



CHEMYIOI

Chapter 2

الذرات

الايونات


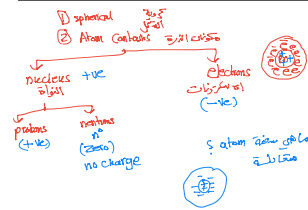
الجزيئات

Atoms, Ions, and Molecules

Chapter 2 ATOMS MOLECULES AND IONS

• ATOM () The smallest bit of a matter
 Defined as the smallest particle which can enter into chemical combination

• ELEMENTS () Simple form of matter

$n^0 \rightarrow$ inside nucleus
 $p^+ \rightarrow$ inside nucleus
 $e^- \rightarrow$ outside nucleus
 Nu \rightarrow Center of atom

• charge of e^- = charge of p^+

$$-1 = +1$$

$$-2 = +2$$

• mass of $n =$ mass of p
 $1.67262 \times 10^{-24} = 1.67262 \times 10^{-24}$

$n > e$
 $p > e$

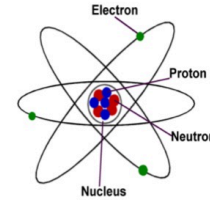
| PARTICLE | CHARGE UNIT |
|----------|-------------|
| e | -1 |
| p | +1 |
| n | 0 |

❖ The atoms can be identified by the number of protons and neutrons

❖ ATOMIC NUMBER (Z) :- العدد الذري → العدد الإيجابي no. of protons in the nucleus $Z = P$

❖ MASS NUMBER (A) :- العدد الكتلي → العدد الإجمالي total no. of protons and neutrons

$$A = P + n$$



Representation of an atom



$$Z = n(p)$$

$$A = Z + n(p)$$

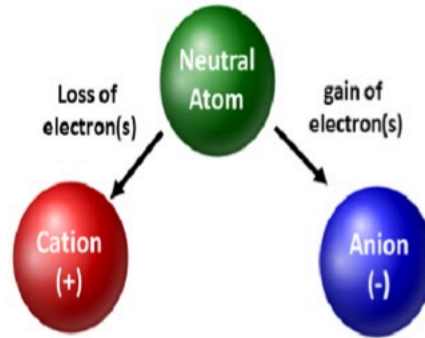
$$n(e) = n(p) \text{ for neutral atom}$$

mass number ← A
Atomic number ← Z

❖ Ions [الأيونات] :- An ion is an atom or a group of atoms that has a net positive or negative charge

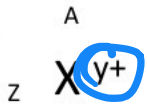
Na

Na⁺



| <u>CATION (+)</u> | <u>ANION (-)</u> |
|----------------------------------|----------------------------------|
| LOSS e Has + ve charge | GAIN e Has - ve charge |

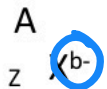
❖ Representation of a cation



$$n(e) \text{ for cation} = P - y$$

+ \rightarrow loss e^-
- \rightarrow gain e^-

❖ Representation of an anion



$$n(e) \text{ for anion} = P + (y)$$

Na \rightarrow $e = P$

Na⁺ \rightarrow e

Q1) Multiple Choice

1.1) How many protons, neutrons, and electrons are, respectively, there in $^{59}\text{Co}^{2+}$?

- (a) 32, 27, 24 (b) 27, 32, 25 (c) 32, 27, 25
(d) 27, 32, 29 (e) 27, 32, 24

1.2) How many electrons and neutrons are there in $^{51}\text{V}^{2+}$?

- (a) 23 electrons and 30 neutrons
(b) 21 electrons and 28 neutrons
(c) 48 electrons and 68 neutrons
(d) 18 electrons and 26 neutrons
(e) 46 electrons and 66 neutrons

$p = \text{Atomic number}$

$e = 23 - 2 = 21$ (charge)

$\text{mass} = p + n$
 $51 = 23 + n$
 $n = 28$

1.3) The element which has 27 protons, and 32 neutrons is ?

- a) Co
b) Fe
c) Mn
d) Si
e) Al

1.4) The number of electrons, protons and neutrons present in $^{27}\text{Al}^{3+}$ is respectively ?

