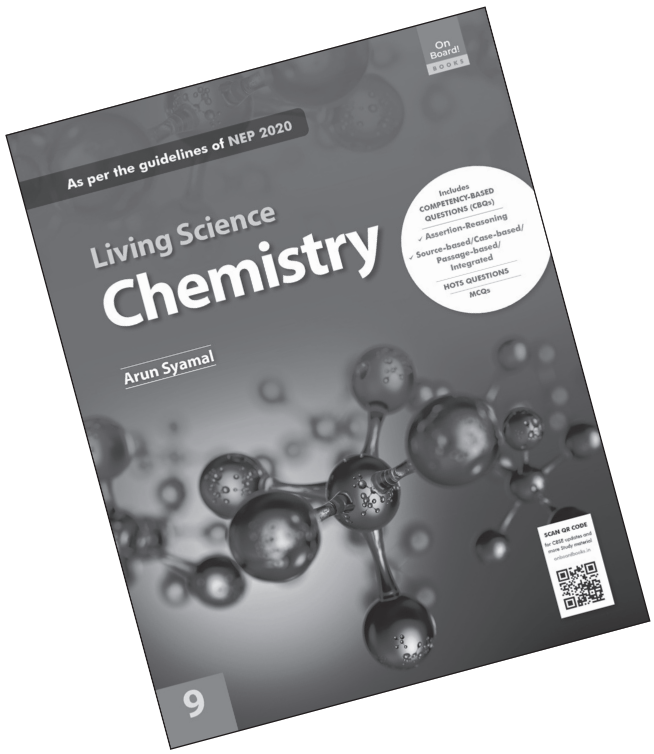
# TEACHER'S HANDBOOK

## CBSE Living Science
## CHEMISTRY
### Book 9




On Board! BOOKS

An imprint of Ratna Sagar P. Ltd.

# Contents

## CHAPTER – 1

## MATTER IN OUR SURROUNDINGS

**P. 13 Check Your Progress 1**

1. Refer Activity 1 from page 8 of the textbook.
2. When a purple-coloured crystal of potassium permanganate is dissolved in water it breaks down further into smaller particles that occupy the space between the molecules of water, imparting a purple colour to the water.
3. The intermixing of particles of two or more different substances on their own is called diffusion. For example, the fragrance of perfumes can be felt from a distance because of diffusion of vapours of perfumes in the air.
4. The smallest particle of a matter which is capable of independent existence and which exhibits the properties of matter is called molecule of that matter. The diameter of the molecules of matter, in general, is of the order of $10^{-9}$ m.
5. Refer Activity 4 from page 9 of the textbook.
6. The characteristics of the particles of matter are:
   - **i.** They have space between them.
   - **ii.** The particles of matter are continuously moving.
   - **iii.** The particles of matter are very small.
   - **iv.** The particles of matter attract each other.

**P. 27 Check Your Progress 2**

1. **a.** liquid **b.** solid **c.** gas
2. The diameter of the molecules of matter, in general, is of the order of $10^{-9}$ m.
3. Examples of diffusion:
   - **i.** The aroma of lit incense stick can be felt from a distance because of the diffusion of smoke particles of incense in the air.
   - **ii.** The fragrance of perfumes can be felt from a distance because of diffusion of vapours of perfumes in the air.
4. **a.** maximum – solid

   **b.** minimum – gas
5. Due to the presence of strong intermolecular attractive forces, solids are rigid and incompressible while due to the presence of extremely weak intermolecular attractive forces, gases do not have a fixed shape and volume, so they can be compressed easily.
6. The conversion of one state of matter to another state of matter is called change of state. It can be brought about by varying the temperature and pressure.
7. With an increase in temperature, the kinetic energy of the particles of matter increases and the particles move faster.
8. Solids have definite shape due to the presence of strong interparticle attractive forces. Liquids do not have definite shape because of weaker interparticle attractive forces. Gases do not have definite shape due to the absence of any significant interparticle attractive forces. Solids and liquids have definite volume while gases do not have definite volume.
9. **a.** solid to liquid **b.** solid to gas
   **c.** solid to liquid **d.** liquid to gas
   **e.** solid to gas
10. **a.** The temperature at which a solid changes into a liquid is called the melting point of the solid.

    **b.** The temperature at which a liquid changes into a gas (or vapour) is called the boiling point of the liquid.
11. A substance does not exhibit any change in temperature at melting point and boiling point.
12. Latent heat of vaporisation of water is the amount of heat energy required to change unit mass of water into vapour at atmospheric pressure at the boiling point of water without any change of temperature. The value of latent heat of vaporisation of water is $22.6 \times 10^5$ J kg$^{-1}$.
13. The quantity of heat energy required to change unit mass of ice into water at atmospheric pressure at its melting point (0°C) without any change of temperature is called the latent heat of fusion of ice. The value of latent heat of fusion of ice is $3.35 \times 10^5$ J kg$^{-1}$.
14. Evaporation is an endothermic process. For example, drying of wet clothes in the sun.
15. **a.** The phenomenon of change of liquid into vapours at any temperature below the boiling point of the liquid is called evaporation.

    **b.** The process during which a solid on heating changes directly into vapour without passing through the intermediate liquid state is called sublimation.

    **c.** The process of change of state directly from a gas to a solid without changing into the liquid state is called deposition.

## P. 29 EXERCISES

### A. Objective Type Questions

**I. Choose the most appropriate answer.**

| | | | | |
|---|---|---|---|---|
| **1.** a | **2.** c | **3.** b | **4.** d | **5.** b |
| **6.** c | **7.** d | **8.** b | **9.** c | **10.** b |
| **11.** b | **12.** a | **13.** d | **14.** c | **15.** b |
| **16.** a | **17.** b | **18.** b | | |

**II. Write True or False.**

| | | | | |
|---|---|---|---|---|
| **1.** T | **2.** T | **3.** F | **4.** T | **5.** F |
| **6.** T | **7.** F | **8.** T | **9.** T | **10.** T |
| **11.** F | **12.** T | **13.** F | | |

**III. Fill in the blanks.**

| | |
|---|---|
| **1.** closely | **2.** less |
| **3.** evaporation | **4.** $3.35 \times 10^5$ J $kg^{-1}$ |
| **5.** whole | **6.** liquid, volume |
| **7.** boiling point | **8.** melting point |
| **9.** bulk | **10.** liquid, solid |
| **11.** sublimation | **12.** J $kg^{-1}$ |
| **13.** $10^{-9}$ m | **14.** gaseous |

**IV. Match the items in column A with the items in column B.**

| | | | | |
|---|---|---|---|---|
| **1.** e | **2.** d | **3.** b | **4.** c | **5.** a |

**V. Assertion–Reasoning Type Questions** CBQ

| | | | | |
|---|---|---|---|---|
| **1.** a | **2.** a | **3.** a | **4.** a | **5.** a |
| **6.** a | **7.** c | **8.** c | **9.** d | **10.** b |

**VI. Very Short Answer Type Questions**

**1.** Matter is defined as something which occupies space and possesses mass. For example, air, wood, water, etc.

**2.** Liquid

**3.** Solid, liquid and gas

**4.** gas < liquid < solid

**5.** Oxygen < water < sugar

**6.** Carbon dioxide < alcohol < water < sugar < sodium chloride

**7.** The smallest particle of a compound which is capable of independent existence and which exhibits the properties of the compound is called the molecule.

**8.** Matter: chair, air, almonds, lemon water and smell of perfume.

**9.** Steam produces more severe burns than boiling water. The water molecules in steam at 100°C have more energy than water at 100°C. This is because the water molecules in steam have extra heat energy in the form of latent heat of vaporisation.

**10.** Diffusion

**11.** Rigidity

**12.** Fluidity

**13.** Solid < liquid < gas

**14. a.** 293 – 273 = 20°C

**b.** 470 – 273 = 197°C

**15. a.** 25 + 273 = 298 K

**b.** 373 + 273 = 646 K

**16.** $10^{-9}$ m

**17.** In gases, the intermolecular spaces are very high. The molecules collide with each other as well as the walls of container. Hence, the gases exert pressure.

**18.** Alcohol will evaporate faster.

**19.** Water gets evaporated from the wet cloth and there occurs cooling due to evaporation. As a result, butter does not melt quickly.

**20.** Carbon monoxide < ethanoic acid < water < sugar < salt

**21.** Intermolecular forces and kinetic energy of the molecules.

**22.** The process in which vapours on cooling get converted into liquid is called condensation.

Sublimation is defined as a process during which a solid on heating, changes directly into the vapour phase without passing through the intermediate liquid state.

**23.** Surface area, temperature, humidity and speed of wind.

**24.** Ethanol evaporates faster than water because the intermolecular attractive forces between the particles in ethanol are weaker than those in water.

**25.** Water evaporates faster in a Petri dish than in the test tube because the Petri dish has a greater surface area. Hence, the rate of evaporation increases with an increase in surface area.

**26.** The human body undergoes cooling by perspiration even when surrounded by a temperature higher than the body temperature.

27. The fifth state of matter is called Bose-Einstein Condensate which is created by cooling a gas of very low density to super low temperatures. It was discovered by Albert Einstein and Satyendra Nath Bose.

28. When a solid changes into a liquid, the interparticle forces of attraction become weaker.

29. When a liquid is heated, the interparticle forces become weaker and molecules move freely.

30. In gases, there are large empty spaces between the molecules and the intermolecular attractive forces are also very weak.

31. Fluidity

## B. Short Answer Type-I Questions

1. If we dissolve some sugar/salt in 40–50 mL of water, the level of water does not rise. This proves that matter is particulate in nature.

2. Yes, because it regains its original shape on removing the force.

3. Yes, because it regains its original shape on relieving the stress.

4. Materials can be commonly classified into solids, liquids and gases. The examples of each group are as follows:

   Solids: Wood and iron

   Liquids: Milk and water

   Gases: Oxygen and hydrogen

5. In solids, the particles are fixed at their positions and cannot move about freely. In gases, due to large spaces between particles, diffusion is possible.

6. Drying of clothes and formation of rain.

7. **a.** The force of attraction between different particles of matter is called intermolecular force.

   **b.** The distance between different particles is called intermolecular space.

8. Evaporation causes cooling because the evaporating vapour carries away heat. The liquid particles absorb energy from the surrounding in order to regain the energy lost during the evaporation process and as a result the surrounding becomes cooler.

9. We should wear cotton clothes during summer. During summer, we sweat more because of the mechanism of our body which keeps us cool. Cotton, being a good absorber of water helps in absorbing the sweat and exposing it to the atmosphere for easy evaporation. This causes cooling and we feel comfortable.

10. It takes longer time for the evaporation process on a rainy day because humidity is higher on a rainy day. Hence, the rate of evaporation decreases with an increase in humidity.

## C. Short Answer Type-II Questions

1. Materials differ from each other in terms of shapes, sizes, colour, texture, etc. However, materials have some similarities as well on the basis of their physical state, rigidity, etc. For example, plastic and leather look different and they are used for different purposes, but both have some similarities as well.

2. **a.** The process during which a solid on heating changes directly into vapour without passing through the intermediate liquid state is called sublimation. For example, dry ice and iodine undergo sublimation on heating.

   **b.** The phenomenon of change of a liquid into vapours at any temperature below the boiling point of the liquid is called evaporation. For example, drying of clothes and formation of rain.

3. Clothes which absorb moisture keep us cool. The moisture absorption capacity of clothes made from cotton, terrycot, polyester and nylon decreases as follows:

   cotton > terrycot > polyster > nylon

   The moisture in such clothes absorbs heat from our body and as a result we feel cool. Cotton absorbs sweat from our body and exposes it to the atmosphere. This increases the rate of evaporation of sweat and makes us feel comfortable.

   The wet clothes absorb heat from our body and as a result we feel cool.

4. The matter around us is made up of particles. The characteristics of the particles of matter are as follows:

   **i.** Particles of matter are very small.

   **ii.** Particles of matter are continuously moving.

   **iii.** Particles of matter attract each other.

   **iv.** Particles of matter have space between them.

5. Water does not have a definite shape. Water has only one upper surface.

   The wood has a definite shape and definite volume. It is hard and cannot be deformed easily.

6. Because water is a liquid and ice cream is a solid, ice cream will absorb more heat from the surrounding. In other words, water possesses the additional latent heat of fusion. Hence, ice cream appears colder than water at the same temperature.

7. The temperature remains constant during melting and boiling because the energy gets used up in changing the state by overcoming the forces of attraction between the molecules.

   This heat is called the latent heat.

8. The energy of 1 kg of water at 0°C is $3.35 \times 10^5$ J, more than that of ice at the same temperature. In the process of fusion, 1 kg of ice at 0°C is able to withdraw from the surroundings $3.35 \times 10^5$ J more heat energy that 1 kg of water at the same temperature (0°C) could do. Hence, at 0°C, ice is more effective in cooling than the same quantity of water at the same temperature (0°C).

9. Latent heat of vaporisation of water is the amount of heat energy required to change unit mass of water into vapour at atmospheric pressure at the boiling point of water without any change of temperature. The value of latent heat of vaporisation of water is $22.6 \times 10^5$ J $kg^{-1}$. The energy of 1 kg of steam at 100 °C is $22.6 \times 10^5$ J, more than that of water at the same temperature (100 °C). This means that steam at 100 °C is a more effective heating agent than water at the same temperature (100 °C).

10. The phenomenon of change of liquid into vapours at any temperature below the boiling point of the liquid is called evaporation.

    Evaporation is an endothermic process. During evaporation, a liquid absorbs heat energy from any other body in contact with it or from the surroundings. For example, when wet clothes are dried in the sunlight, the water present in the wet clothes absorbs heat energy from sunlight and undergoes evaporation.

11. The heat supplied to the substance during melting and boiling is used up in changing the state by overcoming the intermolecular forces of attraction between the molecules and hence it does not cause a rise in temperature. Hence, temperature remains constant during the change of state.

12. Different forms of matter are interconvertible and it can be done by varying the temperature and pressure. Also, it can be noted that by decreasing or increasing the intermolecular distance, the states of matter can be changed from one state to another.

## D. Long Answer Type Questions

1. Anything that occupies space and has mass is called matter. All matter is made up of particles. These particles are very small in size, move continuously, attract each other and have spaces between them. Various activities can be performed to show that matter is particulate in nature.

   Refer Activities 1, 2 and 3 from pages 8 and 9 of the textbook.

2. Liquids and gases are called fluids, yet they differ from each other in many aspects. In liquids, the interparticle distances are smaller and interparticle forces are stronger than those in gases. Consequently, liquids show very low compressibility as compared to gases. Also, they have definite volume unlike gases.

3.

| Solid | Liquid | Gas |
|---|---|---|
| Solids have definite shape due to the presence of strong interparticle attractive forces. | Liquids do not have definite shape because of weaker interparticle attractive forces. | Gases do not have definite shape due to the absence of significant interparticle forces. |
| Solids have definite volume. | Liquids have definite volume. | Gases do not have definite volume. |
| Due to close-packed structure, solids are hard and have very low compressibility. | Liquids have low compressibility. Due to the presence of significant interparticle empty space in liquids, they are more compressible than solids. | Gases have high compressibility due to the presence of large interparticle empty space. |
| Solids possess high density. | Liquids are less dense than solids. | Gases possess very low density as compared to liquids and solids. |
| Due to the immobility of particles in solids, the particles do not diffuse into one another. | Liquids exhibit slow diffusion. | Gases undergo diffusion freely. |

4. **Rigidity:** Rigidity is the physical property of being stiff and resistant to bending. Solids are highly rigid. Liquids and gases are not rigid.

Thus, they can easily flow and bend.

**Compressibility:** Compressibility is the change in shape of a substance in response to a force applied. Solids cannot be compressed easily. Liquids show very less compressibility. Gases are highly compressible.

**Fluidity:** Fluidity is the ability to flow. Liquids and gases can flow. Thus, they are known as fluids.

**Filling a gas container:** Gases are highly compressible. Thus, large volumes of gases are compressed and stored in containers so that they are easier to store and transport.

**Shape:** Solids have definite shape and retain their shape till an outside force changes their shape. Liquids and gases do not have a definite shape. They take the shape of the container in which they are kept.

**Kinetic energy:** Kinetic energy is the energy possessed by objects by virtue of their motion. The greater the speed of motion, the larger is the kinetic energy. The particles of matter are continuously moving and possess kinetic energy. The motion of the particles is the maximum in gases and is the minimum in solids. Thus, the particles of gases have the maximum kinetic energy and the particles of solids have the minimum kinetic energy. The particles of liquid have the kinetic energy that is intermediate that of the solids and gases.

**Density:** Density refers to the amount of matter that is present per unit volume. Solids are known to have highest density and gases have lowest density. Liquids have a density that is intermediate that of the solids and liquids.

5. Evaporation depends upon the following four factors:

   i. **Surface area:** As evaporation is a surface phenomenon, it depends on the surface area. The escaping of particles from liquid state to vapour state depends on the extent of surface available to them. So, the rate of evaporation increases with surface area and decreases with decrease in surface area, i.e. it is directly proportional to the surface area.

   ii. **Temperature:** As we know, an increase in temperature increases the kinetic energy of more number of molecules, facilitating them to go into the vapour state. Thus, the rate of evaporation increases with temperature, i.e. rate of evaporation is directly proportional to temperature.

   iii. **Wind:** When speed of the wind increases, the rate of evaporation also increases.

   iv. **Humidity:** As we know, humidity means the amount of vapour present in the air. At a given temperature, air cannot hold more than a fixed amount of water vapour. So, the rate of evaporation decreases with increase in the humidity of air.

6. Sublimation is the process during which a solid on heating changes directly into vapour phase without passing through the intermediate liquid phase.

   **Experiment to show sublimation:** A mixture of sand and iodine are taken in a china dish and covered with a perforated asbestos sheet. A funnel is placed over it in inverted position. When the china dish is heated, the violet vapours of iodine pass through the funnel and they condense on the cooler parts of the funnel to form dark shiny crystals of iodine. Refer Figure 1.12 from page 19 of the textbook.

   Examples of subliming material from day to day life are camphor and naphthalene.

7. **a.** A - fusion

   B - condensation

   C - vaporisation

   D - solidification

   E - sublimation

   F - deposition

   **b.** Solid

   **c.** Vapour

   **d.** The gas will liquefy.

8. Refer Activity 12 from page 16 of the textbook.

9. On heating a solid, the kinetic energy of the particles increases and the particles vibrate with greater speed. The heat energy supplied is used up to overcome the forces of attraction between the particles and the solid is converted into liquid. On further increasing the temperature, the particles in the liquid gain more kinetic energy and a stage is reached when the particles gain

enough kinetic energy to escape out of the liquid to form gas.

Refer Activity 13 and Figure 1.11 from pages 17 and 18 of the textbook.

**10.** Water kept in an earthen pot undergoes slow evaporation through the fine pores present in the walls of the earthen pot. During evaporation, the water molecules at the outer surface of the earthen pot absorb heat energy equal to that of latent heat of vaporisation from water and earthen pot, and water is converted into the vapour state. The water vapour takes away with it the heat energy equivalent to the latent heat of vaporisation. As a result, the water inside the earthen pot becomes cool. Since the rate of evaporation increases with increase in temperature, this process works better in summer.

**11.** The intermolecular attractive forces are responsible for bringing the molecules of a matter closer while the motion of the molecules tends to move them away from each other. The physical state of a matter depends on the net effect of these two opposing factors. When the intermolecular attractive forces are very strong and kinetic energy is very small, the matter exists as a solid. When the intermolecular attractive forces are moderate and the kinetic energy is large enough for the molecules to move to-and-fro, the matter exists as a liquid. When the intermolecular attractive forces are negligible and the kinetic energy is very large, the matter exists as a gas.

**12.** The conversion of one state of matter to another state of matter is called change of state. It can be brought about by varying the temperature and pressure. In solids, liquids and gases, the intermolecular forces of attraction are strong, moderate and weak, respectively. On increasing the temperature (or heating), the speed of particles increases which results in change of state of matter. Also, on increasing the pressure, the particles of matter come closer and the distance between the particles decreases while the force of attraction between them increases. Hence, increase or decrease in pressure can change the state of matter. For example, gases can be liquefied by increasing pressure and decreasing temperature. Dry ice (solid $CO_2$) gets directly converted into gaseous $CO_2$ on decreasing pressure to one atmosphere. This is the reason why dry ice is stored under high pressure.

## E. Source-based / Case-based / Passage-based / Integrated Assessment Questions CBQ

**1.** **a.** ii. **b.** i. **c.** ii. **d.** iii. **e.** iii.

**2.** **a.** iii. **b.** ii. **c.** iii. **d.** i. **e.** i.

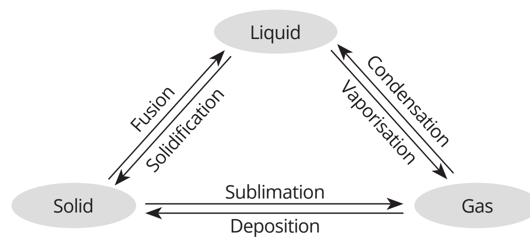
**3.** **a.** iv. **b.** ii. **c.** iv. **d.** ii. **e.** i.

**4.** **a.** iv. **b.** iv. **c.** iii. **d.** iv. **e.** i.

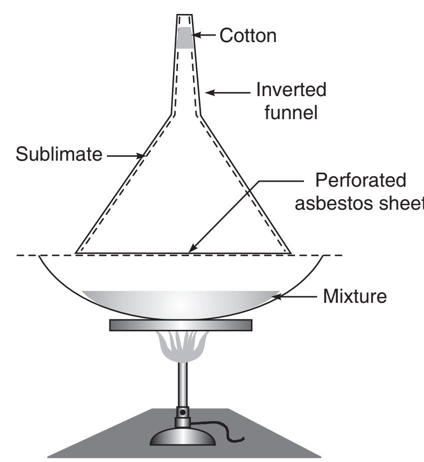
**5.** **a.** ii. **b.** i. **c.** iv. **d.** iii. **e.** iv.

