CHAPTER 1

Matter and Its Composition - law of conservation of mass

LATEST SYLLABUS – SCOPE OF SYLLABUS – MATTER & ITS COMPOSITION – law of conservation of mass

Matter and its Composition: Law of conservation of mass

(i) Explanation of change of state of matter on the basis of Kinetic Theory of Matter.
Main Postulates of Kinetic Theory of Matter and explanation of change of state on the basis of Inter-particle space and Inter-particle attraction and collision.

(ii) Law of Conservation of Mass.
Statement and explanation with examples.

A. INTRODUCTION - To Chemistry

1. CHEMISTRY - A DEFINITION

Chemistry deals with the study of behaviour of – *matter*

Chemistry is concerned with the – Composition, structure and properties of matter and the phenomenon which occurs when different kinds of matter undergo changes.

2. CHEMISTRY - A BRIEF HISTORY

• **Around 400 B.C.**	**Matter** – its behaviour & nature were developed and conclusions drawn.
• **Fourth century B.C.**	**Aristotle & Plato** – put forth their element theory to resemble the nature of matter.
• **Before 16th century**	**Alchemy** – A new school of Chemistry was developed where – *alchemists* – were inspired by the changes in matter.
MODERN CHEMISTRY	
• **In 1661**	**Robert Boyle** - studied the concepts of matter including elements & gases & their behaviour
• **In 1774**	**A. L. Lavoisier** - ushered in the quantitative era of Chemistry.
• **In 1807**	**John Dalton** - postulated his famous – ***atomic theory***.
• **17th & 18th century**	**Henry Cavendish, Humphry Davy, Joseph Priestley** – enhanced the developments in study of matter & Chemistry.
• **By end of 19th century**	**Atom** – Its divisibility into sub-atomic particles was established which laid the foundation to newer concepts in Chemistry.

3. CHEMISTRY - BASIC DIVISIONS

Chemistry is a broad science with basic divisions as a result of its diversity

• **Inorganic Chemistry**	A very wide branch which includes ***study of matter*** - elements and compounds ***except for those of carbon***.
• **Organic Chemistry**	The branch is devoted to the ***study of carbon*** & its numerous compounds.
• **Analytical Chemistry**	The branch deals with ***identification and determination of the composition of specimens of matter*** and for devising efficient analytical techniques and procedures for chemical reactions.
• **Physical Chemistry**	The branch is concerned with ***theoretical aspects of Chemistry***. Physics is used to explain various chemical phenomenon.
• **Biochemistry**	Deals with ***substances & chemical processes*** which occur in ***living matter***.

B. INTRODUCTION – To Matter

MATTER AND ITS COMPOSITION

- *DEFINITION OF MATTER –*

  Matter is defined as anything which –
  occupies space and *has mass* and *can be perceived by our senses.*
  Matter is classified into – living and non-living.

- *COMPOSITION OF MATTER –*

  Matter in any state is composed of small particles – molecules, atoms or ions.

- *CHARACTERISTICS OF MATTER –*

  Matter occupies space, which is called '*volume*'.
  Matter has *mass* and *weight*, the quantity of matter represents its – '*mass*'
  while the gravitational pull on matter, its – '*weight*'.
  Matter can be perceived by physical senses i.e. touch, sight, smell etc.
  Examples of matter – Living things - animals & plant kingdom. *Non-living things* - earth, water, air etc.

- *STATES OF MATTER*

  All matter exists in one of the three states - i.e. *solid, liquid* or *gaseous* [vapour] classified on the basis of difference in certain – *physical properties.*

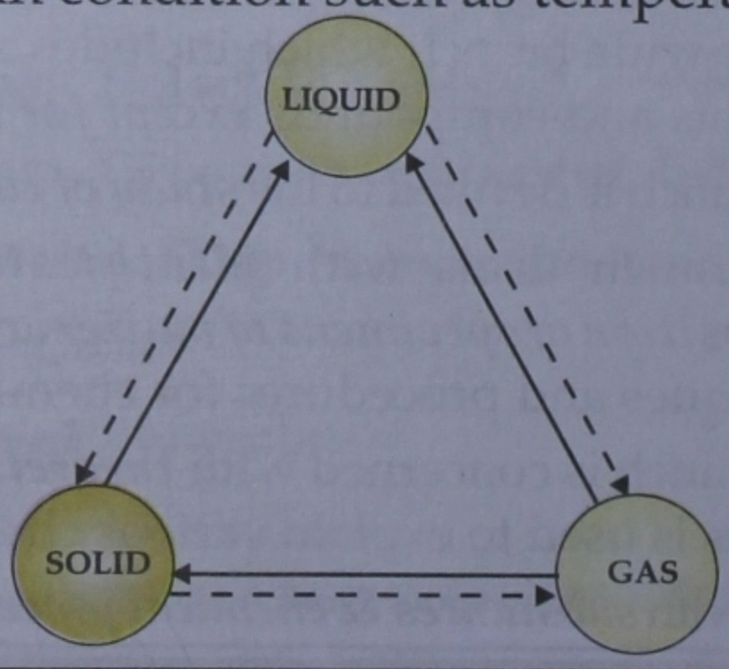
  Solids – Solids have a *definite* mass, volume & shape and are *highly rigid.*
  They *cannot flow,* have *high density* and are almost *incompressible*
  & have *any number of free surfaces.*

