FUNDAMENTALS OF STOICHIOMETRY

LEARNING OBJECTIVES:

- *Atom & a.m.u*
- *Atmoic weight, molecular weight & Gram molecular volume*
- Mole Concept
- *Stoichiometric Relations*
- Molecular formula & Emperical formula

REAL LIFE APPLICATIONS:

Φ It is used in Engineering streem in mass spectroscopy which is used to determine atomic amd molemlar masses of known and unknown complexes.

Φ Stoichiometric applications are always used in space astronamy , where the rey takes place between oxygen and hydrogen

§§ **Introduction:**

1. Atom: The term atom was introduced by Dalton. Atom is the smallest particle of matter that takes part in a chemical reaction.
Atom is also defined as the smallest particle of an element that retains all the properties of an element.

2. Atomic mass unit (a.m.u.): It is the smallest unit of mass and is used to measure the masses of atoms and subatomic particles.
The mass of one a.m.u. is equal to the mass of $\frac{1}{12}^{th}$ the mass of C-12 atom. The other names of a.m.u. are Aston, Dalton and Avogram.
Note: 1 a.m.u. = 1.66×10^{-24} g or 1.66×10^{-27} kg.

3. Atomic weight:

Ψ The atomic weight or the relative atomic mass (RAM) of an element is defined as the number of times an atom of an element is heavier than the mass of $\frac{1}{12}^{th}$ of C-12 isotope's atom.

Ψ Relative atomic mass of an element.

$$(\text{RAM}) = \frac{\text{Mass of 1 atom of that element}}{\frac{1}{12} \times (\text{Mass of C} - 12 \text{ atom})}$$

Ψ Atomic weight has no units.

Ψ The relative atomic mass of an element indicates the number of times one atom of that element is heavier than $\frac{1}{12}^{th}$ of mass of C- 12 isotopes atom. For example, the atomic weight of calcium is 40. This means that an atom of calcium is on average is 40 times the mass of 1/12 the mass of C- 12 isotope's atom.

Ψ Atomic weights of many elements are not whole numbers due to the presence of stable isotopes.

Ψ The number of atoms of a particular isotope present in 100 atoms of a natural sample of that element is called its relative abundance which always remains constant for a given element.

Ψ Natural chlorine is a mixture of two isotopes with relative abundances 75% (Cl-35) and 25% (Cl-37) approximately.
Then, the atomic weight of chlorine is $\frac{(75 \times 35) + (25 \times 37)}{100} = 35.5$

Mass of one atom of an element = Relative atomic mass $\times$ mass of $\frac{1}{12}^{th}$ the mass of C- 12
The Atomic number and Mass number for 1 to 30 elements.

Z	Name	Symbol	Mass Number
1	Hydrogen	H	01.00794
2	Helium	He	04.002602
3	Lithium	Li	06.941
4	Beryllium	Be	09.012182
5	Boron	B	10.811
6	Carbon	C	12.0107
7	Nitrogen	N	14.0067
8	Oxygen	O	15.9994
9	Fluorine	F	18.998403
10	Neon	Ne	20.1797
11	Sodium	Na	22.989769
12	Magnesium	Mg	24.3050
13	Aluminium	Al	26.9815386
14	Silicon	Si	28.0855
15	Phosphorus	P	30.973762
16	Sulphur	S	32.065
17	Chlorine	Cl	35.453
18	Argon	Ar	39.948
19	Potassium	K	39.0983
20	Calcium	Ca	40.078
21	Scandium	Sc	44.955912
22	Titanium	Ti	47.867
23	Vanadium	V	50.9415
24	Chromium	Cr	51.9961
25	Manganese	Mn	54.938045
26	Iron	Fe	55.845
27	Cobalt	Co	58.933195
28	Nickel	Ni	58.6934
29	Copper	Cu	63.546
30	Zinc	Zn	65.38

4.Gram Atomic Weight (GAW):

(a) Atomic weight of an element expressed in grams is known as its gram atomic weight. For example, the atomic weight of hydrogen is 1.008. So, the gram-atomic weight of hydrogen is 1.008 g.

(b) Gram atomic weight of any substance is also called its gram atom. For example, 1 gram atom of carbon weighs 12 gram and 1 gram atom of nitrogen weighs 14 grams.

(c) Number of gram atoms $= \frac{\text{Given weight}}{\text{Gram atomic weight}}$.

For example, the number of gram atoms in 5 g of hydrogen =5/1 = 5.

(d) Weight of x gram atoms = x $\times$ Gram atomic weight.

(e) 1 gram atom or gram atomic weight of an element contain = 6.023×10^{23} atoms.

(f) Number of atoms in a given substance (given element) = Number of gram atoms $\times 6.023 \times 10^{23}$.

(g) Number of atoms in 1 gram of an element = $\frac{6.023\times10^{23}}{\text{Atomic weight}}$.

5. Gram Molecular Weight (GMW):

(a) It is the molecular weight of an element or compound expressed in grams. For example, the molecular weight of hydrogen gas is 2. So, the gram molecular weight of hydrogen is 2 g.

(b) Gram molecular weight of a substance is also called its gram molecule or mole molecule. For example, the weight of 1 gram molecule or mole molecule of H_2O is 18 grams and the weight of 1 gram molecule of N_2O is 44 grams.

(c) Number of moles $= \frac{\text{Given weight}}{\text{Gram Molecular weight}}$.

(d) Weight of x moles of any compound = x $\times$ Gram molecular weight.

(e) Number of molecules in a given substance= Number of gram molecules $\times 6.023 \times 10^{23}$.

(f) Weight of substance in grams = Number of gram molecules $\times$ GMW.

Note:

(a) Gram atomic mass of an element and Molar mass of an element are just the same.

(b) Gram molecular weight of a substance and Molar mass of a substance are also just the same.

Molecule, relative molecular mass, G.M.W, G.M.V.:

6. Molecule: The term molecule was introduced by Avogadro. Molecule is the smallest particle

of matter that exists independently and is formed by the combination of atoms. Molecule is also defined as the smallest particle of matter that can exist and retains all the properties of that substance.

Note: A molecule splits into atoms first before taking part in a chemical reaction.