- a) 10, 13, 27
b) 13, 13, 14
c) 14, 10, 13
d) 10, 13, 14
e) 14, 10, 13

1.5) How many electrons and neutrons are there in $^{138}\text{Ba}^{2+}$?

- (a) 54 electrons and 81 neutrons (b) 54 electrons and 82 neutrons
(c) 58 electrons and 81 neutrons (d) 56 electrons and 83 neutrons

€ 54 electrons and 80 neutrons

1.6) How many electrons and neutrons are there in $^{207}\text{Pb}^{2+}$?

- (a) 84 electrons and 125 neutrons
- (b) 82 electrons and 125 neutrons
- (c) 80 electrons and 125 neutrons
- (d) 82 electrons and 207 neutrons
- (e) 82 electrons and 127 neutrons

1.7) The sum of protons and electrons in Sr_3P_2 compound is

- a) 160
- b) 170
- c) 180
- d) 190
- e) 288**

$P_{\text{Sr}} = 38$ $P_{\text{P}} = 15$

$(38) \times 3 + (15) \times 2 =$
 $114 + 30 = \underline{144}$
 $144 \times 2 = 288$

1.8) The sum of number of protons and electrons in $^{56}_{26}\text{Fe}^{3+}$ is ?

- (a) 46
- (b) 47
- (c) 48
- (d) 49
- (e) 51

1.9) The no. of protons, electrons and neutrons present in $^{65}\text{Zn}^{2+}$ is ?

- a) 30,30,35
- b) 32,30,35
- c) 30,28,35
- d) 28,30,35
- e) 35,28,30

1.10) What is the total number of protons and electrons in Zr^{+4} ?

- a) 90 b) 45 c) 58 d) 110 e)

1.11) The element which has 25 protons, and 30 neutrons is ?

- a) Co
- b) Al
- c) Fe
- d) Mn
- e) Si

Mn → 54.9

Q2) Fill in the blanks

- a) The number of electrons in Mn^{4+} is
- b) The number of electrons in K^+ ion is
- c) The atomic number of an atom which has 48 neutrons and 45 electrons is
- d) The number of electrons in N^{3-} is
- e) The number of electrons in Ni^{2+} is
- f) The number of protons in N^{3-} is
- g) The number of protons in Li^+ ion is
- h) The atomic number of an atom which has 35 neutrons and 33 electrons is
- i) The number of protons in K^+ ion is
- j) The atomic number of an atom which has 51 neutrons and 40 electrons is
- k) The number of protons in Ca^{2+} is

Q3) Fill in the table below

| | | | |
|--------------------|----|-----------|----|
| No. of electrons | 16 | | 10 |
| No. of protons | 16 | | 7 |
| Symbol of atom/ion | | Ba^{2+} | |

| | | | |
|--------------------|----|----|----|
| No. of electrons | 18 | 18 | 10 |
| No. of protons | 16 | 20 | 7 |
| Symbol of atom/ion | | | |

$$P = e$$

$$P + n$$

ISOTOPES [النظائر]:- Atoms that have the same atomic no. but different mass number (Isotopes play similar chemical properties)



hydrogen-1
(protium)



hydrogen-2
(deuterium)



hydrogen-3
(tritium)

$P =$ Atomic number

Uranium has 2 isotopes Known as

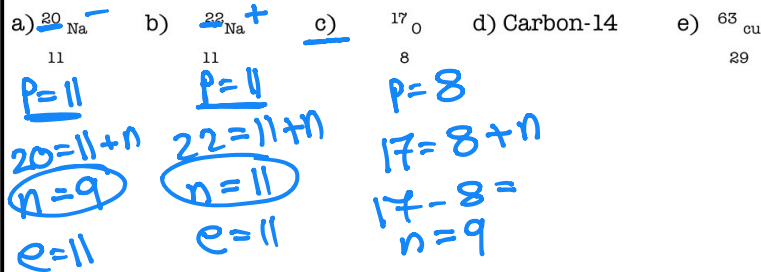
Uranium -235 ${}^{235}\text{U}$

Uranium -238 ${}^{238}\text{U}$

| | ${}^{12}_6\text{C}$ | ${}^{13}_6\text{C}$ | ${}^{14}_6\text{C}$ |
|-----|--|---------------------|---------------------|
| P | 6 | 6 | 6 |
| e | 6 | 6 | 6 |
| n | $\text{mass} = P + n$ $12 = 6 + n$ $12 - 6 =$ $n = 6$ | $n = 7$ | $n = 8$ |

