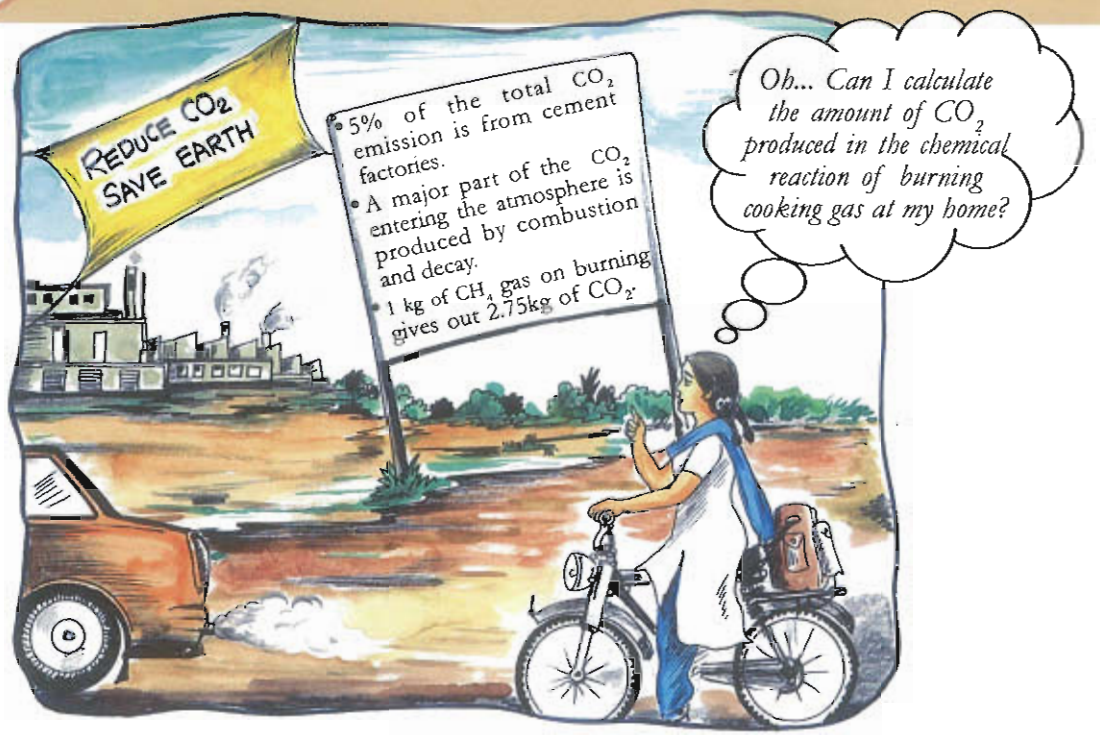
2 CHEMICAL REACTIONS AND THE MOLE CONCEPT



Let us examine some chemical reactions;

- Burning of firewood.
- Mg reacting with dilute hydrochloric acid.
- Sodium thiosulphate solution ($Na_2S_2O_3$) reacting with dilute hydrochloric acid.
- Calcium carbonate reacting with dilute hydrochloric acid.
- Sodium carbonate reacting with dilute acetic acid.

Which of these reactions are familiar to you? Which are the ones to be performed?

Write in your science diary the materials required for each experiment and the procedure to be adopted for conducting the experiment.

Experiment

Materials required :

Procedure :

Observation :

Conduct the reactions. Do all these reactions proceed at the same speed?

✶ Which are the reactions that proceeded fast?

✶ Which are the ones that proceeded slowly?

Sometimes you might have wished to increase the speed of some of these reactions and decrease the speed of some others.

Experiment 1 : Burning of firewood

★ What are the reactants in this experiment?

★ Write the methods that can be adopted to increase the speed of this reaction.

★ And to decrease?

Speed of chemical reactions and concentration

Does the concentration of the reactant influence the speed of a reaction?

Examine this by conducting the reaction between magnesium and hydrochloric acid. Perform the experiment using very dilute acid as well as acid of higher concentration.

Concentration

The amount of a substance present in unit volume is considered as the concentration of the substance. The concentration of a solution is the amount of solute present in its unit volume. If the amount of solute in unit volume of the solution is high, it is called a concentrated solution and if the amount of solute is low it is called a dilute solution.

Let us consider two samples of sugar solution such that one contains 10 g sugar dissolved in 100 mL water and the other contains 20 g sugar dissolved in 100 mL water. Which will be the more concentrated solution?

The concentration of an aqueous solution is decreased by adding water and the resulting solution is called a dilute solution.

★ The procedure of the experiment

★ Observation

Write down the systematic procedure and the observations in the science diary.

Collision Theory

For a chemical reaction to take place the reactant molecules should collide with one another. However all collisions between reactant molecules need not lead to a chemical reaction. Only those molecules having energy greater than a certain threshold value can undergo effective collisions leading to the formation of products.

