2 Gas Laws and Mole Concept

Properties of gases

- Each gas contains a large number of minute particles called molecules.
- The volume of a gas molecule is very less when compared to the total volume of the gas.
- The molecules of a gas are in a state of rapid random motion in all directions.
- During this motion, the gas molecules collide with each other and also collide with the walls of the container in which it is kept.
- ***As the collisions of molecules are perfectly elastic in nature, there is no loss of energy.***
- ***The collision of the gas molecules with the walls of the container creates the pressure of the gas.***
- The force of attraction between the gas molecules and with the wall of the container is comparatively less.
- Energy of gas molecules is very high
- Distance between the molecules is comparatively large
- Freedom of movement of molecules very high

Volume of a gas

If a gas ,kept in a cylinder having a volume of 1 litre, is completely transferred to another 5 litre cylinder, its volume becomes 5 litres.

Volume of a gas is the volume of the container which it occupies.

1. Pull the piston of a syringe backwards. Press the piston after closing the nozzle of the syringe.

What will happen to the volume of air inside the syringe?

When we press the piston after closing its nozzle, the volume of the gas inside the syringe decreases.

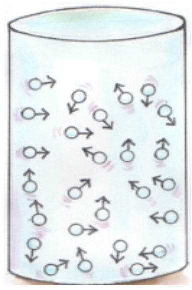
Temperature of a gas

When a gas is heated , the temperature increases. The kinetic energy of the molecules increases. The average kinetic energy is a measure of the temperature of a gas.

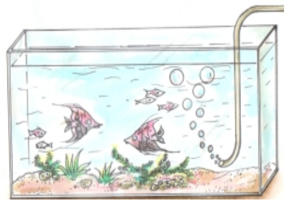
Pressure of a gas

Force exerted per unit area is called pressure.

Force on unit area= Total force exerted on the surface / Surface area



♥♥♥ Relation between Volume of a gas and Pressure (Boyle's Law)



2.♥♥♥ The size of the air bubbles rising from the bottom of an aquarium increases. Give reason.

Here the temperature is constant. From bottom to top, the external pressure decreases.

Hence volume of the bubble increases. (Boyle's law).

Boyle's law states that at a constant temperature, volume of a definite mass of gas is inversely proportional to its pressure. If P is the pressure and V the volume, then P x V is a constant.

♥♥♥ Relation between Volume of a gas and its Temperature (Charle's Law)

3.♥♥♥ Take a dry bottle (an injection bottle) having a rubber stopper. Fix an empty refill through the rubber stopper. Fill a drop of ink into in the lower end of the refill tube, then close the bottle. Dip this arrangement in luke warm water.

What do you observe?

The ink rises up.

What is the reason for the rising of the ink upwards?

When the temperature increases, the volume of the gas inside the bottle increases. This will push the ink up .

What did you observe on cooling the bottle after taking it out? Why?

On cooling the bottle, the volume of the gas decreases. Then the ink goes down.

When the temperature increases, the volume of the gas increases. When temperature decreases, volume of the gas decreases.

The table given below shows the relation between volume and temperature of a fixed mass of a gas. (Pressure is kept constant)

Volume V	**Temperature T (In Kelvin scale)**	**V/T**
900 mL	300 K	900 / 300 = **3**
960 mL	320 K	960 / 320 = **3**
819 mL	273 K	819 / 273 = **3**

[Note that the temperature is stated in kelvin scale]

Charle's law states that , At constant pressure, the volume of a definite mass of a gas is directly proportional to the temperature in Kelvin Scale.

If V is volume and T the temperature, Then V/T will be a constant.

4. ♥♥♥ *If an inflated balloon is kept in sunlight, it will burst. What may be the reason for this?*

When the temperature increases, the volume of the gas inside the balloon increases and finally it will burst. (Charle's Law)

♥♥♥ Relation between volume of a gas and number of molecules

Avogadro's Law

At constant temperature and pressure the volume of a gas is directly proportional to number of molecules. This is Avogadro's Law

When a balloon is being inflated , the number of molecules present in it also increases. At the same time the volume of the gas also increases.