PROBLEMS:

Q2.1. Calculate no. of protons, neutrons, and electrons



Q2.2. What is the atomic number of an element if one of its isotopes has 117 neutrons and mass no. 195?

atomic = P

↑
mass = P + n

195 = ?? + 117

P = 78

195
78?? X

Q2.3.

| Element /ions | n (p) | n (e) | n (n) |
|----------------------------|-------|-------|-------|
| $^{27}_{13}\text{Al}$ | | | |
| $^{27}_{13}\text{Al}^{3+}$ | | | |
| $^{80}_{35}\text{Br}^{-1}$ | | | |
| $^{80}_{35}\text{Br}$ | | | |
| $^{12}_6\text{C}$ | | | |
| $^{13}_6\text{C}$ | | | |
| $^{14}_6\text{C}$ | | | |

ISOTOPES

ELEMENTS



Metalloids

الاجزاء الفلزات



Metals

اللافلزات

Non metals

(+ve)
loss e^-

gain e^-
(-ve)

Metals : [المعادن]

Good conductor of heat and electricity

Eg: Copper, Silver etc

Metalloids:[الفلزات]

Shows properties intermediate between those of metals and non-metals

Eg: Boron ,Silicon, etc

Non- metals:[اللافلزات]

Poor conductor of heat and electricity

Eg: Oxygen, Fluorine etc

❖ **The Periodic Table** :- [الجدول الدوري]

A chart in which elements having similar chemical and physical properties are grouped together

❖ Horizontal rows are known as **Periods**: There are **7 periods** in the Periodic table

❖ Vertical columns are known as **Groups**: There are **18 groups** in the Periodic table