  Liquids – Liquids have a *definite* mass & volume but *no definite shape* and are *less rigid.*
  They *can flow* & take up the shape of the container in which they are stored.
  Liquids have comparatively *less density,* are very *slightly compressible*
  & have *one upper surface.*

  Gases – Gases have a *definite* mass but *no definite volume or shape,* are *not rigid* at all.
  They *can flow* and take up the shape and volume of the container in which they are stored.
  Gases have *least density,* are *highly compressible* and have *no free surfaces.*
  [***Vapour*** – is gaseous form under specific conditions but – *solid or liquid under ordinary conditions.*]

- *CHANGE OF STATE OF MATTER*

  Interconversion of matter involves –
  change of matter from one state to another and back to its original state.
  It is affected by changes in condition such as temperature, pressure etc.



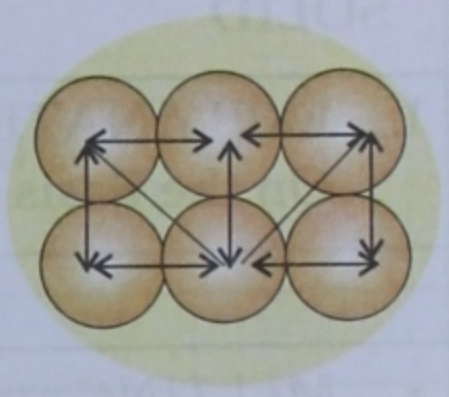
C. MAIN POSTULATES OF – KINETIC THEORY OF MATTER

I. MAIN POSTULATES OF – *KINETIC THEORY OF MATTER* – are summarized below

- *COMPOSITION OF MATTER*
  All matter in any state is composed of – small *particles* [molecules, atoms or ions].
- *INTER-PARTICLE SPACE*
  The particles are arranged – in a way such that *spaces or gaps* exist between them.
- *INTER-PARTICLE ATTRACTION*
  The particles – *attract* each other with a *force*.
  The inter- particle attraction – *decreases* with *increasing distance* and vice-versa.
- *ENERGY POSSESSED BY – PARTICLES OF MATTER*
  Kinetic energy – The particles are in continuous random motion and possess *kinetic energy*.
  The kinetic energy of the particles –
  increases on application of *heat* [thermal energy] and the particles move *more randomly*.
  Potential energy – Particles *interact* and possess *potential energy* also.

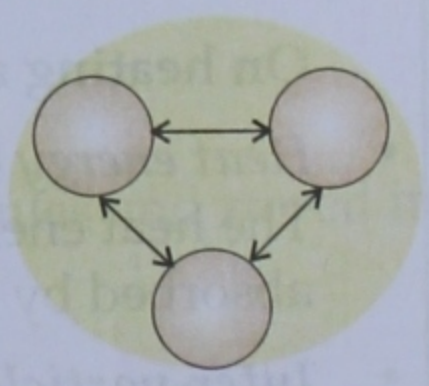
II. SOLIDS – Inter-particle space & Inter-particle attraction

- *INTER-PARTICLE SPACE*
  Particles are closely packed & can vibrate about their mean positions only.
  Hence solids do not flow, are rigid and have definite shape and volume.
  Inter-particle space between the particles is – ***minimum***.
- *INTER-PARTICLE ATTRACTION*
  Inter-particle attraction between the particles is – ***maximum***
- *ENERGY POSSESSED BY – PARTICLES OF MATTER*
  Kinetic energy of molecules in a solid is – *least*.