The same happens when a cylinder is being filled by a gas

These examples are i n accordance with Avogadro's Law

♥♥♥ Towards mole concept..

♥♥♥ If the relative atomic mass of an element is x grams, x grams of it contains **6.022×10^{23} atoms .**

♥♥♥ **Look at the following table for clarification**

Element	Atomic Mass	Atomic Mass in grams	Mass Actually taken	Number of Atoms
Hydrogen	**1**	**1 g**	**1 g**	**6.022×10^{23}**
Carbon	**12**	**12 g**	**12 g**	**6.022×10^{23}**
Nitrogen	**14**	**14 g**	**14 g**	**6.022×10^{23}**
Oxygen	**16**	**16 g**	**16 g**	**6.022×10^{23}**
Sodium	**23**	**23 g**	**23 g**	**6.022×10^{23}**
Magnesium	**24**	**24 g**	**24 g**	**6.022×10^{23}**
Aluminium	**27**	**27 g**	**27 g**	**6.022×10^{23}**
Chlorine	**35.5**	**35.5g**	**35.5g**	**6.022×10^{23}**
Calcium	**40**	**40 g**	**40 g**	**6.022×10^{23}**

♥♥♥ *The mass of an element in grams equal to its atomic mass is called 1 Gram Atomic Mass (1 GAM) of the element. This may also be shortened as 1 Gram Atom.*

Hence the table given above can be modified as

Element	Atomic Mass	Atomic Mass in grams	Mass Actually taken	GAM	Number of Atoms
Hydrogen	**1**	**1 g**	**1 g**	**1 GAM**	6.022×10^{23}
Carbon	**12**	**12 g**	**12 g**	**1 GAM**	6.022×10^{23}
Nitrogen	**14**	**14 g**	**14 g**	**1 GAM**	6.022×10^{23}
Oxygen	**16**	**16 g**	**16 g**	**1 GAM**	6.022×10^{23}
Sodium	**23**	**23 g**	**23 g**	**1 GAM**	6.022×10^{23}
Magnesium	**24**	**24 g**	**24 g**	**1 GAM**	6.022×10^{23}
Aluminium	**27**	**27 g**	**27 g**	**1 GAM**	6.022×10^{23}
Chlorine	**35.5**	**35.5g**	**35.5g**	**1 GAM**	6.022×10^{23}
Calcium	**40**	**40 g**	**40 g**	**1 GAM**	6.022×10^{23}

♥♥♥ ***One gram atomic mass (1 GAM) of any element contains 6.022×10^{23} atoms. This number is known as Avagadro number. This is indicated as N_A.***

♥♥♥ **Have a close look at the table given below**

Element	Atomic Mass	Atomic Mass in grams	Given mass	Number of GAM	Number of Atoms
Hydrogen	1	1 g	1 g	1 GAM	6.022×10^{23}
Hydrogen	**1**	**1 g**	**2 g**	**2 GAM**	$2 \times 6.022 \times 10^{23}$
Carbon	12	12 g	12 g	1 GAM	6.022×10^{23}
Carbon	**12**	**12 g**	**24 g**	**2 GAM**	$2 \times 6.022 \times 10^{23}$
Nitrogen	14	14 g	14 g	1 GAM	6.022×10^{23}
Nitrogen	**14**	**14 g**	**42 g**	**3 GAM**	$3 \times 6.022 \times 10^{23}$
Oxygen	16	16 g	16 g	1 GAM	6.022×10^{23}
Oxygen	**16**	**16 g**	**80 g**	**5 GAM**	$5 \times 6.022 \times 10^{23}$
Sodium	23	23 g	23 g	1 GAM	6.022×10^{23}
Sodium	**23**	**23 g**	**230 g**	**10 GAM**	$10 \times 6.022 \times 10^{23}$

From the table given above , it is clear that

♥♥♥

Number of Gram Atomic Mass = **Given Mass in grams / GAM of element**

5 ♥♥♥ How many GAM is present in 46 g of sodium?