## F. Diagrammatic Questions

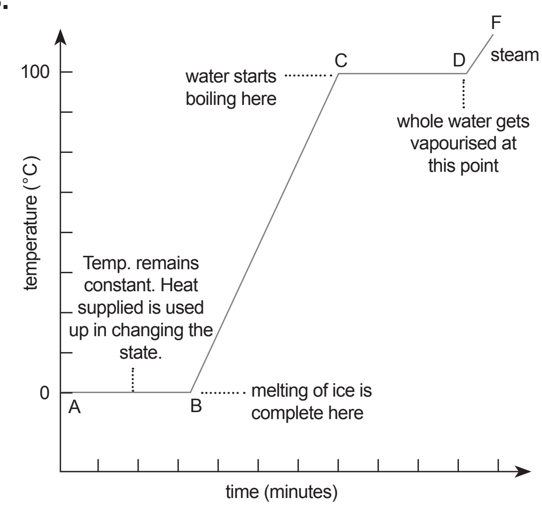
**1.**




**2.**

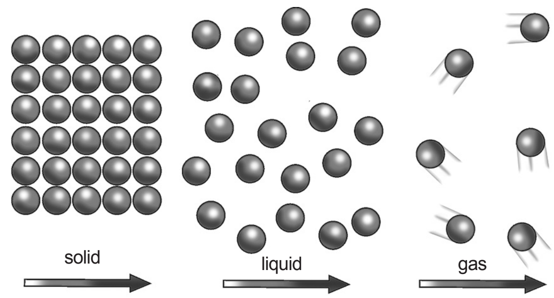



**3.**



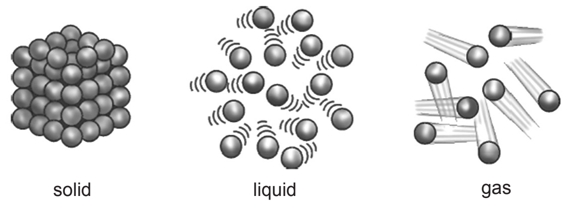

A graph to show the effect of temperature on physical states of water

4.



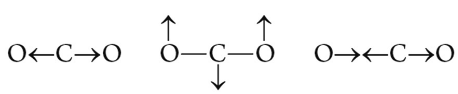

Effect of heat on the interparticle spacing in different physical states of matter

5.




Molecular models of solid, liquid and gas

6.




Vibratory motions of carbon dioxide molecule

## G. Higher Order Thinking Skills (HOTS) Questions

1. Air < exhaust from chimneys < cotton < water < honey < chalk < iron rod.
2. When both ice and water are present.
3. $22.6 \times 10^5$ J/kg. We get this value from the latent heat of vaporisation of water.
4. Nylon < polyester < terrycot < cotton.
5. The sprinkling of water on open ground or roof causes water to absorb energy from the open ground, roof and surrounding and get evaporated. The evaporation of water causes a cooling effect since it makes use of the very large latent heat of vaporisation.
6. The phenomenon is called diffusion. Ammonia is a strong colourless gas. When Amit spilled the bottle of ammonia, the particles of ammonia gas diffused with the particles of air. But, when the students immediately opened the doors and window of the laboratory, the pungent gas went out of the room after some time, and the students got relief.
7. No, at 95 °C, it will not boil and at 105 °C, it will be present in the form of steam.

## H. Value-Based Questions (Optional)

1. **a.** The temperature at which a liquid changes into a gas (or vapour) is called the boiling point.

   **b.** The heat supplied to the substance during boiling is used up in changing the state by overcoming the intermolecular forces of attraction between the molecules, hence it does not cause a rise in temperature. This is why, temperature remains constant during boiling.

   **c.** Difference between boiling and evaporation

| Boiling | Evaporation |
|---|---|
| It occurs fast. | It occurs slow. |
| Bubbles are formed during boiling. | No bubbles are formed during evaporation. |
| It occurs throughout the matter. | It takes place only from the exposed surface of the matter. |
| It occurs at a definite temperature – boiling point. | It occurs at all temperature. |
| Source of energy is needed for boiling. | Energy is supplied by surroundings during evaporation. |

   **d.** Care for others, scientific temperament, etc.

2. **a.** The process during which a solid on heating changes directly into vapour without passing through the intermediate liquid state is called sublimation.

   **b.** Solids which change directly into vapour phase without passing through the intermediate liquid state are called sublimable solids. For example, camphor and iodine.

   **c.** Helping others, sharing knowledge, etc.

3. **a.** Diffusion

   **b.** $NH_3$

   **c.** Alertness, scientific temperament, care for others, etc.

   **d.** Always be alert, handle all the chemicals carefully, etc.

**P. 37 TEST PAPER**

1. It means that by varying the temperature and pressure, one state of matter can be changed into another.

2. Solids have a fixed volume and a definite shape because the intermolecular forces are very strong in solids. Hence, the molecules are very closely packed and there is very little or no movement of molecules.

3. a. Intermixing of particles of two different types of matter on their own is known as diffusion.

   b. The phenomenon of change of a liquid into vapours at any temperature below the boiling point of the liquid is called evaporation.

   c. The forces between the molecules of matter are known as intermolecular forces.

   d. The spaces between molecules of matter are known as intermolecular spaces.

4. The factors governing the states of matter are the intermolecular attractive forces and the motion of molecules. The physical state of a matter depends on the net effect of these two factors. Intermolecular attractive forces keep the molecules together while kinetic energy tends to keep them apart.

5. The temperature remains constant during melting and boiling because the energy gets used up in changing the state by overcoming the forces of attraction between the molecules. This heat is called latent heat.

6. This is because at 273 K the ice particles possess less energy than the particles of water at the same temperature, the difference being the latent heat of fusion. Thus, ice can take more heat from the surrounding and cause more cooling.

7. It is the heat energy required to change 1 kg of water into steam at its boiling point and atmospheric pressure. Its value is $22.6 \times 10^5$ J/kg.

8. We should wear cotton clothes during summers. During summer, we sweat more because of the mechanism of our body which keeps us cool. We know that evaporation causes cooling. Cotton, being a good absorber of water helps in absorbing the sweat and exposing it to the atmosphere for easy evaporation. This causes cooling and we feel comfortable.

9. The rate of evaporation increases with the increase in temperature. Since the temperature in the sunny areas is higher than that in the shade, the wet clothes dry quicker in the sun than in the shade.

## CHAPTER – 2
## IS MATTER AROUND US PURE?

**P. 39-40 Check Your Progress 1**

1. **a.** heterogeneous **b.** homogeneous
**c.** homogeneous **d.** heterogeneous
**e.** homogeneous **f.** homogeneous
**g.** homogeneous **h.** homogeneous
**i.** homogeneous **j.** homogeneous
2. **a.** compound **b.** compound **c.** mixture
**d.** element **e.** mixture **f.** compound **g.** mixture
**h.** compound **i.** compound **j.** compound
3. Wax contains various hydrocarbons containing 22–30 carbon atoms and it does not have any definite composition.
4. Milk contains fats, proteins, carbohydrates, vitamins, etc. and milk does not have a definite composition.

**P. 48-49 Check Your Progress 2**

1. **a.** mixture **b.** element **c.** mixture **d.** mixture
**e.** mixture **f.** compound **g.** compound
**h.** element **i.** element **j.** mixture **k.** mixture
**l.** compound **m.** element **n.** mixture
2. Most abundant element – oxygen, next most abundant element – silicon
3. **a.** C, H **b.** C, H, O **c.** Ca, O, Cl **d.** Ca, C, O
**e.** Ca, Cl, H, O **f.** C **g.** C, H
4. Strongest interparticle attractive force – potassium chloride; weakest interparticle attractive force – carbon monoxide
5. neon, chromium, molybdenum
6. **a.** homogeneous **b.** heterogeneous
**c.** heterogeneous **d.** heterogeneous
**e.** heterogeneous **f.** heterogeneous
7. sugar
8. steam
9. **a.** elements **b.** Mercury **c.** compound
**d.** heterogeneous **e.** heterogeneous
**f.** homogeneous
10. **a.** T **b.** F **c.** T **d.** F **e.** F **f.** T

**P. 54 Check Your Progress 3**

1. 54.54% (*m*/*m*)
2. 29.16% (*m*/*m*)
3. 142.07 L
4. Gold: 75% (*m*/*m*); copper: 25% (*m*/*m*)
5. 8.00 % (*m*/*v*)
6. 9.6% (*v*/*v*)
7. 16.0% (*m*/*m*)
8. 3.35% (*m*/*m*)
9. 10% (*m*/*m*)
10. 15% (*m*/*m*)

**P. 59 Check Your Progress 4**

1. **a.** smoke **b.** whipped cream **c.** milk **d.** ruby
2. **c.** boot polish
3. **a.** and **d.**
4. Refer Table 2.7 from page 57 of the textbook.
5. **a.** $10^{-6}$, $10^{-9}$ **b.** colloidal, true **c.** $< 10^{-9}$ **d.** solid
**e.** fat, water
6. **a.** F **b.** F **c.** T **d.** T **e.** F

**P. 71-72 Check Your Progress 5**

1. The needs for separating the components of a mixture are:
   - **i.** To get a pure sample of a substance.
   - **ii.** To remove any undesirable or harmful components.
   - **iii.** To obtain the useful components of a mixture.
2. The process during which a solid on heating changes directly into vapour without passing through the intermediate liquid state is called sublimation. On cooling the vapour, a solid is obtained. The solid obtained by sublimation is called sublimate. For example, separation of ammonium chloride from a mixture containing sodium chloride and ammonium chloride.
3. Refer Activity 7 from page 61 of the textbook.
4. Refer Activity 8 from page 61 of the textbook.
5. Refer Activity 10 from page 62 of the textbook.
6. Refer Activity 11 from page 63 of the textbook.
7. A mixture of iron filings and sulphur can be separated by using a magnet. In many industries, the waste materials often contain scrap iron. Large electromagnets fitted to a crane are used to separate the scrap iron, which is then recycled by melting and is put to use again.
8. Separation of a mixture of propanone (boiling point 56.5 °C) and ethanol (boiling point 78 °C) can be done by simple distillation.
9. Refer Activity 15 from page 65 of the textbook.
10. Separation of a mixture of benzene (boiling point 80 °C) and toluene (boiling point 110 °C) can be done by fractional distillation.
11. Separation of a mixture containing kerosene oil and water can be done by using a separating funnel. Refer Activity 16 from page 66 of the textbook.

12. Refer Activity 18 from page 67 of the textbook.
13. Separating a mixture of sodium chloride, sand and iodine: Iodine sublimes on heating, sodium chloride is soluble in water and chalk is insoluble in water. These properties are made use of in the separation. Refer Figure 2.21 from page 69 of the textbook.
14. Gunpowder is a mixture of charcoal, sulphur and nitre (potassium nitrate). Potassium nitrate is soluble in water, sulphur is soluble in carbon disulphide and charcoal is insoluble in both the solvents. These properties are made use of in the separation. The flow chart of the process is shown in Figure 2.22 on page 69 of the textbook.
15. Sulphur is soluble in carbon disulphide, sodium chloride is soluble in water and carbon is insoluble in both the solvents. These properties are made use of in the separation. Refer Figure 2.23 from page 69 of the textbook.

**P. 74 Check Your Progress 6**

1. A physical change is reversible in nature.
2. A chemical change is irreversible in nature.
3. Refer Table 2.9 from page 73 of the textbook.

**P. 76 EXERCISES**

**A. Objective Type Questions**

**I. Choose the most appropriate answer.**

| | | | | |
|---|---|---|---|---|
| **1.** a | **2.** d | **3.** d | **4.** a | **5.** c |
| **6.** b | **7.** a | **8.** a | **9.** a | **10.** b |
| **11.** b | **12.** c | **13.** c | **14.** c | **15.** a |
| **16.** b | **17.** b | **18.** d | **19.** d | **20.** a |
| **21.** b | | | | |

**II. Write True or False.**

| | | | | |
|---|---|---|---|---|
| **1.** F | **2.** T | **3.** F | **4.** T | **5.** F |
| **6.** T | **7.** T | **8.** F | **9.** F | **10.** T |
| **11.** F | **12.** F | **13.** T | **14.** T | **15.** T |
| **16.** F | **17.** F | | | |

**III. Fill in the blanks.**

| | |
|---|---|
| **1.** compound | **2.** solution |
| **3.** fixed ratio | **4.** oxygen |
| **5.** petrol | **6.** < 25 °C |
| **7.** semi-metals | **8.** ninety-one |
| **9.** hydrogen | **10.** aerosol |
| **11.** Brownian motion | **12.** Tyndall effect |
| **13.** physical | **14.** retain |
| **15.** homogeneous | |

**IV. Match the items in column A with the items in column B.**

| | | | | |
|---|---|---|---|---|
| **1.** c | **2.** a | **3.** e | **4.** b | **5.** f |
| **6.** h | **7.** d | **8.** g | | |

**V. Assertion – Reasoning Type Questions** CBQ

| | | | | |
|---|---|---|---|---|
| **1.** a | **2.** a | **3.** c | **4.** d | **5.** c |
| **6.** c | **7.** c | **8.** d | **9.** c | **10.** d |

**VI. Very Short Answer Type Questions**

1. An element is the simplest form of a substance which cannot be split up into two or more simpler substances.

   A compound is a pure substance which is made up of two or more elements combined in a definite proportion by mass.
2. Lightest metal – lithium, heaviest metal – osmium.
3. Element having smallest atomic size – hydrogen.

   Element having largest atomic size – francium.
4. Characteristics of metals:
   - **i.** Metals are electropositive elements because they have the tendency to lose electrons.
   - **ii.** Metals are generally malleable (can be beaten into very thin sheets) and ductile (can be drawn into wires).
5. Non-metal having the lowest melting and boiling points – helium.

   Non-metal having the highest melting and boiling points – carbon.
6. Characteristics of a mixture:
   - **i.** The constituents of a mixture can be separated by simple physical methods such as filtration, sublimation, evaporation, magnetic effects, etc.
   - **ii.** A mixture does not have a fixed composition.
7. A pure substance is a substance which contains only one type of particles. These particles are similar to one another and cannot be separated into simpler particles by any physical process.
8. Gas forming liquid first: oxygen (boiling point – 183 °C); gas evaporating first: nitrogen (boiling point – 196 °C).
9. Nitrogen – 196 °C < argon – 186 °C < oxygen – 183 °C
10. Sublimation
11. Smog
12. Centrifugation

13. We can make a saturated solution unsaturated by heating it and by adding more solvent.
14. **a.** Components of gun powder: carbon, sulphur and potassium nitrate.
    **b.** Components of stainless steel: iron, carbon, nickel and chromium.
15. A solution is a homogeneous mixture of two or more substances.
16. Alloy
17. A heterogeneous mixture which contains very fine particles of solute (of the diameter > $10^{-6}$ m) dispersed throughout the solvent without getting dissolved in it is called suspension.
18. Properties of suspension:
    **i. Heterogeneous nature:** Suspension is heterogeneous in nature.
    **ii. Particle size:** The diameter of the particles in a suspension is > $10^{-6}$ m. The particles of suspension can be seen with naked eye.
19. 118, oganesson
20. Elements occur in nature in free state and combined state.
21. **Brownian movement:** The colloidal particles seem to move randomly in a zig-zag motion in all directions, when seen under a microscope. This zig-zag motion of colloidal particles is called as the Brownian motion. The phenomenon was first observed by Robert Brown and is named after him.
22. The phenomenon of scattering of light by colloidal particles as a result of which the path of the beam of light becomes visible is called the Tyndall effect.
23. The process of separation of the components of a mixture based on the difference in adsorption of different components on the surface of a solid is known as chromatography.
24. The chromatographic technique is applicable for separating the components having similar properties. The applications of chromatographic method are to separate:
    **i.** Components in a dye
    **ii.** Pigments from natural colours
25. Centrifugation (churning)
26. Evaporation
27. A homogeneous mixture is one which has a uniform composition throughout its mass.

    A heterogeneous mixture is one which does not have a uniform composition throughout its mass.
28. Characteristics of non-metals:
    **i.** Non-metals are electronegative elements and have a tendency to gain electrons.
    **ii.** Non-metals are poor conductor of heat and electricity.
29. Characteristics of a colloidal solution:
    **i. Filterability:** The size of colloidal particles is smaller than the size of pores of a filter paper. Therefore, the colloidal particles pass through a filter paper. It is not possible to separate the dispersed phase from the dispersion medium by ordinary filtration.
    **ii. Heterogeneity:** Colloidal solution is heterogeneous in nature.
30. Refer applications of colloids from pages 56 and 57 of the textbook.
31. 25 °C
32. **a.** Alloys
    **b.** Oxygen dissolved in water
33. Oxygen
34. A temporary change in which no new substance is formed and the composition of the substance is not altered, though certain specific physical properties may change, is called physical change.
35. A permanent change in which the original substance gives rise to one or more substances with different properties is called a chemical change.

### B. Short Answer Type–I Questions

1. Air is a mixture. It contains several gases. It shows the properties of its constituent gases.
2. Petrol is considered to be a mixture because it is a mixture of hydrocarbons.
3. Water is a compound because:
    **i.** It has a definite composition. In water, hydrogen and oxygen are always present in a fixed ratio.
    **ii.** Its constituent elements (i.e. hydrogen and oxygen) cannot be separated by simple physical methods.
4. The colloidal particles scatter light in all directions and path of light becomes visible.
5. Soap solution will scatter light because it is a colloid.
6. A mixture in which the diameter of the particles is intermediate between that of true solution and suspension is called colloidal solution.

**Dispersed phase:** The component of a colloidal solution which is present in smaller proportion and consists of particles of colloidal dimension ($10^{-9}$ to $10^{-6}$ m), constitute the dispersed phase.

**Dispersion medium:** The component of a colloidal solution which is present in excess and acts as a medium in which the solute particles are dispersed, forms the dispersion medium.

**7.** A solution in which no more solute can be dissolved at a particular temperature is called a saturated solution.

A solution in which more quantity of solute can be dissolved at a particular temperature is called an unsaturated solution.

A solution that contains more solute than required to prepare a saturated solution at any given temperature is called supersaturated solution.

**8.** **a.** blood – mixture
**b.** kerosene – mixture
**c.** petrol – mixture
**d.** water – compound
**e.** toothpaste – mixture

**9.** **a.** Vinegar – true solution
**b.** Muddy water – colloid
**c.** mist – colloid
**d.** Aluminium paint – colloid

**10.** **Homogeneous mixtures:**
**a.** soda water   **d.** vinegar
**e.** filtered tea

**Heterogeneous mixtures:**
**b.** wood   **c.** air
**f.** soil

**11.** Characteristics of a chemical compound:
**i.** A compound is composed of two or more elements combined together chemically in a fixed proportion by mass.
**ii.** A compound is homogeneous substance. This means that a compound has the same properties and composition throughout the mass.
**iii.** The properties of a compound are entirely different from those of its constituent elements.
**iv.** The formation of a compound is accompanied by the evolution or absorption of energy.

**12.**

| Compound | Mixture |
|---|---|
| The components of a compound do not retain their properties. | The components of a mixture retain their individual properties. |
| The components of a compound are always present in a definite proportion by mass. | A mixture does not have a definite composition. |

**13.** Chemically, matter is classified into either a pure substance or a mixture of two or more pure substances. A pure substance is further classified into an element and a compound.

**14.** Characteristics of a solution:
**i.** A solution is homogeneous in nature.
**ii.** The particles of solute in solution pass easily through a filter paper.
**iii.** The diameter of particles in a solution is less than $10^{-9}$ m.
**iv.** The particles of a solution are so small that they are not visible even through a high power microscope.

**15.** The reasons for separating the components of a mixture are:
**i.** To get a pure sample of a substance.
**ii.** To remove any undesirable or harmful components.

## C. Short Answer Type–II Questions

**1.** Compounds: Water, dry ice and sugar
Element: Silver
Mixtures: Sea water, petrol, brass and steel

**2.** Mixtures are of two types:
**i.** Homogeneous mixtures: For example, solution of sodium chloride in water, air, etc.
**ii.** Heterogeneous mixtures: For example, muddy water, smoke, oily water, etc.

**3.** Every liquid has a particular boiling point at 1 atmospheric pressure. If the given colourless liquid boils at exactly 100 °C, i.e. 373 K at 1 atmospheric pressure, then it is pure water. If the boiling point of the liquid is even slightly above 373 K, then it is contaminated.

**4.** Coal is considered as a mixture and not a pure substance because it contains many other elements other than carbon, such as hydrogen, sulphur, nitrogen, etc. Also, it does not have a fixed composition.

**5.** An element is the simplest form of a substance which cannot be split up into two or more simpler substances by any physical or chemical method. For example: oxygen, gold, etc.

A compound is a pure substance which is made up of two or more elements combined in a definite proportion by mass. For example: chalk, glucose, etc.

A mixture is that form of matter in which two or more pure substances (elements or compounds) are simply mixed together in any proportion by mass. For example: air, milk, etc.

**6.** A solution in which a substance is dissolved in water is called an aqueous solution. For example, solution of sugar in water.

A solution obtained by dissolving a substance in a liquid other than water is called a non-aqueous solution. For example, solution of sodium hydroxide in ethanol.

**7.** The particle size for a true solution, a suspension and a colloid are as follows:

**i.** True solution: $< 10^{-9}$ m

**ii.** Colloid: $10^{-9}$ to $10^{-6}$ m

**iii.** Suspension: $> 10^{-6}$ m

**8.**

| True solution | Colloid |
|---|---|
| Homogeneous | Heterogeneous |
| Transparent | Generally transparent but may also be translucent. |
| Particles are neither visible with naked eye nor under microscope. | Particles are not visible with naked eye but are visible under microscope. |
| Particles pass through filter paper and parchment paper. | Particles do not pass through parchment paper but pass through filter paper. |
| Does not exhibit Tyndall effect. | Exhibits Tyndall effect. |
| Example: air | Example: smoke |

**9. a.** A compound is a pure substance made up of two or more elements combined in a definite proportion by mass.

**b.** A heterogeneous mixture in which the diameter of the solute particles is intermediate between that of a true solution and a suspension is called a colloid.