7. Molecular weight:

Ψ Relative molecular mass or molecular weight is defined as the number of times a molecule is heavier than $\frac{1}{12}^{th}$ the mass of C-12 isotope's atom.

$$\text{RMM} = \frac{\text{Average mass of one molecule}}{\text{Weight of } 1/12^{th} \text{ of C-12 atom}}.$$

Ψ Relative molecular mass or molecular weight has no units.

Ψ Molecule is heavier than $\frac{1}{12}^{th}$ the mass of C-12 isotope's atom. For example, the molecular weight of calcium carbonate is 100, it implies that mass of one molecule of calcium carbonate is 100 times heavier than $\frac{1}{12}^{th}$ the mass of C-12 isotope's atom.

If the relative molecular mass or molecular weight of any compound is M, then its molecular mass is 'M' a.m.u. = Molecular weight $\times$ $\frac{1}{12}^{th}$ the mass of C-12 atom.

Steps to calculate the molecular weight:

a. Write the formula of the compound or the molecule.
b. Identify the different types of elements present in it and write their symbols along with the number of atoms.
c. Now multiply the number of atoms with the atomic weights of the respective elements.
d. Finally add them to get molecular weight.

8. Gram molecular volume(GMV):

The volume occupied by 1 gram molecule of a dry gas at S.T.P. is called Gram Molecular Volume.

The experimental value of 1gram molecular volume of a gas is 22.4 litre at S.T.P or 22.4 dm^2 at S.T.P or 22400 cm^3 at S.T.P.

9. Avogadro's Number:

The number of atoms present in 12 g (Gram Atomic Mass) of carbon $^{12}_{6}C$ is called Avagadro's number. It is denoted by letter N_A or L.

Its value is 6.023×10^{23}.

Vapour density is the density of a vapour in relation to that of hydrogen. It may be defined as mass of a certain volume of a substance divided by mass of same volume of hydrogen.

vapour density = mass of *n* molecules of gas / mass of *n* molecules of hydrogen

(By definition, the molar mass of a gas is the ratio of the mass of one molecule of gas to that of an hydrogen atom under similar conditions.)

Therefore:

vapour density = molar mass of gas / molar mass of H_2

vapour density = molar mass of gas / 2

vapour density = ½ × molar mass

(and thus: molar mass = 2 × vapour density)

TEACHING TASK

Single Correct Choice Type:

1. What is N value
1) 6.023×10^{23} atoms 2) 3.0115×10^{23} atoms
3) 1.505×10^{23} atoms 4) 12.0×10^{23} atoms

2. Which of the following is correct?
1) Molecular weight of oxygen is 32.
2) Gram molecular mass of sulphur (S_8) is 256 g.
3) The weight of one molecule of O_3 is 48 amu. 4) All

3. What is Avogadro's number?
1)12.046×10^{23} 2) 6.023×10^{23} 3) 3.0115×10^{23} 4) 1.505×10^{23}

4. The weight of 1 mole of atoms of an element = _____.
1) 1.66×10^{-24} g 2) Gram molecular weight
3) Gram atomic weight 4) 6.023×10^{23} g

5. The total mass of 100 atoms of silicon is:
1) 2800 2) 2800 amu 3) $28 \times 1.66 \times 10^{-22}$g 4) Both 2 and 3

6. If the atomic weight of oxygen were taken as 100, then what would be molecular weight of water
1) 18 2) 102 3) 112.5 4) 142.5

7. Natural Boron is a mixture of ${}_5B^{10}$, ${}_5B^{11}$ with relative abundance of 20 % and 80 %. Find the atomic weight of boron.
1) 10 2) 11 3) 10.8 4) 11.2

8. The weight of 1 mole of calcium atoms of an element = _____ grams.
1) 40 g 2) 20 g 3) 10 g 4) 5 g

9. Gram atomic weight of an element contain _____ number of atoms.
1) 6.023×10^{23} 2) 3.0115×10^{23} 3) 1.505×10^{23} 4) 12.046×10^{23}

10. The ratio of number of atoms present in 1 gram of hydrogen to the number of molecules present in 2 gram of hydrogen is :
1) 1 : 2 2) 2 : 1 3) 1 : 1 4) 1 : 3

Multi Correct Choice Type

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

1. The weight of ammonia molecule is:
1) 17a.m.u 2) 17×10^{-3} 3) $17 \times 1.66 \times 10^{-24}$g 4) $17 \times 1.66 \times 10^{-27}$ Kg

2. 1 a.m.u is approximately equal to
1) 1.66×10^{-24} g 2) 1.66×10^{-27} g
3) 1/12 th the mass C-12 4) Mass of hydrogen atom

Reason Type:

1. *Statement I :* a.m.u. is the smallest unit of mass used to measure the masses of atoms and subatomic particles.
*Statement II :*1 a.m.u.= 1.67×10^{-24}g

1) Both statement I and statement II are correct
2) Both statement I and statement II are incorrect
3) Statement I is correct andstatement II is incorrect.
4) Statement I is incorrect and statement II is correct

Matrix Match Type:

- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column–I** have to be matched with statements (p, q, r, s) in **Column–II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

  *If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

1.

Column - I	***Column - II***
a) Phosporous	1) Monoatomic
b) Helium	2) Diatomic
c) Oxygen	3) Triatomic
d) Ozone	4) Poly atomic
	5) Tetra atomic

V. Comprehension Type:

- *This section contains paragraph. Based upon each paragraph multiple choice questions have to be answered. Each question has 4 choices (A) , (B) ,(C) and (D) out of which **ONLY ONE i**s correct. Choose the correct option.*

Relative molecular mass or molecular weight is defined as the number of times a molecule is heavier than $\frac{1}{12}^{th}$ the mass of C-12 isotope's atom.

$$\text{RMM} = \frac{\text{Average mass of one molecule}}{\text{Weight of } 1/12^{th} \text{ of C-12 atom}}$$

1. Find the number of gram molecules of hydrogen present in 1 gram molecule of methane gas.
1) 1 2) 2 3) 4 4) 8

2. 100 g of which gas contains of the maximum number of gram molecules?
1) SO_2 2) O_2 3) He 4) H_2

LEARNER'S TASK

BEGINNERS

Single Correct Choice Type:

1. 1 amu is equal to the mass of:
1) $\frac{1}{12}$th of C - 12 atom 2) $\frac{1}{14}$th of O-16 atom
3) 1g of H_2 4) 1.66×10^{-23} kg

2. The weight of Helium atom in grams is:
1) 2 2) 4 3) 6.64×10^{-24} 4) 1.66×10^{-24}

3. Which of the following is the smallest particle of matter that exist independently?
1) Atom 2) Molecule 3) element 4) compound

4. A: H_2O, CH_4, NH_3; B: H_2, N_2, O_2, F_2
1) 'A' contains homogeneous molecules. 2) B' contains hetereogeneous molecules.
3) A' contains hetereogeneous molecules. 4) All

5. Calculate the actual mass of one molecule of carbon dioxide
1) 44 g 2) 44 amu 3) 6.023×10^{23} 4) 7.304×10^{-23} g

6. Calculate the mass of 1.5 g molecule of sulphuric acid
1) 157g 2)147g 3) 98g 4) 100g

7. Calculate the mass of 2.5 gram atoms of oxygen

1) 80g 2) 70g 3) 100g 4) 32g

II. Answer the following: ACHIEVERS

1. Given that the abundances of isotopes Fe^{54} , Fe^{56} and Fe^{57} are 5% , 90% and 5% respectively , the atomic mass of Fe is.....
2. The weight of 1X 10^{22} molecules of $CuSO_4$ is----------

EXPLORERS

III. Multi Correct Choice Type:

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

1. The mass of one atom of an unknown element is 4 × 1.66 × 10^{-24}g. The substance is

1) Hydrogen 2) Helium 3) Oxygen 4) Sulphur

IV. Reasoning Type:

- *This section contains certain number of questions. Each question contains Statement – 1 (Assertion) and Statement – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct Choose the correct option.*

1. *Statement I :* 1 a.m.u. = 1.66 $\times 10^{-24}$ g or 1.66 $\times 10^{-27}$ kg.
   Statement II: Atomic weight has no units.
   1) Both statement I and statement II are correct
   2) Both statement I and statement II are incorrect
   3) Statement I is correct andstatement II is incorrect.
   4) Statement I is incorrect and statement II is correct

V. Comprehension Type:

- *This section contains paragraph. Based upon each paragraph multiple choice questions have to be answered. Each question has 4 choices (A) , (B) ,(C) and (D) out of which **ONLY ONE i**s correct. Choose the correct option.*

Relative atomic mass of an element $(\text{RAM}) = \dfrac{\text{Mass of 1 atom of that element}}{\frac{1}{12} \times (\text{Mass of C-12 atom})}$

1. The total mass of 100 atoms of silicon is:

   1) 2800 2) 2800 amu 3) 28 × 1.66 × 10^{-22}g 4) Both 2 and 3
2. If the atomic weight of oxygen were taken as 100, then what would be molecular weight of water

   1) 18 2) 102 3) 112.5 4) 142.5
3. Natural Boron is a mixture of $_5B^{10}$, $_5B^{11}$ with relative abundance of 20 % and 80 %. Find the atomic weight of boron.

   1) 10 2) 11 3) 10.8 4) 11.2

VI. HOTS

1. The ratio of weight of 6.023 $\times 10^{23}$ atoms of hydrogen to the weight of 6.023 $\times 10^{23}$ molecules of hydrogen is :

   1) 1 : 2 2) 2 : 1 3) 1 : 1 4) 1 : 3
2. 100gr of which gas contians of the maximum number of gram molecule

   1) SO_2 2) O_2 3) He 4) H_2
3. 1 atomic mass unit =

   1) 1.66x10^{27}gr 2) 1.66x10^{-24}gr 3) 1.66x10^{-27}gr 4) 1.66x10^{-19} gr
4. Natural chlorine is mixture of two isotopes with relative abundances 75% (chlorine 35) and

25% (Cl 37) approximately
1) 35.5 2) 37 3)35 4) 37.5

KEY

ΦΦ TEACHING TASK :

I.	1-1	2-4	3-2	4-2	5-4	6-2	7-3	8-1	9-1	10-1	11-1
II.	1-1,3,4	2-1,2,3									
III.	1-1										
IV.	1-5,1,2,3										
V.	1-2	2-4									

ΦΦ LEARNER'STASK :

☐ **BEGINNERS :**

I.	1-1	2-2	3-3	4-3	5-2	6-2	7-1

☐ **EXPLORERS :**

III.	1-2			
IV.	1-1			
V.	1-4	2-2	3-3	
VI.	1-1	2-2	3-2	4-1

§§ Mole concept

In order to count the articles we use the terms Donzen (1 Dozen = 12 Units), Gross (1Gross = 144 Units), Ream (1 Ream = 500 Units) and so on. In the same way in order to count the small and micro particles we use the term called mole

***1 mole contains avagadro number of particles (Avagadro number* = 6.023 $\times 10^{23}$)**

To show the quantitative relationships in chemical equation there is a need of bridge word to make relationships between weight, volume and number of molecules. That bridge word is called as one mole.

1 mole = 1 G.M.W = 1 G.M.V = 1 Avogadro number.

1 mole of hydrogen atoms	=	6.023×10^{23} atoms of hydrogen
1 mole of hydrogen molecules	=	6.023×10^{23} molecules of hydrogen
1 mole of carbon dioxide	=	6.023×10^{23} molecules of carbon dioxide
1 mole of electrons	=	6.023×10^{23} electrons
1 mole of sodium ions (Na^+)	=	6.023×10^{23} Na^+ ions

Example 1. $H_2 + Cl_2 \rightarrow 2HCl$

i) 1 mole of H_2 reacts with 1mole of Cl_2 to form 2moles of HCl

ii) 2g of H_2 reacts with 71g of Cl_2 to form 2x36.5 = 73g of HCl

iii) if all the volumes of the reacting substances are at STP conditions,then 22.4 L of H_2 gas reacts with 22.4L of Cl_2 gas to form 2x 22.4 L = 44.8 L of HCl

Example 2. The amount of oxygen formed when 12.26g of KClO3 is heated-----

Example 3. $CaCO_3 \rightleftharpoons CaO + CO_2$ The number of moles of CO_2 obtained by the decomposition of 50g of $CaCO_3$ is------

Ψ Symbol of the mole unit.