From the given note it can be inferred that a chemical reaction takes place due to effective collisions between reactant molecules.

★ Write down the reason for the increase in the speed of a reaction on increasing the concentration.

For reactions involving gases the molecules move closer to each other on increasing the pressure. Isn't this equivalent to increasing the concentration? Examine the pictures and arrive at a conclusion.

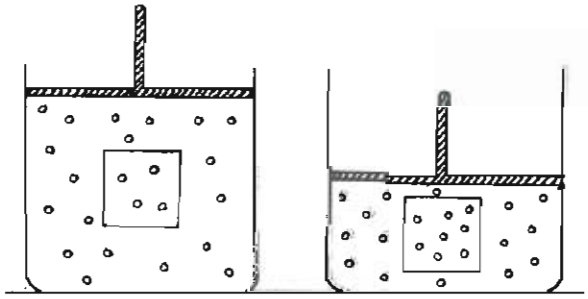


Fig. 2.1

What will happen to the rate of collision between molecules on increasing the pressure? Will it increase or decrease?

Can't you now explain why the speed of chemical reactions between gases increases with an increase in pressure?

Speed of chemical reactions and surface area

Have you noticed that firewood is cut into small pieces for easy burning? Why does the firewood burn faster when it is used in small pieces?

Take some dilute hydrochloric acid in a beaker. Take two marble pieces ($CaCO_3$) of equal size. Put one into a boiling tube or beaker. Crush the other into smaller pieces and put them into another boiling tube or beaker. Add equal quantities of dilute acid to each and observe.

The equation for the reaction is

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

★ Which gas evolves in the form of bubbles?

★ In which vessel does the reaction take place faster?

Fig. 2.2 shows the marble ($Ca\ CO_3$) placed in acid solutions in the above activity. Using the figure and the hints given below, try to explain the reasons for your observation.

Hints

- The concentration of acid in the two experiments
- The difference in the surface area of reactants
- The possibility of higher number of acid molecules coming in contact with calcium carbonate at a time.

Our conclusion.

When solid substances are split into small pieces, the surface area increases, resulting in an increase in the possibility of collision between reactant molecules. This is why the speed of the reaction increases.

In the experiment we conducted earlier, if the marble pieces are further crushed into still smaller pieces or powdered, what change will occur in the reaction speed?

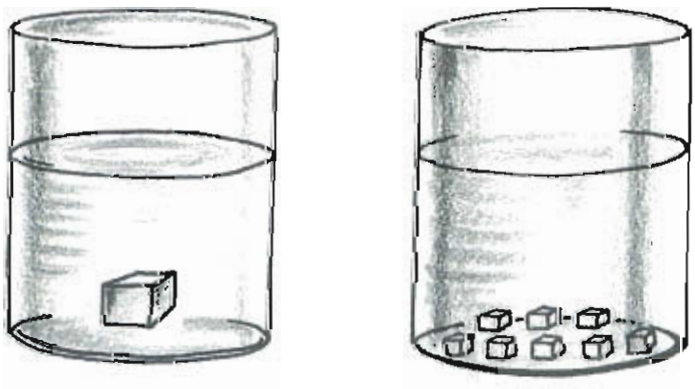


Fig. 2.2

What other examples can be given from daily life in which the speed of chemical reactions is increased by increasing the surface area of solid substances?

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•

Speed of reactions and temperature

Temperature is another factor which affects the speed of a chemical reaction. Take note of the procedure of an experiment to illustrate the effect of temperature on the speed of chemical reactions.

Take powdered sodium thiosulphate crystals in a beaker, dissolve it in water and prepare a dilute solution. Take equal quantities of this solution in two boiling tubes. Heat the solution in one boiling tube using a spirit lamp. Now add equal quantities of dilute hydrochloric acid into the two boiling tubes and observe. Note down the observation in your science diary.

The colour change is due to the precipitation of sulphur as a result of the reaction. When heated, the kinetic energy of the molecules increases resulting in an increase in the number of effective collisions. This is why the speed of the reaction increased. In general the speed of chemical reactions increases considerably on increasing the temperature.

Speed of chemical reactions and catalyst

Hydrogen peroxide is a compound which decomposes slowly into water and oxygen at ordinary temperature.

Hydrogen peroxide (H_2O_2)

Water (H_2O) and hydrogen peroxide (H_2O_2) are two different compounds containing hydrogen and oxygen. Unlike water, the common oxide of hydrogen, hydrogen peroxide is unstable. It slowly decomposes into water and oxygen.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

Hydrogen peroxide is used as an antiseptic and a mild bleaching agent.

Let us perform an experiment using this compound.

Take hydrogen peroxide solution in two test tubes. Add a little manganese dioxide into one of these.

★ What is the observation?

★ Introduce a glowing incense stick into the evolving gas. What do you observe?

★ Which is the gas?

★ Reason for your inference

Doesn't this indicate that the speed of the reaction increased on addition of manganese dioxide? By examining the manganese dioxide left after the completion of the reaction, it can be seen that there is no change in its quantity or the chemical properties. That is, no chemical change has occurred to manganese dioxide in this reaction.