**c.** A mixture is that form of matter in which two or more pure substances (elements or compounds) are simply mixed together in any proportion by mass.

**10. a.** A mixture of nitrogen and helium.

**b.** A mixture of ethanol and water.

**c.** Copper dissolved in gold.

**11.** Nature uses colloids extensively. The raw natural rubber and muddy water are nothing but colloids. The formation of deltas at the river mouth occurs due to the coagulation of colloidal clay particles in the presence of sea water containing salts such as sodium chloride, potassium chloride, etc.

**12.**

| Colloid | Suspension |
|---|---|
| Heterogeneous | Heterogeneous |
| Generally transparent but may also be translucent. | Hazy to opaque. |
| Particles are not visible with naked eye but are visible under microscope. | Particles are visible with naked eye. |
| Very slow settling, reasonable settling under high speed centrifugation. | Particles settle down under gravity. Heavier particles settle down faster than lighter particles. |
| Exhibits Tyndall effect. | Tyndall effect may be observed. |
| Example: milk | Example: chalk water |

**13. a.** Magnetic separation

**b.** Sublimation

**c.** Paper chromatography

**14. a.** Centrifugation

**b.** Evaporation or crystallisation

**c.** Sublimation

**15.** Since salt is soluble in water, the mixture will first be dissolved in water. Salt will get dissolved in water and sulphur and sand will settle at the bottom as insoluble residue. Salt can be separated from water by evaporation. The residue can then be dissolved in carbon tetrachloride, in which sulphur dissolves. Sulphur can also be separated from this mixture by evaporation. Now, only sand will be left behind as the residue.

**16.** Refer to Answer 8 given on page 15.

When a strong beam of light is passed through a colloidal solution, the light gets scattered and the path of light becomes visible. This serves as a test for colloids.

**17.** The impure sample of copper sulphate is taken and dissolved in hot water and the solution is filtered to remove suspended impurities. The filtrate is transferred into a china dish and heated on a water bath till three-fourth water is evaporated and the solution gets concentrated. The china dish is removed from the water bath and covered with a watch glass. Crystals of pure copper sulphate pentahydrate are formed which are filtered and dried.

**18.** **i.** Separating a mixture containing water and kerosene oil.

**ii.** Separating a mixture containing water and benzene.

**iii.** Separating and removing lighter molten slag from the top of molten iron in the metallurgy of iron.

**19.** **i.** Separating butter from curd.

**ii.** Separating coagulated blood and blood plasma in pathological laboratories.

**iii.** Separating water from wet clothes in washing machines.

**20.**

| Homogeneous mixture | Heterogeneous mixture |
|---|---|
| A homogeneous mixture has a uniform composition throughout its mass. | A heterogeneous mixture does not have a uniform composition throughout its mass. |
| The components of a homogeneous mixture are so thoroughly mixed that these cannot be distinguished from one another. | In a heterogeneous mixture, the components can be easily distinguished. |
| All parts of a homogeneous mixture exhibit same property. | All parts of a heterogeneous mixture are not alike. |
| For example, a solution of sugar in water, natural gas, etc. | For example, a mixture of sand and water, sulphur and iron filings, etc. |

**21.** Separating a mixture of sodium chloride, chalk and iodine:

Iodine sublimes on heating, sodium chloride is soluble in water and chalk is insoluble in water. These properties are made use of in the separation.

**22.** Distillation is employed to separate two liquids that are miscible. The boiling points of these liquids should be fairly far apart. When distilled, the liquid with the lower boiling point distils over first, and is collected. It is the first fraction. It consists mostly of the liquid with a lower boiling point and small quantities of the other liquid. During the distillation process for the first fraction, the temperature remains constant. When that liquid is completely distilled out, the temperature starts rising. When it reaches the boiling point of the other component of the mixture, the second liquid starts boiling. In this way both the liquids can be separated.

A fractionating column can also be used for fractional distillation. It is usually used if the boiling points of liquids are not very far apart. The fractionating columns obstruct the smooth upward flow of the vapours. In this process, only the vapours of the liquid with the lower boiling point pass through, while the vapours of the higher boiling liquids condense and flow back into the distilling flask.

**23.** It is given that the difference in boiling points of petrol and kerosene is more than 25 °C. So, the two can be separated using the process of simple distillation. The component with a lower boiling point will distil out first, while the component with the higher boiling point will distil out later.

**24.** A mixture of two immiscible liquids is taken in a separating funnel. The separating funnel is stoppered and the contents are shaken thoroughly. The separating funnel is allowed to stand for some time when two separate layers are formed. The liquid with lower density forms the upper layer and the liquid with higher density forms the lower layer. The stopper is taken out and the lower layer is run out into a beaker by opening the tap of the separating funnel. When the liquid in the lower layer flows out completely, the tap is closed to retain the lighter liquid in the separating funnel.

**25.** Clean air is a homogeneous mixture of various gases such as oxygen, nitrogen, carbon dioxide, water vapour and noble gases (namely, helium, neon, argon and krypton). Since, these gases have different freezing and boiling points, these gases can be separated by liquefaction of air followed by fractional distillation of liquid air in a specially designed column.

**26.** The characteristics of a physical change are:

**i.** No new substance is formed. Only the physical properties of the substance change.

ii. A physical change is generally temporary and reversible.

iii. The mass of a substance undergoing a physical change remains the same.

**27.** The characteristics of a chemical change are:

i. One or more new substances are formed.

ii. The chemical change is permanent and quite often irreversible.

iii. The chemical composition and the chemical properties of the substance undergoing a chemical change get completely changed.

## D. Long Answer Type Questions

**1.**

| Compound | Mixture |
|---|---|
| A compound is a homogeneous substance. | A mixture may be homogeneous (solution) or heterogeneous. |
| The components of a compound do not retain their properties. | The components of a mixture retain their individual properties. |
| The components of a compound are always present in a definite proportion by mass. | A mixture does not have a definite composition. |
| A compound exhibits definite physical constants such as density, melting point, boiling point, etc. | A mixture does not have definite physical constants such as density, melting point, boiling point, etc. |
| When a compound is prepared energy changes in the form of heat, light and sound are observed. | When a mixture is prepared, energy changes in the form of heat, light and sound are not observed. |

**2.**

| True solution | Colloidal solution | Suspension |
|---|---|---|
| Homogeneous | Heterogeneous | Heterogeneous |
| Transparent | Generally transparent but may also show translucence. | Hazy to opaque |
| Particles are neither visible with naked eye nor under microscope. | Particles are not visible with naked eye but are visible under microscope. | Particles are visible with naked eye. |
| Particles pass through filter paper and parchment paper. | Particles do not pass through parchment paper but pass through filter paper. | Particles do not pass through parchment paper or filter paper. |
| Does not exhibit Tyndall effect. | Exhibits Tyndall effect. | Tyndall effect may be observed. |

**3.** The main properties of colloids are:

i. Colloids are heterogeneous in nature.

ii. The size of particles of a colloid is too small to be individually seen by naked eye.

iii. Colloids are big enough to scatter a beam of light passing through it and make its path visible.

iv. They do not settle down when left undisturbed.

v. Colloidal particles exhibit Brownian motion.

**4.** Refer to Answer 2 given on page 17.

**5.** **a.** Refer Table 2.4 from page 45 of the textbook.

**b.** Refer to Answer 2 given on page 17.

**6.** Refer Table 2.2 from page 43 of the textbook.

**7.** The process of separating the components of a mixture based on the difference in adsorption of different components on the surface of a solid is known as chromatography.

Separating coloured components (dyes) of black ink by paper chromatography:

Take a strip of filter paper (25 cm long and 1.5 cm wide) and mark a line on it with a pencil about 5 cm from one end. Put a small drop of black ink at the centre of the line using a capillary tube and dry the spot in air. Suspend the filter paper into a gas jar containing water (solvent) so that the spot is slightly above the water level. Stopper the gas jar so that the space inside the gas jar becomes saturated with water vapour. Allow the arrangement to stand for some time. Water rises along the filter paper due to the absorption of water molecules on the cellulose molecules of filter paper. Water reaches the spot and removes the components of ink at various speeds. After water has reached a suitable height, open the gas jar, remove the paper and dry the filter paper in air. Two or three coloured spots are observed at different distances from the reference line. The coloured component which is more soluble in water rises faster than the other components.

The activity shows that black ink is a mixture of several dyes.

8. a. A solution in which no more solute can be dissolved at a particular temperature is called a saturated solution.

b. Chemically a pure substance is a kind of matter that cannot be separated by any physical process.

c. A mixture in which the diameter of the solute particles is intermediate between that of true solution and suspension is called a colloid.

d. A heterogeneous mixture which contains very fine particles of solute (of the diameter $> 10^{-6}$ m) dispersed throughout the solvent without getting dissolved in it is called suspension.

e. A mixture is that form of matter in which two or more pure substances (elements or compounds) are simply mixed together in any proportion by mass.

9. Water is processed by the following steps to make it suitable for human consumption.

i. **Screening:** Water from river / lake is passed through screens having large number of holes. Here, the floating matter is retained by these screens.

ii. **Sedimentation:** Water is then pumped into settling tank where most of the suspended particles settle down at the bottom due to the force of gravity. The supernatant water is then sent to another tank called the loading tank.

iii. **Loading:** A solution of alum, which acts as a coagulant, is added to the water in the loading tank. Alum forms insoluble gelatinous and flocculent precipitate which absorbs and entangles very fine suspended particles as well as colloidal particles, which settle down easily under gravity. Alum also removes colour, odour and unwanted taste from the water.

iv. **Filtration:** The supernatant water from the loading tank is passed through a filtering set containing beds of fine sand, coarse sand and coarse gravel. Filtration removes all the suspended impurities including colloidal matter and most of the bacteria and microorganisms.

v. **Aeration:** The filtered water is passed through an aeration tank where air is passed to kill microorganisms and to saturate water with oxygen.

vi. **Chlorination:** A calculated concentrated solution of chlorine is mixed with aerated water. Chlorine acts as a disinfectant and kills the harmful disease causing microorganisms. The process of killing the disease causing bacteria and microorganisms from water and making water safe for use, is called sterilisation of water.

10. a. Fractional distillation

b. Evaporation

c. Distillation

d. Dissolution of sulphur in $CS_2$ followed by filtration and evaporation

e. Dissolution of iodine in ethyl alcohol followed by filtration and evaporation.

11. Refer Table 2.4 from page 45 of the textbook.

12. Refer Table 2.9 from page 73 of the textbook.

13. a. In chromatography, the components of mixture get separated based on the difference in adsorption of different components on the surface of a solid.

b. The components of blue ink can be separated by the following method:

Take a strip of filter paper (25 cm long and 1.5 cm wide) and mark a line on it with a pencil about 5 cm from an end. Put a small drop of blue ink at the centre of the line using a capillary tube and dry the spot in air. Suspend the filter paper into a gas jar containing water (solvent) so that the spot is slightly above the water level. Stopper the gas jar so that the space inside the gas jar becomes saturated with water vapour. Allow the arrangement to stand for some time. Water rises along the filter paper due to the adsorption of water molecules on the cellulose molecules of filter paper. Water reaches the spot and removes the components of ink at various speeds. After water has reached a suitable height, open the gas jar, remove the filter paper and dry it in air. Two or three coloured spots are observed at different distances from the reference line. The coloured component which is more soluble in water rises faster than the other components.

c. Chromatography is not restricted to separating only coloured compounds because chromatography can be used for separating the components of a mixture that are soluble in the same solvent whether the components are coloured or not. It can also be used for components having similar properties like:

**i.** Components in a dye

**ii.** Drugs in blood

**iii.** Pigments from natural colours

## E. Source-based/Case-based/Passage-based/Integrated Assessment Questions CBQ

| | | | | | |
|---|---|---|---|---|---|
| **1.** | **a.** ii. | **b.** iii. | **c.** iv. | **d.** iv. | **e.** iv. |
| **2.** | **a.** ii. | **b.** iv. | **c.** iii. | **d.** ii. | **e.** ii. |
| **3.** | **a.** iii. | **b.** i. | **c.** ii. | **d.** iii. | **e.** i. |
| **4.** | **a.** ii. | **b.** ii. | **c.** i. | **d.** ii. | **e.** iii. |
| **5.** | **a.** iv. | **b.** ii. | **c.** ii. | **d.** iii. | **e.** ii. |

## F. Diagrammatic Questions

**1.** Refer Figure 2.19, page 68 of the textbook.

**2.** Refer Figure 2.4, page 56 of the textbook.

## G. Higher Order Thinking Skills (HOTS) Questions

**1.** Decantation is unsuitable for separation of immiscible solids because the solid particles do not sediment, instead they will keep floating and thus when one liquid is poured, small quantities of the other liquid also flows along with it.

**2.** China dish.

**3.** Only **c.** is correct.

**4.** Burning of candle is both, a physical and a chemical change because:

**i.** The candle is made of wax. When it burns, the wax converts from the solid state to the liquid state. This is the physical change.

**ii.** When the wax burns, the carbon compounds in the wax are converted to carbon dioxide, carbon monoxide and water vapours. This is a chemical change.

**5.** Nitre is soluble in water, sulphur is soluble in $CCl_4$ while charcoal is soluble in none of the two solvents. This can be made use of for separating the components of gunpowder.

## H. Value-Based Questions (Optional)

**1. a.** The method of separating insoluble solid particles from a liquid by passing it through a filter paper is called filtration.

**b.** The process of filtration is as follows:

A filter paper is folded into a semi-circle and then again folded to obtain a quarter circle. The filter paper is opened to form a cone and is then placed in a glass funnel which is supported on a funnel stand. A few drops of water are added to the filter paper so that the filter paper stays in place on the glass funnel and also to prevent the formation of any air bubble in between the filter paper and glass funnel. The mixture containing solid and liquid is stirred with the help of a glass rod and is then poured into the glass funnel, a little at a time, using the glass rod.

Refer Figure 2.8 from page 62 of the textbook.

**c.** Kindness, caring nature, respect for elders, helpful nature, etc.

**2. a.** Argemone oil is mixed with mustard oil and dried papaya seeds are mixed with black pepper.

**b.** The student displayed qualities such as honesty, showing responsible behaviour, etc.

**c.** We can fight against food adulteration by spreading awareness among the people about it, saying no to adulterated food items and encouraging everyone around us to buy quality certified products.

**d. i.** Metanil yellow is used as adulterant in dal for colouring. Its presence in dal can be tested by adding a few drops of HCl to a test sample. If the solution turns pink, it indicates the presence of metanil yellow.

**ii.** Starch is used as an adulterant in milk. To test the presence of starch in milk, add a few drops of iodine to the milk sample. Appearance of blue colour indicates the presence of starch.

## P. 85 TEST PAPER

**1. a.** A solution in which the solute particles are of very small size (diameter < $10^{-9}$ m) is called a true solution.

**b.** A heterogeneous mixture which contains small insoluble particles of solute spread throughout the solvent without getting dissolved in it is called a suspension.

**c.** A mixture in which the diameter of the solute particles is intermediate between that of a solution and a suspension, is called a colloid.

**d.** The process in which the suspended particles in a solution settle down under the action of gravity is called sedimentation.

**e.** Evaporation is the process by which liquid is converted into its vapour form below the boiling point of the liquid. It is a surface phenomenon.

**2.** To get a pure sample of a substance or a mixture.

**3.** Refer Table 2.9 from page 73 of the textbook.

**4.** Kerosene is considered a mixture because it contains several hydrocarbons.

**5.** Refer Table 2.4 from page 45 of the textbook.

**6.** Refer Table 2.7 from page 57 of the textbook.

**7.** **a.** Copper dissolved in gold.

**b.** Amalgam of mercury with sodium.

**c.** Oxygen dissolved in water.

**8.** When a beam of light is passed through a colloidal solution, the colloidal particles scatter light in all directions, and the path of light becomes visible when seen from a direction at right angle to that of the incident light. It is called Tyndall effect.

## CHAPTER – 3

## ATOMS AND MOLECULES

**P. 89-90 Check Your Progress 1**

1. a. According to the law of conservation of mass, during a chemical reaction, matter is neither created nor destroyed but remains conserved. This means that in a chemical reaction, the total mass of the products is equal to the total mass of the reactants.

   b. The law of constant proportions states that whatever be the method of its formation or whatever may be its source, a chemical compound always consists of the same elements combined together in the same proportion by mass.

2. The law of multiple proportions states that when two elements combine to form two or more compounds, then the different masses of one element which combine with a fixed mass of the other, bear a simple ratio to one another.

3. $\underset{5.0\ g}{CaCO_3} \xrightarrow{heat} \underset{2.8\ g}{CaO} + \underset{2.2\ g}{CO_2}$

   Mass of reactant = 5.0 g

   Mass of products = 2.8 g + 2.2 g = 5.0 g

   Since the total mass of the products is equal to the total mass of the reactant, the observations are in agreement with the law of conservation of mass.

4. In the first experiment:

   The percentage of zinc in its oxide

   $= \frac{1.31}{1.63} \times 100 = 80.36\%$

   The percentage of oxygen in zinc oxide

   = 100 – 80.36 = 19.64%

   In the second experiment:

   The percentage of zinc in its oxide

   $= \frac{2.12}{2.65} \times 100 = 80\%$

   The percentage of oxygen in zinc oxide

   = 100 – 80 = 20%

   Since the percentages of zinc and oxygen in both the experiments are the same, the law of constant proportions is verified.

5. In the first experiment:

   The percentage of copper in copper oxide

   $= \frac{1.179}{1.476} \times 100 = 79.87\%$

   The percentage of oxygen in black copper oxide

   = 100 – 79.87 = 20.13%

   In the second experiment:

   The percentage of copper in copper oxide

   $= \frac{1.098}{1.375} \times 100 = 79.85\%$

   The percentage of oxygen in black copper oxide

   = 100 – 79.85 = 20.15%

   Since the percentages of copper and oxygen in both experiments are the same, the law of constant proportions is verified.

6. In the first experiment:

   The percentage of copper in copper(II) oxide

   $= \frac{0.85}{1.06} \times 100 = 80.18\%$

   The percentage of oxygen in copper(II) oxide

   = 100 – 80.18 = 19.82%

   In the second experiment:

   The percentage of copper in copper(II) oxide

   $= \frac{3.19}{3.98} \times 100 = 80.15\%$

   The percentage of oxygen in copper(II) oxide

   = 100 – 80.15 = 19.85%

   Since the percentages of copper and oxygen in both the experiments are the same, the law of constant proportions is verified.

7. In the first experiment:

   The percentage of iron in its oxide

   $= \frac{6.10}{8.72} \times 100 = 69.95\%$

   The percentage of oxygen in iron oxide

   = 100 – 69.95 = 30.05%

   In the second experiment:

   The percentage of iron in its oxide

   $= \frac{8.98}{12.84} \times 100 = 69.93\%$

   The percentage of oxygen in iron oxide

   = 100 – 69.93 = 30.07%

   Since the percentages of iron and oxygen in both the experiments are the same, the law of constant proportions is verified.

8. 48 g

9. For the first oxide, mass percentage of phosphorus = 56.36.

   Mass percentage of oxygen will be 100 – 56.36 = 43.64

Thus,

43.64 g of oxygen reacts with 56.36 g of phosphorus

1 g of oxygen reacts with $\frac{56.36}{43.64}$ = 1.29 g of phosphorus

For the second oxide, mass percentage of phosphorus = 43.66

Mass percentage of oxygen will be 100 – 43.66 = 56.34

Now, 56.34 g of oxygen reacts with 43.66 g of phosphorus

1 g of oxygen reacts with $\frac{43.66}{56.34}$ = 0.77 g of phosphorus

Ratio of phosphorus masses which combine with 1 g of oxygen = 1.29 : 0.77 or 3 : 5

Since 3:5 is a simple ratio, the law of multiple proportion is supported by the given data.

**10.** For the first chloride, mass % of phosphorus = 22.54

Mass % of chlorine will be 100 – 22.54 = 77.6

This means, 77.6 g of chlorine reacts with 22.54 g of phosphorus

1 g of chlorine reacts with $\frac{22.54}{77.6}$ = 0.29 g of phosphorus

For the second chloride, mass% of phosphorus = 14.87

Mass % of chlorine will be 100 – 14.87 = 85.13

So, 85.13 g of chlorine reacts with 14.87 g of phosphorus

1 g of chlorine reacts with $\frac{14.87}{85.13}$ = 0.17 g of phosphorus

Ratio of phosphorus masses which combine with 1 g of chlorine = 0.29 : 0.17 or 5 : 3

Since 5 : 3 is a simple ratio, the law of multiple proportion is supported by the given data.

**P. 96 Check Your Progress 2**

**1.** The main postulates of Dalton's atomic theory are as follows:

**a.** Matter is composed of very tiny particles called atoms.

**b.** Atoms are incapable of being destroyed or created.

**c.** Atoms of any pure substance can neither be subdivided nor changed into atoms of another element.

**d.** All atoms of an element are identical in terms of mass, size and other properties.

**e.** Atoms of one element differ in mass and other characteristics from those of other elements.

**f.** Chemical combination results in the union of atoms in numerical proportions to form a large number of new substances.

**g.** The relative number and kinds of atoms are constant in a given compound.

**2.** It means that the average mass of a calcium atom as compared to 1/12th the mass of one C–12 atom is 40.

**3. a.** The atomic mass ($A$) of an element is defined as the average mass of an atom of an element in atomic mass unit.

