CHAPTER 2

Matter and its composition

For updates

2.1 Knowledge: Matter and its states

SLO: C-09-B-01 **SLO: C-09-B-02**	✓ *Define matter as a substance with mass and volume.* ✓ *Describe the three main states of matter (solid,liquid, gas) and their distinguishing macroscopic properties: density, compressibility, and fluidity*	**15** **16**	

2.2 Knowledge: Exotic states of matter

SLO: C-09-B-03	✓ *Recognize other forms of matter beyond the three basic states (e.g., plasma, bose-einstein condensates, liquid crystals)*	**19**	

2.3 Knowledge: Allotropic forms of Carbon

SLO: C-09-B-04	✓ *Explain the allotropic forms of solids (some examples may include diamond, graphite, and fullerenes).*	**21**	

2.4 Knowledge: Types of Matter Based on Their Chemical Composition

SLO: C-09-B-05 **SLO: C-09-B-06** **SLO: C-09-B-07**	✓ *Explain the differences between elements, compounds and mixtures.* ✓ *Identify solutions, colloids, and suspensions as mixtures and give an example of each.* ✓ ***Explain the effect of temperature on solubility and formation of unsaturated and saturated solutions***	**24** **27** **29**	

SLO: C-09-B-01	*Define matter as a substance having mass and occupying space*

cognitive Level: (k) **Type of assessment: Summative**

Multiple Choice Questions (MCQs)

1. Which of the following statements best defines matter?

A. Anything that has mass and occupies space
B. Anything that emits light or sound
C. Anything that changes state when heated
D. Anything that conducts electricity

2. Which of the following is considered an exotic state of matter?

A. Liquid
B. Gas
C. Plasma
D. Solid

3. What is a distinguishing characteristic of the Bose-Einstein Condensate (EBC) as an exotic state of matter?

A) It is formed at extremely high temperatures.
B**) It is formed at extremely low temperatures where particles occupy the same quantum state**.
C) It is a state where gases become ionized.
D) It is a common state found in daily life

Short response questions (SRQs) (3 Marks Each

Q1. Define matter in your own words and provide three examples that demonstrate different states of matter. Explain how each example fits the definition of matter?

1 mark for providing a correct definition of matter. 1 mark for giving three examples of matter. 1 mark for providing correct explanations for the examples.

Definition of Matter (1 mark): **Matter** is anything that has mass and occupies space.

Examples and Explanations (2 marks): **a. Ice (solid):** Ice has a definite shape and volume, occupies space, and has mass, demonstrating it is matter. *(0.5 mark)* **b. Water (liquid)**: Water takes the shape of its container, has a fixed volume, and has mass, proving it occupies space and is matter. *(0.5 mark)* **c. Air (gas):** Air fills any available space in a container, has mass, and occupies volume, fitting the definition of matter. *(1 mark)*

Q2. Explain the difference between fundamental states of matter and exotic states of matter, as described in the organogram. Provide an example of each type and discuss why exotic states are considered unusual compared to the fundamental states. (3 Marks)

1 mark for explaining the fundamental states of matter.
1 mark for describing exotic states of matter.
1 mark for providing an example of each and explaining why exotic states are considered unusual.

Fundamental States of Matter (1 mark): The fundamental states of matter include **solid, liquid, and gas**, which are commonly observed in everyday life. Solids have a fixed shape and volume, liquids have a fixed volume but no fixed shape, and gases have neither fixed volume nor shape.**Exotic States of Matter (1 mark):**Exotic states, such as **plasma** and **Bose-Einstein Condensate (BEC)**, occur under extreme conditions like very high or very low temperatures. Plasma forms at extremely high temperatures when gases become ionized, while BEC forms at near absolute zero when particles act as a single quantum state.

Examples and Uniqueness (1 mark):

- **Example of Fundamental State:** Ice (solid), water (liquid), or air (gas).

- **Example of Exotic State:** Plasma in lightning or BEC in ultra-cold laboratories.
  Exotic states are unusual because they exhibit unique properties, such as electrical conductivity in plasma or superfluidity in BEC, which are not found in the fundamental states.

Q3. If matter is defined as anything that has mass and occupies space, evaluate why certain forms of energy, like sound or heat, do not qualify as matter. Provide examples to support your explanation?

1 mark for explaining why sound does not qualify as matter.
1 mark for explaining why heat does not qualify as matter.
1 mark for providing relevant examples to support the explanation**.**

Why Sound Is Not Matter (1 mark): Sound is a vibration that travels through a medium, such as air or water, but it does not have mass or occupy space. It is a form of energy transferred through mechanical waves.
Why Heat Is Not Matter (1 mark): Heat is the transfer of thermal energy between substances. It does not have mass or volume, as it is not a physical substance but it is energy in motion.
Examples (1 mark):

- Sound Example: The vibration of a guitar string produces sound, but the sound itself has no mass or volume.
- Heat Example: The warmth from a fire radiates as thermal energy but does not occupy space or have weight.