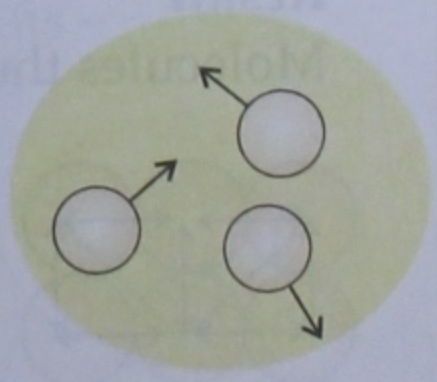
III. LIQUIDS – Inter-particle space & Inter-particle attraction

- *INTER-PARTICLE SPACE*
  Particles are comparatively less compact and the molecules are –
  free to move within the liquid, but do not leave the liquid.
  Hence liquids can flow, have a definite volume and are less rigid.
  Inter-particle space between the particles is – ***slightly more than solids***.
- *INTER-PARTICLE ATTRACTION*
  Inter-particle attraction is – ***less compared to solids***.
- *ENERGY POSSESSED BY – PARTICLES OF MATTER*
  Kinetic energy of molecules in a liquid is – *large*.

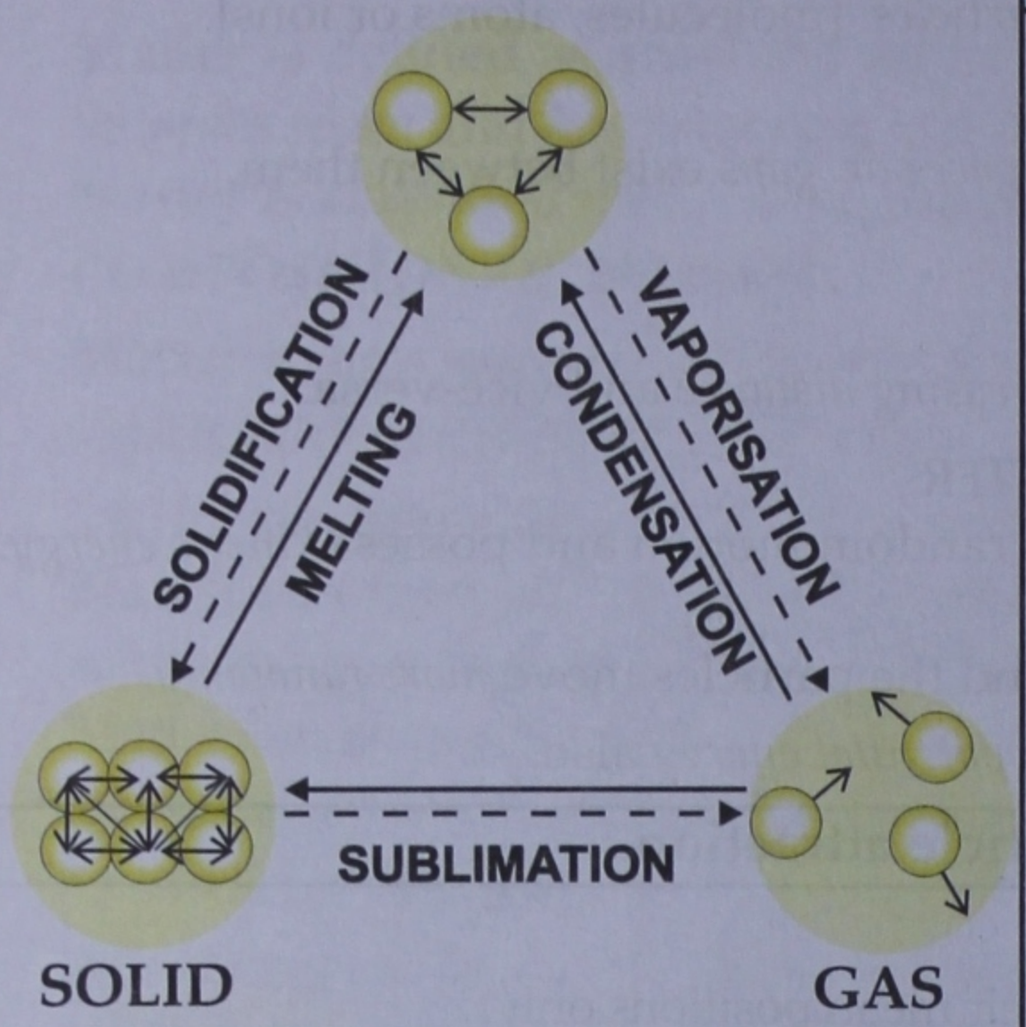


IV. GASES – Inter-particle space & Inter-particle attraction

- *INTER-PARTICLE SPACE*
  Particles [atoms/molecules]-show minimum compactness and
  particles are free to move in any direction, hence can fill any space.
  Gases have no definite shape or volume, can flow & are easily compressible.
  Inter-particle space between the particles is – ***comparatively very large***.
- *INTER-PARTICLE ATTRACTION*
  Inter-particle attraction is – ***negligible***.
- *ENERGY POSSESSED BY – PARTICLES OF MATTER*
  Kinetic energy of molecules in a gas is – ***very large***.