The unit of mole is given a symbol mol. So, if you want to express one mole, you may write it as 1 mol.

Ψ Important relations related to mole:

(a) 1 mole of particles = 6.023 $\times 10^{23}$ particles (atoms/ molecules/ions/electrons/protons/

neutrons/nucleons).

(b) The weight of 1 mole atoms of an element = gram atomic weight of the element.

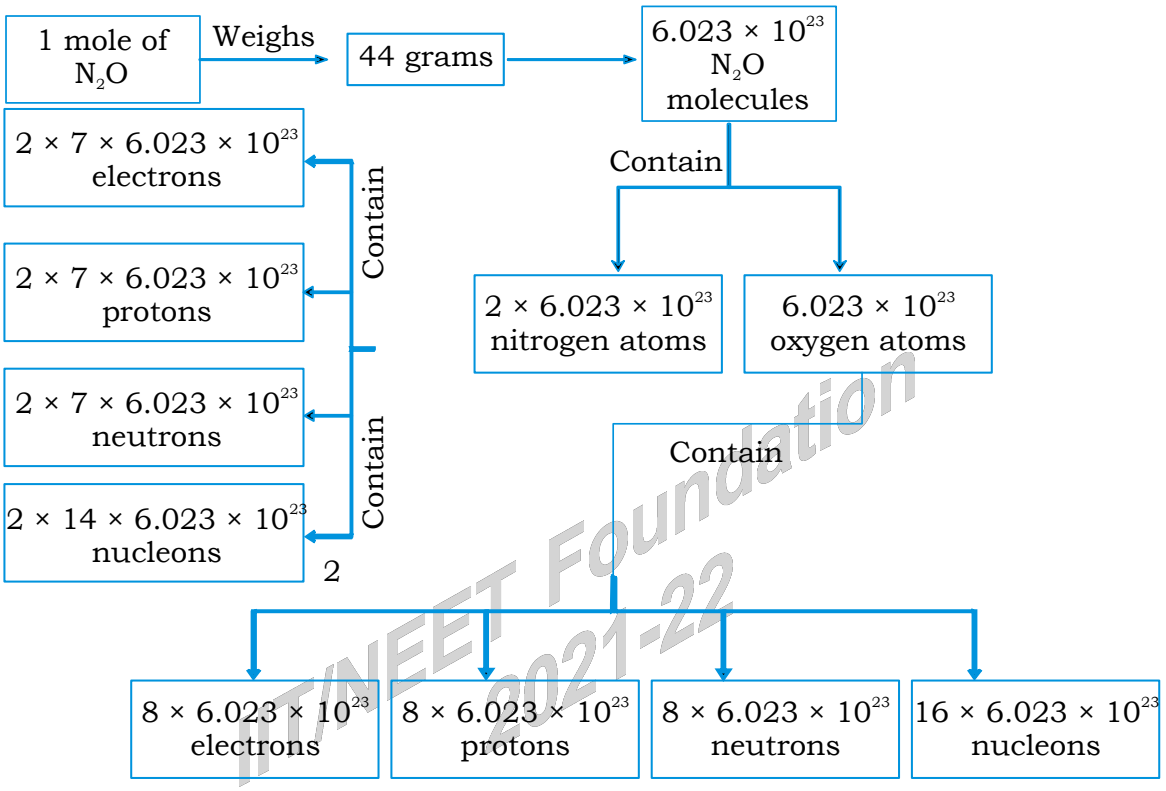
(c) The weight of 6.023×10^{23} atoms of an element = gram atomic weight of the element.

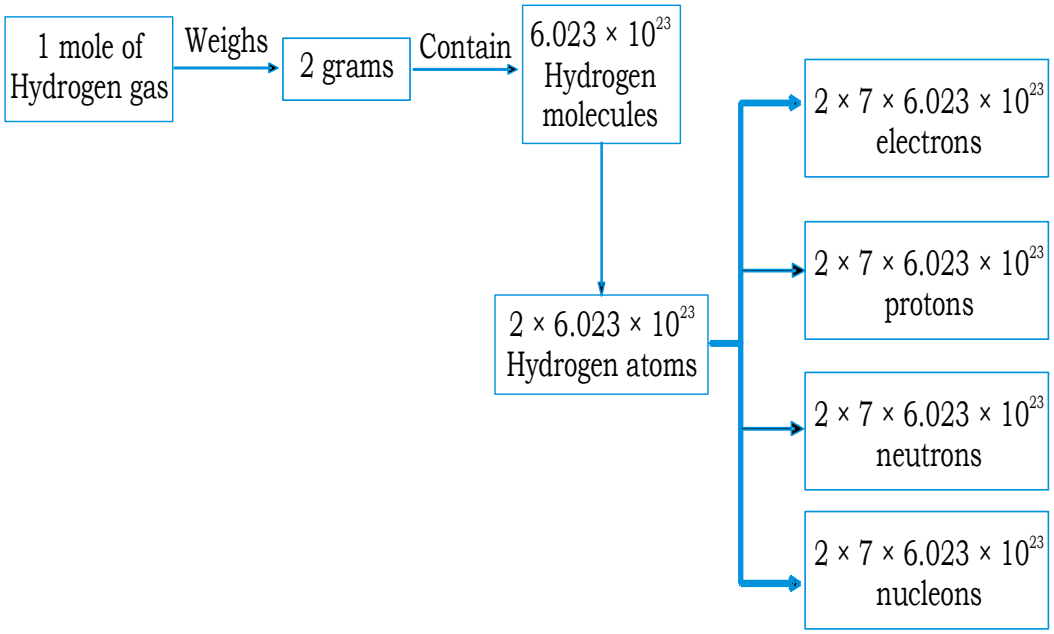
(d) The weight of 1 mole molecules of a compound = gram molecular weight of a compound.

(e) The weight of 6.023×10^{23} molecules of a compound = gram molecular weight of the compound.

(f) The weight of 1 mole of formula units of a salt = gram formula weight of the salt.