(Hint: 1 GAM of sodium means 23 grams of Sodium)

Answer:

Number of GAM = **Given Mass in grams / GAM of element**

= **46 g / 23 g**

= **2**

It contains 2 × 6.022 x 10^{23} atoms of sodium

6.♥♥♥ How many GAM is present in 69 g of sodium?

(Hint: 1 GAM of sodium means 23 grams of Sodium)

Answer:

Number of GAM = **Given Mass in grams / GAM of element**

= **69 g / 23 g**

= **3**

It contains 3 × 6.022 x 10^{23} atoms of sodium

Number of Atoms = **Number of GAM** x 6.022 x 10^{23}

7.♥♥♥ Calculate the number of atoms present in each of the sample?

(Atomic mass N = **14**, O = **16)**

a) 42 g Nitrogen

b) 80 g Oxygen

Answer:

a) 42 g Nitrogen

Number of GAM = **Given Mass in grams / GAM of element**

= 42 g / **14 g**

= **3**

It contains 3 x 6.022 x 10^{23} atoms of Nitrogen

b) 80 g Oxygen

Number of GAM = **Given Mass in grams / GAM of element**

= 80 g / **16 g**

= **5**

It contains 5 x 6.022 x 10^{23} atoms of Oxygen

8.♥♥♥ Complete the table given below.

Element	**Atomic Mass**	**Atomic Mass in grams**	**Given mass**	**Number of GAM**	**Number of Atoms**
Hydrogen	1	1 g	4 g	**........(a)........**	**..........(b)..........**
Carbon	**12**	**12 g**	**.........(c).........**	**5 GAM**	**..........(d)..........**
Nitrogen	**14**	**14 g**	**42 g**	**........(e)........**	**...........(f)..........**
Oxygen	**16**	**16 g**	**........(g).........**	**........(h)........**	**5 x 6.022 x 10^{23}**

(a) = 4 (b) = 4 x 6.022 x 10^{23} **(c) = 60 g** (d)= 5 x 6.022 x 10^{23}

(e)= 3 **(f) = 3 x 6.022 x 10^{23}** (g) = 80 g **(h) = 5**

♥♥♥ One mole of atoms

One mole of atoms = 6.022 x 10^{23} atoms = 1GAM

9. ♥♥♥ Find the number of mole atoms of the following

a.

Element	Atomic Mass	Atomic mass in grams	Mass taken	Number of GAM	Number of atoms	Number of mole atoms
Hydrogen	1	1 g	1 g	1 GAM	6.022×10^{23}	
Carbon	12	12 g	12 g	1 GAM	6.022×10^{23}	
Nitrogen	14	14 g	14 g	1 GAM	6.022×10^{23}	
Oxygen	16	16 g	16 g	1 GAM	6.022×10^{23}	

Answer:

Element	Atomic Mass	Atomic mass in grams	Mass taken	Number of GAM	Number of atoms	Number of mole atoms
Hydrogen	1	1 g	1 g	1 GAM	6.022×10^{23}	1
Carbon	12	12 g	12 g	1 GAM	6.022×10^{23}	1
Nitrogen	14	14 g	14 g	1 GAM	6.022×10^{23}	1
Oxygen	16	16 g	16 g	1 GAM	6.022×10^{23}	1