D. EXPLANATION OF CHANGE OF STATE OF MATTER – On the Basis of Kinetic Theory of Matter



CHANGE OF STATE OF MATTER			*THE TERM*
SOLID	→	LIQUID	Melting
LIQUID	→	SOLID	Solidification
LIQUID	→	GAS	Vaporisation
GAS	→	LIQUID	Condensation
SOLID	⇌	GAS [VAPOUR]	Sublimation

I. EXPLANATION OF CHANGE OF STATE OF MATTER – On the Basis of Kinetic Theory of Matter

SOLID state to – *LIQUID* state

- ***MELTING***

  Process of change from –
  solid state to a liquid state at a particular temperature is called *melting*.

- ***EXPLANATION ON BASIS OF – KINETIC THEORY***

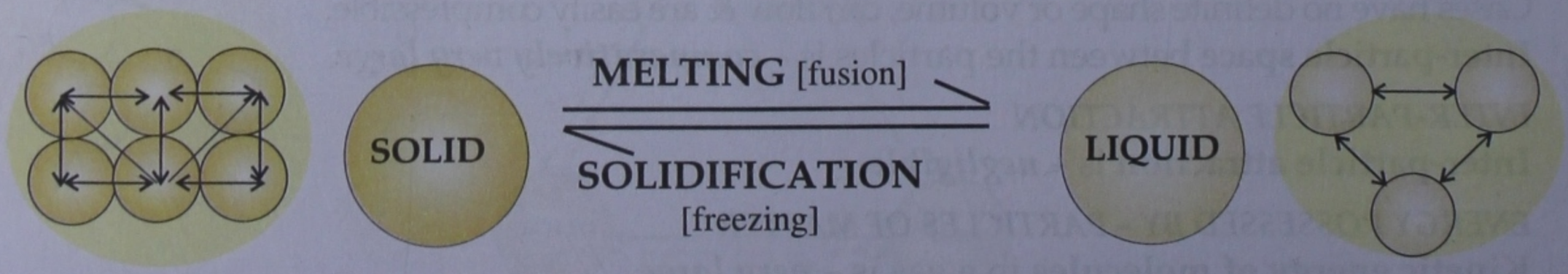
  On heating a solid – [at its melting point]

- ***Heat energy - stored as potential energy***
  The heat energy supplied to the solid is –
  absorbed by its molecules and stored in the form of potential energy.

- ***Inter-particle space – increases***
  The stored potential energy – increases the inter-particle space.

- ***Inter-particle attraction – decreases***
  The force of attraction between the particles – *decreases*.

- ***Result***
  Molecules thus become free & the *solid* starts changing into the – ***liquid state***.



D. EXPLANATION OF CHANGE OF STATE OF MATTER – [Contd.]
On the Basis of Kinetic Theory of Matter

LIQUID state to – _SOLID_ state

- ***SOLIDIFICATION [Freezing]***

  Process of change from –
  Liquid state to solid state at a particular temperature is called – *freezing* or *solidification*.

- ***EXPLANATION ON BASIS OF – KINETIC THEORY***

  On cooling a liquid [at its freezing point]

- ***Potential energy released - in form of heat energy.***

  On cooling a liquid the stored potential energy in the molecules is released as – heat energy.

- ***Inter-particle space – decreases***

  The released potential energy causes the inter-particle space to – *decrease*.

- ***Inter-particle attraction – increases***

  The force of attraction between the particles – *increases*.

- ***Result***

  Molecules are hence not in a position to be free or migrate and the – liquid starts changing into the – ***solid state***.

LIQUID state to – _GASEOUS state_

- **VAPORISATION**

  Process of change from –
  Liquid state to a gaseous [vapour] state is called – *vaporisation*.

- ***EXPLANATION ON BASIS OF – KINETIC THEORY***

  On heating a liquid [at its boiling point]

- ***Heat energy absorbed - stored as potential energy.***

  The heat energy supplied to the liquid is absorbed by its molecules and stored in the form of – potential energy.