Catalysts are substances which influence a chemical reaction by altering the speed of the reaction without themselves

undergoing any permanent chemical change. In this case manganese dioxide acts as a catalyst which increases the speed of the reaction. Whereas phosphoric acid can act as a catalyst decreaseing the speed of decomposition of hydrogen peroxide.

Another important aspect is that a substance which acts as a catalyst in one reaction need not necessarily act as a catalyst in another reaction.

We have now learnt some factors that influence the speed of a chemical reaction. List them and their general influence.

Factors which influence the speed of chemical reactions	Influence
•	
•	
•	
•	
•	

Table 2.1

In the experiments we conducted, you might have noticed that the reaction stopped after some time.

When did the reaction between magnesium and acid stop? Why did it stop?

Magnesium was completely used up/ Acid was completely used up (✓ the correct answer).

Now let's do another experiment.

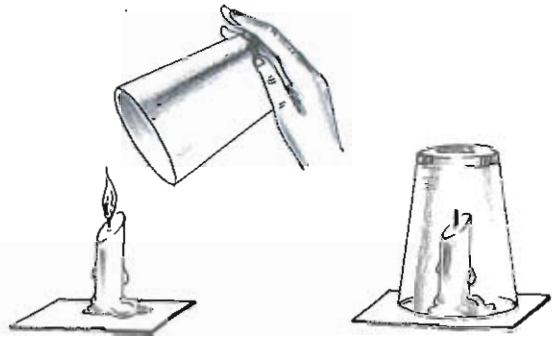


Fig. 2.3

Fix a lighted candle over a glass plate and cover it with a glass tumbler. Why is the flame put out?

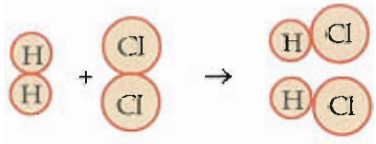
Candle exhausted/Oxygen exhausted (✓ the correct answer)

If a lighted candle is not covered with a glass tumbler like this, how long would it burn? What is the reason for the flame getting extinguished in this case?

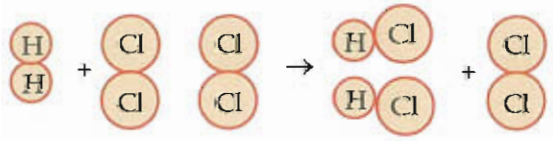
Candle exhausted/Oxygen exhausted (✓ the correct answer)

Examine the balanced equation showing hydrogen reacting with chlorine to form hydrogen chloride.

$$H_2 + Cl_2 \rightarrow 2HCl$$



According to this equation how many molecules of chlorine (Cl_2) are required to react with one molecule of hydrogen (H_2)?



If we allow two chlorine molecules to react with one hydrogen molecule, how many chlorine molecules will remain as per the above balanced equation?

Can you write down how the reaction takes place in the instances shown in Table 2.2 ?

Hydrogen molecules	Chlorine molecules	Molecules likely to be formed	Molecules remaining after the completion of the reaction
H_2	$2Cl_2$	2HCl	$1Cl_2$
$2H_2$	$2Cl_2$	4HCl	Nothing remains
$3H_2$	$2Cl_2$	.....	.....
$10H_2$	$8Cl_2$	.....	$2H_2$
$20H_2$	.....	40HCl	Nothing remains

Table 2.2

If equal number of H_2 molecules and Cl_2 molecules were to combine, the reaction will be completed and none of the reactants will be left out.

See the reaction between hydrogen and oxygen forming water.

$$2H_2 + O_2 \rightarrow 2H_2O$$

Here the number of oxygen molecules (O_2) required is exactly half the number of hydrogen molecules for the reaction to be completed.

However it is impossible to count extremely minute particles like molecules and atoms exactly and make them react in this manner.

★ Why?

Number and mass

Analyse this situation.

Fig. 2.4

Two persons went to a grocery shop for a job. The shop owner said: "This sack is full of green gram. All the grains have the same mass. I want one lakh grains as fast as possible and whoever does this first will get the job".

Imagine that you are one of the persons seeking the job.

★ How will you do this?

Have you noticed that coins of the same denomination in large quantities are counted in banks by weighing?

Would this be possible if coins of different masses are mixed up?

In the case of particles of the same mass we can conclude that a fixed mass will always contain the same number of particles.

This means that from the number of particles the total mass can be found out and from the total mass the number of particles can be ascertained.

