Introduction

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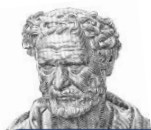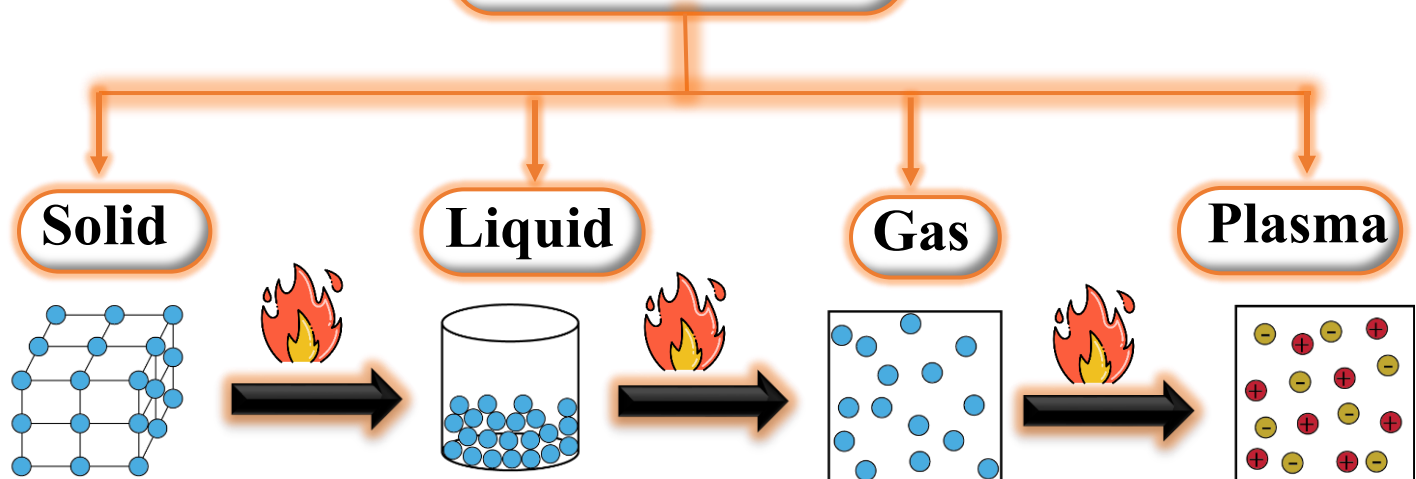
Chemistry

Is the study of Properties of Matter and Changes That occur in matter (دراسة خواص الماده و التغيرات التى تحدث بها)

Matter

Anything that has mass and takes up space. (يشغل حيز من الفراغ)

States of Matter (حالات المادة)

| Solid | Liquid | Gas | Plasma |

History of atom (تاريخ الذرة)

Democritus Postulate (أفتراض ديموقريطس)

All mater consists of very small __indivisible__ particles called Atomos

غير قابل لتجزئه

Dalton Atomic Theory (<u>Atomic theory of matter</u>)

Atoms are the fundamental building blocks of matter (John Dalton)
(الذرة هي الوحدة الأساسية في بناء المادة)

Dalton Postulates (أفتراضات دالتون)

1 All matter whether <u>elements</u>, <u>compounds</u> or a <u>mixture</u> is composed of extremely small particles called ➡ (**atoms**)

2 All atoms of a given element are <u>identical,</u> but atoms of different elements are <u>different.</u>

    EXAMPLE

          Identical   **Identical**

Hydrogen atoms ● ● ●   **and**   **Oxygen atoms** ● ● ●

                               ● ● **Different**

3 Compounds are formed when atoms <u>combine</u> with each other.

    EXAMPLE

     2 Hydrogen atoms + 1 Oxygen atoms ➡ **Water (H_2O)**

        ● ●   ●   ●●●
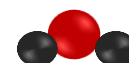
4 **In Chemical Reaction**: Atoms of an element <u>are not</u> changed into atoms of different elements.