- ***Inter-particle space increases***

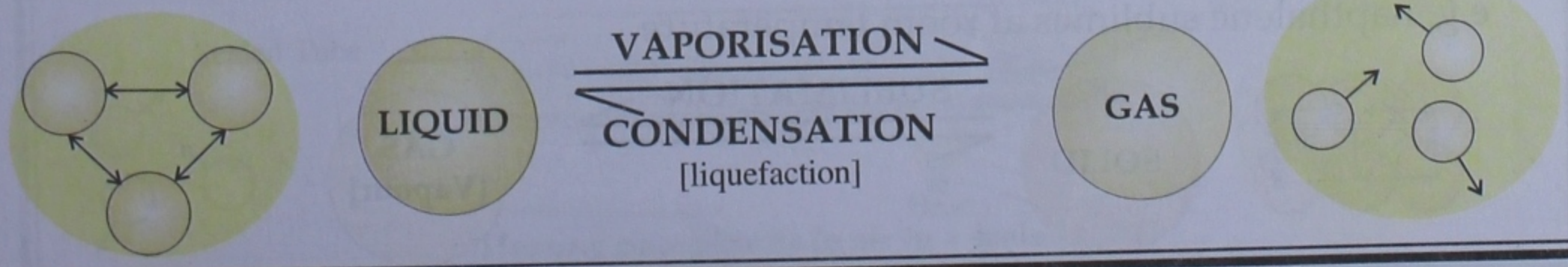
  The stored potential energy – *increases* the inter-particle space.

- ***Inter-particle attraction decreases to negligible***

  The force of attraction decreases drastically till it becomes – *almost negligible*.

- ***Result***

  The molecules thus become almost completely free and escape as – *gas* [or vapour] since they cannot remain in liquid state.



D. EXPLANATION OF CHANGE OF STATE OF MATTER – [Contd.]
On the Basis of Kinetic Theory of Matter

GASEOUS state to – *LIQUID* state

- **CONDENSATION [liquefaction]**

  Process of change from –
  gaseous state to liquid state without any fall in temperature is called –
  liquefaction or *condensation*.
- ***EXPLANATION ON BASIS OF – KINETIC THEORY***

  On Cooling a Gas
- ***Potential energy released - in the form of heat energy.***

  On cooling the gas molecules lose their potential energy in the form of heat energy.
- ***Inter-particle space decreases to a great extent***

  The released potential energy causes a – *decrease* in the inter-particle space.
- ***Inter-particle attraction – increases***

  Force of attraction between the particles or molecules – *increases*.
- ***Result*** – Molecules come very close and hence are not free to migrate and – the gaseous state changes into the – ***liquid state***.

SOLID state to – *GASEOUS [vapour] state*

- **SUBLIMATION**

  The process due to which a *solid directly changes to gaseous state* [vapour state] and on cooling directly changes back to solid state, without changing into liquid state. The gaseous or vapour form is called – **sublime**.

  The solid state formed from gaseous state on cooling is called – **sublimate**.
- ***EXPLANATION ON BASIS OF – KINETIC THEORY***

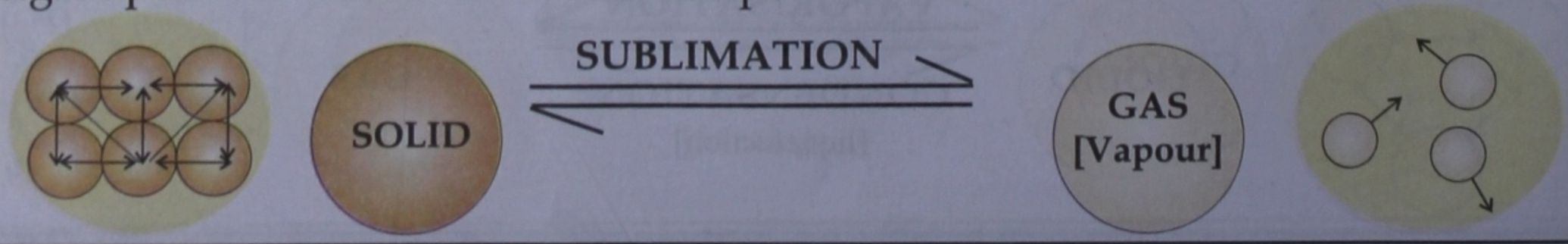
  On heating a sublimable solid [e.g. ammonium chloride, iodine]
- ***Inter-particle attraction is – low***

  Sublimable solids have very little force of attraction between their molecules – and have high potential energy stored in their molecules.
- ***On heating a sublimable solid the inter-particle attraction is – overcome.***

  On heating, the inter-particle attraction is overcome and the molecules break away from other molecules and escape from the surface of the solid in the form of vapour.