Group 1- Known as **Alkali metals**

Group 2- Known as **Alkaline earth metals**

المجموعات والفترات في الجدول
الدوري

Group 3-12 - Known as **Transition elements**

Group 17- Known as **Halogens**

Group 18- known as **Noble gas/rare gas**

Periodic Table of the Elements

| 1 IA | | | | | | | | | | | | 18 VIIIA | | | | | |
|--|--|---|--|--|---|--|---|---|---|--|--|--|--|---|--|---|--|
| 1 H Hydrogen 1.008 | 2 He Helium 4.003 | | | | | | | | | | | | | | | | |
| 3 Li Lithium 6.938 | 4 Be Beryllium 9.012 | | | | | | | | | | | 5 B Boron 10.81 | 6 C Carbon 12.011 | 7 N Nitrogen 14.007 | 8 O Oxygen 15.999 | 9 F Fluorine 18.998 | 10 Ne Neon 20.180 |
| 11 Na Sodium 22.990 | 12 Mg Magnesium 24.305 | 13 Al Aluminum 26.982 | 14 Si Silicon 28.085 | 15 P Phosphorus 30.974 | 16 S Sulfur 32.06 | 17 Cl Chlorine 35.45 | 18 Ar Argon 39.948 | | | | | | | | | | |
| 19 K Potassium 39.098 | 20 Ca Calcium 40.078 | 21 Sc Scandium 44.956 | 22 Ti Titanium 47.867 | 23 V Vanadium 50.942 | 24 Cr Chromium 51.996 | 25 Mn Manganese 54.938 | 26 Fe Iron 55.845 | 27 Co Cobalt 58.933 | 28 Ni Nickel 58.693 | 29 Cu Copper 63.546 | 30 Zn Zinc 68.38 | 31 Ga Gallium 69.723 | 32 Ge Germanium 72.630 | 33 As Arsenic 74.922 | 34 Se Selenium 78.971 | 35 Br Bromine 79.904 | 36 Kr Krypton 83.798 |
| 37 Rb Rubidium 85.468 | 38 Sr Strontium 87.62 | 39 Y Yttrium 88.906 | 40 Zr Zirconium 91.224 | 41 Nb Niobium 92.906 | 42 Mo Molybdenum 95.95 | 43 Tc Technetium (98) | 44 Ru Ruthenium 101.07 | 45 Rh Rhodium 102.91 | 46 Pd Palladium 106.42 | 47 Ag Silver 107.87 | 48 Cd Cadmium 112.41 | 49 In Indium 114.82 | 50 Sn Tin 118.71 | 51 Sb Antimony 121.76 | 52 Te Tellurium 127.60 | 53 I Iodine 126.90 | 54 Xe Xenon 131.29 |
| 55 Cs Cesium 132.905 | 56 Ba Barium 137.327 | 57-71 Lanthanides | 72 Hf Hafnium 178.49 | 73 Ta Tantalum 183.84 | 74 W Tungsten 183.84 | 75 Re Rhenium 186.21 | 76 Os Osmium 190.23 | 77 Ir Iridium 192.22 | 78 Pt Platinum 195.08 | 79 Au Gold 196.97 | 80 Hg Mercury 200.59 | 81 Tl Thallium 204.38 | 82 Pb Lead 207.2 | 83 Bi Bismuth 208.98 | 84 Po Polonium (209) | 85 At Astatine (210) | 86 Rn Radon (222) |
| 87 Fr Francium (223) | 88 Ra Radium (226) | 89-103 Actinides | 104 Rf Rutherfordium (267) | 105 Db Dubnium (268) | 106 Sg Seaborgium (269) | 107 Bh Bohrium (270) | 108 Hs Hassium (277) | 109 Mt Meitnerium (278) | 110 Ds Darmstadtium (281) | 111 Rg Roentgenium (282) | 112 Cn Copernicium (285) | 113 Nh Nihonium (286) | 114 Fl Flerovium (289) | 115 Mc Moscovium (290) | 116 Lv Livermorium (293) | 117 Ts Tennessine (294) | 118 Og Oganesson (294) |
| 57 La Lanthanum 138.91 | 58 Ce Cerium 140.12 | 59 Pr Praseodymium 140.91 | 60 Nd Neodymium 144.24 | 61 Pm Promethium (145) | 62 Sm Samarium 150.36 | 63 Eu Europium 151.96 | 64 Gd Gadolinium 157.25 | 65 Tb Terbium 158.93 | 66 Dy Dysprosium 162.50 | 67 Ho Holmium 164.93 | 68 Er Erbium 167.26 | 69 Tm Thulium 168.93 | 70 Yb Ytterbium 173.05 | 71 Lu Lutetium 174.97 | | | |
| 89 Ac Actinium (227) | 90 Th Thorium 232.04 | 91 Pa Protactinium 231.04 | 92 U Uranium 238.03 | 93 Np Neptunium (237) | 94 Pu Plutonium (244) | 95 Am Americium (243) | 96 Cm Curium (247) | 97 Bk Berkelium (247) | 98 Cf Californium (251) | 99 Es Einsteinium (252) | 100 Fm Fermium (257) | 101 Md Mendelevium (258) | 102 No Nobelium (259) | 103 Lr Lawrencium (266) | | | |

1 ← Atomic Number
H ← Element Symbol
 Hydrogen ← Element Name
 1.008 ← Atomic Weight

Alkali Metals
Alkaline Earth Metals
Transition Metals
Actinides
Post-Transition Metals
Metalloids
Noble Gases
Lanthanides
Reactive Nonmetals
Unknown Chemical Properties