UNDERSTANDING OF A MOLE





Some more important relations:

Φ No of gram atoms or mole atoms = $\frac{\text{Given weight}}{\text{Gram atomic weight}}$.

Φ Number of moles (n) = $\frac{\text{Given weight}}{\text{Gram Molecular weight}}$

Φ Weight of *x* gram atoms = $x \times$ Gram atomic weight

Φ Weight of *x* moles of any compound = $x \times$ Gram molecular weight

Φ 1 gram atom or gram atomic weight of an element contains 6.023×10^{23} atoms.

Φ 1 gram molecule or gram molecular weight of a substance contains 6.023×10^{23} molecules.

Φ Number of atoms in a given substance(given element)=Number of gram atoms(n_g)$\times 6.02310^{23}$

Φ Number of molecules in a given substance (N_m) = Number of moles (n) $\times 6.023 \times 10^{23}$

Φ Number of atoms in 1 gram of an element = $\frac{6.023 \times 10^{23}}{\text{Atomic weight}}$

Φ Number of molecule in 1 gram of a substance = $\frac{6.023 \times 10^{23}}{\text{Molecular weight}}$

Φ Weight of an element in grams = Number of gram atoms $\times$ GAW

Φ Weight of substance in grams = Number of moles $\times$ GMW

Φ Number of atoms of an element per molecule can be calculated if MW and percentage mass of that element are given by using the formula.

$$\text{No. of atoms} = \frac{\text{MW} \times \text{Percentage mass}}{\text{At. wt} \times 100}$$

[Note: Number of atoms is always is a whole number]

Φ No. of atoms present in given amount of substance (N_a)

= No. of molecules (N_m) × No. of atoms present in 1 molecule of the substance.

= No. of moles (n) × N_A × No. of atoms present in 1 molecule of the substance.

Φ No. of subatomic particles (electrons / protons/ neutrons/ nucleons, etc) present in given amount of substance (N_p)

= No. of molecules (N_m) × No. of subatomic particles present in 1 molecule of the substance.

= No. of moles (n) × N_A × No. of subatomic particles present in 1 molecule of the substance.

§§ Stoichiometric Equation:-

A chemical equation in which number of atoms of each element is same on the side of reactants and products is called **Stoichiometric equation**.

Example: $2KNO_3 \rightarrow 2KNO_2 + O_2$

§§ Stoichiometric relations

Mainly there are three types stoichiometric relations. They are

1.Weight - weight relationship:

Solving problems on Weight-Weight relationship involves four steps

Step-I :- Write the Stoichiometric equation

Step-II :- Write their respective number of moles

Step-III :- Write their respective Molecular weights/ Atomic Weights

Step-IV :- Write the data given in sum

What is the weight of CO_2 produced when 10g of $CaCO_3$ is decomposed?

$$CaCO_3 \rightarrow CaO + CO_2$$

1 mole of $CaCO_3$ → 1 mole of CO_2

100 g → 44g

10g → ? = 4.4g

2.Weight - volume relationship:

Solving problems on Weight-Volume relationship involves four steps

Step-I :- Write the Stoichiometric equation

Step-II :- Write their respective number of moles

Step-III :- Write their respective Molecular weights/ Atomic Weights & Gram molar volumes

Step-IV :- Write the data given in sum

What is the volume of CO_2 produced at STP when 10g of $CaCO_3$ is decomposed?

$$CaCO_3 \rightarrow CaO + CO_2$$

1 mole of $CaCO_3$ → 1 mole of CO_2

100g → 22.4 lit

10g → ? = 2.24lit

3.Volume - volume relationship:

Solving problems on Volume-Volume relationship involves four steps

Step-I :- Write the Stoichiometric equation

Step-II :- Write their respective number of moles

Step-III :- Write their respective Gram molar volumes

Step-IV :- Write the data given in sum

Calculate the volume of O_2 required for the complete combustion of 500ml of methane gas?

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

1 mole of methane + 2 moles of oxygen

22.4 lit → 44.8 lit

500ml → ? = 1lit

While calculating this problems, 1) balance the chemical equation, 2) observe the required compounds according to problem and convert them into moles, 3) read the question clearly and observe it belongs to which type, 4) Convert mole into their respective relationships and 5) finally do the cross multiplication with given value in question.

Other than this there more relations just like weight - number of molecules,volume - number of molecules, number of molecules - number of molecules.

§§ ***Molecular formula:***

The formula which represents the actual number of atoms of various elements present in the molecule of a compound is called molecular formula.

§§ ***Emperical formula:***

The formula that gives the relative number of atoms of each element present in a molecule of the compound is called emperical formula.

Simply by removing a common factor from the molecular formula we can get emperical formula.

Therefore , molecular formula = Empirical formula X n = $(\text{Empirical formula})_n$

where n = molecular formula weight / Empirical formula weight

For example, the empirical formula of a compound having molecular mass of 78 is CH.

So , n = 78 / 13 = 6.

Therefore , the molecular formula of the compound is

6 X (CH) = C_6H_6

In case , the value of n is one , then the empirical formula and the molecular formula of the substances are the same.

¶¶ ***Additional types of Problems:***

1) Number of electrons present in a molecule:

After finding the formula we can calculate the number of electrons in that molecule.For example, in $CaCO_3$, there are one calcium atom, one carbon atom and three oxygen atoms.

So, total number of atoms are five. Now coming to number of electrons, calcium atom contains 20, carbon atom contains 6 and oxygen atom contains 8, but there are three atoms are there in the above molecule, so the number of total electrons are 8x3=24. Hence, the molecule contains 20 + 6 + 24 = 60 electrons.

If two molecules or two ions which contains the same number of electrons are called as isoelectronic.

2) Relationship between mole, atom and electrons:

We are clear that any one mole contains 6.023 x 10^{23} molecules. Now, we have to calculate how many atoms and how many electrons are there in one mole of molecules. We can get this by simple multiplication of number of atoms or number electrons for that molecule and Avogadro number.

§§ ***Atomicity:***

Number of atoms present in a molecule is called as its atomicity. For example, in O_2, atomicity is 2.