**b.** The relative atomic mass ($A_r$) of an element is the average mass of an atom of an element as compared to 1/12th the mass of one carbon-12 atom.

**4.** The mass equal to 1/12th of the mass of $^{12}C$ atom is called one atomic mass unit (u). The mass of 1/12th of $^{12}C$ atom ($1.66 \times 10^{-24}$ g) is taken as 1 u. This means that the mass of a $^{12}C$ atom is 12 u.

Since 1 atomic mass unit is equal to a very small mass ($1.66 \times 10^{-24}$ g) and such a small mass cannot be measured on a balance, the atomic mass unit is not a practical unit. The atomic masses are expressed on relative scale based on the mass of one $^{12}C$ atom.

**5.** The atomic masses are expressed on relative scale based on the mass of one $^{12}C$ atom.

**6.** The size of atoms is very small. The idea of the size of an atom is obtained from the radius of the atom. The radius of an atom is measured in nanometer (nm) [1 nm = $10^{-9}$ m]. The smallest atom is hydrogen atom, whose radius is of the order of $10^{-10}$ m. We cannot see atoms and molecules even with the help of the most powerful microscope available on the earth. Modern techniques such as Scanning Tunneling Electron Microscopy (STEM) have been used to record the magnified images of the surfaces of some elements showing atoms.

**P. 102–103 Check Your Progress 3**

**1. a.** A molecule is the smallest particle of an element or a compound which can exist in the free state independently under ordinary conditions and exhibits all the properties of the substance (element or compound).

**b.** The number of atoms of all the elements present in a molecule of a substance is known as atomicity of that molecule.

c. The charged species formed when an atom gains or loses electrons is called ion. An ion can be positively or negatively charged. A positively charged ion is called cation and a negatively charged ion is called anion.

2. a. Valency of an atom is the number of electrons a particle loses or gains or shares during the course of a chemical reaction. The particles may be atoms or group of atoms.

   b. The electrons present in the outermost shell of an atom are called valence electrons.

3. **Trivalent elements:** Nitrogen and aluminium

   **Tetravalent elements:** Tin and lead

4. **a.** $AlPO_4$ **b.** $BaCO_3$ **c.** $Cu_3(PO_4)_2$

5. **a.** $Na^+$ **b.** $Cl^-$ **c.** $PO_4^{3-}$

6. A chemical formula is the symbolic representation of a molecule of the compound. It denotes the number of atoms of different elements present in one molecule of the compound. The formula of a compound indicates the fixed proportion in which, by mass, the atoms combine.

7. Elements present in $Fe_2O_3$ : iron and oxygen

   Name of the compound: iron(III) oxide

8. **a.** 4 **b.** 5 **c.** 3

9. The symbolic representation of a molecule of a substance representing the actual number of various atoms present in it is called the molecular formula. For example, the molecular formula of carbon dioxide is $CO_2$, containing one atom of carbon and two atoms of oxygen.

   Empirical formula of a compound is the simplest formula which gives the simplest ratio in whole numbers between the number of atoms of different elements present in one molecule of the compound. Empirical formula of a compound does not indicate the actual number of atoms of the elements present in the compound. It only gives the simplest whole number ratio between the number of atoms of all the elements present in the compound

10. The relation between empirical formula and molecular formula of a compound is given by:

    Molecular formula = $n$ × empirical formula, where $n$ is an integer.

    The value of $n$ is obtained by the following relationship:

    $$n = \frac{\text{Molecular mass}}{\text{Empirical formula mass}}$$

11. **a.** Aluminium sulphate

    **b.** Calcium chloride

    **c.** Potassium sulphate

    **d.** Potassium nitrate

    **e.** Calcium carbonate

**P. 112 Check Your Progress 4**

1. **a.** 63 u **b.** 64 u **c.** 60 u **d.** 180 u **e.** 342 u
2. $H_2$ – 2 u, $O_2$ – 32 u, $Cl_2$ – 71 u, $CO_2$ – 44 u, $CH_4$ – 16 u, $C_2H_6$ – 30 u, $C_2H_4$ – 28 u, $NH_3$ – 17 u, $CH_3OH$ – 32 u
3. 19.83 times
4. $N_2O_5$
5. 0.25 mol
6. 56 g
7. $9.033 \times 10^{22}$ atoms
8. **a.** $6.45 \times 10^{23}$ atoms **b.** $13.38 \times 10^{23}$ atoms. Hence 60 g of Al has more number of atoms.
9. $1.99 \times 10^{-23}$ g
10. 4 g
11. 32 u, Symbol of element: S
12. $12.044 \times 10^{19}$ molecules
13. 7.2 g
14. 0.2 mol
15. $4.65 \times 10^{-23}$ g
16. $1.673 \times 10^{21}$ molecules
17. 31 : 3
18. **a.** 88.89 **b.** 94.12; Law of multiple proportions
19. **a.** $6.022 \times 10^{22}$ **b.** $2.41 \times 10^{24}$ **c.** $18.066 \times 10^{23}$ **d.** 0.01 **e.** 0.0199 **f.** 0.39

**P. 115 EXERCISES**

**A. OBJECTIVE TYPE QUESTIONS**

**I. Choose the most appropriate answer.**

| | | | | |
|---|---|---|---|---|
| **1.** d | **2.** a | **3.** c | **4.** c | **5.** b |
| **6.** c | **7.** b | **8.** b | **9.** a | **10.** a |
| **11.** c | **12.** d | **13.** c | **14.** b | **15.** a |
| **16.** c | **17.** a | **18.** c | **19.** d | **20.** b |
| **21.** c | **22.** c | **23.** b | **24.** a | |

**II. Write True or False.**

| | | | | |
|---|---|---|---|---|
| **1.** F | **2.** T | **3.** F | **4.** T | **5.** T |
| **6.** F | **7.** F | **8.** F | **9.** T | **10.** F |
| **11.** T | **12.** F | **13.** T | **14.** T | **15.** T |
| **16.** T | **17.** T | **18.** T | **19.** T | **20.** F |

### III. Fill in the blanks.

1. zero
2. atomicity
3. 16.0
4. $6.022 \times 10^{23}$
5. $1.67 \times 10^{-24}$ g
6. 0.02, $1.2 \times 10^{22}$
7. $6.022 \times 10^{23}$
8. $2.99 \times 10^{-23}$ g
9. $1.51 \times 10^{23}$
10. $2.657 \times 10^{-23}$ g
11. $1.5 \times 10^{23}$
12. $6.022 \times 10^{22}$
13. $6.022 \times 10^{22}$
14. 4.144 g
15. $7.307 \times 10^{-23}$ g
16. one
17. g $mol^{-1}$
18. polyatomic ion

### IV. Match the items in column A with the items in column B.

**1.** c **2.** a **3.** g **4.** b **5.** d
**6.** e **7.** f

### V. Cross out the incorrect statements.

The incorrect statements are **2**, **3**, **4**, **5** and **6**.

### VI. Assertion–Reasoning Type Questions CBQ

**1.** a **2.** a **3.** a **4.** a **5.** c
**6.** c **7.** a **8.** a **9.** b **10.** d

### VII. Very Short Answer Type Questions

**1. a.** An atom is the smallest particle of an element which takes part in a chemical reaction and maintains its chemical identity throughout all physical and chemical changes.

**b.** A small, heavy, positively charged mass at the centre of an atom is called nucleus.

**2.** Radius of an atom: $\sim 10^{-10}$ m

**3.** $O_3$ and $S_8$

**4.** $10^{-10}$ m

**5.** $NO_2$ and $SO_2$

**6.** The mass equal to 1/12th the mass of $^{12}C$ atom is called one atomic mass unit (u).

**7.** $1.672 \times 10^{-24}$ g

**8.** It means that the average mass of a bromine atom as compared to 1/12th the mass of one C–12 atom is 80.

**9.** 12 u

**10.** Cation: $K^+$ and anion: $Cr_2O_7^{2-}$

**11.** He and Ne

**12. a.** $Zn_3(PO_4)_2$ **b.** $Fe_2(CO_3)_3$

**13. a.** 3 **b.** 5

**14.** The gas is monoatomic.

**15.** $6.022 \times 10^{23}$

**16.** $6.022 \times 10^{23}$

**17.** 63.5 g

**18.** Atoms can neither be created nor destroyed in a chemical reaction.

**19.** The relative number and kinds of atoms are constant in a given compound.

**20.** Mass of 1 mole of carbon = 12 g

That means weight of $6.022 \times 10^{23}$ atoms of carbon is 12 g.

Mass of one atom of carbon = $\frac{12}{6.022 \times 10^{23}}$ = $1.99 \times 10^{-23}$ g

**21.** The chemical formula of ammonia is $NH_3$. We are given that the atomic mass of nitrogen is 14 u and that of hydrogen is 1 u. So, mass of nitrogen in ammonia = 14 u and mass of hydrogen in ammonia = $3 \times 1$ = 3 u. Thus, ratio by mass of nitrogen and hydrogen = 14: 3.

**22.** Methane has the same empirical formula as the molecular formula ($CH_4$).

**23. a.** The number of atoms of all the elements present in a molecule of a substance is known as atomicity of that molecule.

**b.** The relative molecular mass of a compound is the average mass of its one molecule compared to 1/12th the mass of one carbon-12 atom. It is a pure number and it does not have a unit.

**24. a.** $Ni(NO_3)_2$

**b.** $Al_2(SO_4)_3$

**25.** Significance of the symbol of an element:

i. Symbol represents name of the element.
ii. It represents one atom of the element.
iii. It represents a definite mass of the element (equal to atomic mass expressed in gram).
iv. It represents mass of the element which contains one Avogadro's number of atoms of the element.

**26. a.** Atomicity of $CH_4$ = 5

**b.** Atomicity of $SO_3$ = 4

**27.** Mass of proton, $m_p = 1.673 \times 10^{-24}$ g and mass of neutron, $m_n = 1.676 \times 10^{-24}$ g. The mass of electron, $m_e = 9.10939 \times 10^{-28}$ g.

**28. Molecular formula:** The symbolic representation of a molecule of a substance representing the actual number of various atoms present is called molecular formula.

**Empirical formula:** The formula which gives the simplest ratio in whole numbers between the number of atoms of different elements present in one molecule of the compound is called empirical formula.

**29.**

| Atom | Molecule |
|---|---|
| An atom is the smallest particle of an element, which takes part in a chemical reaction and maintains its chemical identity throughout all physical and chemical changes. | A molecule is the smallest particle of a substance which can exist independently and exhibits all properties of the substance. |
| An atom can be further divided into electrons, protons and neutrons. | A molecule can be divided into atoms. |

**30.** The charged species formed when an atom gains or loses electrons is called ion. A positively charged ion is called cation and a negatively charged ion is called anion.

**31.** The charge possessed by the Avogadro's number of electrons is called one faraday.

**32.** This means that the combining capacity of noble gases is zero, since they have completely filled valence shell. Thus, they do not need to react with other elements to complete their octets.

**33.** The molecular masses of compounds are also very small and these cannot be measured directly. The molecular masses of compounds are expressed as relative molecular masses ($M_r$). The relative molecular mass of a compound is the average mass of the molecules of a compound as compared to the 1/12th the mass of one carbon-12 atom.

The average mass of one molecule of a compound in atomic mass unit is called molecular mass ($M$), Hence, molecular mass ($M$) = $M_r \times 1$ u = $M_r$ u.

**34.** The quantity of a substance which contains Avogadro's number of chemical units (atoms, molecules or ions) of the substance is called mole.

**35.** The quantity of an element equal to the relative atomic mass in gram is termed as the gram atomic mass of the element.

The quantity of an element or compound equal to the relative molecular mass in gram is termed as the gram-molecular mass of the element or compound.

**36.** Mass of one mole of any substance is called its molar mass. The unit of molar mass is g $mol^{-1}$.

## B. Short Answer Type-I Questions

**1.** **a.** Manganese and oxygen

**b.** Manganese dioxide

**2.** $6.022 \times 10^{23}$, the mass of one Avogadro's number of nitrogen atoms is 14 g.

**3.** 3.0 g

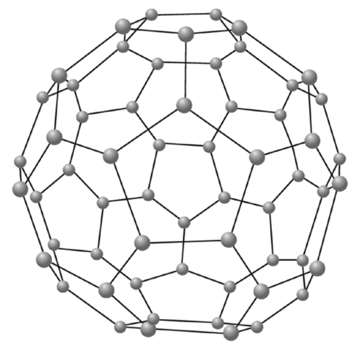
**4.** Triatomic molecules – $O_3$ and $CO_2$

Polyatomic molecules – $S_8$ and $Se_8$

**5.** Two pentaatomic anions: $SO_4^{2-}$ and $PO_4^{3-}$

Two tetraatomic anions: $CO_3^{2-}$ and $NO_3^{-}$

**6.** Buckminsterfullerene is a spherical fullerene molecule which has the formula $C_{60}$. It has carbon atoms arranged in the shape of a football.



Structure of buckminsterfullerene

**7.** Yes, the nucleus consists of several other unstable particles such as mesons, positrons, neutrinos, antineutrinos, gluons and quarks.

**8.** Molecular mass of $H_2SO_4 = 2 \times 1 + 32 + 4 \times 16 = 98$

Molecular mass of $H_3PO_4 = 3 \times 1 + 31 + 4 \times 16 = 98$

**9.** Mass percentage of an element

$$= \frac{\text{Mass of the element in the compound}}{\text{Total mass of the compound}} \times 100$$

**10.** Molecular mass of $CO_2 = 12 + 2 \times 16 = 44$.

Gram-molecular mass = 44 g

**11.** 12 g of carbon is present with 32 g of oxygen.

6 g of carbon will be present with $\frac{32 \times 6}{12} = 16$ g of oxygen

**12.** **a.** 4 **b.** 2 **c.** 4 **d.** 4

**13.** The quantity of a substance which contains Avogadro's number of chemical units (atoms, molecules or ions) of the substance is called mole. The SI symbol of mole is mol.

**14.** Gram-atoms of carbon is 1 and gram-atoms of oxygen is 2.

**15.** $n = m/M$

16. The symbol of an element is an abbreviation (short name) for the full name of the element. Dalton's symbols were difficult to remember and draw. So these are not used in chemistry.

17. **a.** $H_2S$ **b.** $FeCl_2$

## C. Short Answer Type-II Questions

1. **Law of conservation of mass:** According to the law of conservation of mass, during a chemical reaction, matter is neither created nor destroyed but remains conserved. This means in a chemical reaction the total mass of the products is equal to the total mass of the reactants. For example,

   **i.** In the reaction of hydrogen ($H_2$) and chlorine ($Cl_2$), 2 g of $H_2$ reacts with 71 g of $Cl_2$ to give 73 g of HCl.

   $$H_2 + Cl_2 \rightarrow 2HCl$$

   Molecular mass 2 71 $2 \times 36.5 = 73$

   The mass of the reactants is equal to the mass of the products, i.e. the total mass is conserved.

   **ii.** When 12 g of calcium carbonate is heated till no further loss in weight, 5.28 g of carbon dioxide was produced. The mass of the residue (calcium oxide) was found to be 6.72 g.

   $$\underset{12\text{ g}}{CaCO_3} \xrightarrow{\text{heat}} \underset{6.72\text{ g}}{CaO} + \underset{5.28\text{ g}}{CO_2}$$

   Mass of reactant = 12 g

   Mass of products = 6.72 g + 5.28 g = 12 g

   The mass of the reactants is equal to the mass of the products, i.e. the total mass is conserved.

2. Some of the major drawbacks of Dalton's atomic theory are:

   **i.** Atom is no longer considered as the smallest indivisible particle.

   **ii.** Atoms of the same element have different masses.

   **iii.** Atoms of some different elements have some masses.

3. According to Dalton's atomic theory, atoms are indivisible particles which can neither be created nor be destroyed. However, atoms can be divided into electrons, protons and neutrons. So, the correct postulate should be that atoms can further be divided into electrons, protons and neutrons.

4. According to Dalton's atomic theory, atoms of a given element are identical in mass and chemical properties. Also, atoms of different elements have different masses and chemical properties. However, isotopes are atoms of an element which have different atomic masses, while isobars are atoms of different elements which have different atomic numbers but same atomic masses. So, the modified postulates are:

   **i.** Atoms of a given element are identical in atomic number and chemical properties.

   **ii.** Atoms of different elements have different atomic numbers and chemical properties. However, they may have similar atomic masses.

5. Refer Activity 1 from page 86 of the textbook.

6. Ionic compounds are soluble in water and insoluble in organic solvents. Ionic compounds have high melting and boiling points. Ionic compounds contain cation and anion.

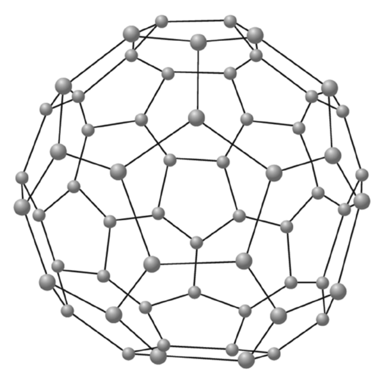
7. Nickel and oxygen. Nickel oxide. Valency of nickel is 3.

8. Average mass of one mole of any substance is the molar mass. It is calculated by the formula

   $$\text{Molar mass} = \frac{\text{Mass of the substance}}{\text{Amount of substance in moles}}$$

   $$\text{Number of moles of a substance} = \frac{\text{Mass}}{\text{Molar mass}}$$

9. The molecule with the formula $C_{60}$ is called buckminsterfullerene. It contains sixty carbon atoms ($C_{60}$) bonded together to produce a structure similar to a football.



Structure of buckminsterfullerene

10. The law of constant proportions states that whatever be the method of its formation or whatever may be its source, a chemical compound always consists of the same elements combined together in the same proportion by mass. For example, pure water taken from any source contains hydrogen and oxygen in

1 : 8 ratio (by mass) only. Similarly, calcium oxide prepared by any of the three methods, i.e. heating calcium carbonate, heating calcium hydroxide or heating calcium nitrate yields calcium oxide with a mass ratio of calcium to oxygen as 5 : 2.

**11.** The postulates of Dalton's atomic theory are as follows:

**i.** All matter is made of very tiny particles called atoms.

**ii.** Atoms are indivisible particles which cannot be created or destroyed in a chemical reaction.

**iii.** Atoms of a given element are identical in mass and chemical properties.

**iv.** Atoms of different elements have different masses and chemical properties.

**v.** Atoms combine in the ratio of small whole numbers to form compounds.

**vi.** The relative number and kinds of atoms are constant in a given compound.

**12.** 1 amu is $1/12^{th}$ mass of one carbon atom

$= (1/12) \times 1.9924 \times 10^{-23} = 1.66 \times 10^{-24}$ g

**13.** Elements have fractional atomic masses due to the presence of isotopes. The atomic mass is the average value of atomic masses of different isotopes of an element.

**14.** The atomic mass of an element is the weighted average of the actual masses of all the isotopes of an element.

For example, oxygen occurs in nature as a mixture of isotopes $^{16}O$, $^{17}O$ and $^{18}O$ having atomic masses of 15.995 u, 16.999 u and 17.999 u, respectively. The relative abundance of these three isotopes is 99.763%, 0.037% and 0.200%. Thus, the atomic mass of oxygen is expressed as the weighted average of the atomic masses of these three isotopes, i.e.

Atomic mass of oxygen =

$$\frac{(99.763 \times 15.995) + (0.037 \times 16.999) + (0.200 \times 17.999)}{100}$$

$= 15.999$ u

**15.** **a.** 12 **b.** 4 **c.** 7 **d.** 3

**16.** **a.** $AlN$ **b.** $Mg_3N_2$ **c.** $Al_2(SO_4)_3$ **d.** $KF$ **e.** $MgF_2$ **f.** $K_3N$

**17.** **a.** $N_2O_3$ **b.** $Na_3PO_4$ **c.** $PbBr_2$

**18.** **a.** $Al_2O_3$ **b.** $Ca(OH)_2$ **c.** $K_2S$ **d.** $PCl_5$ **e.** $BF_3$ **f.** $CuSO_4 \cdot 5H_2O$

**19.** **a.** Sodium sulphate

**b.** Sodium nitrate

**c.** Magnesium carbonate

**d.** Barium chloride

**e.** Chromium(III) sulphate

**f.** Ammonium sulphate

**20.** **a.** 3 **b.** 5

**21.** The formula which gives the simplest ratio in whole numbers between the number of atoms of different elements present in one molecule of the compound is called empirical formula. The symbolic representation of a molecule of a substance representing the actual number of various atoms present is called molecular formula.

The relation between molecular formula and empirical formula is as follows:

Molecular formula = $n \times$ empirical formula

where $n$ is an integer.

**22.** The law of multiple proportion is obeyed by the given experimental data. According to this law, when two elements combine to form two or more compounds, then the different masses of one element which combine with a fixed mass of the other, bear a simple ratio to one another.

### D. Long Answer Type Questions

**1.** The two postulates of Dalton which have been modified by the present day knowledge of nature of matter are:

**i.** Atoms of any substance are indivisible (this has been modified because it has been proved that atom can be further divided into electrons, protons and neutrons).

**ii.** All atoms of an element are identical in terms of mass, size and other properties (this has been modified after the discovery of isotopes).

**2.** The drawbacks of Dalton's atomic theory are as follows:

**i.** Atom is no longer considered as the smallest indivisible particle. Towards the end of nineteenth century, it was found that an atom was composed of still smaller subatomic particles such as electron, proton and neutron.

**ii.** Atoms of the same element have different masses. For example, chlorine has two types of atoms with masses 35 u and 37 u. Such atoms of an element with different masses are called isotopes.

iii. Atoms of some different elements have same masses. The atoms of different elements with same mass numbers are called isobars. For example, the atoms of potassium and calcium have the same mass number (40).

iv. Substances made up of same kind of elements have different properties. For example, diamond, graphite and charcoal are made up of carbon atoms but they possess different physical properties.

v. The ratio in which different atoms combine to form a compound is fixed and integral but may not be simple. For example, a molecule of sugar having the formula $C_{12}H_{22}O_{11}$ contains C, H and O in the ratio 12 : 22 : 11. The ratio is fixed and integral but not simple.