b. ♥♥♥

Element	Atomic mass	Atomic mass in grams	Given mass	Number of GAM	Number of atoms	Number of mole atoms
Hydrogen	1	1 g	1 g	1 GAM	6.022×10^{23}	
Hydrogen	1	1 g	2 g	2 GAM	$2 \times 6.022 \times 10^{23}$	
Carbon	12	12 g	12 g	1 GAM	6.022×10^{23}	
Carbon	12	12 g	24 g	2 GAM	$2 \times 6.022 \times 10^{23}$	
Nitrogen	14	14 g	14 g	1 GAM	6.022×10^{23}	
Nitrogen	14	14 g	42 g	3 GAM	$3 \times 6.022 \times 10^{23}$	
Oxygen	16	16 g	16 g	1 GAM	6.022×10^{23}	
Oxygen	16	16 g	80 g	5 GAM	$5 \times 6.022 \times 10^{23}$	
Sodium	23	23 g	23 g	1 GAM	6.022×10^{23}	
Sodium	23	23 g	230 g	10 GAM	$10 \times 6.022 \times 10^{23}$	

Answer:

Element	Atomic mass	Atomic mass in grams	Given mass	Number of GAM	Number of atoms	Number of mole atoms
Hydrogen	1	1 g	1 g	1 GAM	6.022×10^{23}	1
Hydrogen	**1**	**1 g**	**2 g**	**2 GAM**	**$2 \times 6.022 \times 10^{23}$**	**2**
Carbon	12	12 g	12 g	1 GAM	6.022×10^{23}	1
Carbon	**12**	**12 g**	**24 g**	**2 GAM**	**$2 \times 6.022 \times 10^{23}$**	**2**
Nitrogen	14	14 g	14 g	1 GAM	6.022×10^{23}	1
Nitrogen	**14**	**14 g**	**42 g**	**3 GAM**	**$3 \times 6.022 \times 10^{23}$**	**3**
Oxygen	16	16 g	16 g	1 GAM	6.022×10^{23}	1
Oxygen	**16**	**16 g**	**80 g**	**5 GAM**	**$5 \times 6.022 \times 10^{23}$**	**5**
Sodium	23	23 g	23 g	1 GAM	6.022×10^{23}	1
Sodium	**23**	**23 g**	**230 g**	**10 GAM**	**$10 \times 6.022 \times 10^{23}$**	**10**

♥♥♥ Molecular Mass and Gram Molecular Mass

10.♥♥♥The atomic masses of certain elements are given below.

(H=1 ,C =12 , N=14 , O= 16 , Na = 23 , S= 32)

Find the Molecular Mass and GMM of the following

1. H_2 **2.** O_2 **3.** N_2 **4.** H_2O **5.**NH_3

6.CO_2 **7.**NaOH **8.** $C_6H_{12}O_6$ **9.**Na_2CO_3 **10.** H_2SO_4

Sl No	Element/ Compound	Chemical Formula	Molecular Mass	GMM
1	**Hydrogen , H_2**	**H_2**	1+1 =**2**	**2 g**
2	**Oxygen , O_2**	**O_2**	16+16 =**32**	**32 g**
3	**Nitrogen , N_2**	**N_2**	14+14=**28**	**28 g**
4	**Water ,H_2O**	**H_2O**	1+1+16 = **18**	**18 g**
5	**Ammonia ,NH_3**	**NH_3**	14+1+1+1=**17**	**17 g**
6	**Carbondioxide ,CO_2**	**CO_2**	12+16+16=**44**	**44 g**
7	**Sodium hydroxide,NaOH**	**NaOH**	23+16+1=**40**	**40 g**
8	**Glucose,$C_6H_{12}O_6$**	**$C_6H_{12}O_6$**	(12 x 6) + (1 x12) + (16 x6)= 72 +12 + 96= **180**	**180 g**
9	**Sodium carbonate, Na_2CO_3**	**Na_2CO_3**	= (23 x 2) + (12 x 1) + (16 x 3) = 46 + 12 + 48 **= 106**	**106 g**
10	**Sulphuric acid, H_2SO_4**	**H_2SO_4**	(1 x 2) + (32 x 1) +(16 x 4) = 2 + 32 + 64 **= 98**	**98 g**