    ∴ (Atoms can't be **Created** or **Destroyed**) **الذرة لا تفني ولا تستحدث من العدم**
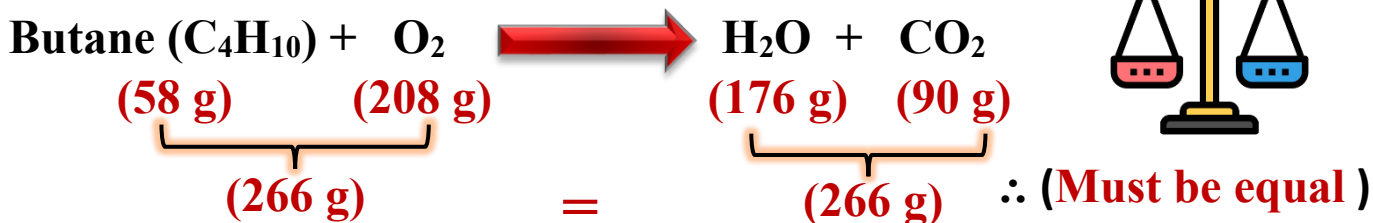
Laws built the basis of atomic

1 ## Conservation of mass

Matter is neither created nor destroyed (**total mass before and after reaction are equal**)

🦇 EXAMPLE

Butane (C_4H_{10}) + O_2 ➡️ H_2O + CO_2
(58 g)   (208 g)   (176 g)   (90 g)

(266 g)   =   (266 g)   ∴ (**Must be equal**)

---

2 ## Definite Proportions

<u>Different</u> samples of the <u>same</u> compound always contain the <u>same</u> <u>elements in the same proportions</u> by mass

(العينات المختلفه لنفس المركب تحتوى على نفس النسبه من كتله العناصر المكونه له)

🦇 EXAMPLE

• $CuCO_3$ ➡️ **1Cu: 1C: 3O**

Ex 1: (mass of Cu= 63 g, mass of C= 12 g and mass of O = 16 g)

∵ Total mass= 63 + 12 + (16 x 3) = **123 g**

∴ %Cu= $\frac{63}{123}$ x100 = **51%**   ∴ %C= $\frac{12}{123}$ x100 = **10%**

∴ %O = $\frac{16 x 3}{123}$ x100 = **39%**

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Ex 2: (mass of Cu= 126 g, mass of C= 24 g and mass of O = 32 g)

∵ Total mass= 126 + 24 + (32 x 3) = **246 g**

∴ %Cu= $\frac{126}{246}$ x100 = **51%**   ∴ %C= $\frac{24}{246}$ x100 = **10%**

∴ %O = $\frac{32x3}{123}$ x100 = **39%**

∴ [Obtain the **same Percentages** for both samples **(1)** and **(2)**]

Multiple Proportions

3

For Two elements formed a **different series** of compounds, the **ratios** of masses of one element that combine with fixed mass of second element can be reduced to ratio of whole small number

↳ Ex: **N** with **O** formed **NO** (1:1), **N₂O** (2:1), **N₂O₅** (2:5).

example

➢ **Oxygen combines with carbon to form Carbon monoxide (CO) and Carbon dioxide (CO₂) found the ratio of O in CO to O in CO₂**

Substance	Mass of C	Mass of O	Ratio of O in CO/CO₂
CO CO₂	12 g 12 g	16 g 32 g	Ratio = $\frac{16}{32}$ = $\frac{1}{2}$

∴ **Ratio of Oxygen in CO/CO₂ with a fixed carbon = 1:2**

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Scientists and their discovery

Scientists	Discovery	Experiment
J.J. Thomson	**Electrons**	**Cathode ray**
Millikan	**Charge of electron**	**Oil drop**
Rontgen	**Radioactivity**	**Photographic plate**
Marie curie	**Radioactivity**	**uranium**
Antoine	**Radioactivity**	**Photographic plate exposed to uranium**
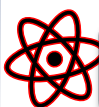
Discovery of subatomic Particles

| Scientists	Discovery	Experiment
J.J. Thomson	**Atom is a +Ve sphere in which electrons are embedded (تنغمس)**	**Plum pudding model**
Rutherford	**nucleus**	**+Ve charge and most mass in nucleus. electrons occupy the remaining space**
Chadwick	**neutron**	**Thin sheet of beryllium**

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J.J. Thomson's Cathode ray

1 Discovered **the electron &** proposed **plum pudding model**

2 measured the **charge to mass ratio**
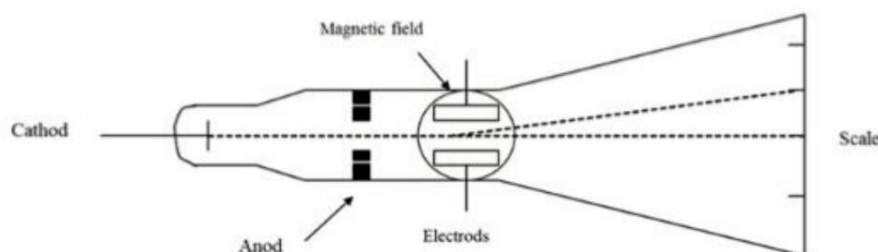
Thomson Demonstrated that about cathode rays

A) Cathode Rays travel in straight lines.