SLO: C-09-B-02	*State the distinguishing macroscopic properties of commonly observed states of solids, liquids and gasses in particular density, compressibility and fluidity.*

cognitive Level: (U) **Type of assessment: Summative**

Multiple Choice Questions (MCQ)

1. Which of the following properties is why solids do not change shape easily?
a) Low density
b) High fluidity
c) Low compressibility
d) High compressibility

2. Which property allows gases to fill any container they are placed in?
a) High-density
b) High compressibility
c) Low fluidity
d) Low density

3. Which of the following statements about the density of solids, liquids, and gases is correct?
a) Gases are denser than liquids and solids.
b) Liquids are less dense than gases but more dense than solids.
c) Solids are typically the most dense, followed by liquids, and then gases.
d) Solids and liquids have the same density.

Short response Questions(SRQs) (3 Marks Each)

Q1. Why do solids have low fluidity compared to liquids and gases? To support your answer, draw a simple diagram showing the particle arrangement in solids, liquids, and gases?
1 mark for explaining why solids have low fluidity.
1 mark for accurately describing and comparing particle arrangements in solids, liquids, and gases.
1 mark for a correct and clearly labelled diagram showing particle arrangements in solids, liquids, and gases.

Explanation of Low Fluidity in Solids (1 Mark):
Solids have low fluidity because their particles are tightly packed in a fixed, rigid structure. This arrangement restricts the particles' ability to move past each other, preventing flow.

Description and Comparison of Particle Arrangements (1 Mark):

- **Solids:** Particles are closely packed in an organised structure with minimal movement.
- **Liquids:** Particles are close together but can slide past one another, enabling flow.
- **Gases:** Particles are far apart and move freely, resulting in high fluidity.

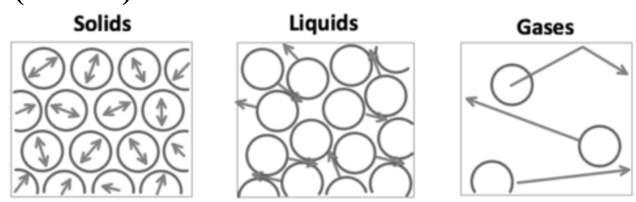

Diagram (1 Mark):

Q2**.** Explain why gases are highly compressible while solids are not. Draw a diagram to illustrate the difference in particle spacing between a solid and a gas?

1 mark for explaining why solids have low fluidity.
1 mark for an accurate description and comparison of particle arrangements in solids, liquids, and gases.
1 mark for a correct and clearly labelled diagram showing particle arrangements in solids, liquids, and gases.

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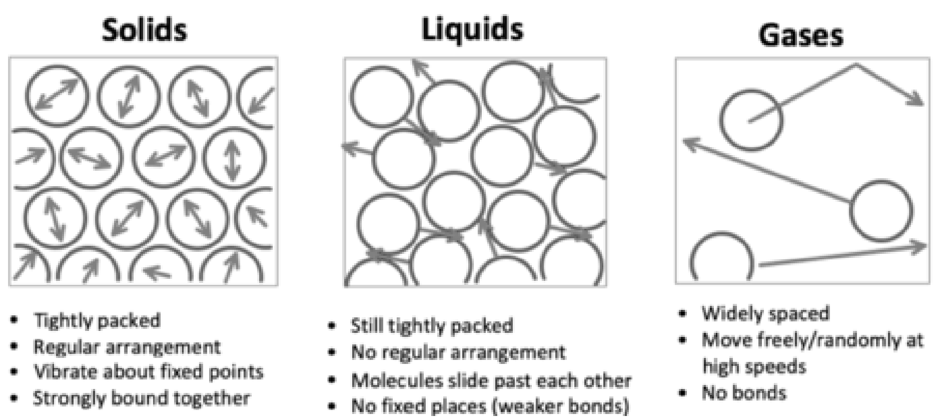


Q3. Describe the density of solids, liquids, and gases, and draw a diagram that represents the density differences among them. Label each state and indicate which one is most dense and least dense.

	Marks
Description of density differences	**1.5**
Accurate and labelled diagram representing densities	**1.5**

Explanation of Density in Solids (1.5 Mark): Solids have the highest density because their particles are tightly packed together in a fixed structure, leaving minimal space between them.

Comparison of Densities (1.5 Mark):

- Liquids: Have moderate density as their particles are close but not as tightly packed as in solids.
- Gases: They have the lowest density because their particles are widely spaced and move freely, occupying a much larger volume.

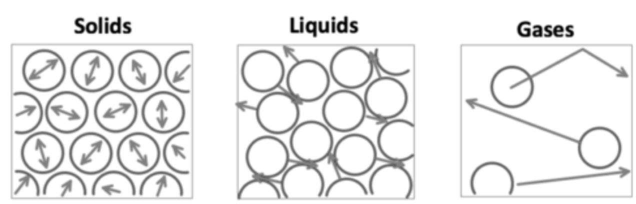
EXTENDED RESPONSE QUESTION (ERQs)

Q1 Draw a diagram illustrating the particle arrangement in solids, liquids, and gases. Based on your diagram, explain the differences in density, compressibility, and fluidity for each state of matter. Finally, complete the table below to compare and contrast these properties across the three states of matter. Provide examples to support your explanation. "Marking Scheme (6 Marks)

Diagram (2 Marks): Draws and labels particle arrangements of solids, liquids, and gases accurately.
Solids (1 Mark): Explains density, compressibility, and fluidity with examples.
Liquids (1 Mark): Explains density, compressibility, and fluidity with examples.
Gases (1 Mark): Explains density, compressibility, and fluidity with examples.
Comparison (1 Mark): Compares and contrasts properties of solids, liquids, and gases.