H^1

$P=1$

$e=1$

Periodic Table of the Elements

POST TRANSITION METALS

| | | | | | | | | | | | | | | | | | |
|---------------|----------|----|---|---|---|---|---|---|----|----|----|--------|--------|--------|--------|----------|-----------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| H | He | | | | | | | | | | | | | | | | |
| Group 1 | Alkaline | | | | | | | | | | | | | | | halogens | Noble gas |
| Alkali metals | earth | | | | | | | | | | | charge | charge | charge | charge | charge | charge |
| | metals | | | | | | | | | | | +3 | +4 | -3 | -2 | -1 | 0 |
| charge | charge | | | | | | | | | | | | -4 | | | | |
| +1 | +2 | * | | | | | | | | | | | | | | | |
| | | ** | | | | | | | | | | | | | | | |

Transition metals

Shows more than one charge

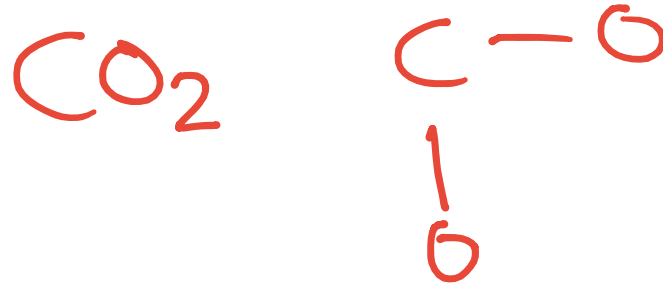
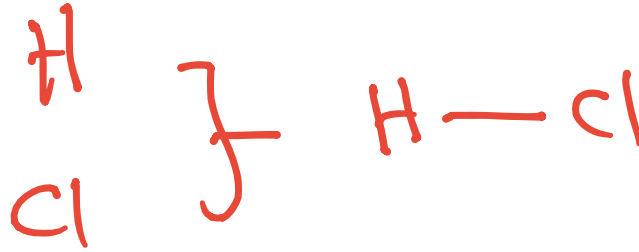
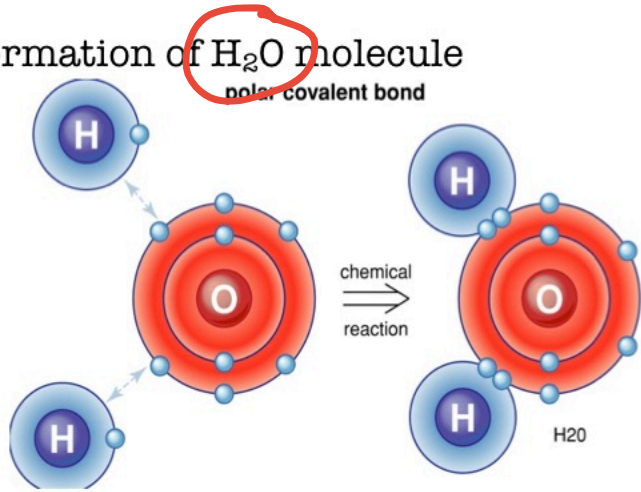
Lanthanoids

Actinoids

Molecules: [الجزئيات-]

A molecule is an arrangement of two or more atoms which are held by chemical bond [رابطة
كيميائية]

Eg: Formation of H_2O molecule
polar covalent bond



❖ Diatomic molecules: - which contain two same/different atoms

[جزيئات ثنائية الذرة]

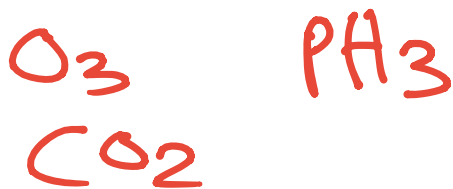


Eg - H₂, O₂, N₂ and group 17 elements - F₂, Cl₂, Br₂, I₂ - [contain same atoms]

HCl, CO, HBr [contain different atoms]

❖ Polyatomic molecules: جزيئات متعددة الذرات
Molecules contain more than two same /different atoms