B) Cathode rays are negative in charge.

C) are deflected by electric and magnetic fields.

D) produce sharp shadows

E) are capable of moving a small paddle wheel.

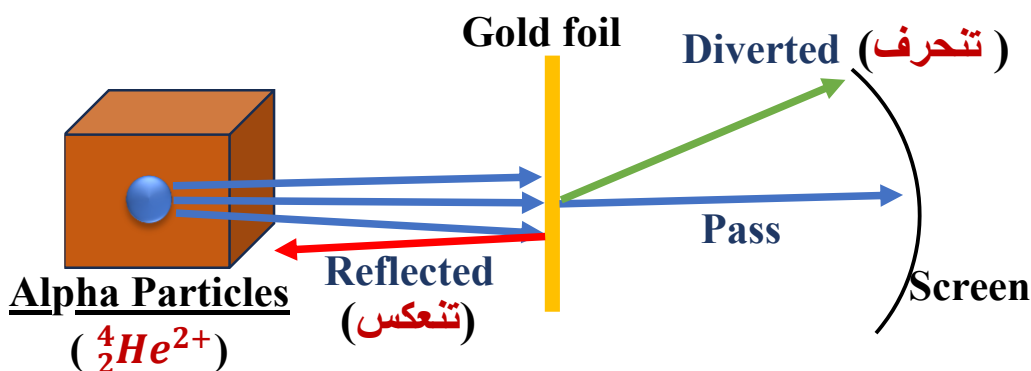∴ Cathode rays consist of **-ve charged particles** (electrons)

Conclusion

❖ Atom emits **-ve charged particles** (electrons)
❖ Electrons are part of atoms

Note Be : Cathode rays discovered by **Faraday**

Rutherford Experiment

Gold foil

Diverted (تنحرف)

Pass

Screen

Alpha Particles
($_2^4He^{2+}$)

Reflected (تنعكس)

According to Rutherford Experiment

When **alpha particles** beamed at a thin metal (**Gold**) film:

A) **Most** of them will **pass** without changing direction due to most of the **atom space**.

B) A **few** are **diverted** by **repulsion** from the positively charged **nucleus**.

C) **Very few** are **reflected** backward due to a close **collision** with the **dense nucleus**.

Important Notes

❖ **Rutherford** discovered the **positively charged nucleus** & atom consists **mostly of empty space**.

❖ **J. J. Thomson** showed that atoms emit **negative particles** (electrons)
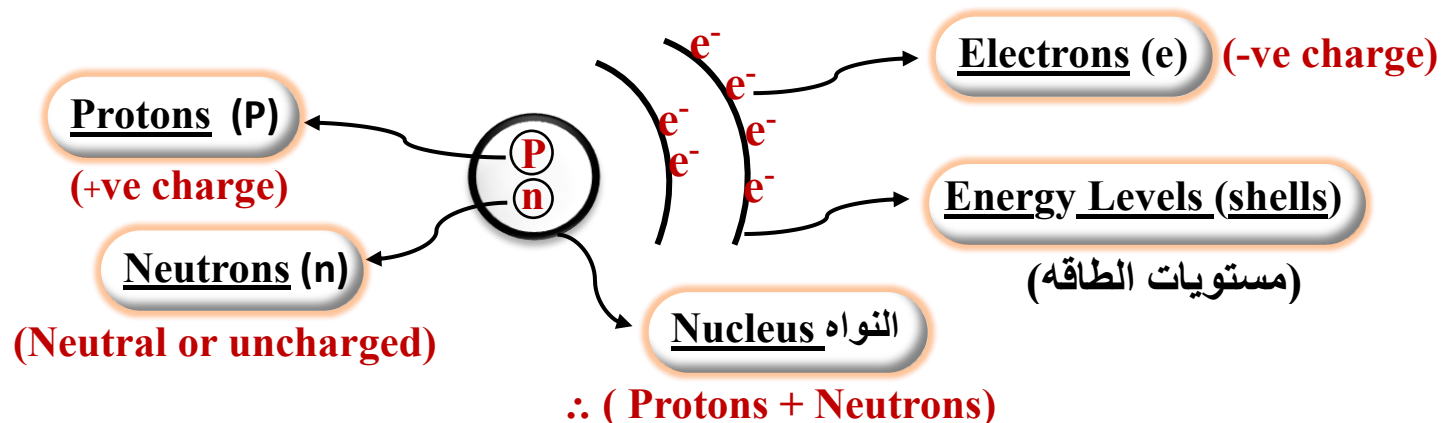
Atomic Structure (التركيب الذرى)