TEACHING TASK

I. Single Correct Choice Type:

1. Calculate the no. of atoms present in 4.4 grms of CO_2
1) 6×10^{23} 2) 2.4×10^{23} 3) 3×10^{23} 4) 1.8×10^{23}

2. In 0.32 grms of methane the no. of moles is
1) 0.1 2) 0.02 3) 0.01 4) 1.2

3. When 180 gms of glucose is subjected to combustion the volume of CO_2 liberated at STP is
1) 22.4 lts 2) 67.2 lts 3) 44 lts 4)134.4 lts

4. Calculate the number of atoms of oxygen present in 88 g CO_2. What would be the weight of CO having the same number of oxygen atoms?
1) 224 g, 6.023×10^{23} 2) 222 g, 12.056×10^{23}
3) 120 g, 18.023×10^{23} 4) 112 g, 24.02×10^{23}

5. A compound contains 28% N and 72% of a metal by weight. Three atoms of metal combine with two atoms of N. Find the atomic weight of metal.
1) 26 2) 24 3) 22 4) 34

6. Which one of the following pairs of gases contain the same number of molecules?
1) 16 g of O_2 and 14 g of N_2 2) 8 g of O_2 and 22 g of CO_2
3) 28 g of N_2 and 22 g of CO_2 4) 32 g of O_2 and 32 g of N_2

7. The number of oxygen atoms in 4.4 g of CO_2 is approximately is
1) 1.2×10^{23} 2) 6×10^{22} 3) 6×10^{23} 4) 12×10^{23}

8. The number of water molecules in 1 litre of water is (N_A = Avogadro number)
1) 18 2) 18 × 1000 3) N_A 4) $55.55N_A$

9. The largest number of molecules are present in
1) 34g of water 2) 28g of CO_2
3) 46g of CH_3OH 4) 54g of N_2O_5

10. The number of moles of sodium oxide in 620 g of it is
1) 1 mole 2) 10 moles 3) 18 moles 4) 100 moles

II. MCQs with more than one answer:

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

1. Mass of 6.02X 10^{23} electrons is
1) 0.55 mg 2) 55 mg 3)5.5 X 10^{-4} g 4) 9.8 X 10^{-31} g

2. which of the following represents 32 gms of the substance
1)1 mole of oxygen atoms 2)1g atom of sulphur
3)22.4lit of oxygen gas at STP 4)1mole of sulphur molecule

3. which of following have the same mass.
1)0.1 mole of O_2 gas 2)0.1 mole of SO_2
3)6.02X10^{22} molecules of SO_2 gas 4)1.204X10^{23} molecules of O_2 gas

4. 8 grams of O_2 has the same no of molecules as in
1)11 gams of CO_2 2)22 gams of CO_2 3)7gram of CO 4)14g of CO

5. Which of the following is correct?
1) 1mole of atoms = 6.023 X 10^{23} atoms
2) 1 gram atom contains 1 mole of atoms
3) 1gram molecule contains 1mole of molecules
4) 1 gram molecule of oxygen weighs same as 2 gram atoms of oxygen

III. Correct the sentence if it is wrong, otherwise rewrite the sentence.

1. Amount of sodium in 1 mole of sodium is 23g
2. Amount of nitrogen in 1 mole of nitrogen is 7grams
3. 9.2 grams of sodium contains 2.4 x 10^{23} atoms
4. The volume of 5 gram molecules of methane gas is 112lit

IV. MATCHING:

- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column–I** have to be matched with statements (p, q, r, s) in **Column–II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

  *If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

1.

List-1		**List-2**
A.3g atom of O_2	(	)1. 8.50g of H_2O_2
B.2g atom of O_2	(	)2.11.2lit of CO_2 at STP
C.0.5g atom of O	(	)3. 22.4 lit of O_3
D.1g atom of O2	(	)4. 49 g of H_2SO_4
		5. 1 mole of $CaCO_3$

A.a-3,b-1,c-4,d-5 B.a-3,b-1,c-4,d-2 C.a-1,b-2,c-3,d-4 D.a-3,b-1,c-5,d-4

2.

List-1		**List-2**
A.1 mole glucose	(	)1. 3.6X10^{24} c atoms
B.1 mole of $BaCO_3$	(	)2. 1.5 moles of O_2
C.1 mole of sucrose	(	)3. 5.5 moles of O_2
D.1 mole SO_2	**(**	**)4.** 1.8X10^{24} atoms
		5. 6X10^{23} atoms

A.a-4,b-3,c-2,d-1 B.a-1,b-2,c-3,d-4 C.a-3,b-2,c-1,d-4 D.a-5,b-3,c-2,d-1

LEARNER'S TASK

BEGINNERS (Level - I)

I. Single Correct Choice Type:

1. How many molecule would be there 0.01 moles of NaOH.
A) 6.023×10^{23} B) 6.023×10^{21} C) 6.023×10^{22} D) 6.023×10^{20}

2. 44 gms of CO_2 contains
A) 2 moles of oxygen atoms B) 1 mole of oxygen atoms
C) 1.5 moles of oxygen atoms D) 2.5 moles of oxygen atoms

3. The molecular formula of glucose is $C_6H_{12}O_6$ the emperical formula is
A) $C_2H_4O_6$ B) CH_2O C) CHO D) None

4. 0.75 moles of oxygen occupies volume at STP
A) 16.8lit B) 22.4lit C) 11.2lit D) 44.8lit

5. 11.2lit of O_3 contains how much weight at STP
A) 44g B) 28g C) 24g D) 34g

6. 1.5 x 1023 molecules of chlorine occupies how much volume at STP
A) 22.4lit B) 11.2lit C) 5.6 lit D) 44.8lit

7. 28g of nitrogen gas contains how many atoms
A) 6 x 10^{23} B)24 x 10^{23} C) 3 x 10^{23} D) 18 x 10^{23}

8. $CaCO_3 \rightarrow CaO + CO_2$. From this equation, to get 11g of carbon dioxide how much calcium carbonate should decompose. (Ca = 40, C = 12, O = 16)
A) 25g B) 50g C) 75g D) 45g

9. What volumes of SO_2 is liberated a liters at STP by burning 4 gms of sulphur in 10 litrs of O_2
A) 2.8 lts. B) 12.7 lts C) 11.2 lts D) 22.4 lts.