**3.** The symbolic representation of a molecule of a substance representing the actual number of various atoms present is called molecular formula.

The significance of molecular formula is as follows:

**i.** It indicates the names of various elements present in the compound.

**ii.** It indicates the number of various atoms present in one molecule of the compound.

**iii.** Relative molecular mass of the compound can be calculated from the molecular formula.

**iv.** Mass of each element present in one mole of the compound can be found out from the molecular formula. Thus, the percentage composition of each element in the compound can be found out.

**v.** Molecular formula gives the number of gram-atoms of each element present in one mole of the substance.

**4.** The molar mass of caffeine is 194 g/mol. So, mass of $6.022 \times 10^{23}$ molecules of caffeine = 194 g

Mass of 1 molecule of caffeine

$$= \frac{194}{6.022 \times 10^{23}} = 3.22 \times 10^{-22} \text{ g}$$

## E. Source-based/Case-based/Passage-based/Integrated Assessment Questions CBQ

| | | | | | |
|---|---|---|---|---|---|
| **1.** | **a.** ii. | **b.** iv. | **c.** iv. | **d.** iii. | **e.** i. |
| **2.** | **a.** i. | **b.** ii. | **c.** iii. | **d.** iv. | **e.** iii. |
| **3.** | **a.** ii. | **b.** iii. | **c.** iii. | **d.** i. | **e.** iv. |
| **4.** | **a.** i. | **b.** iii. | **c.** iv. | **d.** iii. | **e.** ii. |
| **5.** | **a.** iv. | **b.** ii. | **c.** i. | **d.** i. | **e.** iii. |

## F. Numerical Problems

**1.** Molar mass of water = 18 g/mol

That means 18 g of water contains $6.022 \times 10^{23}$ molecules, so 0.06 g of water contains

$$= \frac{0.06 \times 6.022 \times 10^{23}}{18} = 0.02 \times 10^{23}$$

$= 2 \times 10^{21}$ molecules

**2.** Atomic mass of oxygen = 16 u

That means 16 g of oxygen contains $6.022 \times 10^{23}$ atoms.

**3.** Avogadro's number = $6.022 \times 10^{23}$

Expenditure per second = 1000000 = ₹ $10^6$

Time taken to spend ₹ $6.022 \times 10^{23}$

$$= \frac{6.023 \times 10^{23}}{10^6} = 6.023 \times 10^{17} \text{ s}$$

1 year = 60 × 60 × 24 × 365 = 31536000 s

Number of years in $6.022 \times 10^{17}$ s

$$= \frac{6.022 \times 10^{17}}{31536000} = 1.91 \times 10^{10} \text{ years}$$

**4.** Formula of methane = $CH_4$

Molecular mass = 12 + 4 = 16 u

16 g of methane contains $6.022 \times 10^{23}$ molecules

1.6 g of methane contains

$$= \frac{6.022 \times 10^{23} \times 1.6}{16} = 6.022 \times 10^{22} \text{ molecules}$$

**5. a.** Formula of sulphuric acid = $H_2SO_4$

Molecular mass = 2 × 1 + 32 + 4 × 16 = 98 u

98 g of $H_2SO_4$ contains 1 mole

392 g of $H_2SO_4$ contains

$$= \frac{1 \times 392}{98} = 4 \text{ moles}$$

**b.** Atomic mass of aluminium = 27 u

27 g of aluminium contains 1 mole

9 g of aluminium contains

$$\frac{9}{27} = 0.33 \text{ moles}$$

**6. a.** Formula of methane = $CH_4$

Molecular mass = 16 u

16 g of methane contains

= $6.022 \times 10^{23}$ molecules

$1 \times 10^{23}$ molecules contain

$$= \frac{16 \times 1 \times 10^{23}}{6.022 \times 10^{23}} = 2.657 \text{ g of methane}$$

**b.** Formula unit mass of $KNO_3 = 39 + 14 + 3(16) = 101$

101 g of $KNO_3$ contains = 1 mole

0.1 mole contains

$$= \frac{101 \times 0.1}{1} = 10.1 \text{ g of } KNO_3$$

**7.** The molar mass of sodium carbonate is 106 g/mol. Therefore, number of formula units of $Na_2CO_3$ in 106 g = $6.022 \times 10^{23}$

Number of formula units of $Na_2CO_3$ in 5.3 g

$$= \frac{6.022 \times 10^{23} \times 5.3}{106} = 3.011 \times 10^{22}$$

One formula unit of $Na_2CO_3$ contains one carbon atom, two sodium atoms and three oxygen atoms. So, the number of carbon atoms in $3.011 \times 10^{22}$ formula units of $Na_2CO_3 = 3.011 \times 10^{22}$.

Number of sodium atoms in $3.011 \times 10^{22}$ formula units of $Na_2CO_3 = 6.022 \times 10^{22}$

Number of oxygen atoms in $3.011 \times 10^{22}$ formula units of $Na_2CO_3 = 3 \times 3.011 \times 10^{22} = 9.034 \times 10^{22}$

**8. a.** Molar mass of $CO_2$ = 44 g/mol

1 mole of $CO_2$ contains 44 g

3 moles of $CO_2$ contains

$$= \frac{3 \times 44}{1} = 132 \text{ g}$$

**b.** Molar mass of $NH_3$ = 17 g/mol

1 mole of $NH_3$ contains 17 g

0.2 mole of $NH_3$ contains

$$= \frac{0.2 \times 17}{1} = 3.4 \text{ g}$$

**9.** The mass equal to 1/12$^{th}$ of the mass of a $^{12}C$ atom is called one atomic mass unit. The atomic mass unit is abbreviated as amu and is denoted by the symbol u (unified mass). Hence,

1 atomic mass unit = 1 u

$$= \frac{\text{Mass of one } ^{12}\text{C atom}}{12}$$

The absolute mass of one $^{12}C$ atom

$$= 1.9924 \times 10^{-23} \text{ g}$$

$$\text{Hence, } 1 \text{ u} = \frac{1.9924 \times 10^{-23}}{12} = 1.66 \times 10^{-24} \text{ g}$$

**10. a.** Molar mass of ammonia $NH_3$ = 17 g/mol

17 g of $NH_3$ contains $6.022 \times 10^{23}$ molecules

1 molecule contains mass

$$= \frac{17 \times 1}{6.022 \times 10^{23}} = 2.823 \times 10^{-23} \text{ g of } NH_3$$

**b.** Molar mass of oxygen = 32 g/mol

32 g of $O_2$ contains $6.022 \times 10^{23}$ molecules

1 molecule contains

$$= \frac{32 \times 1}{6.022 \times 10^{23}} = 5.314 \times 10^{-23} \text{ g of } O_2$$

**11. a.** Mass of iron = 56 g

**b.** Mass of $1 \times 10^{23}$ atoms of carbon (to be calculated)

$$= \frac{12 \times 1 \times 10^{23}}{6.022 \times 10^{23}} = 1.993 \text{ g}$$

**c.** Mass of 1 gram-atom of silver = 108 g

Mass of 0.1 gram-atom of silver = 10.8 g

**d.** Mass of 1 gram-atom of nitrogen = 14 g

Mass of 5 gram-atom of nitrogen = $5 \times 14$ = 70 g

Hence, 5 gram-atom of nitrogen weighs the most.

**12.** Molar mass of carbon dioxide = 44 g/mol

44 g of $CO_2$ contains $6.022 \times 10^{23}$ molecules

4.4 g of $CO_2$ contains

$$= \frac{6.022 \times 10^{23} \times 4.4}{44} = 0.6022 \times 10^{23} \text{ molecules}$$

28 g nitrogen contains $6.022 \times 10^{23}$ molecules

$0.6022 \times 10^{23}$ molecules contains

$$= \frac{0.6022 \times 10^{23} \times 28}{6.022 \times 10^{23}} = 2.8 \text{ g of nitrogen}$$

**13. a.** Molar mass of $Cl_2 = 2 \times 35.5 = 71.0$ g/mol

71 g of $Cl_2$ contains 1 mole

2.5 moles of $Cl_2$ contains = $71 \times 2.5$ = 177.5 g of $Cl_2$

**b.** Molar mass of $H_2O$ = 18 g/mol

1 mole of water has a mass of 18 g.

**14.** Molar mass of $H_2S$ = 2 + 32 = 34 g/mol

34 g of $H_2S$ contains 1 mole of $H_2S$

0.40 mole of $H_2S$ contains

= $0.40 \times 34$ = 13.6 g of $H_2S$

**15.** Molar mass of $H_2O_2 = 2 + 2 \times 16 = 34$ g/mol

34 g of $H_2O_2$ contains 1 mole

$$17 \text{ g of } H_2O_2 \text{ contains} = \frac{17 \times 1}{34} = 0.5 \text{ mole}$$

**16.** Molar mass of $Na_2SO_3 = 2 \times 23 + 32 + 3 \times 16$ = 126 g/mol

126 g of $Na_2SO_4$ contains 1 mole

10 moles contain = $\frac{126 \times 10}{1}$

$= 1260\text{ g} = 1.26\text{ kg of } Na_2SO_3$

**17.** Molar mass of $NH_3$ = 17 g/mol

17 g of $NH_3$ contains $6.022 \times 10^{23}$ molecules

2 g of $NH_3$ contains = $\frac{6.022 \times 10^{23} \times 2}{17}$

$= 0.708 \times 10^{23}$ molecules

Molar mass of $SO_2 = 32 + 2 \times 16 = 64$ g/mol

64 g of $SO_2$ contains $6.022 \times 10^{23}$ molecules

$0.708 \times 10^{23}$ molecules contains

$= \frac{64 \times 0.708 \times 10^{23}}{6.022 \times 10^{23}} = 7.53\text{ g of } SO_2$

**18.** In Lithium Nitrate ($Li_3N$)

| **Element** | Li | N |
|---|---|---|
| **Ratio by mass** | 21 | 14 |
| **Atomic mass** | 7 | 14 |

Ratio of masses of Li : N = 3 : 2.

**19. a.** $2 \times 14 = 28$ u

**b.** $F_2 = 2 \times 19 = 38$ u

**c.** $CO = 12 + 16 = 28$ u

**d.** $NH_4OH = 14 + 4 + 16 + 1 = 35$ u

**e.** $H_2SO_4 = 2 \times 1 + 32 + 4 \times 16 = 98$ u

**f.** $C_2H_5OH = 2 \times 12 + 5 \times 1 + 16 + 1 = 46$ u

**20. a.** $KMnO_4 = 39 + 55 + 4 \times 16 = 158$ u

**b.** $K_2Cr_2O_7 = 2 \times 39 + 2 \times 52 + 7 \times 16 = 294$ u

**c.** $Cu(NO_3)_2.6H_2O$

$= 63.5 + 2 \times 14 + 6 \times 16 + 12 \times 1 + 6 \times 16$

$= 295.5$ u

**d.** $(NH_4)_2SO_4 = 2 \times 14 + 8 \times 1 + 32 + 4 \times 16$
$= 132$ u

**e.** $CuSO_4{\cdot}5H_2O$

$= 63.5 + 32 + 4 \times 16 + 10 \times 1 + 5 \times 16$
$= 249.5$ u

**f.** $NaOH = 23 + 16 + 1 = 40$ u

**21. a.** Molar mass of $ZnSO_4{\cdot}7H_2O$

$= 65.5 + 32 + 4 \times 16 + 7 \times 18 = 287.5$ g/mol

287.5 g of $ZnSO_4{\cdot}7H_2O$ contains 126 g of water of crystallisation.

Percentage of water of crystallisation

$= \frac{126}{287.5} \times 100 = 43.83\%$

**b.** Molar mass of $Na_2SO_4{\cdot}10H_2O$

$= 2 \times 23 + 32 + 4 \times 16 + 10 \times 18 = 322$ g/mol

322 g of Glauber's salt contains 180 g of water of crystallisation.

Percentage of water of crystallisation

$= \frac{180}{322} \times 100 = 55.90\%$

**c.** $CuSO_4{\cdot}5H_2O$

Molar mass of $CuSO_4{\cdot}5H_2O$

$= 63.5 + 32 + 4 \times 16 + 5 \times 18$

$= 249.5$ g/mol

249.5 g of $CuSO_4{\cdot}5H_2O$ contains 90 g of water of crystallisation.

Percentage of water of crystallisation

$= \frac{90}{249.5} \times 100 = 36.07\%$

**d.** Molar mass of $Na_2CO_3{\cdot}10H_2O$

$= 2 \times 23 + 12 + 3 \times 16 + 10\ (2 \times 1 + 1 \times 16)$
$= 286$ g/mol

286 g of washing soda contains 180 g of water of crystallisation.

100 g of washing soda will contain

$= \frac{180}{286} \times 100$ g

= 62.94 g water of crystallisation

The percentage of water of crystallisation in washing soda = 62.94% by mass.

**22. a.** Molar mass of $P_4 = 4 \times 31 = 124$ g/mol

124 g contains $6.022 \times 10^{23}$ molecules

200 g contains

$= \frac{200 \times 6.022 \times 10^{23}}{124}$

$= 9.7 \times 10^{23}$ molecules

**b.** Each phosphorus molecule contains 4 atoms.

∴ Number of atoms in $9.71 \times 10^{23}$ molecules

$= 9.7 \times 10^{23} \times 4 = 38.8 \times 10^{23}$

$= 3.88 \times 10^{24}$ atoms

**23. a.** Molar mass of $Na_2SO_3$

$2 \times 23 + 32 + 3 \times 16 = 46 + 32 + 48$
$= 126$ g/mol

Mass of 10 moles of $Na_2SO_3 = 126 \times 10$
$= 1260$ g

**b.** Atomic mass of sodium = 23 u

Mass of 1 mole of sodium ion = 23 g

Mass of 1.5 mole of sodium = 23 × 1.5
= 34.5 g

**c.** Molar mass of ammonia = 17 g/mol

1 mole of ammonia contains $6.022 \times 10^{23}$ molecules.

Mass of $6.022 \times 10^{23}$ molecules = 17 g

Mass of $1.5 \times 10^{23}$ molecules

$$= \frac{17 \times 1.5 \times 10^{23}}{6.022 \times 10^{23}} = 4.23 \text{ g}$$

**d.** Molar mass of $CuSO_4 \cdot 5H_2O$

= 63.5 + 32 + 4 × 16 + 10 × 1 + 5 × 16

= 249.5 g/mol

1 mole of $CuSO_4 \cdot 5H_2O$ has a mass of 249.5 g.

0.5 mole of $CuSO_4 \cdot 5H_2O$ has a mass

$$= \frac{0.5 \times 249.5}{1} = 124.75 \text{ g}$$

**24. a.** Atomic mass of sodium = 23 u

23 g of sodium contains $6.022 \times 10^{23}$ atoms

100 g of sodium contains

$$= \frac{6.022 \times 10^{23} \times 100}{23}$$

$= 26.2 \times 10^{23} = 2.62 \times 10^{24}$ atoms

**b.** Atomic mass of Fe = 56 u

56 g of Fe contains $6.022 \times 10^{23}$ atoms

100 g of Fe contains

$$= \frac{6.022 \times 10^{23} \times 100}{56}$$

$= 10.75 \times 10^{23}$

$= 1.08 \times 10^{24}$ atoms

Hence, 100 g of sodium has more number of atoms.

**25. a.** $H_2O$

Atomic mass of oxygen = 16 u

Atomic mass of hydrogen = 1 u

So, molecular mass of water = 2 × 1 + 16
= 18 u

**b.** $CO_2$

Molecular mass of $CO_2$

= Atomic mass of carbon
+ 2 × Atomic mass of oxygen

= 12 + 2 × 16 = 12 + 32 = 44 u

**c.** $CH_4$

Molecular mass of $CH_4$

= Atomic mass of carbon
+ 4 × Atomic mass of hydrogen

= 12 + 4 × 1 = 16 u

**26.** The chemical formula of sodium sulphate is $Na_2SO_4$. So, formula unit mass of $Na_2SO_4$

= 2 × Atomic mass of sodium + Atomic mass of sulphur + 4 × Atomic mass of oxygen

= 2 × 23 + 32 + 64 = 142 u

So, Percentage of sodium $= \frac{46}{142} \times 100 = 32.4\%$

Percentage of sulphur $= \frac{32}{142} \times 100 = 22.5\%$

Percentage of oxygen $= \frac{64}{142} \times 100 = 45\%$

**27. a.** $C_2H_2$ = 2 × 12 + 2 × 1 = 26 g/mol

**b.** $S_8$ = 8 × 32 = 256 g/mol

**c.** $P_4$ = 4 × 31 = 124 g/mol

**d.** HCl = 1 + 35.5 = 36.5 g/mol

**e.** $HNO_3$ = 1 + 14 + 3 × 16 = 63 g/mol

**28. a.** 52 moles of Ar

1 mole of Ar contains $6.022 \times 10^{23}$ atoms of Ar. So, number of atoms in 52 moles of argon

$= 52 \times 6.022 \times 10^{23}$

$= 3.132 \times 10^{25}$

**b.** 52 g of He

Molar mass of helium is 4 g/mol. So, there are $6.022 \times 10^{23}$ atoms of He in 4 g. So, number of atoms in 52 g

$= 13 \times 6.022 \times 10^{23} = 7.83 \times 10^{24}$

## G. Higher Order Thinking Skills (HOTS) Questions

**1.** Atomic mass of potassium = 39 u

39 g of potassium contains $6.022 \times 10^{23}$ atoms

100 g of potassium contains

$$= \frac{6.022 \times 10^{23} \times 100}{39} = 15.44 \times 10^{23}$$

$= 1.54 \times 10^{24}$ atoms

56 g of Fe contains $6.022 \times 10^{23}$ atoms

100 g of Fe contains

$$= \frac{6.022 \times 10^{23} \times 100}{56} = 10.75 \times 10^{23}$$

$= 1.08 \times 10^{24}$ atoms

100 g of potassium has more number of atoms.

**2. c.** We are given that the molecular formula of buckminsterfullerene is $C_{60}$. So, molar mass would be mass of one mole of buckminsterfullerene

= 60 × molar mass of one carbon atom

= 60 × 12 = 720 g/mol

Also, the number of atoms of carbon in one gram molecule of buckminsterfullerene would be

$= 6.022 \times 10^{23} \times 60$

$= 3.6 \times 10^{25}$

**3. a.** Molar mass of DDT

= 14 × 12 + 9 × 1 + 5 × 35.5

= 354.5 g/mol

354.5 g of DDT contains $6.022 \times 10^{23}$ molecules

0.1 g of DDT contains

$$= \frac{6.022 \times 10^{23} \times 0.1}{354.5} = 0.00169 \times 10^{23}$$

$= 1.7 \times 10^{20}$ molecules

One molecule of DDT has 5 Cl atoms

$1.7 \times 10^{20}$ molecules of DDT have

$= 1.7 \times 10^{20} \times 5$

$= 8.5 \times 10^{20}$ Cl atoms

**b.** $1.7 \times 10^{20}$

**c.** 354.5 g of DDT contains 1 mole

0.1 g of DDT contains

$$= \frac{1 \times 0.1}{354.5} = 0.0003 \text{ moles}$$

**4.** Molar mass of cisplatin

= 195 + 2 × 14 + 6 × 1 + 2 × 35.5 = 300 g/mol

300 g of cisplatin contains $6.022 \times 10^{23}$ molecules

0.1 g of cisplatin contains

$$= \frac{6.022 \times 10^{23} \times 0.1}{300}$$

$= 0.002 \times 10^{23}$

$= 2.007 \times 10^{20}$ molecules

**a.** Each molecule of cisplatin contains one atom of platinum.

$2.007 \times 10^{20}$ molecules will contain $2.007 \times 10^{20}$ atoms of platinum.

**b.** $2.007 \times 10^{20}$ molecules

**c.** 300 g of cisplatin contains 1 mole

0.1 g of cisplatin contains

$$= \frac{1 \times 0.1}{300} = 0.0003 \text{ mole}$$

**5.** The molar mass of chloromycetin is 323 grams. So, number of moles in 0.2 g of chloromycetin

$$= \frac{0.2}{323} = 0.0006$$

So, number of molecules of chloromycetin in 0.0006 moles would be $0.0006 \times 6.022 \times 10^{23}$

$= 3.73 \times 10^{20}$

**a.** One molecule of chloromycetin contains 2 atoms of nitrogen. So, $3.73 \times 10^{20}$ molecules of chloromycetin will contain $2 \times 3.73 \times 10^{20}$ $= 7.46 \times 10^{20}$ atoms of nitrogen.

**b.** $3.73 \times 10^{20}$ molecules of chloromycetin.

**c.** There are 0.0006 moles of chloromycetin.

**6.** Molar mass of penicillin

= 16 × 12 + 18 × 1 + 2 × 14 + 4 × 16 + 32

= 334 g/mol

334 g of penicillin contains $6.022 \times 10^{23}$ molecules

0.2 g of penicillin contains

$$= \frac{6.022 \times 10^{23} \times 0.2}{334} = 0.0036 \times 10^{23}$$

$= 3.6 \times 10^{20}$ molecules

**a.** Each molecule of penicillin has 2 atoms of nitrogen

$3.6 \times 10^{20}$ molecules of penicillin will have

$= 2 \times 3.6 \times 10^{20} = 7.2 \times 10^{20}$ atoms

**b.** Each molecule has 1 atom of S.

$\therefore$ $3.6 \times 10^{20}$ molecules will have $3.6 \times 10^{20}$ atoms of sulphur.