Rutherford

Atom is consisting from **three** subatomic particles (**Neutrons, Protons** and **Electrons**)

e^- e^- e^- e^- e^- e^-

Electrons (e) (-ve charge)

Protons (P)

(+ve charge)

P n

Energy Levels (shells)

(مستويات الطاقه)

Neutrons (n)

(Neutral or uncharged)

Nucleus النواه

∴ (Protons + Neutrons)

Particle	Charge	Mass (g)
Protons (P)	+1	1.6727×10^{-24}
Neutrons (n)	0	1.6750×10^{-24}
Electrons (e)	-1	9.11×10^{-28}

Important Notes

1. **The atom is electrically neutral:** (سبب التعادل الكهربي في الذرة)

   Due to the number of **+Ve Protons** = number of **-Ve Electrons**

2. mass of Neutrons > mass of Protons >> mass of electrons

∴ The mass of an atom **depends** on the **nucleus** only (**P** & **n**) and neglects mass of electrons (**very small**)

(كتلة الذرة تتركز في نواتها، لأن كتلة الإلكترونات صغيرة ومهملة)

Element (العنصر)

Mass Number (Atomic weight)

(العدد الكتلى)

$$_Z^A X$$

Element Symbol

(رمز العنصر)

Atomic Number

(العدد الذرى)

1 **Atomic Number : (Z)** It is the number of Protons (P).

2 **Mass Number : (A)** № of Protons (P) + № of Neutrons (n).

3 **Number of Neutrons** (Mass Number - Atomic Number).

Or

(Mass Number – № of Protons)

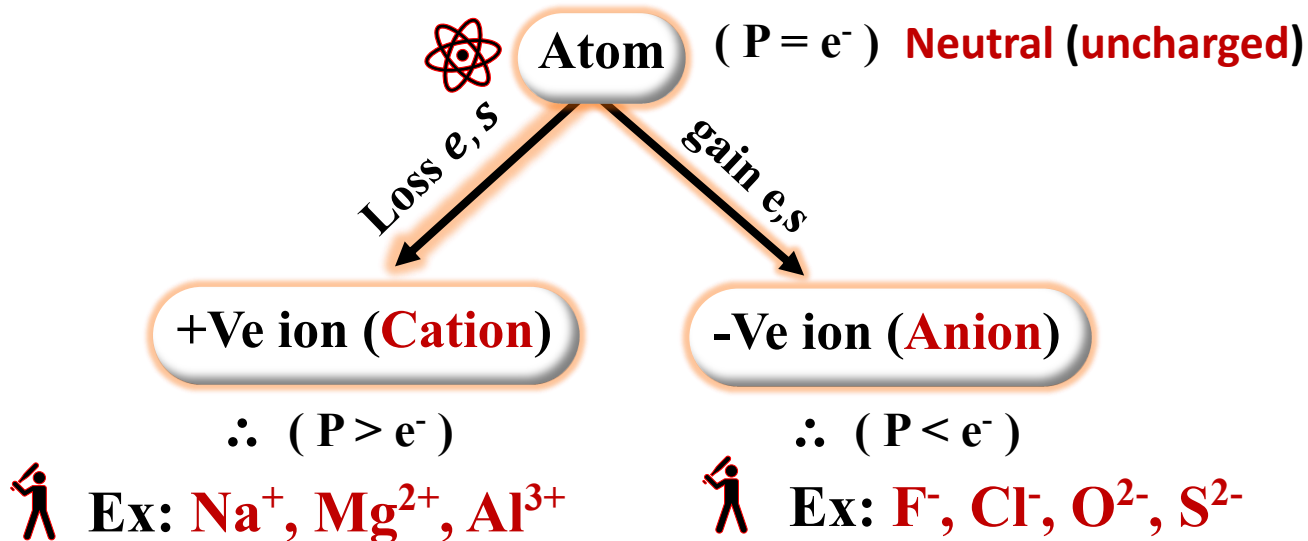$$\therefore \boxed{n = A - Z = A - P}$$

Important Notes 🔬

Due to atom is electrically neutral so (№ of **Protons** = № of **Electrons**)

∴ Atomic Number (**Z**) = № of **P** = № of **e⁻** (**Neutral atom only**)

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Atom ($P = e^-$) **Neutral (uncharged)**