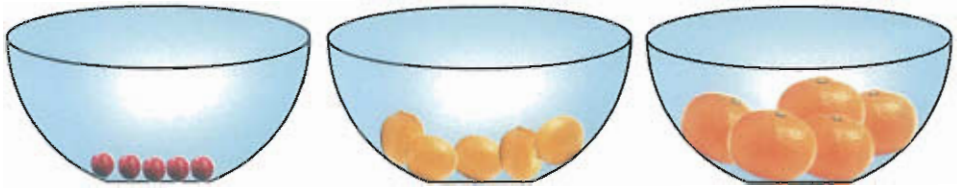


Fig. 2.5

Atoms and molecules of an element are particles having fixed masses. Hence their number in a known mass of an element can be estimated using this method.

It was observed that atoms of different elements always combine in a fixed ratio by mass to form molecules of compounds. This was the basis for establishing the relationship between mass and number. For example whatever be the method by which water is produced, the ratio between the number of hydrogen atoms and oxygen atoms is 2:1 and the ratio of their masses, 1:8.

Is it possible to find a relation between relative atomic masses and the number of atoms?

See one more instance.

Suppose a shop has a collection of grapes each with the same size and mass. The shop also has a similar stock of lemons and oranges. Assume that the mass of each lemon is 10 times that of a grape and the mass of each orange, 40 times that of a grape.

When one kilogram of grapes is bought let there be 'x' number of grapes in it.

★ If one kilogram of lemons is bought will it contain 'x' number of lemons? Why?

★ To get 'x' number of lemons how many kilograms are required?

★ What is the reason for your conclusion?

The number will be equal in one kilogram grapes, 10 kilogram lemons and 40 kilogram oranges.

Instead of one kilogram, if we take one quintal grapes, 10 quintals lemons and 40 quintals oranges, they will also contain equal number of the fruit.

★ What about 10g grapes, 100g lemons and 400g oranges?

This means that when different substances each containing the same type of particles with their masses in grams or kilograms in the same proportion as their relative masses are taken, the number of particles in each will be equal.

And what if we think of atoms in a similar way?

Element	Relative atomic mass
H	1
He	4
C	12
N	14
O	16
Cl	35.5

Table 2.3

Suppose 1g hydrogen contains x number of atoms.

Will 1g helium contain x atoms?

To get x number of atoms how many grams of helium are required? .....

To get x number of carbon atoms how many grams of carbon are required?

- -

And what about other elements?

★ What conclusions can you draw about the relation between the mass and the number of particles in the elements enlisted above?

- -

Examine whether your conclusion agrees with the statement given below.

When different elements are taken in grams which are numerically equal to their relative atomic masses, the number of atoms will be equal.

The amount of an element in grams which is numerically equal to its atomic mass is called one gram atomic mass (GAM) of the element

If we take one gram atomic mass of any element, the number of atoms contained in it will be the same. Don't you want to know this number?

Avogadro number

The number of atoms in one gram atomic mass of any element has been found to be 6.022×10^{23}. This number is called Avogadro number, denoted by N_A.

According to this how many atoms will be present in one gram hydrogen?

1 g hydrogen = _ _ _ _ atoms

4 g helium = _ _ _ _ atoms

How many grams of the following substances are required to get 6.022×10^{23} atoms?

N = - - - - - - g

O = - - - - - - g

Na = - - - - - - g

Definite masses of samples of some elements taken are given in Table 2.4. Fill up columns 2 and 3 of the table by finding the number of gram atomic masses and the number of atoms respectively in each case.

Mass of the sample element taken (g)	Number of gram atomic masses	Number of atoms present
• 60 g Hydrogen		
• 60 g Carbon		
• 160 g Oxygen		
• 1 g Oxygen		
• 50 g Chlorine		
•		

Table 2.4

Molecular mass

If we take a hydrogen molecule (H_2) instead of a hydrogen atom, what will be the relative mass? As H_2 molecule contains two H atoms its relative mass should be 2. The relative mass of a molecule is called its molecular mass. Molecular mass will be the sum of the relative atomic masses of all the atoms present in the molecule.

How can the molecular mass of H_2O be found?

H_2O has two 'H' atoms and one 'O' atom

Total mass of 'H' atoms = 1×2

Total mass of 'O' atom = 16×1

Molecular mass of H_2O

= $(1 \times 2) + (16 \times 1) = 2 + 16 = 18$

Substance	Formula	Molecular mass	Gram molecular mass	Atomic masses
• Hydrochloric acid	HCl			H = 1
• Sodium hydroxide				C = 12
• Sulphuric acid				N = 14
• Calcium carbonate	$CaCO_3$			O = 16
• Ammonium sulphate	$(NH_4)_2SO_4$			S = 32
• Sodium chloride				Cl = 35.5
				Na = 23
				Ca = 40

Table 2.5

The molecular formula of glucose is $C_6H_{12}O_6$. What will be the molecular mass of glucose?

The molecular mass of $C_6H_{12}O_6$

= (12 × 6) + (1 × .....) + (..... × .....) = ...

The amount of a substance in grams which is numerically equal to the molecular mass of the substance is its gram molecular mass (GMM).

In the case of monoatomic molecules, gram molecular mass and gram atomic mass are equal. Example: Helium, Neon.