**c.** $3.6 \times 10^{20}$

**d.** 334 g of penicillin contains 1 mole

0.2 g of penicillin contains

$$= \frac{0.2 \times 1}{334} = 0.0006 \text{ moles}$$

**7.** Molar mass of saccharin

= 7 × 12 + 5 × 1 + 14 + 3 × 16 + 32 = 183 g/mol

183 g of saccharin has $6.022 \times 10^{23}$ molecules

0.2 g of saccharin has

$$= \frac{6.022 \times 10^{23} \times 0.2}{183} = 0.007 \times 10^{23}$$

$= 7 \times 10^{20}$ molecules

**a.** Each molecule has 1 nitrogen atom

$\therefore$ $7 \times 10^{20}$ molecules will have $7 \times 10^{20}$ nitrogen atoms.

**b.** $7 \times 10^{20}$

c. 183 g of saccharin contains 1 mole

0.2 g of saccharin contains

$$= \frac{0.2 \times 1}{183} = 0.001 \text{ mole}$$

8. Molar mass of $P_4O_{10} = 4 \times 31 + 10 \times 16$

$= 284$ g/mol

284 g of $P_4O_{10}$ contains $6.022 \times 10^{23}$ molecules

0.5 g of $P_4O_{10}$ contains

$$= \frac{6.022 \times 10^{23} \times 0.5}{284} = 0.0106 \times 10^{23}$$

$= 1.06 \times 10^{21}$ molecules

Each molecule has 10 oxygen atoms

$1.06 \times 10^{21}$ molecules have

$= 1.06 \times 10^{21} \times 10 = 1.06 \times 10^{22}$ atoms

Therefore, **d**. is correct.

9. The chemical formula of caffeine is $C_8H_{10}N_4O_2$ and its molar mass is 194 g $mol^{-1}$. So, the number of moles of caffeine in 0.2 g

$$= \frac{0.2}{194} = 0.001$$

**a.** 1 mole of caffeine contains 4 moles of nitrogen atoms. So, 0.001 moles of caffeine will contain $4 \times 0.001$ moles of nitrogen atom.

Now, 1 mole of nitrogen atom

$= 6.022 \times 10^{23}$ nitrogen atoms

So, 0.004 moles of nitrogen atom

$= 2.4088 \times 10^{21}$ nitrogen atoms

**b.** 1 mole of caffeine contains $6.022 \times 10^{23}$ molecules of caffeine. So, 0.001 moles of caffeine will contain $0.001 \times 6.022 \times 10^{23}$

$= 6.022 \times 10^{20}$ molecules of caffeine

**c.** 0.001 moles of the compound.

10. The manganate ion is denoted by $MnO_4^{2-}$, while the permanganate ion is denoted by $MnO_4^-$. The formula of the compound containing manganate ion is $K_2MnO_4$. Its name is potassium manganate. The formula of the compound containing permanganate ion is $KMnO_4$. Its name is potassium permanganate.

11. The total number of electrons present in one molecule of ammonia is 7 + 3 = 10. So, the number of electrons present in one mole of ammonia will be

$= 6.022 \times 10^{23} \times 10$

$= 6.022 \times 10^{24}$

12. Yes, the nucleus consists of several other unstable particles such as mesons, positrons, neutrinos, antineutrinos, gluons and quarks. Antineutrino and neutrino are neutral particles.

## H. Value-Based Questions (Optional)

1. **a.** Though there were some short comings in Dalton's atomic theory, some of its postulates are still applicable in modern atomic theory. These are:

   **i.** All matter is made of very tiny particles called atoms.

   **ii.** Atoms combine in the ratio of small whole numbers to form compounds.

   **iii.** The relative number and kinds of atoms are constant in a given compound.

   **b.** Following are the points of disagreement of modern atomic theory with Dalton's theory:

   **i.** According to Dalton's theory, atoms are indivisible particles. However, we know that atoms can be further divided into electrons, protons and neutrons.

   **ii.** According to Dalton's theory, atoms of a given element are identical in terms of mass and chemical properties. However, isotopes are atoms of same element having different properties.

   **iii.** According to Dalton's theory, atoms of different elements have different masses and properties. However, isobars are atoms of different elements having same atomic mass.

   **c.** Even though a few postulates of Dalton's theory were incorrect, it was the result of years and years of research and experimentation. Hence, we learn values like hardworking nature and dedication from Dalton.

   **d.** Hardwork, dedication towards work, scientific temperament, etc.

## P. 124 TEST PAPER

1. **a.** The quantity of a substance which contains Avogadro's number of chemical units (atoms, molecules or ions) of the substance is called mole. The SI unit of mole is mol.

   **b.** The mass of one mole of any substance is called its molar mass.

   **c.** The quantity of an element or compound equal to the relative molecular mass in gram is termed as the gram-molecular mass of the element or compound.

2. **a.** Valency of an atom is the number of electrons a particle loses or gains or shares during the

course of a chemical reaction. The particles may be atoms or group of atoms.

**b.** The electrons present in the outermost shell of an atom are called valence electrons.

**3.** The postulates of Dalton's atomic theory are as follows:

**i.** All matter is made of very tiny particles called atoms.

**ii.** Atoms are indivisible particles which cannot be created or destroyed in a chemical reaction.

**iii.** Atoms of a given element are identical in mass and chemical properties.

**iv.** Atoms of different elements have different masses and chemical properties.

**v.** Atoms combine in the ratio of small whole numbers to form compounds.

**vi.** The relative number and kinds of atoms are constant in a given compound.

No, this theory is only partly valid. Two postulates are not valid. The major drawback of Dalton's atomic theory is that according to this theory, atom is the smallest particle of matter. But now it is an established fact that atom can be further sub-divided into electrons, protons and neutrons. Also, Dalton stated that atoms of an element are identical but the discovery of isotopes proved this postulate wrong.

**4.** **a.** 6 **b.** 5 **c.** 4 **d.** 3

**5.** **a.** $Al_2(CO_3)_3$ **b.** $Mg_3(PO_4)_2$

**6.** **a.** Mass of one mole of Mg = 24 g

Therefore, mass of 4.17 moles of Mg

$= 4.17 \times 24 = 100.08$ g

**b.** Mass of one mole of $P_4$ = 124 g

Mass of 0.25 moles = $0.25 \times 124 = 31$ g

**c.** Mass of one mole of $NH_3$ = 17 g

Mass of 4.17 moles = $17 \times 4.17 = 70.89$ g

**d.** Mass of one mole of $CH_4 = 12 + 1 \times 4 = 16$ g

Mass of 32 moles = $32 \times 16 = 512$ g

## CHAPTER – 4
## STRUCTURE OF THE ATOM

**P. 130–131 Check Your Progress 1**

1. G J Stoney
2. J J Thomson
3. A discharge tube is a cylindrical glass tube about 60 cm long, fitted with two metallic electrodes sealed at the two ends. The positive electrode of the discharge tube is called anode and the negative electrode is called cathode. The discharge tube has a side tube fitted with a stopcock through which the air present in the discharge tube can be pumped out by a vacuum pump.
4. William Crookes
5. When the pressure of air in a discharge tube is reduced to about 0.001 mm of Hg, the emission of pink light by air stops and the glass walls of the discharge tube opposite to the cathode start to glow with a faint greenish light and inside of the discharge tube turns dark. The green glow is due to the fluorescence of the walls produced by the bombardment of the glass by invisible rays coming out from the cathode. These invisible rays coming out from the cathode are called cathode rays.
6. An electron is defined as a subatomic fundamental particle having mass equal to (1/1837)th of that of a hydrogen atom and carrying one unit of negative charge.
7. Negative
8. Cathode rays consist of negatively charged particles.
9. i. **Cathode rays travel in straight lines:** When an opaque solid object such as a metal cross is placed in the path of cathode rays, a shadow of the metal cross is formed on the wall opposite to the cathode. The shadow of the object can be formed only if the cathode rays travel in straight lines.

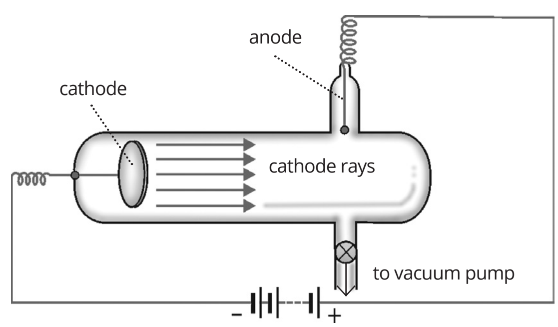
   ii. **Cathode rays produce mechanical effects:** Cathode rays produce mechanical motion of a paddle wheel when it is placed in the path of the cathode rays. This indicates that the cathode rays consist of material particles having mass and kinetic energy.

   iii. **Cathode rays are deflected by an electric field:** When cathode rays are passed through a strong electric field formed by placing positively charged and negatively charged plates in their path, they are deflected towards positively charged plate in their path and this shows that they consist of negatively charged particles.

   iv. **Cathode rays produce X-rays on striking metal targets:** When cathode rays are directed against metal targets (Cu, Mo, etc.), penetrating X-rays are generated.
10. Deflection produced by the magnetic field gets balanced by the deflection produced by the electric field, resulting in no deflection of the electron beam.
11. R A Millikan, oil-drop experiment
12. Thomson
13. The mass of an electron is calculated from the value of *e*/*m* and *e* as follows:

$$\text{Mass of electron } (m) = \frac{\text{Charge}}{\text{Charge/Mass}} = \frac{e}{e/m}$$
$$= \frac{1.602 \times 10^{-19}\,\text{C}}{1.759 \times 10^{11}\ \text{C kg}^{-1}}$$
$$= 9.109 \times 10^{-31}\ \text{kg}$$

14. 0.0005487 u
15. 1837
16. In Oil-Drop Experiment, Millikan put a charge on a tiny drop of oil, and measured how strong an applied electric field had to be in order to stop the oil-drop from falling. Since he was able to work out the mass of the oil-drop and he could calculate the force of gravity on one drop, he could determine the electric charge that the drop must have. By varying the charge on different drops, he noticed that the charge was always a multiple of $-1.602 \times 10^{-19}$ C, the charge on a single electron. This meant that these were electrons carrying this unit charge.
17. Electrons are essential constituents of all matters. An electron is known as a fundamental particle – a particle found in all atoms.
18. 




Emission of cathode rays in the discharge tube opposite to the cathode (pressure = $10^{-5}$ atm, voltage = 10000 V)

**19.** When the pressure of air in the discharge tube is reduced to about 0.001 mm of Hg, the emission of pink light by air stops and the glass walls of the discharge tube opposite to the cathode start to glow with a faint greenish light and inside of the discharge tube turns dark. The green glow is due to the fluorescence of the walls produced by the bombardment of the glass by invisible rays coming out from the cathode. These invisible rays coming out from the cathode are called cathode rays. Thus, when electrical discharge is passed through gases at very low pressures, cathode rays are produced.

**20.** **a.** A pink glow is emitted by the air inside the tube.

**b.** The glass wall opposite to the cathode glows with a faint greenish light and the inside of the discharge tube turns dark.

**21.** **a.** Cathode rays consist of negatively charged particles.

**b.** Cathode rays consist of material particles having mass and kinetic energy.

**c.** Cathode rays travel in straight lines.

**22.** **i.** When the pressure in the discharge tube is reduced to 1 mm of Hg, a pink glow is emitted by the air inside the tube.

**ii.** When the pressure of air in the discharge tube is reduced to about 0.001 mm of Hg, the emission of pink light by air stops and the glass walls of the discharge tube opposite to the cathode start to glow with a faint greenish light and inside of the discharge tube turns dark. The green glow is due to the fluorescence of the walls produced by the bombardment of the glass by invisible rays coming out from the cathode. These invisible rays coming out from the cathode are called cathode rays.

**23.** **a.** electrons **b.** $-1.602 \times 10^{-19}$

**c.** 0.0005487 **d.** $1.759 \times 10^{11}$

**e.** north **f.** inside, outside

**24.** **a.** F **b.** F **c.** T **d.** F **e.** F **f.** F **g.** T **h.** F

## P. 133 Check Your Progress 2

**1.** In a discharge tube, the rays travel in the straight lines in the opposite direction to that of the cathode rays, passing through the perforations (canals) of the cathode and produce fluorescence on a screen placed on the other end of the second chamber. Since these rays pass through the canals in the cathode, they are called canal rays or anode rays.

**2.** Goldstein

**3.** Goldstein

**4.** Wein

**5.** *e* remaining constant, *m* varies for different gases.

**6.** In a discharge tube, when electrical discharge is passed through a gas at a very low pressure (0.001 mm of Hg), cathode rays are formed. The cathode rays are stream of fast moving electrons. When these electrons strike the atoms or molecules of the gas in the discharge tube, one or more electrons are knocked off from the atoms or molecules of the gas and as a result, ionisation of atoms or molecules occurs and positively charged particles are formed. These positively charged particles (ions) of the gas constitute the anode rays.

**7.** The anode rays were found to get deflected by an electric field and they bend towards the negative plate. They also get deflected by a magnetic field in a direction opposite to that of the cathode rays. This indicates that anode rays are made up of positively charged particles.

**8.** Charge on particles; cathode rays are negatively charged but anode rays are positively charged.

**9.** Positive

**10.** They deflect towards the negative plate.

**11.** They deflect in the direction opposite to that of cathode rays.

**12.** **i.** Anode rays consist of positively charged particles.

**ii.** Anode rays travel in straight lines.

**iii.** Anode rays are deflected by the electric field and they bend towards the negative plate.

**iv.** Anode rays are deflected by the magnetic field in the direction opposite to that of cathode rays.

**13.** **a.** Atoms consist of negatively charged particles.

**b.** Atoms consist of positively charged particles.

**14.** **a.** positively charged

**b.** less

**c.** negatively, positively

**d.** Goldstein

**e.** $19.5 \times 10^4$ C $g^{-1}$

**15.** **a.** F **b.** F **c.** F **d.** F **e.** F

## P. 135 Check Your Progress 3

**1.** No

**2.** Electron, proton and neutron.

**3.** Chadwick

**4.** Neutron has the following characteristics:

**i.** Neutron is an electrically neutral particle having no electrical charge.

**ii.** Neutron has a mass of $1.676 \times 10^{-24}$ g which is slightly higher than that of proton ($1.673 \times 10^{-24}$ g). The mass of neutron in the atomic mass unit is 1.0089 u.

**iii.** Neutron is a stable particle inside the nucleus but it is unstable outside the nucleus.

**5.** $1.676 \times 10^{-24}$ g, 1.0089 u

**6.** 2

## P. 144 Check Your Progress 4

**1.** In Rutherford's alpha-particle scattering experiment, since most of the alpha particles passed through the gold foil without any deflection, the major part of the space in an atom is empty.

**2.** Proton

**3.** Drawbacks of Rutherford model:

**i.** It does not say anything about the distribution of electrons around the nucleus and the energy of electrons.

**ii.** Due to a change in the direction, a moving body undergoes acceleration, even while moving at a constant speed. A charged particle on acceleration should emit electromagnetic radiation. Hence, an electron in an orbit is expected to emit radiation. The energy carried by radiation coming from the motion of electron and the orbit is expected to shrink continuously. Thus, the electron should follow a spiral path and ultimately fall into the nucleus. But this does not happen. Thus, Rutherford's model cannot explain the stability of an atom.

**4.** According to Bohr's atomic model:

**i.** In an atom, the electrons revolve around the nucleus in certain definite circular paths called orbits. Such orbits differ from each other in their radii. Only certain discrete orbits of electrons are allowed inside the atom.

**ii.** Each orbit has a definite energy. These orbits are known as energy levels or energy shells. The orbits or energy shells are numbered as 1, 2, 3, 4, … or *K*, *L*, *M*, *N*, ... shells starting from the nucleus. The integers 1, 2, 3, 4, … are called principal quantum numbers ($n$). The energy shell nearest to the nucleus has minimum energy and the energy shell farthest from the nucleus has maximum energy

**iii.** As long as an electron remains in a particular orbit, it does not radiate energy.

**iv.** An electron loses energy when it jumps from an orbit of higher energy ($E_2$) to an orbit of lower energy ($E_1$) and energy equal to $E_2 - E_1$ is given out in the form of electromagnetic radiation. An electron gains energy from outside when it jumps from an orbit of lower energy ($E_1$) to an orbit of higher energy ($E_2$). The change in energy, $\Delta E$ is given by: $\Delta E = E_2 - E_1 = h\nu$, where $h$ is Planck's constant and $\nu$ is the frequency of radiation emitted or absorbed.

**5.** According to Bohr–Bury scheme:

**i.** The electron orbits are designated by the number $n$ where $n$ = 1, 2, 3, 4, . . . . The maximum number of electrons which can be accommodated in an energy shell (orbit) is given by $2n^2$ where $n$ stands for the number of the orbit.

**ii.** The outermost shell of an atom cannot accommodate more than eight electrons, even if it has the capacity to accommodate more electrons. This is because the presence of eight electrons in the outermost shell makes the atom very stable.

**iii.** It is not always necessary to fill up an orbit completely before starting the next higher orbit. For filling of electrons in various shells, we have to also remember the following: The filling of electrons in the second shell ($n = 2$) begins only after the first shell is filled with two electrons. The filling of electrons in the third shell ($n = 3$) begins only after the second shell is filled with eight electrons. The filling of the fourth shell ($n = 4$) begins even before the third shell is completely filled.

**6.** The circular orbits having definite energy around the nucleus in which electrons revolve are known as energy levels or energy shells.

Electronic configuration of $^{31}_{15}P$ is 2, 8, 5.

**7.** ~ $10^{-13}$ cm

**8.** Electronic configuration of an element with atomic number 17 is 2, 8, 7.

## P. 147 Check Your Progress 5

1. **a.** The atomic number of an element is equal to the number of protons present in the nucleus of an atom of that element. It is represented by *Z*. For example, an atom of carbon has six protons and hence, the atomic number of carbon is six.

   Since an atom is electrically neutral, the total number of electrons in an atom is also equal to its atomic number.

   **b.** The sum of the number of protons and neutrons in the atom of an element is called its mass number. It is represented by *A*.

   For example, an atom of nitrogen has 7 protons and 7 neutrons and hence, its mass number is 14.

   Atomic number is the more fundamental property of an element.
2. 14, 19
3. The protons and neutrons present in the nucleus of an atom are collectively called nucleons.
4. Atomic number = 2 + 8 + 3 = 13
5. 17, 35

## P. 150 Check Your Progress 6

1. 3
2. $^{35}_{17}Cl$ Since the outermost shell of chlorine has seven electrons, it can gain an electron to complete its octet and become stable. Thus chlorine is chemically more reactive.
3. 5; Valency: 3, 5
4. **a.** 3 **b.** 2 **c.** 4 **d.** 1
5. **a.** 1 **b.** 3, 5 **c.** 1
6. The electronic configuration of sodium is 2, 8, 1. The loss of the valence electron would produce a stable, completely filled outermost shell having 8 electrons. Hence, sodium is chemically very reactive. The electronic configuration of fluorine is 2, 7. The gain of one electron would produce a stable, completely filled outermost shell having 8 electrons. Hence, fluorine is also chemically very reactive.

## P. 156–157 Check Your Progress 7

1. Proton is a positively charged particle found in the atoms of all elements. Charge and mass of proton: +1, 1.0076 u
2. $1.673 \times 10^{-24}$ g, $1.602 \times 10^{-19}$ C
3. Proton
4. Neutron
5. 1837:1
6. **i.** When electrical discharge is passed through gases at very low pressure, cathode rays are produced which are actually electrons.

   **ii.** When these electrons strike the atoms or molecules of the gas in the discharge tube, one or more electrons are knocked off from the atoms or molecules of the gas and as a result, ionisation of atoms or molecules occurs and positively charged particles are formed. These positively charged particles (ions) of the gas constitute the anode rays.

   Thus, these two observations showed that an atom is divisible.
7. Different mass and different sign of charge.
8. Proton and neutron
9. Positive
10. Chadwick
11. When a sheet of a lighter metal such as beryllium, lithium or boron is bombarded with high energy $\alpha$-particles, there is an emission of a highly penetrating radiation. When this radiation is allowed to strike a paraffin block, protons having very high velocity are released. In 1932, Chadwick showed that the highly penetrating radiation, produced by lighter metals, was due to the neutral particles of approximately unit mass but little heavier than proton. Chadwick named these particles as neutrons (*n*).
12. $1.673 \times 10^{-24}$ g
13. No
14. Because number of positively charged protons is equal to the number of negatively charged electrons.
15. $^{1}_{1}H$
16. Nucleus is the positively charged body inside an atom surrounded by electrons. Nature of charge is positive.
17. Rutherford
18. Rutherford
19. By Rutherford's $\alpha$-particle scattering experiment.
20. Deflections of $\alpha$-particle by the nucleus of an atom.
21. Since very few $\alpha$-particles are deflected by small angles, the deflection is due to an enormous repulsive force between positively charged $\alpha$-particles and some positive body present within the atom. The $\alpha$-particles coming close to this positive body get deflected by small angles. This positively charged body inside the atom was named as nucleus.

**22.** According to Rutherford's alpha-particle scattering experiment, most of the mass of an atom is concentrated in the nucleus. The mass of the nucleus is due to protons and neutral particles (called later as neutrons by Chadwick and Rutherford in 1932) having mass almost equal to the mass of proton. Also, since most of the $\alpha$-particles passed through the gold foil without any deflection, the major part of space in an atom is empty.

**23.** The atomic number of an element is equal to the number of protons present in the nucleus of an atom of that element. It is represented by *Z*.