Loss e,s   gain e,s

+Ve ion (Cation)   **-Ve ion (Anion)**

∴ ($P > e^-$)   ∴ ($P < e^-$)

Ex: Na^+, Mg^{2+}, Al^{3+}   **Ex: F^-, Cl^-, O^{2-}, S^{2-}**

EXAMPLE

1 **Carbon** C_6^{12} ⟹ ∴ A = **12** and Z= **6**

∴ P=Z = **6** and n = A-Z = 12-6= **6**

∵ **Neutral atom** ∴ P= e = **6**

2 **Nitrogen** N_7^{14} ⟹ ∴ A = **14** and Z= **7**

∴ P=Z = e = **7** and n = A-Z = 14-7= **7**

3 **Sodium** Na_{11}^{23} ⟹ ∴ A = **23** and Z= **11**

∴ P=Z = e = **11** and n = A-Z = 23-11= **12**

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Answer the Following:

➤ **Calculate the number of Protons, Neutrons and Electrons:**

1 $_{12}^{24}Mg$ **2** $_{47}^{107}Ag$ **3** $_{27}^{59}Co$

4 $_{11}^{23}Na^+$ **5** $_{13}^{26}Al^{3+}$ **6** $_{8}^{16}O^{2-}$

Answer

1 $_{12}^{24}Mg$
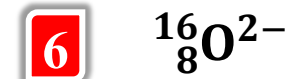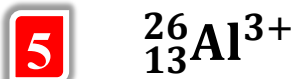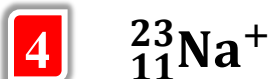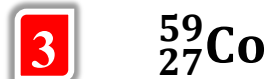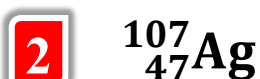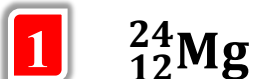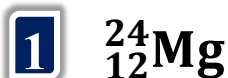
∴ A = **24** and Z= **12**

∴ P= **12**

∴ n = 24-12=**12**

∴ P= e = **12**

(Neutral atom)

2 $_{47}^{107}Ag$
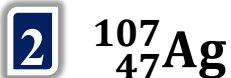
∴ A = **107** and Z= **47**

∴ P= **47**

∴ n = 107-47=**60**

∴ P= e = **47**

(Neutral atom)

3 $_{27}^{59}Co$

∴ A = **59** and Z= **27**

∴ P= **27**

∴ n = 59-27=**32**

∴ P= e = **27**

(Neutral atom)

4 $_{11}^{23}Na^+$ ↘ **(Loss 1 e⁻)**
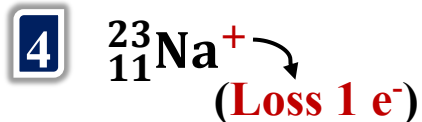
∴ A = **23** and Z= **11**

∴ P= **11**

∴ n = 23-11=**12**

∴ e = 11-1= **10**

(Cation)

5 $_{13}^{26}Al^{3+}$ ↘ **(Loss 3 e⁻)**
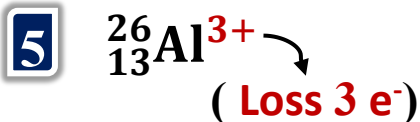
∴ A = **26** and Z= **13**

∴ P= **13**

∴ n = 26-13=**13**

∴ e = 13-3= **10**

(Cation)

6 $_{8}^{16}O^{2-}$ ↘ **(gain 2 e⁻)**
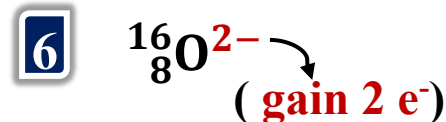
∴ A = **16** and Z= **8**

∴ P= **8**

∴ n = 16-8=**8**

∴ e = 8+2= **10**

(Anion)

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Isotopes (النظائر)

🏹 Define

Atoms of same elements having <u>same</u> atomic Number (Z), but <u>different</u> in mass number (A) due to the <u>difference</u> in Number of neutrons.