♥♥♥ Number of Molecules

♥♥♥ *Analyse the table given below*

Element / Compound	Molecular Mass	Mass in grams	GMM	Number of molecules
Hydrogen **(H_2)**	2	2 g	1 GMM	6.022×10^{23} H_2 molecules
Oxygen**(O_2)**	32	32 g	1 GMM	6.022×10^{23} O_2 molecules
Nitrogen**(N_2)**	28	28 g	1 GMM	6.022×10^{23} N_2 molecules
Water**(H_2O)**	18	18 g	1 GMM	6.022×10^{23} H_2O molecules
Ammonia**(NH_3)**	17	17 g	1 GMM	6.022×10^{23} NH_3 molecules
Carbon dioxide **(CO_2)**	44	44 g	1 GMM	6.022×10^{23} CO_2 molecules

♥♥♥ ***The amount** of a substance in grams **equal to its molecular mass** is called **Gram Molecular Mass***
One gram molecular mass of any substance contains Avagadro number of molecules.

11. ♥♥♥One GMM oxygen is 32g Oxygen. This contains 6.022×10^{23} oxygen molecules.

(a) How many GMM are there in 64g oxygen?
(b) How many molecules are present in it?

Answer:

(a) One GMM oxygen is 32g Oxygen.
Hence ,
Number of GMM in 64 g oxygen = 64g/32g
=2

(b)
Number of molecules in 64g Oxygen = Number of GMM x 6.022×10^{23}
= 2 x 6.022×10^{23}

♥♥♥
Number of Gram Molecular Mass = Mass given in grams / Gram Molecular Mass **(GMM)**

12. ♥♥♥ Calculate the number of GMM and number of ,molecules in each of the following samples

(a) 360 g glucose (Molecular mass = 180)
(b) 90 g Water (Molecular mass = 18)

Answer:

(a) 360 g glucose

Number of Gram Molecular Mass = Mass given in grams / Gram Molecular Mass **(GMM)**
= 360 g / 180 g
= 2

Number of molecules = Number of GMM x 6.022×10^{23}
= 2 x 6.022×10^{23}

(b) 90 g glucose

Number of **G**ram **M**olecular **M**ass = Mass given in grams / Gram Molecular Mass **(GMM)**
= 90 g / 18 g
= 5

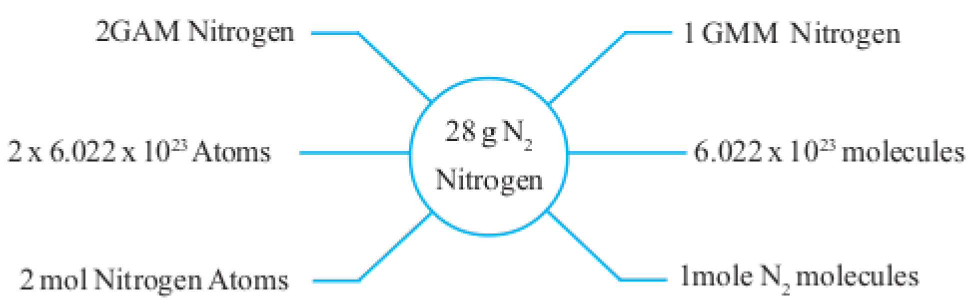
Number of molecules = Number of GMM x 6.022 x 10^{23}
= 5 x 6.022 x 10^{23}

♥♥♥ **Number of Molecules = Number of GMM x 6.022 x 10^{23}**

♥♥♥ One Mole of molecules

♥♥♥ ***6.022 x10^{23} molecules are called one mole molecule.***   ***1 GMM = 1 Mole = 6.022 x10^{23} molecules.***

♥♥♥ N_2 is a diatomic molecule. The molecular mass of nitrogen is 28. Look at the word diagram given below.



Problem Part – Quick Review	
♥♥♥ **For Atoms**	♥♥♥**For Molecules**
Number of GAM = Given mass in grams / GAM of the element	**Number of GMM = Given mass in grams / GMM**
Number of Atoms = Number of GAM x 6.022×10^{23}	**Number of Molecules = Number of GMM x 6.022×10^{23}**