  Conversely on cooling – the gaseous state changes back to the solid state [sublimate].
- ***Sublimation in the absence of heat***

  Sublimation can take place in absence of heat
  e.g. napthalene sublimes at room temperature.



E. LAW OF CONSERVATION OF MASS

INTRODUCTION

John Dalton

- Proposed in his theory of the atom that atoms can –
  neither be created nor destroyed, but change from one form to another.
- Hence, matter too which is made up of atoms can be –
  neither created nor destroyed.

Lavoisier [1789]

- Formulated the law on basis of experimental evidence –
- He heated tin with air in a closed vessel and found that –
  the ***total mass*** of tin and air before the chemical change –
  remained unaltered even after the chemical change producing tin oxide –
  provided the temperature remained constant.
  Hence, before and after the experiment – the mass remained the same.

LAW OF CONSERVATION OF MASS - Statement

**"In any chemical reaction, the total mass of the reacting substances –
is equal to the total mass of the products of the reaction –
provided masses, are measured under similar conditions."**

EXPLANATION

- If A & B react to form C & D then according to –
  Law of Conservation of Mass

Mass of A + Mass of B = Mass of C + Mass of D

Example:
In formation of Iron [II] sulphide - by heating iron and sulphur.
56 parts of Fe & 32 parts of sulphur chemically combine to form – 88 parts of FeS.

Mass of iron	+	*Mass of sulphur*	=	*Mass of iron [II] sulphide*
56	+	32	=	88

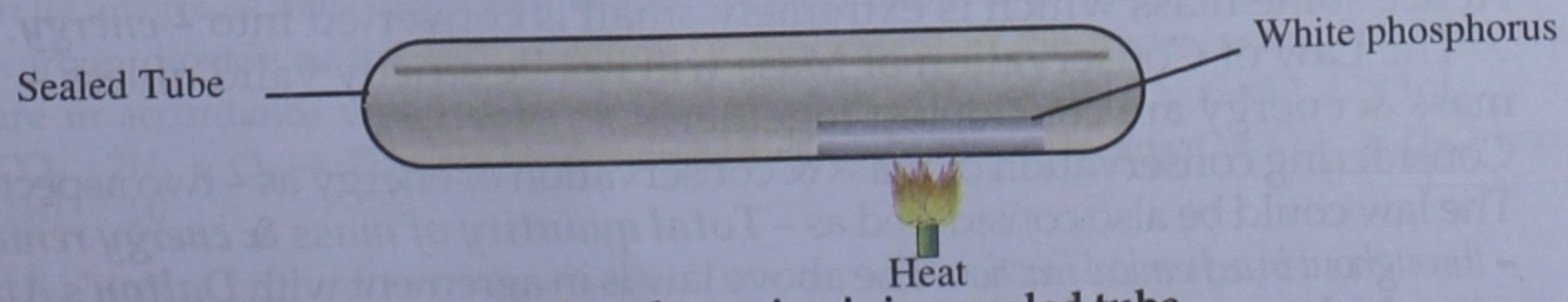
EXAMPLES - Experiments

The law of conservation of mass may be verified by – simple experiments

EXPERIMENT – 1

- A sealed tube containing phosphorus was weighed and –
  heated carefully to initiate complete burning of phosphorus.
- When the reaction was completed, the tube was cooled & re-weighed.

Conclusion : ***No change in weight was detected before and after the experiment.***



