_4 → silane
NH_3 → Ammonia
PH_3 → phosphine
H_2O → water
H_2S → Hydrogen sulfide

• Acids and bases: * Acids:

- according to physical state:
  - A) if it is gas or liquid we name the compound as in the previous cases
  - B) if it is aqueous (dissolved in water) we name it as acid ~~or base~~.
- oxyacids: acids that contain hydrogen, oxygen and another element, the H written first.
- simple acids:

HF	Hydrofluoric acid	HI	Hydroiodic acid
HCl	Hydrochloric acid	HCN	Hydrocyanic acid
HBr	Hydrobromic acid	H_2S	Hydrosulfuric acid.

- naming oxyacids:

- إذا انتهى الشق الأيمن (المجموعة الأيونية) بـ"ate" نستبدله بـ"ic" ثم "acid"
- " " " " بـ"ite" " بـ"ous" " "

examples: $HClO_3$ ⟶ chloric acid
(H → acid, ClO_3 → chlorate)

- a) H_2CO_3 → carbonic acid
- b) HNO_3 → nitric acid
- c) $HClO$ → hypochlorous acid
- d) HIO_2 → iodous acid
- e) HFO → hypofluorous acid

* Bases: can be described as a substance that yields hydroxide ions (OH^-) when dissolved in water.

عناصر المجموعة الأولى والثانية و الثالثة & OH تكون كهاي

- $NaOH$ → Sodium hydroxide
- KOH → Potassium hydroxide
- $Al(OH)_3$ → Aluminum hydroxide
- $Mg(OH)_2$ → Magnesium hydroxide

عناصر إنتقالية مع OH . يجب تحديد حسب العنصر الإنتقالي

- $Fe(OH_2)_2$ → Iron (II) hydroxide or ferrous hydroxide
- $Zn(OH_2)_2$ → Zinc (II) hydroxide

* Hydrates: compound contains water molecule weakly bounded in it crystals. (contains water)

- $MgSO_4 . 7H_2O$ → Magnesium sulfate heptahydrate
- $CuSO_4 . 5H_2O$ → Cupper (II) sulfate pentahydrate
- $FeCl_3 . 7H_2O$ → Iron (III) chloride heptahydrate

we use the greek numbers as in naming molecular compounds.

example: $BaCl_2 . 2H_2O$ → Barium chloride di Hydrate.

Naming Compounds

- **Ionic compound**
  - group (1,2,3) A with (5,6,7)
    - الفلز كما هو واللافلز نلحقه بـ ide
      - NaCl → sodium chloride
      - LiF → Lithium Floride
      - Al_2O_3 → Aluminium oxide
  - T.E
    العناصر الإنتقالية
    - الفلز كما هو ثم شحنته واللافلز نلحقه بـ ide
      - Cu_2O → Copper (I) oxide
        - Cu → x, O → −2
        - $0 = 2x - 2$
        - $2x = 2$
        - $x = 1$
- **Molecular compound**
  - (non-metal + non-metal)
    group (5,6,7) with the same groups or with Hydrogen.
    - نكتب عدد ذرات كل عنصر ملحقة بـ الأرقام الإغريقية .
      - N_2O_4 → dinitrogen tetraoxide
      - SO_3 → sulfur trioxide
        (لا نضع mono)
- **Acids and Bases**

* 2.9 & 2.10 : Chemical reaction and chemical equation:

- **Chemical reaction:** a process in which a substance in changed into one or more new substance.
- **chemical equation:** uses a chemical symbol to show what happen during a chemical reaction.
- **Reactant:** which are the starting material in chemical reaction.
- **Product:** which is the substance formed as a result of a chemical reaction.

- **writing chemical equations:-** $2CO_{(g)} + O_{2(g)} \longrightarrow 2CO_{2(g)}$

example: $2C_2H_6 + 7O_2 \longrightarrow 4CO_2 + 6H_2O$ ✓

$3Mg(NO_3)_2 + 2K_3PO_4 \longrightarrow Mg_3(PO_4)_2 + 6KNO_3$ ✓

$Al_4C_{3(s)} + 12H_2O_{(l)} \longrightarrow 4Al(OH)_{3(s)} + 3CH_{4(g)}$ ✓

$Mg_3N_{2(s)} + 4H_2SO_{4(aq)} \longrightarrow 3MgSO_{4(aq)} + (NH_4)_2SO_{4(aq)}$ ✓

$2NH_{3(g)} + 3O_{2(g)} \longrightarrow 2N_{2(g)} + 6H_2O_{(l)}$ ✓

Questions :

Q1: Balance the following equation:

$1\,Al_2(SO_4)_3 + 6\,KOH \longrightarrow 2\,Al(OH)_3 + 3\,K_2SO_4$

A) 1,3,2,6 B) 2,3,1,4 **c) 1,6,2,3** d) 4,6,2,3

Q2: for $^{59}_{27}X$ what is the number of (P, N) : P = 27, N = 59 − 27 = 32

A) 27, 59 **B) 27, 32** c) 32, 27 d) 32, 59

Q3: Name the following compounds:

a) Mn_2O_4 → manganese (IV) oxide

b) N_2O_3 → dinitrogen trioxide

c) $HClO_2$ → chlorous acid

d) $Ca(CH_3CO_2)_2$ → calcium acetate

e) $HMnO_4$ → permangic acid

f) N_2O_5 → dinitrogen pentoxide

g) Na_2HPO_4 → sodium hydrogen phosphate

$Na_2HPO_4 \rightarrow HPO_4^{-2}$

Q4: what is the formula of the following compou

names:

a) Iron (III) phosphate → $FePO_4$

b) disulfurdinitride → S_2N_2

c) calcium oxide → CaO

d) Aluminum hydride → AlH_3

e) Mercurous sulfide → Hg_2S

Hg_2^{+2}

Hg^{+2}