Find out the molecular masses and gram molecular masses of the substances given in Table 2.5 and write them down (Atomic masses are given on the right side of the table).

As you know the gram atomic mass of hydrogen is 1 g and its gram molecular mass is 2 g.

1 g of hydrogen will contain 6.022×10^{23} atoms.

★ What will be the number of atoms in 2 g of hydrogen?

What will be the number of molecules in 2 g of hydrogen (remember that each hydrogen molecule is formed by the union of 2 hydrogen atoms).

That means if we take one gram molecular mass of hydrogen it will contain 6.022×10^{23} molecules of hydrogen.

Similarly when we take one gram molecular mass of any substance (element or compound) it will contain molecules equal to the Avogadro number (6.022×10^{23}).

1 GMM H_2O = 18 g
= 6.022×10^{23} molecules

1 GMM NH_3 = ...g
= 6.022×10^{23} molecules

1 GMM H_2SO_4 = ...g
= ..... molecules

What is the number of gram molecular masses in 36 g of water?

How many water molecules will be present in it?

And for 90 g water?

The number of gram molecular masses in 90 g of water = $\frac{90 \text{ g}}{\text{GMM of water}}$

The number of molecules in 90 g of water

= _ _ _ _ _ _ _ × _ _ _ _ _ _ _

✶ Samples of some compounds are given.

100 g NaCl	100 g Na_2CO_3	500 g $Ca(OH)_2$
(x)	(y)	(z)

- Find the molecular mass of each substance.
- How many gram molecular masses of substances are present in each sample?

  (Hints : atomic masses Na = 23, Cl = 35.5, C = 12, Ca = 40, H = 1).

✶ How many gram molecular masses of water are present in one kilogram of water?

Mole concept

You are now aware of the fact that one gram atomic mass of an element contains 6.022×10^{23} atoms and one gram molecular mass of a substance contains 6.022×10^{23} molecules.

Mole

One mole is the amount of substance containing 6.022×10^{23} (Avogadro number) particles. In chemistry mole is the unit used to express the amount of a substance. 'mol' is the short form of this. The particles may be molecules, atoms, ions, electrons etc. The type of particle should be specified when the amount of the substances is expressed in mol.

Example:

1 mol hydrogen molecules = 2 g

5 mol oxygen atoms = $5 \times 16\ g = 80\ g$

2 mol sodium ions = $2 \times 23\ g = 46\ g$

etc.

If the amount of an element is expressed in moles without specifying the particle, it should be considered as molecules.

'1 mol oxygen' means 1 mole of oxygen molecules (32 g).

The amount of substance in mol can be expressed also in terms of number of particles, mass and volume.

What is the mass in grams of one mole of hydrogen atom? What is the number of atoms in it?

1 mol hydrogen atoms (H)

= _ _ _ _ _ _ _ _ g.

= _ _ _ _ _ _ _ _ number of atoms

And in one mole of hydrogen molecule (H_2)?

1 mol hydrogen molecules (H_2)

= _ _ _ _ _ _ _ _ g.

1 mol hydrogen molecules (H_2)

= _ _ _ _ _ _ _ _ number of molecules.

Can you find the number of hydrogen atoms in this?

Our inference _ _ _ _ _ _ _ _

Reason for the inference _ _ _ _ _ _ _ _

What will be the values of these in the case of oxygen? (Atomic mass of oxygen 16 and molecular mass 32).

The mass of 1 mole of oxygen atoms

= _ _ _ _ _ _ _ _ g

The number of atoms in 1 mole of oxygen atoms.

= _ _ _ _ _ _ _ _

The mass of 1 mole of oxygen molecules

= _ _ _ _ _ _ _ _ g

The number of molecules in 1 mole of oxygen molecules.

= _ _ _ _ _ _ _ _ molecules.

★ How many molecules are present in one mol water?

1 mol water = _ _ _ _ _ _ _ _ molecules

1 mol water = _ _ _ _ _ _ _ _ g

And what about ammonia (NH_3) gas?

1 mol NH_3 = _ _ _ _ _ _ _ _ molecules

1 mol NH_3 = _ _ _ _ _ _ _ _ g

Can you consolidate the concepts discussed above.

One mole of atoms of an element

= _ _ _ _ _ _ _ _ number of atoms

= _ _ _ _ _ _ _ _ g

One mole of molecules of an element/ a compound.

= _ _ _ _ _ _ _ _ number of molecules

= _ _ _ _ _ _ _ _ g

Can we make a general consolidation for one mole of any substance as follows?

1 mol = 6.022×10^{23} particles.

= 1 GAM

= 1 GMM

Avogadro's law and the mole concept

As you know, Avogadro's law relates the number of molecules of a gas with the volume of a gas at a definite pressure and temperature.

Write down the statement of Avogadro's law.

_ _

_ _

One mole of any gas contains 6.022×10^{23} molecules. Therefore at constant pressure and temperature their volumes should also be equal. This volume is called molar volume. At 0°C (273K) and normal atmospheric pressure (1 atm), the volume of one mole of any gas is 22.4 L.