Eg: O₃, H₂O, NH₃

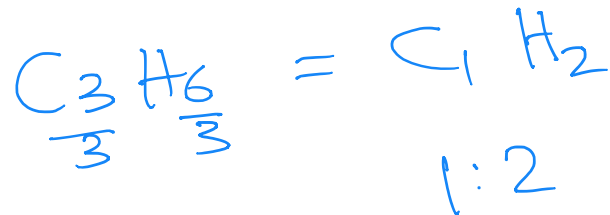
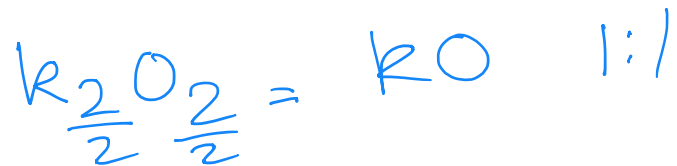
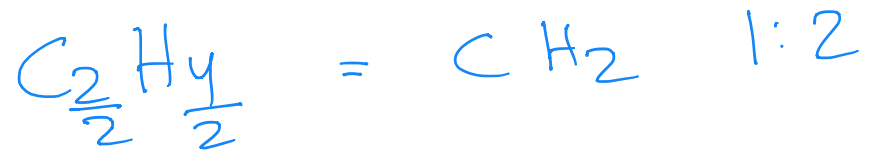


الصيغة الكيميائية
Chemical Formula

Empirical $\frac{ن, ا}{-}$



الصيغة الجزيئية Molecule



❖ IONS:- الأيونات
 an ion is an atom or a group of atoms that has net positive or negative charge

❖ MONOATOMIC IONS:- Contain only one atom
 Eg: Na^+ , Cl^- , H^+ , Mg^{2+} , Fe^{3+}

❖ Polyatomic ions:- two or more atoms combine to form an ion that has net positive or negative charge
 Eg: OH^- , NH_4^+ , NO_3^-

❖ Chemical compounds : is a substance formed when two or more chemical elements are chemically bonded together Eg:- Water, Carbondioxide

❖

Types of compounds

| | |
|--|--|
| <p>❖ <u>Ionic Compounds</u> مركب أيوني (usually) formed from when a metal react With a non-metal (or a poly atomic ion) <u>metal + non metal</u></p> | <p>❖ <u>covalent/Molecular compounds</u> مركب تساهمي Formed when two non-metals react with each other <u>Covalent Bond</u></p> |
|--|--|

Ionic Bond
 electron transfer
 NaCl / Al_2O_3
 $\text{Na} \cdots \text{Cl}$
 MgCl_2 / LiH

تساهمي
 ايونات
 $\text{H} \cdot \text{Cl} \cdot$ non metal
 non metal
 $\text{H} : \text{Cl} :$

Na^+ N_2 H_2

- Metal + Non-metal \longrightarrow ionic compound (usually)
- Metal + polyatomic ion \longrightarrow ionic compounds(usually)
- Non-metal + non- metal \longrightarrow Molecular compounds(usually)
- Hydrogen + non-metal \longrightarrow Molecular compounds(usually)

\downarrow
nonmetal

↑ group 1

PROBLEMS:

Q2.4. Give an alkali metal of period 4

K

Q2.5. Give a metalloid of period 3

Si

Q2.6. Give a metalloid of period 4 group 14

Ge

Q2.7. Give a noble gas of period 5

Xe

$m+n$

Q2.8. (1) classify the following compounds as ionic or molecular compounds

- a) NaCl b) FeCl₃ c) SO₂. d) P₄O₁₀

m ↓
 n ↓

ionic
Compound

m ↓
 n ↓

ionic
Compound

↓
molecular

↓
molecular

↳ $n+n$

Q2.8 (2) Name the metalloid (s) of

a) group 14 period 3

Si

b) group 13

B

c) group 15

As

Sb

d) group 16 period 6

Po

Periodic Table of the Elements

non metal

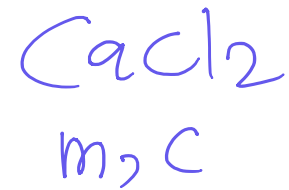
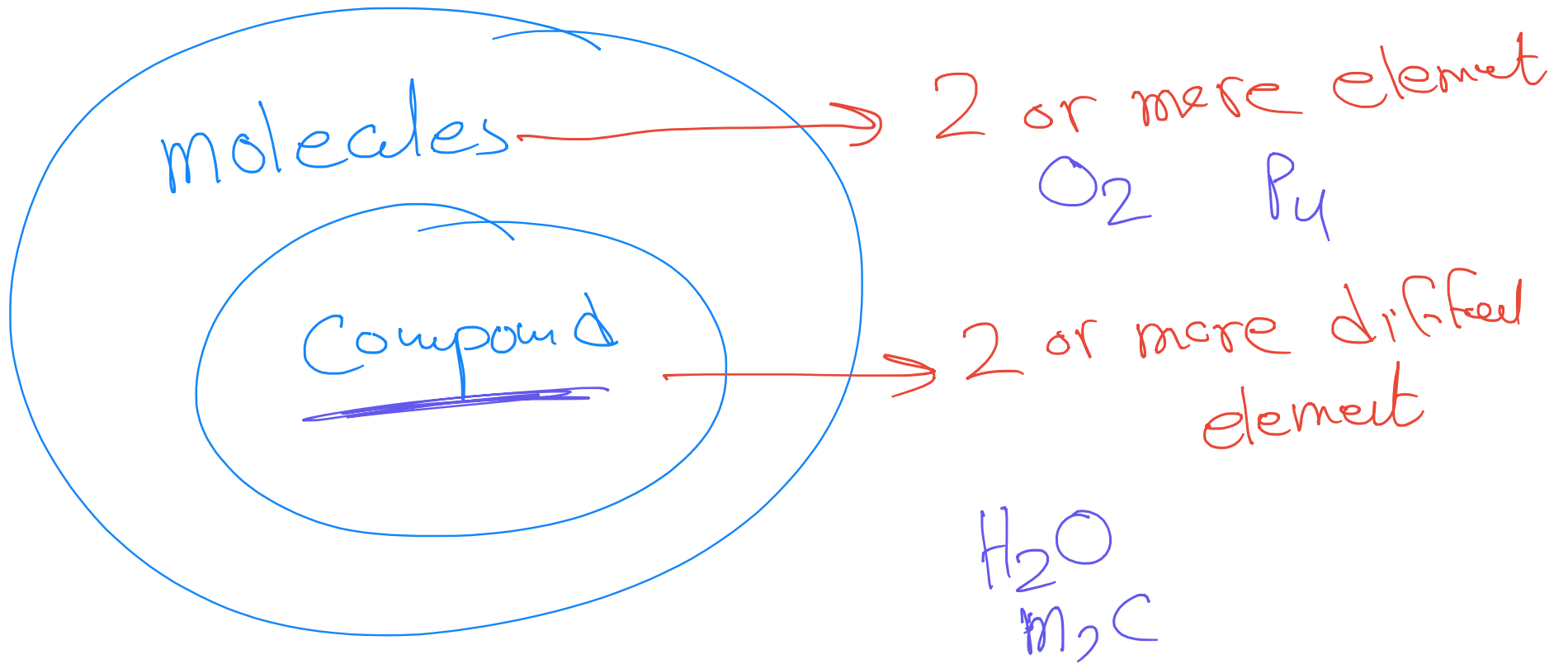
Legend:

- Alkali Metals
- Alkaline Earth Metals
- Transition Metals
- Actinides
- Post-Transition Metals
- Metalloids
- Noble Gases
- Lanthanides
- Reactive Nonmetals
- Unknown Chemical Properties

| | | | | | | | | | | | | | | | | | | | | |
|--|---|------------------------------------|-------------------------------------|---------------------------------|----------------------------------|--------------------------------|----------------------------------|----------------------------------|------------------------------------|-----------------------------------|-----------------------------------|--|---|--|---|--|---|-------------------------------|-------------------------------|-------------------------------|
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Use the periodic table to give an example (only one) of

- ❖ an alkaline earth metal in period 6 Ba
- ❖ a metalloid B Si Ge As Sb Te
- ❖ a nonmetal in period 4 Cl Br Kr
- ❖ a halogen in period 3 Cl



All compound is
molecules but not
all molecules are compounds.