**24.** 16

**25.** Number of protons and neutrons: 9 and 10. Atomic number is 9.

**26.** 16, 16, 16

**27.** Protons and neutrons

**28.** **a.** Atomic number

**b.** Mass number

**c.** 11

**d.** 11

**e.** 12

**29.** 14, 14, 14, $^{28}_{14}Si$

**30.** Atoms of the same element which have same number of protons but different number of neutrons inside their nuclei are called isotopes. For example, there are three isotopes of hydrogen: protium, deuterium and tritium. They are represented as:

| $^{1}_{1}H$ | $^{2}_{1}H$ | $^{3}_{1}H$ |
|---|---|---|
| Protium | Deuterium | Tritium |

**31.** The atoms of different elements with different number of protons (i.e. different atomic numbers) but equal sum of the number of protons and neutrons (i.e. same mass number) are called isobars. Isobars have different physical and chemical properties. An example of isobars is: $^{14}_{6}C$, $^{14}_{7}N$.

**32.** Due to the existence of isotopes.

**33.** Atomic mass of Cl = 75% of 35 + 25% of 37 = 26.25 + 9.25 = 35.5 u.

**34.** 35.45 u

**35.** **a.** 0 **b.** Chadwick

**c.** $10^{-13}$ **d.** nucleons

**e.** protons, electrons **f.** less

**g.** 2, 8, 6

**36.** **a.** T **b.** F **c.** T **d.** T **e.** F **f.** F **g.** T

**P. 159 EXERCISES**

**A. Objective Type Questions**

**I. Choose the most appropriate answer.**

| | | | | |
|---|---|---|---|---|
| **1.** d | **2.** d | **3.** b | **4.** b | **5.** c |
| **6.** b | **7.** b | **8.** a | **9.** a | **10.** b |
| **11.** c | **12.** a | **13.** b | **14.** a | **15.** a |
| **16.** c | **17.** a | **18.** b | **19.** d | **20.** d |
| **21.** a | **22.** d | **23.** c | **24.** b | |

**II. Write True or False.**

| | | | | |
|---|---|---|---|---|
| **1.** T | **2.** T | **3.** F | **4.** T | **5.** T |
| **6.** T | **7.** F | **8.** T | **9.** T | **10.** T |
| **11.** F | **12.** F | **13.** T | **14.** F | **15.** F |
| **16.** T | **17.** F | **18.** F | **19.** T | **20.** F |
| **21.** T | **22.** F | **23.** T | **24.** T | |

**III. Fill in the blanks.**

**1.** negatively **2.** $1.602 \times 10^{-19}$C

**3.** 1837 **4.** neutrons

**5.** 19,19, 39 **6.** Charge

**7.** nucleus **8.** 1/100000

**9.** Proton, neutron **10.** nucleons

**11.** 11 **12.** Zero

**13.** atomic number, mass number

**14.** zero **15.** Rutherford

**16.** Chadwick **17.** isobars

**18.** ground state **19.** isotopes

**20.** 2, 8, 5

**IV. Match the items in column A with the items in column B.**

| | | | | |
|---|---|---|---|---|
| **1.** a | **2.** d | **3.** f | **4.** c | **5.** g |
| **6.** b | **7.** h | **8.** e | **9.** i | |

**V. Assertion–Reasoning Type Questions** CBQ

| | | | | |
|---|---|---|---|---|
| **1.** a | **2.** a | **3.** a | **4.** a | **5.** b |
| **6.** d | **7.** a | **8.** c | **9.** b | **10.** a |

**VI. Very Short Answer Type Questions**

**1.** Michael Faraday

**2.** J J Thomson

**3.** William Crookes

**4.** $1.759 \times 10^{11}$ C $kg^{-1}$

**5.** $9.11 \times 10^{-28}$ g

6. $– 1.602 \times 10^{-19}$ C

7. Cathode rays produce mechanical effects.

8. J J Thomson in 1897

9. $9.1 \times 10^{-31}$ kg, $– 1.602 \times 10^{-19}$ C

10. Hydrogen

11. $1.673 \times 10^{-24}$ g

12. Nucleus consists of several other unstable particles such as mesons, positrons, neutrinos, antineutrinos, gluons and quarks.

13. Positive

14. The number of electrons present in the valence shell of an atom is known as valence electrons.

 The combining capacity of an element is known as its valency.

15. Electronic contiguration of the element is 2, 3; valency = 3

16. 3

17. The gas in the discharge tube is composed of atoms and all atoms contain electrons. On application of high electrical voltage, the electrical energy knocks out some of the electrons from the atoms of the gas taken in the discharge tube. These electrons constitute the cathode rays.

18. In a discharge tube, when electrical discharge is passed through a gas at a very low pressure (0.001 mm of Hg), cathode rays are formed. The cathode rays are stream of fast moving electrons. When these electrons strike the atoms or molecules of the gas in the discharge tube, one or more electrons are knocked off from the atoms or molecules of the gas and as a result ionisation of atoms or molecules occurs and positively charged particles are formed. These positively charged particles (ions) constitute the anode rays.

19. The maximum number of electrons that can be present in the first, second and third electron orbits of atoms are 2, 8 and 8 respectively.

20. 12

21. Each orbit has a definite energy. These orbits are known as energy levels. The lowest energy state ($E_1$) is called ground state and the higher energy states ($E_2$, $E_3$, $E_4$) are called excited states.

22. **a.** Calcium (atomic no. 20); valency – 2

 **b.** Argon (atomic no. 18); valency – 0

23. 4; 4

24. The method of estimating the age of dead objects containing carbon such as fossils and pieces of wood by measuring the amount of the $^{14}_{6}C$ isotope in the dead object relative to that of the $^{14}_{6}C$ isotope in a living object is called radiocarbon dating.

25. Charge

26. Cathode rays

27.

| Fundamental particle | Mass | Charge |
|---|---|---|
| Proton | $1.673 \times 10^{-24}$ g | +1 |
| Electron | $9.109 \times 10^{-28}$ g | –1 |

28. **a.** Goldstein – proton **b.** Thomson – electron **c.** Chadwick – neutron

29. The location of protons – nucleus

 The location of electrons – outside nucleus

 The location of neutrons – nucleus

30. **a.** 0 – neutron **b.** +1 – proton **c.** –1 – electron.

31. Neutron

32. The atomic mass of nitrogen is 14 u and not 21 u because as compared to protons and neutrons, the mass of electrons is negligible. So, the atomic mass of nitrogen is majorly due to the protons and neutrons, which are 14 in total.

33.

| Fundamental particle | Mass | Charge |
|---|---|---|
| Proton | $1.673 \times 10^{-24}$ g | +1 |
| Neutron | $1.676 \times 10^{-24}$ g | 0 |

34. Yes

35. No

36. Difference in number of neutrons.

37. Isotopes

38. Isotopes

39. The chemical properties of an element are dependent on its number of electrons, and the isotopes have same number of electrons because of same atomic number. Therefore, the isotopes have similar chemical properties.

40. No, they have different atomic numbers.

41. $2n^2 = 2 \times (5)^2 = 50$

42. **a.**

43. $^{14}_{7}N$ and $^{15}_{7}N$

44. **a.** 32 **b.** 72

45. The electronic configuration of element with atomic number 12 is 2, 8, 2.

46. Isotopes

47. $^{40}_{18}Ar$ and $^{40}_{20}Ca$

48. **i.** This method is extensively used for finding the age of archaeological samples and objects of historical importance.

**ii.** This technique is also used to determine the age of wine, glaciers and snowfields in which the radioactive level of tritium is measured.

49. Completion of octet in shell.

50. **a.**

## B. Short Answer Type–I Questions

1. When an opaque solid object such as metal cross is placed in the path of cathode rays, a shadow of the metal cross is formed on the wall opposite to the cathode. The shadow of the object can be formed only if the cathode rays travel in straight lines.

2. **Origin of cathode rays:** The gas in the discharge tube is composed of atoms and all atoms contain electrons. On application of high electrical voltage, the electrical energy knocks out some of the electrons from the atoms of the gas taken in the discharge tube. These electrons constitute the cathode rays.

3.

| Fundamental particle | Mass | Relative mass | Relative charge | Location in the atom |
|---|---|---|---|---|
| Proton | $1.673 \times 10^{-24}$ g | 1 u | +1 | Nucleus |
| Neutron | $1.676 \times 10^{-24}$ g | 1 u | 0 | Nucleus |
| Electron | $9.109 \times 10^{-28}$ g | $\frac{1}{1837\text{ u}}$ | –1 | Outside nucleus |

4. *e*/*m* ratio is charge to mass ratio. The value of *e*/*m* ratio of cathode rays is $1.759 \times 10^{11}$ C/kg.

5. In 1932, Chadwick showed that highly penetrating radiation, produced by lighter metals was due to neutral particles of approximately unit mass but little heavier than proton. Chadwick named these particles as neutrons.

6. ${}^{19}_{9}F$: 9 protons and 10 neutrons; ${}^{40}_{18}Ar$: 18 protons and 22 neutrons; ${}^{39}_{19}K$: 19 protons and 20 neutrons; ${}^{40}_{20}Ca$: 20 protons and 20 neutrons; ${}^{80}_{35}Br$: 35 protons and 45 neutrons; ${}^{84}_{36}Kr$: 36 protons and 48 neutrons.

7. **a.** 26 **b.** 26 **c.** 30

8. **a.** Because number of electrons and protons are equal.

**b.** Due to same number of electrons.

9. When cathode rays are passed through a strong electric field formed by placing positively charged and negatively charged plates in their path, they are deflected towards positively charged plate in their path and this shows that they consist of negatively charged particles.

10. Similarity- Same number of protons.

Dissimilarity- Difference in number of neutrons.

11. Isotopes

12. Isotopes are atoms of the same element having same atomic number but different atomic masses. That is, they have the same number of electrons and protons, but the number of neutrons are different. Because they have the same number of electrons, their electronic configuration and hence chemical properties are same.

13. **a.** If the number of electrons in the valence shell of an atom is $\leq$ 4, then the valency of that element is equal to that many number of electrons. However, if the number of electrons are > 4, then the valency of that element can be calculated as $(8-n)$, where $n$ is the number of valence electrons. For example, the number of valence electrons in magnesium is 2, so its valency is 2. In chlorine, the number of valence electrons are 7. So, its valency is 8 – 7 = 1.

**b.** If the number of valence electrons is 8, the element will not be reactive. This is because its outermost shell is complete. However, if the number of valence electrons is < 8, the element will be reactive. The more easily it can achieve stable electronic configuration, the more reactive it will be. For example, the number of valence electrons present in sodium is 1. So, it needs to lose just one electron to achieve noble gas configuration. Hence, it is quite reactive.

14. **a.** ${}^{131}_{53}I$

**b.** ${}^{32}_{15}P$

**c.** ${}^{235}_{92}U$, ${}^{239}_{94}Pu$

**d.** ${}^{33}_{15}P$

## C. Short Answer Type–II Questions

1. When cathode rays are passed through a strong electric field formed by placing positively charged and negatively charged plates in their path, they are deflected towards positively charged plate in their path and this shows that they consist of negatively charged particles.

2. The valency of an element can be determined from the number of valence electrons it has. Let us consider the example of chlorine. Its atomic number is 17 and electronic configuration is 2, 8, 7. It needs one electron more to complete its octet. So, the valency of chlorine will be 1. Similarly, the atomic number of sulphur is 16. Its electronic configuration is 2, 8, 6. So, it needs 2 electrons more to complete its octet. Thus, the valency of sulphur is 2. For magnesium, the valency is 2. This is because the electronic configuration of magnesium is 2, 8, 2 and it needs to lose 2 electrons to achieve stable noble gas configuration.

3. The electron does not fall into the nucleus because according to Bohr's theory, as long as an electron remains in a particular orbit, it does not radiate energy. So, if it will not radiate energy, it will not fall into the nucleus.

4. No, because protons and neutrons are made up of various combinations of smaller elementary particles called quarks having fractional charges and properties such as colour and flavour.

5. i. An atom is made of three particles–electrons, protons and neutrons. Protons and neutrons cannot be called elementary particles as they are made up of various combinations of smaller elementary particles called quarks having fractional charges and properties such as colour and flavour.

   ii. The protons and neutrons are present in a small nucleus which is present in the centre of an atom. That is why these are also called nucleons. The nucleus is positively charged due to the presence of protons.

   iii. The electrons revolve around the nucleus in certain definite circular paths known as orbits (or energy levels).

   iv. The orbits are designated either by numbers 1, 2, 3, 4, etc., also known as quantum number, or by alphabets *K*, *L*, *M*, *N*, etc., starting from the nucleus.

   v. Every orbit is associated with certain minimum amount of energy. The orbit nearest to the nucleus has the minimum energy while the orbit farthest from the nucleus possesses the maximum amount of energy. This model is considered to be most appropriate because the stability of the atom can be explained on the basis of this model. Although the electrons are revolving around the nucleus, but they do not lose energy as long as they revolve in same orbit. The change in the energy of an electron occurs only when it jumps from a lower energy level to a higher energy level or when it comes down from a higher energy level to a lower energy level. In other words, an electron jumps by gaining energy and it loses the same amount of energy when it comes down.

6. The latest particle to be discovered in the structure of the atom is Higgs Boson. It is very unstable and decays into other particles almost immediately. Since the 1960s, scientists have discovered many other particles in the atom, such as quarks, anti-quarks, gluons. So, there might be some other particles inside the nucleus.

7. Because for some particles, the mass gets converted to energy according to the relation

$$E = mc^2$$

   This does not happen for protons and neutrons. Also, protons and neutrons are quite stable inside the nucleus, while other particles are not.

8. Isotopes are used for the treatment of various diseases. For example,

   i. Isotopes $^{60}_{27}Co$, $^{225}_{80}Ra$ and $^{198}_{79}Au$ are used for the treatment of cancer.

   ii. Isotope $^{32}_{15}P$ is used for locating cancer. It is used for the treatment of blood cancer. It is also used in patients suffering from bone fracture to find absorption of phosphorous in their bones.

   iii. Isotopes $^{73}_{33}As$ and $^{131}_{53}I$ are used for locating brain tumor.

   iv. Isotope $^{131}_{53}I$ is used for detection of thyroid disorder and its treatment.

   v. Isotope $^{33}_{15}P$ is used in the manufacturing of steel from cast iron in order to find out the complete removal of phosphorus from steel.

   vi. Radioactive isotopes are used to detect minor cracks in the underground gas pipelines, oil pipelines and water pipelines.

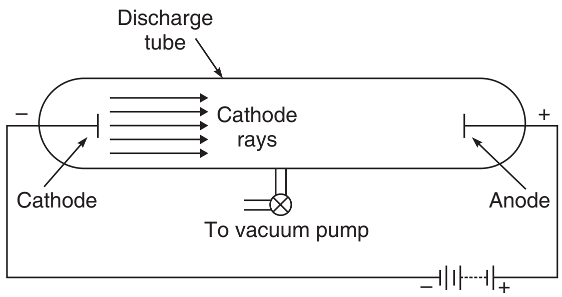
9. The isotopes of hydrogen are protium (proton 1, neutron 0), deuterium (proton 1, neutron 1), and tritium (proton 1, neutrons 2).

10. *e*/*m* ratio for electron = $1.76 \times 10^{11}$ C/kg

$$e/m \text{ ratio for } He^+ = \frac{1.602 \times 10^{-19} \text{C}}{4 \times 1.673 \times 10^{-27} \text{ kg}} = 2.39 \times 10^7 \text{ C/kg}$$

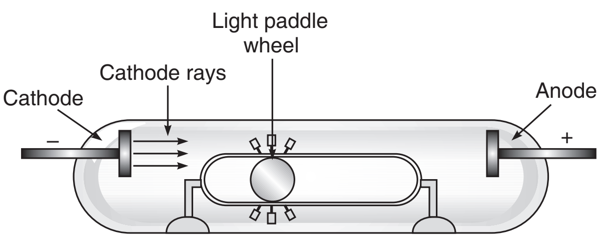
$$e/m \text{ ratio of } He^{2+} = \frac{2 \times 1.602 \times 10^{-19} \text{ C}}{4 \times 1.673 \times 10^{-27} \text{ kg}} = 4.79 \times 10^7 \text{ C/kg}$$

**11.** Cathode rays are produced in a discharge tube. The technique was demonstrated by J J Thomson for the first time. He took a discharge tube and filled it with a gas at very low pressure. He then passed an electric discharge through this gas, and found a glow which emitted from the cathode and went towards the anode. This glow was made up of rays that were named cathode rays as they originated from cathode.




Production of cathode rays

**12.** Cathode rays produce mechanical motion of a paddle wheel when it is placed in the path of the rays. This indicates that the cathode rays consist of material particles having mass and kinetic energy.




Cathode rays can rotate a high paddle wheel placed in their path

**13.** Isotopes are atoms of an element with same atomic number but different mass number. The three isotopes of oxygen differ in the number of neutrons. $^{16}_{8}O$ – 8 neutrons, $^{17}_{8}O$ – 9 neutrons, $^{18}_{8}O$ – 10 neutrons.

**14.** Electrons are essential constituents of all matters. An electron is known as a fundamental particle because it is a particle found in all the atoms.

**15.** The differences in the discharge tubes used for the production of cathode rays and positive rays are as follows:

**i.** The discharge tube used for the production of cathode rays has only one chamber whereas that used for the production of positive rays has two chambers.

**ii.** The discharge tube used for the production of cathode rays has a solid cathode (unperforated) whereas that used in the production of positive rays has a perforated cathode.

**16.** Anode rays deflect and bend towards negatively charged plates. This shows that they are positively charged particles.

**17.** An electron is a negatively charged particle because on subjecting to electric field, it moves towards the positive plate.

**18.** Proton is a positively charged particle because on subjecting to electric field, it moves towards the negative plate.

**19. a. Cathode rays:** When a high voltage is passed through a discharge tube containing air at a very low pressure (0.001 mm of Hg), the discharge tube turns dark and the glass wall of the discharge tube opposite to the cathode starts to glow with a faint greenish light. The green glow is due to invisible rays coming out from the cathode. These rays are called cathode rays.

**b. Anode rays:** Anode rays are formed due to the ionisation of atoms or molecules of the gas taken in the discharge tube.

**c. Electron:** An electron is defined as a subatomic particle having a mass equal to 1/1837th of that of a hydrogen atom and carrying one unit of negative charge.

**d. Proton:** A proton is defined as a subatomic particle having a mass equal to that of a hydrogen atom and carrying unit positive charge.

**e. Neutron:** Neutron is a subatomic, electrically neutral particle having mass equal to that of a proton.

**f. Nucleon:** Protons and neutrons collectively present in a nucleus of an atom are called nucleons.

**20.** Rutherford's alpha particle scattering experiment established the presence of the atomic nucleus. The features of the nucleus deduced from this experiment were:

**i.** The nucleus is a positively charged centre present in the atom. Nearly all the mass of an atom is concentrated in the nucleus.

**ii.** The size of the nucleus is very small as compared to the size of the atom.

**21. a.** It indicates the atomic number which is the number of protons in the element.

**b.** 5 **c.** (11 – 5) = 6 **d.** 5

## D. Long Answer Type Questions

1. J J Thomson discovered the electron.

   In his experiment, Thomson studied the combined effect of electric and magnetic fields on cathode rays.

   When cathode rays are passed through a magnetic field, they are deflected in a direction which shows that they are negatively charged particles. Thomson allowed the cathode rays to pass through magnetic field and electric field arranged perpendicular to each other in succession such that the field produced by the electromagnet was opposite to the electric field. When the cathode rays were passed through electric field only, they were deflected towards the positive plate. Then they were passed through both the electric and the magnetic fields, and the electric and magnetic field strengths were adjusted in such a manner that they balanced each other to produce no deflection in the cathode rays beam. Thus, the deflection produced by the magnetic field was cancelled by the deflection produced in the opposite direction by the electric field (i.e. net deflection = 0).

   By following this method of balancing the deflections of cathode rays, in magnetic and electric fields, Thomson calculated the charge/mass ratio, i.e. $e/m$ ratio. He found the $e/m$ ratio of cathode rays to be $1.759 \times 10^{11}$ C $kg^{-1}$. It was found that the nature of cathode rays (i.e. $e/m$ ratio of the particles) does not depend upon the nature of the gas taken in the discharge tube and the material of the electrodes used in the discharge tube.

   $$e/m = 1.759 \times 10^{11} \text{ C kg}^{-1} = \text{constant}$$

   Refer Figure 4.7 from page 128 of the textbook.

2. The properties of electrons, protons and neutrons (i.e. nature of their charge, mass and location) are given below in a tabulated form:

| Particle | Nature of charge | Mass | Location |
|---|---|---|---|
| Electron | negative (–1) or $-1.6 \times 10^{-19}$ C | $9.1 \times 10^{-31}$ kg | Outside nucleus |
| Proton | positive (+1) or $+1.6 \times 10^{-19}$ C | $1.673 \times 10^{-27}$ kg (1 u) | Nucleus |
| Neutron | No charge | $1.676 \times 10^{-27}$ kg (1 u) | Nucleus |

3. **a.** A small heavy and positively charged core at the centre of an atom is called nucleus.

   **b.** The atoms of an element which have the same number of protons but different number of neutrons are called isotopes.

   **c.** The atoms of different elements which have the same mass number but different atomic numbers are called isobars.

4. Ernest Rutherford performed an experiment in which he bombarded very thin sheets of gold foil with alpha particles, which are helium ions ($He^{2+}$) containing two protons and two neutrons. These particles are emitted by radioactive elements like radium.

   **a.** The alpha particles got deflected which meant the centre of the atom was of the same charge as alpha particle which is positive charge.

   **b.** As gold foil deflected some alpha particles and very few were returned back also, it shows that the centre of an atom is dense, hard and positively charged.

   **c.** Most of the space was empty. This was because the gold foil allowed most of the alpha particles to pass straight through without being deflected.

5. Atoms of an element having the same atomic number but different mass number are called isotopes.

   The isotopes of an element have the following characteristics:

   **i.** The isotopes of an element have the same number of protons and electrons but different number of neutrons.

   **ii.** The isotopes of an element have different mass numbers and therefore, different masses.

   **iii.** The isotopes of an element possess the same electronic configuration and the same number of valence electrons and exhibit the same chemical properties.