Molar volume and STP

273 K (0 °C) and 1 atm pressure is called Standard Temperature & Pressure - STP.

At STP the volume occupied by 1 mole of a gas is 22.4 L. This is called molar volume at STP. On changing temperature or pressure the molar volume also changes.

At ordinary temperature (298 K) and pressure (1 atm) 1 mole of a gas occupies a volume of 24.46 L.

Let us consider one mole of a gas at STP.

At STP, for 1 mole of a gas

Number of molecules = _ _ _ _ _ _ _ _ _ _ _ _

Volume = _

For 2 moles of a gas at STP

Number of molecules = _ _ _ _ _ _ _ × _ _ _ _ _ _ _

Volume = _ _ _ _ _ _ _ × _ _ _ _ _ _ _

Including the aspects discussed above, we can elaborate the meaning of the mole.

1 mol = _ _ _ _ _ _ _ _ _ number of molecules

= _ _ _ _ _ _ _ _ _ g

= _ _ _ _ _ _ _ _ _ volume of a gas at STP.

When mole is expressed in terms of number of particles, or volume of gases at STP, the numerical values will be the same for any substance. But when it is considered in terms of masses you might

have observed that the numerical values change with a change in substances and type of particle.

Can you fill up the blanks in the following?

6.022×10^{23} numbers = _ _ _ _ _ _ _ mol

12.044×10^{23} numbers = _ _ _ _ _ _ _ mol

18.066×10^{23} numbers = _ _ _ _ _ _ _ mol

..... numbers = _ _ _ _ _ _ _ mol

x numbers = _ _ _ _ _ _ _ mol

Write down the equation you have obtained to findout the number of moles when the number of particles are given

$$\text{Number of moles} = \frac{\text{.....}}{\text{.....}}$$

If the mass in grams is given, how can you convert it into number of moles. See the examples given below.

In the case of 64 g of hydrogen gas (H_2), GAM = 1 g and GMM = 2 g.

$$\text{Number of moles of molecules} = \frac{64\,g}{2\,g} = 32$$

If it is 64 g of hydrogen atoms then the

$$\text{number of moles of atoms} = \frac{64\,g}{1\,g} = 64$$

What could be the reason for the answers to be different?

Now if we consider 64 g of oxygen molecules:

$$\text{Number of moles of molecules} = \frac{64\,g}{32\,g} = 2$$

(GMM of O_2 = 32 g)

Find the number of moles if it is 64 g of oxygen atoms.

$$\text{Number of moles of atoms} = \frac{64\,g}{16\,g} = 4$$

(The gram atomic mass of oxygen is 16 g)

What are the factors to be considered when a given mass is converted to number of moles?

- ----------
- ----------

To convert mass in grams into moles,

- In the case of atoms

$$\text{Number of moles} = \frac{\text{.....}}{\text{.....}}$$

- In the case of molecules

$$\text{Number of moles} = \frac{\text{.....}}{\text{.....}}$$

In this manner can you arrive at a relationship for converting volumes of gases at STP into number of moles?

When a certain volume of gas at STP is converted to moles

$$\text{Number of moles} = \frac{\text{.....}}{\text{.....}}$$

- Find the number of moles of molecules in 112 L CO_2 gas at STP.

  Volume at STP = 112 L

  Molar volume of gases at STP = 22.4 L

  $$\text{Number of moles} = \frac{112\,L}{22.4\,L} = 5$$

Find the number of moles in each of the following:

- 140 g Nitrogen gas (N_2)
- 140 g Nitrogen atom
- 85 g Ammonia
- 60.22×10^{23} CO_2 molecules

- 10000 water molecules
- 11.2 L SO_2 gas (at STP)

(Given: Atomic masses H = 1, N = 14, C = 12, O = 16, S = 32).

Similarly, once you know the number of moles, isn't it possible to find the mass in grams or the number of particles (atoms/ molecules), and also the volume at STP in the case of a gas?

If the number of particles is known

$$\text{Number of moles} = \frac{\text{Number of particles}}{6.022 \times 10^{23}}$$

$$\text{Number of particles} = \text{Number of moles} \times 6.022 \times 10^{23}$$

Similarly arrive at the relationships for finding the mass in grams of the substances and the volume of gases at STP.

Mass in grams

- In the case of molecules

  Mass in grams = _____×_____
- In the case of atoms

  Mass in grams = _____×_____

  Volume of a gas at STP

  = _____ × _____

★ 112 L NH_3 (ammonia gas) is taken at STP.

- Calculate the number of moles in it.
- How many molecules will be present in it?
- What will be the mass in gram of this amount of NH_3 gas ?

(Given : Atomic mass N = 14, H = 1)

★ In the given list which are those containing equal number of molecules?

Which are the ones containing equal number of atoms?