🦇 EXAMPLE

$$^1_1H \qquad ^2_1H \qquad ^3_1H$$

Protium   **Deuterium**   **Tritium**

	Protium	Deuterium	Tritium	
N<u>o</u> Of Protons	1	1	1 →	**Same Number**
N<u>o</u> Of neutrons	0	1	2	**Different Number**
Mass n<u>o</u> (A)	1	2	3	

$$^{12}_6C \qquad ^{13}_6C \qquad ^{14}_6C$$
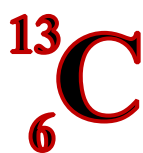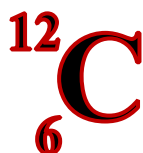
	^{12}C	^{13}C	^{14}C	
N<u>o</u> Of Protons	6	6	6 →	**Same Number**
N<u>o</u> Of neutrons	6	7	8	**Different Number**
Mass n<u>o</u> (A)	12	13	14	

Atomic Weight (الوزن الذرى)

Mass of Carbon $^{12}_{6}C$ is <u>12.000 amu</u>

(**Reference weight**)

Relative Atomic Weight

Measuring the mass of any other atoms relative to the mass of carbon atom (**12.000 amu**)

Ex 1: <u>If relative atomic weight of $^{16}_{8}O$ to $^{12}_{6}C$ is equal 1.3329 , what is the mass of oxygen atom:</u>

Answer

$$\because \quad \frac{Atomic\ mass\ of\ ^{16}_{8}O}{Atomic\ mass\ of\ ^{12}_{6}C} = 1.3329$$

$$\therefore \quad \frac{Atomic\ mass\ of\ ^{16}_{8}O}{12.000} = 1.3329$$

$$\therefore \quad \boxed{Atomic\ mass\ of\ ^{16}_{8}O = 12 \times 1.3329 = 15.9948\ amu}$$

Note

❖ **amu : Atomic mass unit**

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Ex 2: <u>The mass spectrometer showed that the ratio of atomic weight of $^{14}_{7}N$ to $^{12}_{6}C$ is equal **1.1675** , what is the atomic weight of Nitrogen:</u>

Answer

$$\because \quad \frac{Atomic\ mass\ of\ ^{14}_{7}N}{Atomic\ mass\ of\ ^{12}_{6}C} = \mathbf{1.1675}$$

$$\therefore \quad \frac{Atomic\ mass\ of\ ^{14}_{7}N}{12.000} = \mathbf{1.1675}$$

$$\therefore \quad \boxed{\textit{Atomic mass of } ^{14}_{7}N = 12 \times 1.1675 = 14.01\ amu}$$

Quiz

- <u>The mass spectrometer showed that the ratio of the atomic weight of $^{23}_{11}Na$ to $^{12}_{6}C$ is equal **1.916** , what is the atomic weight of sodium:</u>

Average Atomic Weight

> The real atomic weight of carbon is not 12.000 but it is 12.011 (**in the periodic table** فى الجدول الدورى).

☛**Because:** it is determined from the <u>average atomic weight of isotopes</u>.

Average Atomic weight = (At.wt of 1<u>st</u> isotope x % abundance) + (At.wt of 2<u>nd</u> isotope x % abundance) +.......

(**نسبه تواجده فى الطبيعه**)

Ex 1: <u>The mass spectrum of carbon shows that **98.892** % C- atoms are ^{12}C (12.000 amu) and **1.108** % are ^{13}C with mass (13.00335 amu) calculate the atomic weight of naturally occurring:</u>

Answer

∵ **Average At.wt of Carbon** = (12.000 x $\frac{98.892}{100}$ + 13.00335 x $\frac{1.108}{100}$)

∴ **Average At.wt of Carbon = 12.011 amu**

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Ex 2: **Calculate the average atomic mass for magnesium, it contains 78.70 % Mg- atoms are ^{24}Mg with mass (23.99 amu) ,10.15 % are ^{25}Mg with mass (24.984 amu) and 11.17 % are ^{26}Mg with mass (25.98 amu):**

Answer

$$\because \text{ Average At.wt of Mg} = (23.99 \times \frac{78.70}{100} + 24.984 \times \frac{11.17}{100}$$

$$+ 25.98 \times \frac{1.108}{100})$$

$$\therefore \text{ Average At.wt of Mg} = \textbf{24.318 amu}$$

Note

❖ **Uranium U^{235}** is used in __nuclear reactors__ **and** __atomic bombs__ **while its isotopes U^{238} not used.**

Quiz

- **Calculate the average atomic mass for Aluminum, it contains 82.70 % Al-atoms are ^{26}Al with mass (25.894 amu), 8.12 % are ^{27}Al with mass (26.99 amu) and 9.18 % are ^{28}Al with mass (27.898 amu):**

Quiz

Choose the correct

1 The average mass of a carbon atom is 12.011. Assuming you were able to pick up only one carbon unit, the chances that you would randomly get one with a mass of 12.011 is: **(2024)**

A) 0.011%.   B) greater than 50%.   C) 0%.   D) about 12%.   E) 12.011%.