   **iv.** The isotopes of an element exhibit different physical properties such as density, melting point, boiling point, etc.

   **v.** Isotopes differ from isobars in the way that isobars have the same mass number but different atomic number whereas isotopes have the same atomic number.

6. The features of cathode rays are:

   **i.** Cathode rays travel in straight lines.

   **ii.** Cathode rays produce mechanical effects.

iii. Cathode rays are deflected by an electric field.

iv. Cathode rays are deflected by a magnetic field.

v. Cathode rays heat metal foils to incandescence.

vi. Cathode rays impart negative charge to the objects in their path.

vii. Cathode rays cause ionisation of gases.

viii. Cathode rays expose photographic plates.

ix. Cathode rays produce X-rays on striking metal targets.

x. Cathode rays produce fluorescence.

The features of canal rays or anode rays are:

i. Anode rays consist of positively charged particles.

ii. Anode rays travel in straight lines.

iii. Anode rays are deflected by the electric field and they bend towards the negative plate.

iv. Anode rays are deflected by the magnetic field in a direction opposite to that of cathode rays.

v. The nature of anode rays depends upon the nature of the gas taken in the discharge tube.

vi. Anode rays expose photographic plates and films.

vii. Anode rays produce fluorescence in the glass walls of the discharging tube, inside of which is coated with a fluorescent substance.

viii. Anode rays can produce mechanical effect.

**7.** The cathode rays get deflected towards the positive electrode. Yes, the charge can be determined on the electron. As the electrons are deflected towards positively charged plate in their path, this shows that they consist of negatively charged particles called electrons. In 1909, an American chemist, Robert A. Millikan measured the charge (*e*) on an electron by carrying out his famous oil-drop experiment. What Millikan did was to put a charge on a tiny drop of oil, and measure how strong an applied electric field had to be in order to stop the oil-drop from falling. Since he was able to work out the mass of the oil-drop and he could calculate the force of gravity on one drop, he could determine the electric charge that the drop must have. By varying the charge on different drops, he noticed that the charge was always a multiple of $-1.602 \times 10^{-19}$ C, the charge on a single electron. This meant that these were electrons carrying this unit charge. This quantity of electric charge was called electronic charge, *e*. This is the minimum value of negative charge and no stable fundamental particle is known, which contains charge less than this value.

**8.** Thomson proposed a model for the structure of atom on the basis of his discovery of the composition of atom. This atomic model is called Thomson's plum-pudding model of atom. According to this model, an atom is considered to be a sphere of uniform positive charge into which the negatively charged electrons are embedded just like raisins are embedded in a plum-pudding. An important feature of the plum-pudding model is that the mass of an atom is considered to be evenly spread over the atom. This model could account for electrical neutrality of atom. This model was rejected because it could not explain the results of alpha-particle scattering experiment carried out by Rutherford.

**9.** On the basis of α-particle scattering experiment, Rutherford proposed the nuclear model of atom. According to this model,

i. An atom consists of a tiny positively charged nucleus surrounded by negatively charged electrons. The positive charge of the nucleus is due to protons.

ii. The nucleus and electrons are held together by coulombic forces of attraction.

iii. The volume of the nucleus is extremely small as compared to the total volume of atom.

iv. Most of the mass of the atom is concentrated in the nucleus.

v. The number of electrons and protons in an atom are equal.

**10.** Rutherford's alpha particle scattering experiment led to the discovery of the nucleus. In this experiment, a stream of high energy α-particle from a radioactive source (radium, an α-particle emitter) was allowed to bombard a thin gold foil. A circular fluorescent screen coated with zinc sulphide was set up around the gold foil. A tiny flash of light called scintillation was produced whenever an α-particle strike the zinc sulphide coated screen.

Refer Figure 4.12 from page 136 of the textbook.

**11.** The limitations of Rutherford's model of an atom are:

i. It does not say anything about the distribution of electrons around the nucleus and the energy of electrons.

**ii.** Due to change in direction, a moving body undergoes acceleration, even while moving at a constant speed. A charged particle on acceleration should emit electromagnetic radiation. Hence, an electron in an orbit is expected to emit radiation, the energy carried by radiation coming from motion of electron and the orbit is expected to shrink continuously. Thus, the electron should follow a spiral path and ultimately fall into the nucleus. But this does not happen. Thus, Rutherford's model cannot explain the stability of an atom.

**12.** The postulates of Bohr's atomic model are:

**i.** In an atom, the electrons revolve around the nucleus in certain definite circular paths called orbits. Such orbits differ from each other in radii. Only certain discrete orbits of electrons are allowed inside the atom.

**ii.** Each orbit has a definite energy. These orbits are known as energy levels or energy shells. The orbits or energy shells are numbered as 1, 2, 3, 4 ... or *K*, *L*, *M*, *N*, ... shells starting from the nucleus. The integers 1, 2, 3, 4, ... are called principal quantum number ($n$). The energy shell nearest to the nucleus has minimum energy and the energy shell farthest from the nucleus has maximum energy.

**iii.** As long as an electron remains in a particular orbit, it does not radiate energy.

**iv.** An electron loses energy when it jumps from an orbit of higher energy ($E_2$) to an orbit of lower energy ($E_1$) and energy equal to $E_2 - E_1$ is given out in the form of electromagnetic radiation. An electron gains energy from outside when it jumps from an orbit of lower energy ($E_1$) to an orbit of higher energy ($E_2$). The change in energy, $\Delta E$ is given by: $\Delta E = E_2 - E_1 = h\nu$, where $h$ is the Planck's constant and $\nu$ is the frequency of radiation emitted or observed.

**13.** Important application of isotopes include:

**Medicinal use:** Isotopes are used for the treatment of various diseases. For example,

**i.** Isotopes $^{60}_{27}Co$, $^{225}_{88}Ra$, and $^{198}_{79}Au$ are used for the treatment of cancer.

**ii.** Isotope $^{32}_{15}P$ is used for locating cancer. It is used for the treatment of blood cancer. It is also used in patients suffering from bone fracture to find absorption of phosphorus in their bones.

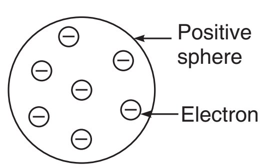
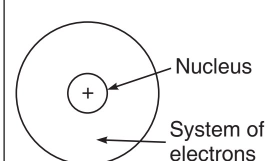
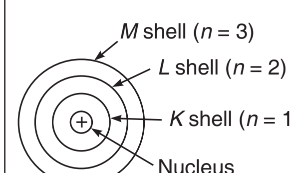
**iii.** Isotope $^{131}_{53}I$ is used for detection of thyroid disorder and its treatment.

**Industrial use:**

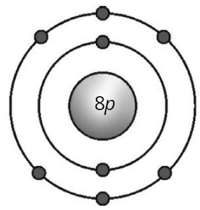
**iv.** Isotope $^{33}_{15}P$ is used in the manufacturing of steel from cast iron in order to find out the complete removal of phosphorus from steel.

**v.** Radioactive isotopes are used to detect minor cracks in the underground gas pipelines, oil pipelines and water pipelines.

**14.**

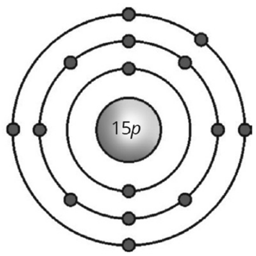
| Feature | Thomson's model of an atom | Rutherford's model of an atom | Bohr's model of an atom |
|---|---|---|---|
| Positive Charge (Protons) | As per Thomson's model of an atom, an atom consists of a positively charged sphere. | The positive charge is concentrated at the core of the atom, which is called nucleus. | The positive charge is present in the core of the atom, called nucleus. |
| Negative charge (electrons) | The electrons are embedded in the positively charged sphere of an atom, like the seeds in a watermelon. | The nucleus is surrounded by electrons, and the electrons and the nucleus are held together by electrostatic force of attraction. | The electrons move in discrete orbits, and each orbit is associated with a definite amount of energy. |
| Diagrammatic representation |   |   |   |

**15.** $2n^2$ rule of Bohr-Bury states that the maximum number of electrons which can be accommodated in an energy shell or orbit is given by $2n^2$, where $n$ stands for the number of the orbit.



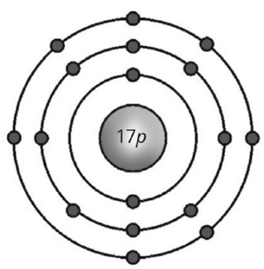

oxygen ($Z$ = 8)

Atomic number 8 – Oxygen atom (O) and its electrons




phosphorus ($Z$ = 15)

Atomic number 15 – Phosphorus atom (P) and its electrons




chlorine ($Z$ = 17)

Atomic number 17 – Chlorine atom (Cl) and its electrons

**16.** Refer Answer 12 from page 46.

**17.** **a.** **Atomic number:** Atomic number of an atom is the total number of protons present within the nucleus of an atom. Example: a sodium atom has 11 protons in its nucleus, so its atomic number is 11.

**b.** **Mass number:** Mass number of an atom is the total number of nucleons present in the nucleus of an atom, i.e. mass Number = no. of protons + no. of neutrons. Example: a sodium atom has 11 protons and 12 neutrons in its nucleus, so its mass number = 11 + 12 = 23.

**c.** **Isotopes:** Isotopes are the atoms of the same element having same atomic number but different mass numbers. Example, hydrogen has three isotopes ${}^{1}_{1}H$, ${}^{2}_{1}H$ and ${}^{3}_{1}H$. The atomic number of all the three is 1, but their mass numbers are 1, 2 and 3, respectively.

**d.** **Isobars:** Isobars are the atoms of different elements having the same mass number but different atomic numbers. Example: mass number of calcium and argon atoms are 40, but different atomic numbers 20 and 18, respectively.

**Uses of isotopes:**

**i.** Isotopes ${}^{60}_{27}Co$, ${}^{225}_{88}Ra$, and ${}^{198}_{79}Au$ are used for the treatment of cancer.

**ii.** Isotope ${}^{32}_{15}P$ is used for locating cancer. It is used for the treatment of blood cancer. It is also used in patients suffering from bone fracture to find absorption of phosphorus in their bones.

**18.** The Bohr and Bury scheme for the distribution of electrons in an atom is based on the following rules:

**i.** The maximum number of electrons which a shell can have is represented by $2n^2$, where $n$ is the quantum number of that particular energy shell. Thus, the maximum number of electrons in the first four shells are:

1st ($K$) shell = $2 \times 1^2 = 2$

2nd ($L$) shell = $2 \times 2^2 = 8$

3rd ($M$) shell = $2 \times 3^2 = 18$

4th ($N$) shell = $2 \times 4^2 = 32$

**ii.** The outermost shell, which is also called valence shell, can have a maximum of 8 electrons.

**iii.** The shell next to (or inner to) the outermost shell, which is called the penultimate shell, can accommodate a maximum of 18 electrons, (if permitted by rule i).

**iv.** Electrons are not accommodated in a given shell unless the inner shells are filled, i.e. the shells are filled in a step-wise manner. But the filling of the fourth shell ($n = 9$) begins even before the third shell is completely filled.

**19.** Thomson's model could not explain the results of Rutherford's alpha particle scattering experiment. Thomson had postulated that an atom consists of a positively charged sphere and the electrons are embedded in it. However, in Rutherford's experiment, most of the alpha particles passed through the gold foil undeflected, while some were deflected by small angles and one out of every 12000 appeared to rebound. So, the results of Rutherford's experiment were contradictory to that of Thomson's model.

**20.** **i.** An atom consists of a tiny positively charged nucleus surrounded by negatively charged electrons. The positive charge of the nucleus is due to protons.

**ii.** The nucleus and electrons are held together by coulombic force of attraction.

**iii.** The volume of the nucleus is extremely small as compared to the total volume of atom.

**iv.** Most of the mass of an atom is concentrated in the nucleus. The mass of the nucleus is due to protons and neutral particles called neutrons having mass almost equal to the mass of proton.

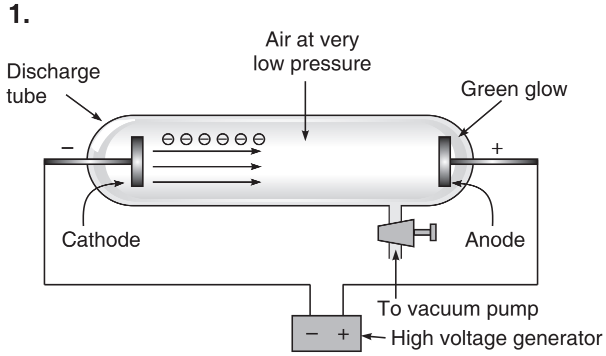
**v.** The number of electrons in an atom is equal to the number of protons in it.

## E. Source-based/Case-based/Passage-based/Integrated Assessment Questions CBQ

| | | | | | |
|---|---|---|---|---|---|
| **1.** | **a.** iv. | **b.** ii. | **c.** iii. | **d.** i. | **e.** iv. |
| **2.** | **a.** i. | **b.** i. | **c.** iv. | **d.** iv. | **e.** ii. |
| **3.** | **a.** iii. | **b.** i. | **c.** iv. | **d.** ii. | **e.** iv. |
| **4.** | **a.** ii. | **b.** iv. | **c.** i. | **d.** iii. | **e.** iv. |
| **5.** | **a.** ii. | **b.** iii. | **c.** i. | **d.** ii. | **e.** iv. |

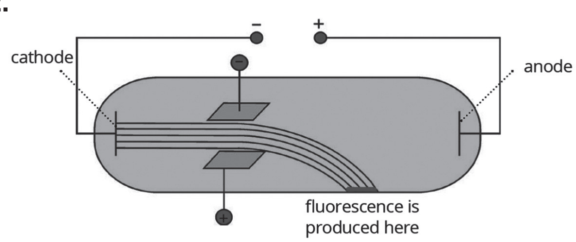
## F. Diagrammatic Questions

**1.**



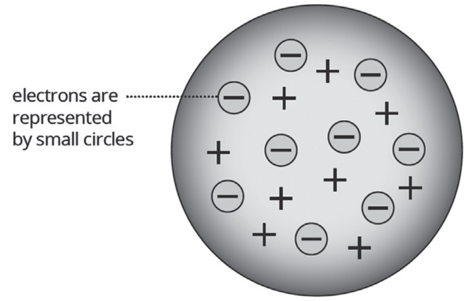

Production of Cathode Rays

**2.**

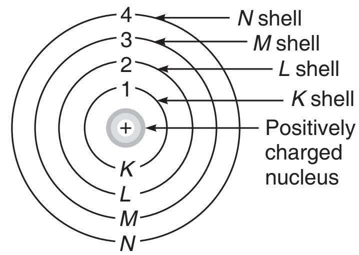



Deflection of cathode rays towards a positively charged plate in an electric field

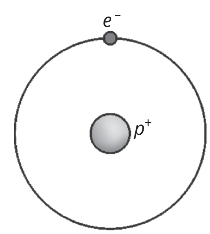
**3.**




**4.**



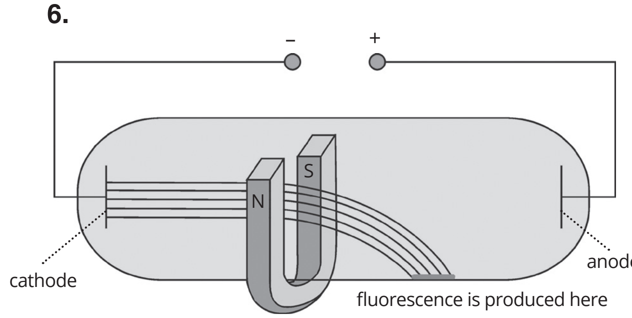

**5.**




H atom

Structure of a hydrogen atom ($p^+$ = proton, $e^-$ = electron)

**6.**




Deflection of cathode rays by a magnetic field

## G. Higher Order Thinking Skills (HOTS) Questions

1. Refer Answer 4 from page 42.
2. Nucleus consist of several other unstable particles such as mesons, positrons neutrinos, antineutrinos, gluons and quarks.
3. Element with atomic number 18 will have octet attained (i.e. 8 electrons in outermost shell). Hence, it will be stable and unreactive where as the element with atomic number 19 will be reactive as it will have one electron in the outermost shell.

**4.** **d.**

**5.** **d.**

**6.** Protons are fundamental subatomic particles that are found in all atoms. Unlike neutron, which is not found in hydrogen atom, the protons are present in the nuclei of all atoms. Since an atom has to be electrically neutral, it will always contain electrons and protons. Otherwise, an atom would not be a neutral entity.

**7.** The mass of an electron is $9.1 \times 10^{-28}$ g. So, to calculate the number of electron which are present in 1 g, we will divide 1 g by mass of an electron, i.e.

$$\text{No. of electrons} = \frac{1}{9.1 \times 10^{-23}} = 1.098 \times 10^{27}$$

So, there are $1.098 \times 10^{27}$ electrons in 1 g.

**8.** Cathode rays consist of negatively charged particles called electrons. Cathode is the negatively charged electrode. When pressure inside a discharge tube, fitted with cathode and anode, is reduced to about 0.001 mm of Hg, the glass walls of the discharge tube opposite to cathode start to glow with a faint greenish light. This proves that cathode rays are produced from cathode. Anode rays on the other hand, consist of positively charged particles which are produced from anode.

**9.** No, unless the particles are discovered their properties cannot be explained.

### H. Value-Based Questions (Optional)

**1. a.** Students need to learn that recognition in the field of science does not come easily. They have to work really hard with full dedication to discover different facts and theories. Since these also require proof and justification, they also need to be patient.

**b.** J J Thomson possessed qualities such as sincerity, dedication, hard working nature and patience.

**2. a.** According to Bohr's theory, as long as an electron moves in a particular orbit, it does not radiate energy. As a result, it does not fall into the nucleus.

**b.** From this, we learn that as long as we are focussed on a particular work, we cannot be distracted by other things.

**3. a.** In Thomson's plum pudding model, the atom was considered to be a sphere of uniform positive charge into which the negatively charged electrons are embedded just like raisins are embedded in a plum-pudding. In this model, mass of atom is considered to be evenly spread over the atom. However, in Rutherford's model of an atom, most of the space in an atom is considered to be empty. Also, the entire mass of the atom is concentrated in the nucleus. The volume of the nucleus is extremely small as compared to the total volume of the atom.

**b.** Bohr's model of an atom could not explain the ability of elements to form molecules by chemical bonds between atoms.

**c.** We learn that something has to go through refinements. There is always a scope of improvement to make any theory more acceptable and better than its earlier form. This is indeed applicable to the improvement of standard of our life.

### P. 169 TEST PAPER

**1. i.** J J Thomson

**ii.** E. Goldstein

**iii.** Chadwick

**2.** When cathode rays are passed through a strong electric field formed by placing positively charged and negatively charged plates in their path, they are deflected towards positively charged plate in their path.

When cathode rays are placed in a magnetic field, they are deflected towards the north pole of the magnet.

**3.** Rutherford performed the α-particle scattering experiment, in which a stream of high energy α-particles from a radioactive source (radium, an α-particle emitter) was allowed to bombard a thin gold foil. A circular fluorescent screen coated with zinc sulphide was set up around the gold foil. A tiny flash of light called scintillation was produced whenever an alpha particle struck the ZnS coated screen.

The conclusions drawn from Rutherford's experiment are as follows:

**i.** An atom consists of a tiny positively charged nucleus surrounded by negatively charged electrons. The positive charge of the nucleus is due to protons.

**ii.** The nucleus and the electrons are held together by coulombic force of attraction.

**iii.** The volume of the nucleus is extremely small as compared to the total volume of atom.

**vi.** Most of the mass of atom is concentrated in the nucleus.

**v.** The number of electrons in an atom is equal to the number of protons in it.

**4. a.** The protons and neutrons present in the nucleus of an atom are collectively called nucleons.

**b.** The atoms of an element which have the same number of protons but different number of neutrons are called isotopes.

**c.** The number of protons present in the nucleus of an atom is known as the atomic number. It is also equal to the number of electrons in the atom.

**d.** The sum of the number of protons and neutrons in the atom of an element is called its mass number.

**5.** The postulates of Bohr's atomic model are:

**i.** In an atom, the electrons revolve around the nucleus in certain definite circular paths called orbits. Such orbits differ from each other in radii. Only certain discrete orbits of electrons are allowed inside the atom.

**ii.** Each orbit has a definite energy. These orbits are known as energy levels or energy shells. The orbits or energy shells are numbered as 1, 2, 3, 4 ... or *K*, *L*, *M*, *N*, ... shells starting from the nucleus. The integers 1, 2, 3, 4, ... are called principal quantum number ($n$). The energy shell nearest to the nucleus has minimum energy and the energy shell farthest from the nucleus has maximum energy.

**iii.** As long as an electron remains in a particular orbit, it does not radiate energy.

**iv.** An electron loses energy when it jumps from an orbit of higher energy ($E_2$) to an orbit of lower energy ($E_1$) and energy equal to $E_2 - E_1$ is given out in the form of electromagnetic radiation. An electron gains energy from outside when it jumps from an orbit of lower energy ($E_1$) to an orbit of higher energy ($E_2$). The change in energy, $\Delta E$ is given by $\Delta E = E_2 - E_1 = h\nu$, where $h$ is the Planck's constant and $\nu$ is the frequency of radiation emitted or observed.

Refer Figures 4.16 and 4.17 from page 138 and 139 of the textbook.

**6.** The two uses of isotopes are:

**i.** Isotopes $^{60}_{27}Co$, $^{225}_{80}Ra$ and $^{198}_{79}Au$ are used in the treatment of cancer.

**ii.** Isotopes $^{73}_{33}As$ and $^{131}_{53}I$ are used for locating brain tumor.

**7. a.** The outermost shell of an atom is known as the valence shell.

**b.** The electrons present in the outermost shell of an atom are known as valence electrons.

**8.** The combining capacity of atoms of elements is known as valency.