(a) 12.044×10^{23} molecules of H_2
(b) 16 g He
(c) 64 g O_2
(d) 11.2 L C_2H_6 at STP
(e) 68 g H_2O_2

Mole concept and balanced chemical equations

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

This is the balanced chemical equation for the combustion of methane gas in oxygen (air).

How many grams of oxygen will be required for the complete combustion of 160 g of methane? How many grams of CO_2 gas will be formed as a result of this reaction?

Can you find them using the mole concept?

1 CH_4 molecule +$2O_2$ molecules → 1CO_2 molecule + $2H_2O$ molecules. Isn't this the meaning of the given equation?

And if we take 10 CH_4 molecules?

10 CH_4 molecules + 20 O_2 molecules → 10 CO_2 molecules + 20 H_2O molecules

Is the equation given above correct?

True/ False

And for 6.022×10^{23} CH_4 molecules?

6.022×10^{23} CH_4 molecules + _____ O_2 molecules → _____ CO_2 molecules + _____ H_2O molecules.

Can't we interpret this as

1 mol CH_4 + 2 mol O_2 → 1 mol CO_2 + 2 mol H_2O?

What is the mass of 1 mol CH_4 in grams?
What is the mass of 1 mol O_2 in grams?

What about expressing the masses of chemical substances in the balanced equation in grams?

..... g CH_4 + ... g O_2 → ..... g CO_2 + ... g H_2O

What is the mass of O_2 required to react with 16 g CH_4 according to this equation? How many grams of CO_2 is formed?

- The amount of O_2 required to react with 16 g CH_4 = 64 g
- The amount of O_2 required to react with 1 g of CH_4 = $\frac{.....}{16}$ g
- The amount of O_2 required to react with 160 g CH_4 = ... × 160 g
- Like this can't you find the amount of CO_2 produced in the reaction?
- The amount of CO_2 produced by the combustion of 16 g CH_4 = ... g
- ----------
  = ... g
- ----------
  = ... g

When each gram of methane undergoes complete combustion, how many times of this will be the amount of CO_2 produced. How many grams of oxygen is used up? Can't you find it? Don't you think that the combustion of other fuels like petrol and cooking gas will also produce similar results? Would the quantity of CO_2 evolved be greater or less than this? Conduct a discussion choosing a good fuel such as LPG as example. The main component of LPG is C_4H_{10} (Butane).

Write the balanced equation for the combustion of this by discussing it with your teacher.

Should n't we take greater care while using fuels?

It is specified in the rules for industries that the chemical waste/chemicals produced by industries should be made harmless by allowing them to react with other chemicals before it is disposed of as an effluent.

For example if an industry produces sulphuric acid as a waste it can be neutralized by reacting it with slaked lime.

$$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$$

- Assume that a small scale rayon factory produces 4900 g H_2SO_4 per day as an effluent. How many grams of lime (slaked lime) will be required to neutralize this? The gram molecular mass of H_2SO_4 is 98 g and that of $Ca(OH)_2$ is 74 g.

Let us calculate.

The mass of $Ca(OH)_2$ required to neutralise 98 g of H_2SO_4 = 74 g

The mass of $Ca(OH)_2$ required to neutralise 1 g of H_2SO_4 = ...

The mass of $Ca(OH)_2$ required to neutralise 4900 g H_2SO_4 = ...

★ What will be the consequence if the factory uses less quantity of lime than this for the purpose?

Several chemicals including sulphuric acid are used as solutions for conducting chemical reactions. In such instances the amount of chemical substances is expressed in terms of the number of moles of solute present in a definite volume of the solution.

A solution containing one mole of solute in one litre of solution is called a one molar solution (or 1 M solution)

The gram molecular mass of sodium chloride (NaCl) is 58.5 g. Two students are trying to prepare a one molar solution (1 M solution) of this. Go through the activity done by these two students

Student 1: Took one litre water in a vessel and dissolved 58.5 g NaCl in it (Fig. 2.6).

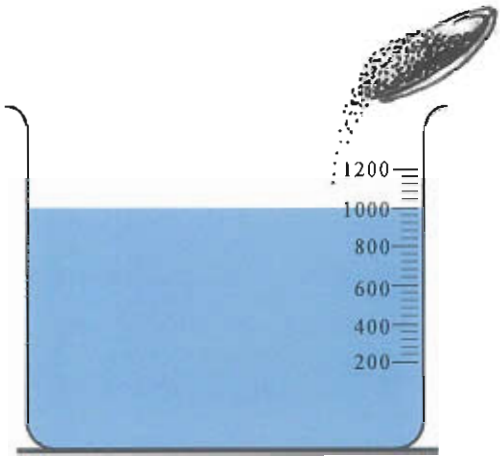


Fig. 2.6

Student 2: Took 58.5 g of NaCl in a vessel and dissolved it by adding small quantities of water until the volume became exactly one litre as shown in the graduated vessel.

In which of these will the total volume of the solution be exactly one litre? If so which is the correct method to prepare 1 M NaCl solution? Why?