2 The first scientist to show that atoms emit any negative particles was:

A) Lord Kelvin.   B) William Thomson.   C) John Dalton.   **(2024)**

D) Ernest Rutherford.   E) J. J. Thomson

3 For $^{40}_{20}Ca^{2+}$ is : **(2024)**

A) 20 p, 20 n, and 22 e.   B) 22 p, 18 n, and 18 e.

C) 22 p, 20 n, and 20 e.   D) 20 p, 20 n, and 18 e.

4 A species with 12 protons and 10 electrons is **(2023)**

A) Ti^{2+} B) Ne^{2-} C) Ne^{2+} D) Mg^{2+} E) Mg

5 Nitric acid, HNO_3, contains what percent hydrogen by mass? **(2023)**

(N= 14 g/mol , H= 1 g/mol, O=16 g/mol)

A) 4.50 %   B) 20.0 %   C) 3.45 %   D) 10.0 %   E) 1.60 %

6 You are given a compound with the formula MCl_2, in which M is a metal. You are told that the metal ion has 26 electrons. What is the identity of the metal? **(2023)**

A) Cr   B) Co   C) Ni   D) Fe   E) Al

7 **Which of the following has 61 neutrons, 47 protons, and 46 electrons?**

     A) $^{108}_{47}Ag$ B) $^{80}_{61}Pm$ C) $^{108}_{47}Cd^+$ D) $^{108}_{47}Ag^+$ E) $^{108}_{46}Pb^{-1}$

8 **The scientist whose alpha particle scattering experiment led him to conclude that the nucleus of an atom contains a dense center of positive charge is: (2024)**

     A) Lord Kelvin.   **B)** Ernest Rutherford.   **C)** William Thomson.

     D) John Dalton.   **E)** J. J. Thomson

9 **Naturally occurring element X exists in three isotopic forms: X-28 (27.977amu, 92.21%), X-29 (28.976amu, 4.70% abundance), and X-30 (29.974 amu, 3.09% abundance). Calculate the atomic weight of X.**

     A) 25.80 amu   **B)** 28 amu   **C)** 28.09 amu   **D)** 35.29 amu   **E)** 86.93 amu

10 **Alpha particles $^4_2He^{2+}$ beamed at thin metal foil may: (2023)**
A) pass directly through without changing direction.
B) be slightly diverted by attraction to electrons.
C) be reflected by direct contact with nuclei.   **D)** a and c   **E)** a, b, and c

11 **Which of the following pairs of compounds can be used to illustrate the law of multiple proportions? (2024)**
A) CH_4 and CO_2 **B)** NH_4 and NH_4Cl **C)** ZnO_2 and $ZnCl_2$
     D) H_2O and HCl **E)** NO and NO_2

12 **For $^{39}_{19}K^+$ is : (2023)**

A) 19 p, 20 n, 18 e   B) 20 p, 19 n, 19 e   C) 19 p, 20 n, 19 e
D) 20 p, 19 n, 20 e   E) 19 p, 20 n, 20 e

13 Gallium consists of two isotopes of masses 68.95 amu and 70.95 amu with abundances of 60.16% and 39.84%, respectively What is the average atomic mass of gallium? **(2023)**