10. Weight of oxygen liberated when 90 kgs of water is electrolysed
A) 80 kgs B) 800 kgs C) 8 kgs D) 850 kgs

11. An ornamental ring contains 275 carats of daimond . How many grams daimond does it have?
1) 55 g 2) 65g 3) 75g 4) 50g

12. Calculate the number of atoms present in 1 g He gas.
A) 1.506 × 10^{23} B) 3.0115 × 10^{23} C) 6.023× 10^{23} D) 12.046 × 10^{23}

13. Calculate the number of Cl^- and Ca^{2+} ions in 222 g anhydrous $CaCl_2$
A) 3N, 6N B) 4N, 2N C) 10N, 5N D) 6N, 3N

14. No.of moles of 106 g of sodium carbonate is .....
A)2 B)1 C)0.5 D)0.1

15. $AgCl + 2Na_2S_2O_3 \rightarrow Na_3[Ag(S_2O_3)_2] + NaCl$. After balancing the equation what number will come before NaCl
A) 1 B) 2 C) 3 D) 4

16. $Al + NaOH + H_2O \rightarrow NaAlO_2 + 3H_2$. After balancing the equation how many atoms of sodium is there on the right hand side
A) 1 B) 2 C) 3 D) 4

17. $NaOH + Cl_2 \rightarrow NaCl + NaClO_3 + 3H_2O$. After balancing the equation how many molecules of sodium chlorate is formed.
A) 1 B) 2 C) 3 D) 4

18. 1 mole of CO_2.
A) 44 B) 44g C) 22 D) 22g

19. 0.5 mole of water contains
A) 6 x 10^{23} B)16 x 10^{23} C) 3 x 10^{23} D) 18 x 10^{23}+/

20. $2Na + Cl_2 \rightarrow 2NaCl$, from this say to get one Avogadro number of molecules, how many molecules of chlorine should be used.
A) 6 x 10^{23} B)16 x 10^{23} C) 3 x 10^{23} D) 18 x 10^{23}

ACHIEVERS (Level - II)

II. Answer the following:

1. How many moles and molecules of O_2 are there in 64 g O_2? What is the mass of one molecule of O_2?
2. From 200 mg of CO_2, 10^{21} molecules are removed. How many grams and moles of CO_2 are left?
3. What is the mas s of 1 mole of oxygen atoms?
4. What is a mole of a substance?
5. Explain the significance of mole?
6. Calculate the mass of 12 X 10^{24} atoms of hydrogen?
7. How many moles are contained in each of the following ?
i) 50 g CaCO3 ii) 20 g of NaOH iii) 80 g of Oxygen iv) 71 g of chlorine
v) 124 g of phosphorous
8. In what respect do the atomic mass and relative atomic mass of a substance differ?
9. How many particles are there in one mole of a substance.?
10. In a certain mass of a gas , the number of atoms and the number of molecules are equal .what conclusion can youn draw from this observation?

EXPLORERS (Level - III)

III. MCQs with more than one answer:

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

1. STP refers
A) 0^0C B) 76 cm of Hg C) 273 K D) 1 atm
2. Which of the following have same number of atoms
A) 24g of carbon B) 16g of oxygen C) 64g of sulphur D) 7g of nitrogen
3. 1 mole of gas contains equal amount of weight in the following
A) CO_2 B) N_2O C) C_3H_8 D) NO_2
4. Which of the following having one gram molar volume
A) 16g of O_2 B) 64g of SO_2 C) 44g of CO_2 D) 18g of H_2O
5. The number of atoms present in 16 grams of O2 is
A) 6.022 X10^{23} B) 3.011 X 10^{23} C) 12.046 X 10^{23} D)3.011 X 10^{22}

IV. Match the following.

- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column–I** have to be matched with statements (p, q, r, s) in **Column–II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

  *If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

1.

a) 44g of CO_2	1) 5.6litres
b) 16g of SO_2	2) 22.4litres
c) 100g of $CaCO_3$	3) 6 x 10^{23}molecules
d) 1.2g of carbon	4) 6 x 10^{22}atoms

A) a - 1, b - 4, c - 2, d - 3 B) a - 3, b - 1, c - 2, d- 4
C) a - 1, b - 2, c - 3, d - 4 D) a - 4, b - 3, c - 2, d - 1

2. a) $xH_2 + yO_2 \rightarrow 2H_2O$ 1) 1, 1
b) $xC + yO_2 \rightarrow CO_2$ 2) 1, 2
c) $xCH_4 + yO_2 \rightarrow CO_2 + 2H_2O$ 3) 2, 1
d) $xAl + yO_2 \rightarrow 2Al_2O_3$ 4) 4, 3
A) a - 1, b - 4, c - 2, d - 3 B) a - 3, b - 1, c - 2, d- 4
C) a - 1, b - 2, c - 3, d - 4 D) a - 4, b - 3, c - 2, d - 1

V. Odd one out and give your reason for your answer.

1. 32g of oxygen, 16g of methane, 18g of water, 22g of carbon dioxide
2. C_2H_6, $C_6H_{12}O_6$, CH_3, B_2H_6.
3. $6x10^{23}$ molecules of HCl, $6x10^{23}$ atoms of N_2, $12x10^{23}$ atoms of O_2, $18x10^{23}$ atoms of O_3

VI. Correct the sentence if it is wrong, otherwise rewrite the sentence.

1. 1 G.M.W of any substance contains $6x10^{23}$molecules.
2. For some molecules, emperical formula and molecular formula is same.
3. Balanced chemical equation may sometimes contain more reactant atoms.