How can we prepare 0.5 M NaCl solution?

Just as we interpreted balanced chemical equations in terms of masses, can't we also interpret them in terms of number of particles, and for gases in terms of their volumes?

What are the different levels at which such an interpretation can be put to use? What are the questions that we can seek an answer for?

Try to prepare a few questions showing the application of the mole concept and balanced chemical equations in relation to everyday life.

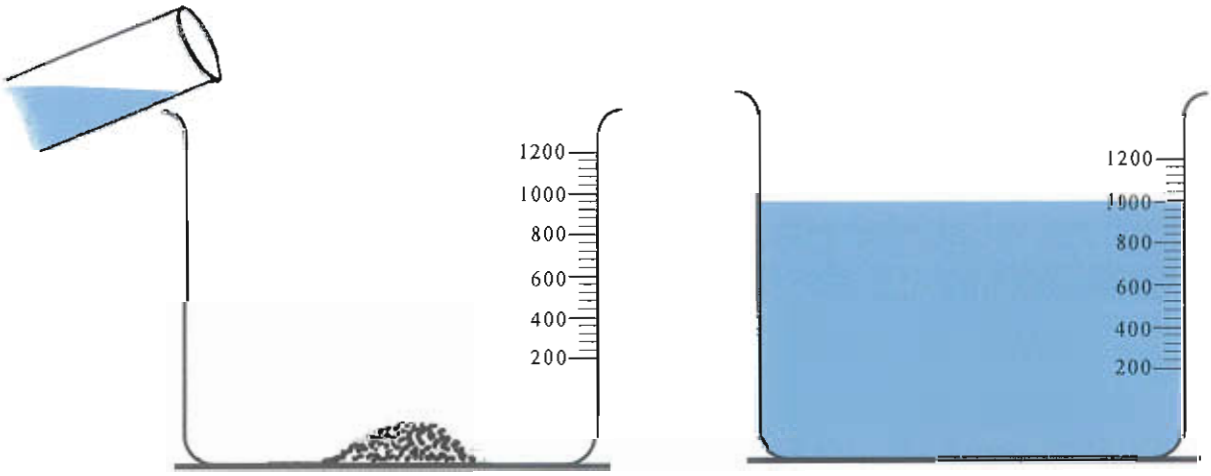


fig. 2.7

Follow up Activities

1. Manu tried three different methods to speed up the reaction between hydrochloric acid and zinc:
   - Increasing the concentration of the acid
   - Increasing the pressure
   - Using powdered zinc

   (a) Which are the methods that would have been successful?

   (b) What would be the reason for the increase of speed in the case of each of the successful methods?

   (c) Give examples from everyday life for such instances.

2. Some equipments and chemicals are mentioned below.

   Test-tubes, beaker, water, magnesium ribbon, calcium carbonate, hydrochloric acid, copper sulphate, gold.

   (a) Which are the materials that you would select to organise an experiment to show the increase of speed of a chemical reaction with increase of concentration?

   (b) Write the procedure for the experiment.

   (c). What explanation can you give for the increase in the speed of the reaction?

3. Some samples are given.

   P. 22.4 L NH_3 (at STP)

   Q. 22 g CO_2

   R. 64 g SO_2

   S. 4 g H_2

   T. 6.022×10^{23} C atoms

   U. 117 g NaCl

   V. 3.011×10^{23} oxygen molecules.

   (a) Group the samples containing the same number of moles.

   (b) Which are the ones containing the same number of molecules?

   (c) Group the samples having same total number of atoms.

   (d) Which are the substances having the same volume at STP? Why?

   (e) Find the mass of P in grams.

4. A cylinder containing NH_3 gas at STP has a volume of 5600 mL.
   (a) How many moles of ammonia are present inside the cylinder?
   (b) What will be the mass of the gas in grams inside the cylinder?
   (c) How many molecules are there in this gas? What is the total number of atoms?

   (Hint : atomic masses N = 14, H = 1)

5. 40 g each of the gases H_2, He, CH_4 and CO_2 are taken at STP.
   (a) Find the number of molecules in each of these.
   (b) Find the volume of each of these and write in the ascending order.
   (Hint : atomic masses H = 1, He = 4, C = 12, O = 16)
   (c) If you find the total number of atoms in each case, would they be in the same order? Write down the order.

6. A room measures 2 m × 3 m × 2 m. Assume that this room is filled with oxygen (O_2) gas at atmospheric pressure and 0 °C.
   (a) What will be the volume of oxygen in litres?
   (b) How many grams of oxygen will be present in the room?
   (c) How many molecules will there be?

7. $2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$

   This is the balanced chemical equation for the reaction between butane and oxygen.
   (a) How many moles of oxygen is required for the complete combustion of 1 mole of butane?
   (b) What is the mass of CO_2 produced by the combustion of 1 mole of butane?
   (c) What is the amount of CO_2 produced on complete combustion of 100 g of butane?