A) 69.75   B) 69.95   C) 70.15   D) 71.95

14 An isotope x of a particle element has an atomic number of 7 and mass number of 15 therefore **(2019)**

A- X is isotope of nitrogen   B- X has 8 neutrons   C-a and b

15 An ion is formed: **(2022)**

A- By either adding or subtracting protons from the atom

B- By either adding or subtracting electrons from the atom

C- By either adding or subtracting neutrons from the atom

D- All of the above

16 Millikan was able to determine: **(2023)**

A- Mass of e,s   B-charge of e,s   C- charge to mass ratio of e,s

17 The first scientist to show that atoms emit any negative particles was:

A) JJ. Thomson   B) Kelvin   C) Ernest Rutherford   D) Bohr

18 Arrange the subatomic particles from least to greatest mass **(2021)**

A) electrons mass = neutrons mass «protons mass

B) electrons mass = protons mass «neutrons mass

C) electrons mass « protons mass «neutrons mass

D)electrons mass «protons mass = neutrons mass

19 The mass number of an atom is the number of……in the atom **(2022)**

A) protons   B) neutrons   C) protons and electrons

D) protons and neutrons   E) electrons and neutrons

20 The number of protons in $_{13}^{26}Al^{3+}$ is **(2021)**

    A) 16   B)13   C) 16   D)27

21 The postulate "The building blocks of matter are extremely **(2023)** small particles, called atoms" is stated by…

    A) Bohr's theory   B) Planck's theory

    C) Dalton's theory   D) Uncertainty principle

22 Isotopes are atoms of the same element that have the same **(2021)** number of..... but differing number of......

    A) electrons, protons   B) protons, electrons

    C) protons, neutrons   D) neutrons, protons

23 The number of protons(P) neutrons (n), and electrons (e) for copper-29, are **(2021)**

A)29p,34n, 29e   B) 29p, 29n, 63e

C) 63p, 29n, 63e   D) 34p, 29n, 34e

24 The postulate "Atoms of an element are neither created nor destroyed in chemical reactions" was assumed by **(2022)**

    A) Rutherford's model   B) Dalton's theory

    C) Bohr's model   D) Planck`s theory

25 What is the average atomic mass for naturally occurring (Cu) if the distribution of isotopes is 69.2% of Cu-63 with atomic mass equal 62.93 amu and 30.8% of Cu-65 with atomic mass equal 64.93 amu?

    A) 63.55   B) 62.93   C) 69.20   D) 64.93

26 Which of the following pairs of compounds can be used to illustrate the law of multiple proportions?

    A) $CaCO_3$ /CO_2 **B)** NH_4 / NH_4Cl **C)** CO_2 / CO **D)** $NaOH$ / HCl

27 The atomic number of a certain element is 19 and its atomic mass is 39. An atom of the element contains…protons and .... neutrons.

     A) 19, 19   B) 19,20   C) 20,19   D) none of these

28 Which pair of atoms constitutes a pair of isotopes of same elements?

     A) $_6X^{14}$, $_7X^{14}$ B) $_6X^{14}$, $_6X^{12}$ C) $_9X^{17}$, $_8X^{17}$ D) $_{10}X^{19}$, $_9X^{19}$

29 The ratio of Oxygen in NO to NO_2 with fixed mass of nitrogen

     A) 2:1   B) 3:1   C) 1:1   D) 1:2

30 The copper atom has the formula $_{29}Cu^{63}$, another isotope of this atom would have: (**2021**)

     A) 29 protons and 34 neutrons   B) 30 protons and 34 neutrons
     C) 29 protons and 36 neutrons   D) 30 protons and 36 electrons

31 Consider the element indium, atomic number 49. The nucleus of an atom of indium-112 contains:

     A) 49 protons, 63 neutrons, 49 electrons
     B) 49 protons, 49 neutrons
     C) 49 protons, 49 alpha particles
     D) 49 protons, 63 neutrons
     E) 49 protons, 112 neutrons

32 Number of neutrons and electrons for $_{28}^{59}Ni^{+2}$ are …… & ……

     A) 31 & 28   B) 28 & 26   C) 31 & 26   D) 28 & 28

33 **Rutherford's experiment was important because it showed that: (2024)**

A) Gold foil can be made to be only a few atoms thick.
B) A zinc sulfide screen scintillates when struck by a charged particle.
C) The mass of the atom is uniformly distributed throughout the atom.
D) An atom is mostly empty space.
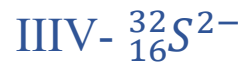E) Radioactive elements give off alpha particles.

34 **Naturally occurring copper exists in two isotopic forms: ^{63}Cu and ^{65}Cu. The atomic mass of copper is 63.55 amu. What is the approximate natural abundance of ^{63}Cu? (2024)**

A) 70%   B) 50%   C) 90%   D) 30%   E) 63%

35 **A pure sample of sodium fluoride (NaF) contains 35g of Na. How many gm of flourine present in the sample? At. mass Na=23, F = 19.**

A) 28.9   B) 19   C) 38   D) 35   E) none

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➤ **What is atomic number ,mass number , number of protons, neutrons and electrons of the following:**

I- $^{197}_{97}Au$ II- $^{90}_{38}Sr$ III- $^{31}_{15}P$ IV- $^{59}_{28}Ni$

V- $^{132}_{55}Cs$ IV- $^{40}_{20}Ca^{2+}$ IIV- $^{18}_{9}F^{-}$ IIIV- $^{32}_{16}S^{2-}$

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➤ **What is the mass of sodium $^{23}_{11}Na$ if the relative mass of $^{13}_{11}Na$ to $^{12}_{6}C$ is 1.9158.**

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➤ **What is the mass of sodium $^{26}_{13}Al$ if the relative mass of $^{26}_{13}Al$ to $^{12}_{6}C$ 2.1667**