Heating phosphorus in air in a sealed tube

E. LAW OF CONSERVATION OF MASS - [Contd.]

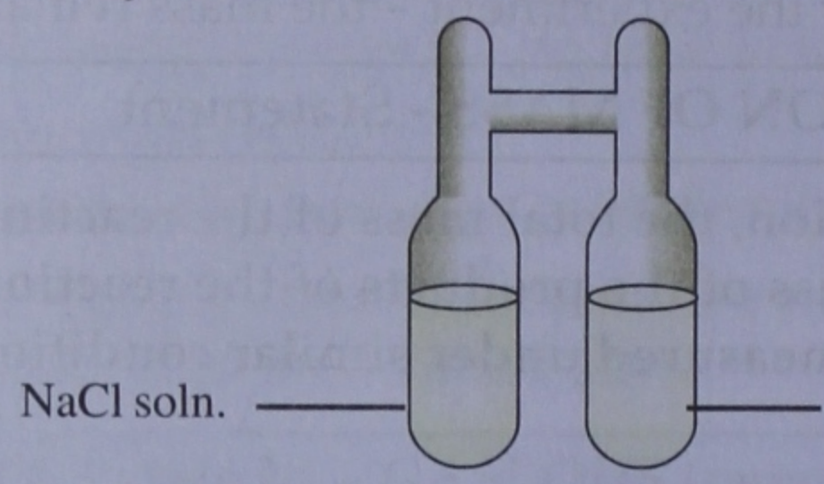
EXPERIMENT – 2

- *Landolt* studied – *Law of Conservation of Mass* – in case of a double decomposition reaction.
- Two solutions of – a] *sodium chloride* and b] *silver nitrate* were taken in – two limbs of a U-shaped tube and the – *limbs sealed*.
- The tube was then weighed and then tilted to – *mix the solutions*.
- *Sodium chloride* reacts with *silver nitrate* and a – precipitate of silver chloride is formed. The tube is then – *re-weighed*.

Conclusion : ***The weight before and after the experiment remained the same.***

$$\underset{[23+35.5]}{NaCl} + \underset{[108+14+48]}{AgNO_3} \rightarrow \underset{[108+35.5]}{AgCl\downarrow} + \underset{[23+14+48]}{NaNO_3}$$

$$\overbrace{\text{Total mass of reactants}}^{228.5} = \overbrace{\text{Total mass of products}}^{228.5}$$



Landolt's Experiment

Example – 0.58 g. of NaCl is dissolved in 250 g. of water. Similarly 1.71 g. of $AgNO_3$ is dissolved in 250 g. of water. The two solutions are mixed & the products formed are 1.44 g. of AgCl & 0.85 g. of $NaNO_3$. Show that the results are in accordance with the Law of Conservation of Mass.

Total mass before chemical change

Mass of NaCl [0.58 g.] + Mass of $AgNO_3$ [1.71 g.] + Mass of water [500 g.] = 502.290 g.

Total mass after chemical change

Mass of AgCl [1.44 g.] + Mass of $NaNO_3$ [0.85 g.] + Mass of water [500 g.] = 502.290 g.

Total Mass of reactants = Total Mass of products [in accordance with Law of Conservation of Mass]

OTHER EXPERIMENTS - with different solutions using above apparatus.

- ***Solutions of lead acetate & sodium sulphate were mixed***

  $Pb(CH_3COO)_2 + Na_2SO_4 \rightarrow PbSO_4\downarrow + 2CH_3COONa$

- ***Solutions of iron [II] sulphate & silver sulphate were mixed***

  $2FeSO_4 + Ag_2SO_4 \rightarrow 2Ag\downarrow + Fe_2(SO_4)_3$

Conclusion : ***In a chemical change matter is neither crated nor destroyed –*** *but there is simple transformation of material substances.*

Hence, Law of Conservation of Mass is also called – ***Law of Conservation of Matter.***

LIMITATIONS -

- During chemical reactions, energy is evolved in the form of – ***heat, light*** etc. It is the chemical energy stored up in the reactants which is released.
- Hence some mass which is extremely small is converted into – ***energy***. ∴ The Law of Conservation of Mass will not be strictly valid unless – mass & energy are considered together.
- Considering conservation of mass & conservation of energy as – two aspects of one law. The law could be also considered as – ***Total quantity of mass & energy remain constant*** – *throughout in a chemical reaction.* The above law is in agrement with ***Dalton's Atomic Theory*** – in which atoms retain their individuality & are – *not created* or *destroyed*.

For additional questions on **Chp. 1** – Refer
'OBJECTIVE WORKBOOK FOR SIMPLIFIED I C S E CHEMISTRY' FOR STD. IX BY DR. VIRAF J. DALAL
[A Supplementary work book for "Simplified I. C. S. E. Chemistry for Std. IX"]

Questions

1994

1. Name a common substance which exists in all the three states of matter.

1995 [discontinued]