VII.HOTS:

1. How many moles of water are present in one ltre of water
1) 2 moles 2) 55.5 moles 3) 55 moles 4)50 moles
2. How many electrons are present in 18 ml of water ?(18 ml = 18 g)
1) 6.02 X 10^{23} 2)6.023 X10^{22} 3) 6.023 X10^{24} 4) 6.023 X 10^{20}
3. How many electrons present in 0.5 moles of water vapour.
A) 3 x 10^{23} B)16 x 10^{23} C) 6 x 10^{23} D) 18 x 10^{23}
4. 1.5 x 1023 molecules of chlorine occupies how much volume at STP
A) 22.4lit B) 11.2lit C) 4.6 lit D) 44.8lit
5. The atomicity of sulphur molecule is
1) 2 2)8 3)6 4)5

RESEARCHERS (Level - IV)

I. Single correct answer type:

1. X ltr of CO is present at STP is completly oxidised to co to. The colume of CO_2 formed is 11.2 ltrs at STP what is the value of X. **(Eamcet 2002E)**
a) 22.4 b) 11.2 c) 5.6 d) 44.8
2. What is the volume in litters of oxygen required at STP to completly convert 1.5 moules of sulphur into sulphare dioxide. **(Eamcet 2003E)**
a) 11.2 b) 22.2 c) 33.6 d) 44.8
3. Which of the following has the largest number of atoms. **(IIT 74)**
a) 0.5g atoms of Cu b) 0.635g of Cu c) 0.25moles of Cu atoms d) 1g Cu
4. One mole of methane contains **(MLNR 86)**
a) 6.02 x 1023 atoms of H b) 4g atoms of hydrogen
c) 1.81x1023 molecules of methene d) 3g carbon
5. The number of moles of sodium oxide in 620g of it is **(BHU 92)**
a) 1 moles b) 10 moles c) 18 moles d) 100 moles
6. The weight of 1 molecule of a compound C60 H22 is **(AIIMS 2002)**
a) $1.3x10^{-20}$g b) $5.01x10^{-21}$g c)$3.72x10^{23}$g d) $1.4x10^{-21}$
7. Vapour density of gas is 22 what is the molecular mass **(AFMC 2000)**
a) 33 b) 22 c) 44 d) 11
8. How many moles of magnesium phosphate will contain 0.25moles of oxygen atoms
a) 0.02 b) $3.125x10^{-2}$ c) $1.25x10^{-2}$ d) $2.5x10^{-2}$
9. Number of atoms in 560g of Fe is **(AIEEE 2002)**
a) is twice that of 70g N2 b) is half that of 20g of hyrogen

c) Both are correct d) None is correct

10. How many moles of electron weight 1 kg(IIT 2002)
A.$6.023X10^{23}$ B.$1/(9.108X10^{31})$
C.$6.023/(9.108X10^{54})$ D.$1/(9.108X6.023)X10^{8}$

11. The mass of one molecule of water is
A) $3 x10^{-26}$ kg B) $3 x10^{-25}$ kg C) $1.5 X 10^{-26}$ kg D)$2.5 X10^{-26}$ kg

12. The molecular weight of gas is 45. Its vapour density at STP is
A) 22.4 B)11.2 C)5.7 D)2.0

13. The number of atoms in 4.25 g of ammonia is approximately
A) $1 X10^{23}$ B)$2 X10^{23}$ C) $4 X10^{23}$ D) $6 X10^{23}$

14. Which of the following has least mass
A) 2 g atom of nitrogen B) $3 x 10^{23}$ atoms of C
C) 1 Mole of S D) 7.0 g of Ag

15. Number of atoms of He in 100 amu of He (atomic weight of He is 4) are
A) 25 B)100 C)50 D) 10

16. The number of moles of sodium oxide in 620g of it is
A) 1 B)10 C)18 D)100

II. ADDITIONAL PRACTICE QUESTIONS:

1. Mass of $6.02x10^{23}$E is
1) 0.55 mg 2) $9.1x10^{-38}$ kg $9.1x10^{-35}$ kg 4) 0.55gr

2. $C + O_2 \rightarrow CO_2$, how many moles of carbon is required to get 33.6lit of carbondioxide
A) 3moles B) 2 moles C) 1.5 moles D) 2.5moles

3. E.F. of $C_6H_{12}O_6$.
A) $C_6H_{12}O_6$ B) $C_3H_6O_3$ C) CH_2O D) CHO

4. How many electrons are there in $NaNO_3$.
A) 66 B) 85 C) 42 D) 24

5. One mole of methane contains how many atoms
A) $6 x 10^{23} x 5$ B) $0.6 x 10^{24} x 5$ C) $30 x 10^{23}$ D) all the above

6. Identify the emperical formula and molecular formula
A) CH_4 B) C_2H_6 C) C_6H_6 D) N_2H_4

7. 0.5 moles of any gas occupies
A) 22.414lit B) 11.2lit C) 5.6lit D) 20.4lit

8. In a balanced equation
A) The number of molecules of both sides are equal.
B) The number of atoms on both sides are same
C) The diatomic molecules present on both sides are equal
D) Reactants and products are same side.

9. How many mlecu;es are present in one gram of hydrogen
A) $6.02 X10^{23}$ B)$3.01 X10^{23}$ C)$2.5X 10^{23}$ D)$1.5X10^{23}$

10. The number of moles of barium carbonate which contains 15 moles of oxygen atoms
A) 5 B)1 C) 3 D) $6.02X 10^{23}$

KEY

ΦΦ TEACHING TASK :

I.	1-4	2-2	3-4	4-4	5-1	6-1	7-1	8-4	9-1	10-2	11-2
	12-3	13-1	14-3								
II.	1-1,2,3	2-2,3	3-2,3,4	4-1,3		5-1,2,3,4					
III.	1-T	2-E	3-T	4-T							
IV.	1-B	2-B									

ΦΦ LEARNER'STASK :

☐ BEGINNERS :

I.	1-B	2-B	3-B	4-A	5-C	6-C	7-A	8-A	`9-A	10-A
	11-A	12-A	13-B	14-B	15-A	16-A	17-A	18-B	19-C	20-C
	21-C	22-C	23-C	24-A	25-A	26-B	27-B	28-B		

☐ EXPLORERS :

III.	1-A,B,C,D	2-B,D	3-	4-B,C,D	5-B	
IV.	1-B	2-B				
V.	1-D	2-C	3-B			
VI.	1-T	2-T	3-F	4-T		
VII.	1-2	2-3	3-1	4-3	5-2	

☐ RESEARCHERS :

I.	1-2	2-3	3-1	4-2	5-2	6-4	7-3	8-2	9-2	10-1	11-1	12-1
	13-3	14-1	15-1	16-2								
II.	1-1	2-3	3-3	4-3	5-1	6-1	7-2	8-2	9-2	10-1		