Additional Questions

1. Explain the meaning of the term 'matter'. What are its characteristics. How do the three states of matter differ from each other. What is meant by the term 'change of state of matter'.
2. State the main postulates of the kinetic theory with reference to –
   a] Composition of matter b] Inter-particle space
   c] Inter-particle attraction d] Energy possessed by particles of matter.
3. How do solids, liquids and gases differ with reference to inter-particle space and inter-particle attraction and collision.
4. With reference to change of state of matter, explain the meaning of the terms –
   a] Melting b] Solidification c] Vaporisation d] Condensation e] Sublimation
5. Explain in brief each of the following change of state of matter – on the basis of kinetic theory of matter with special reference – to the energy possessed by the particles of matter, inter-particle space and inter-particle attraction and collision.
   a] Solid state to liquid state b] Liquid state to solid state
   c] Liquid state to gaseous state d] Gaseous state to liquid state
   e] Solid state to gaseous [vapour] state
6. State the Law of Conservation of Mass. If 'A' & 'B' react to form 'C' & 'D' what would be the mass of 'C' & 'D' in terms of the mass of the reactants under similar conditions.
7. Describe with the help of a diagram – Landolt's Experiment to illustrate the Law of Conservation of Mass. Give two other examples or experimental proofs to illustrate the law.
8. During chemical reactions energy is generally evolved in the form of heat, light etc. From where is this energy obtained. Is this energy taken into consideration when considering the Law of Conservation of Mass.
9. Thermal decomposition of calcium carbonate [$CaCO_3$] gives the respective metallic oxide & carbon dioxide gas only. If 16.8 g. of calcium carbonate gave 8 g.of the respective metallic oxide & 8.8 g. of carbon dioxide respectively, then does the reaction observation agree with the – Law of Conservation of Mass. Explain.
10. A hydrocarbon *[i.e. compound containing carbon & hydrogen only]* burns in air *[oxygen]* giving 0.36 g. water vapour & 0.44 g. of carbon dioxide as the only products. If the weight of the hydrocarbon is 0.16 g., show that the results are in accordance with – Law of Conservation of Mass. [H=1, C=12, O=16]
    [$\underset{[12]}{C} + O_2 \rightarrow \underset{[44]}{CO_2}$; $2\underset{[4]}{H_2} + O_2 \rightarrow 2\underset{[36]}{H_2O}$] *[Calculate the total mass of carbon & hydrogen in CO_2 & H_2O respectively.]*

Unit Test Paper 1 — Matter and its Composition

30 marks

Q.1 Fill in the blanks with the correct word from the words in brackets to complete each sentence. [5]

1. Change of state of matter is _____ [affected/not affected] by changes in condition such as temperature and pressure.
2. As per kinetic theory of matter, all matter in any state is composed of _____ [molecules/atoms or ions/molecules, atoms or ions].
3. The inter-particle attractive force ___ [increases/decreases] with increasing distance between particles.
4. The particles are in continuous random motion and possess kinetic energy which _____ [increases/decreases] on application of heat.
5. Forces of attraction of particles of matter in gases is _____ [large/negligible].

Q.2 Give reasons for the following. [5]

1. Solids, liquids and gases are considered as matter, but light is not.
2. On heating a solid at its melting point the inter-particle space increases.
3. On heating a liquid at its boiling point, heat energy is converted to potential energy.
4. On heating a sublimable solid the inter-particle attraction is overcome.
5. When a change of state of matter takes place from gaseous state to liquid state, the inter-particle space decreases to a great extent.

Q.3 Select the correct word from the words in bracket to complete each statement. [5]

1. The quantity of matter represents its _____, while the gravitational pull its _____ [weight/mass]
2. During change of state from liquid to gaseous state on heating a liquid at its boiling point, the heat energy absorbed is stored as _____ [kinetic / potential] energy.
3. Solidification is also termed as _____ [fusion/freezing].
4. The kinetic energy of molecules in a solid is _____ [low/very large].
5. In ammonium chloride, the inter-particle attraction is _____ [high/low].

Q.4 With reference to the Law of Conservation of Mass – Give reasons for the following. [5]

1. The Law of Conservation of Mass is also known as the – Law of Indestructibility of matter.
2. The Law of Conservation of Mass will not be strictly valid unless mass & energy are considered together.
3. When sodium chloride solution reacts with silver nitrate solution , the total number of atoms and their mass, before and after the chemical change remains unaltered.
4. When solutions of silver nitrate [$AgNO_3$] and potassium chromate [K_2CrO_4] are mixed together, the mass of potassium nitrate [KNO_3] and silver chromate [Ag_2CrO_4] formed, is equal to the original mass of the reactants only if the masses are measured under similar conditions.
5. The Law of Conservation of Mass is in agreement with Dalton's Atomic Theory.

Q.5 Fill in the blanks given below with the words 'increase/s', 'decrease/s' or 'remains constant /the same' in each case: [5]

1. During solidification or freezing, the inter-particle attraction _____.
2. A sealed tube containing phosphorus was weighed and heated carefully. After completion of the reaction, the tube was re-weighed under similar conditions. The weight of the tube now _____.
3. Total quantity of mass and energy together _____ throughout in a chemical reaction.
4. Change from gaseous state to liquid state results due to _____ in inter-particle space.
5. In the formation of Iron [II] sulphide, by heating iron and sulphur, the mass of iron [II] sulphide _____ when compared with the total mass of iron and sulphur heated.