Diagram (2 Marks) Draw the following diagrams:

- **Solid**: Particles are drawn closely packed in a fixed, orderly arrangement with no spaces between them.
- **aLiquid**: Particles are drawn closely packed but in an irregular, slightly spread-out arrangement, allowing them to move around each other.
- **Gas:** Particles are drawn widely apart, with a lot of empty space between them, and move freely in all directions.



Each diagram should be clearly labelled with arrows indicating particle movement for liquids and gases to demonstrate fluidity.

2. Explanation for Solids (1 Mark)

Density: Solids have a high density because their particles are closely packed in a fixed structure, resulting in little space between them. For example, metals like iron and copper are very dense.

Compressibility: Solids are almost incompressible as their particles are tightly bound together, with no space to be squeezed closer.

Fluidity: Solids do not exhibit fluidity; their particles are fixed in place and can only vibrate, preventing them from flowing.

3. Explanation for Liquids (1 Mark)

Density: Liquids have a moderate density; their particles are close together but not in a fixed arrangement, allowing some space for movement. Water, for example, is denser than gases but less dense than most solids.

Compressibility: Liquids are nearly incompressible because their particles are still close, though they have the freedom to move around each other.

Fluidity: Liquids have high fluidity; they can flow and take the shape of their container due to their particles sliding past one another.

Explanation for Gases (1 Mark)

Density: Gases have low density as their particles are far apart and spread out. For example, the air we breathe is much less dense than any liquid or solid.

Compressibility: Gases are highly compressible because there is much space between their particles, allowing them to be pushed closer together under pressure.

Fluidity: Gases have very high fluidity; they move freely and expand to fill the entire volume of any container because their particles move in all directions.

4. **Comparison and Contrast (Table) (1 Mark)**

Property	Solids	Liquids	Gases
Density	High density due to closely packed particles in a fixed arrangement.	Moderate density: particles are close but can move around each other.	The low density is caused by particles being far apart and spreading out.
Compressibility	It is almost incompressible because particles are tightly packed and have little space between them.	Nearly incompressible; particles are close together but not fixed, allowing slight movement.	Highly compressible; large spaces between particles allow them to be squeezed closer together.
Fluidity	No fluidity; particles are fixed in position and can only vibrate.	High fluidity: particles can move past each other, allowing the liquid to flow.	Very high fluidity; particles move freely in all directions, filling any container.

SLO: C-09-B-03	***Identify that state is a distinct form of matter (examples could include familiarity with plasma, intermediate states and exotic states e.g. BEC or liquid crystals)***

Cognitive Level: (U) **Type of assessment: Summative**

Multiple Choice Questions (MCQs)

1. Which of the following states of matter consists of charged particles commonly found in stars

a) Solid b) Liquid
c) Gas **d) Plasma**

2. What is the key condition required for the formation of a Bose-Einstein Condensate (BEC)?

A) Extremely high pressure
B) Extremely low temperatures, near absolute zero
c) High electrical conductivity
d) Strong magnetic fields

3. Liquid crystals exhibit properties between which two common states of matter?

a) Solid and Gas
b) Liquid and Gas
c) Solid and Liquid

d) Plasma and Gas

4. Which exotic state of matter can flow without any resistance and forms at temperatures close to absolute zero?

a) Plasma b) Liquid Crystal

c) Gas **d) Bose-Einstein Condensate (BEC)**

5. In which everyday technology are liquid crystals most commonly used?

a) Microwave ovens

b) Liquid Crystal Displays (LCDs)

c) Batteries

d) Electric generators

SHORT RESPONSE QUESTIONS(SRQs)

Q1:What is plasma? Describe one natural example where plasma is found, and explain one property that distinguishes it from other states of matter. (3 Marks)

Definition of Plasma (1 Mark): Correctly defines plasma as a state of matter with charged particles.
Natural Example (1 Mark): Provide a correct natural example where plasma is found (e.g., stars, lightning).
Distinguishing Property (1 Mark): Explains one property that differentiates plasma from other states (e.g., electrically conductive).

Definition of Plasma: Plasma is a state of matter consisting of charged particles, such as ions and free electrons, formed when gases are heated to very high temperatures.(1mark)

Natural Example: Plasma is found in the sun and other stars, where the intense heat causes gases to ionize, creating a plasma state.(1mark)

Distinguishing Property: Plasma is electrically conductive, unlike solids, liquids, and gases, and it reacts strongly to electric and magnetic fields.(1mark)

Q2.Explain what a Bose-Einstein Condensate (BEC) is, state the conditions necessary for its formation, and mention one key property of this state of matter. (3 Marks)

Definition of BEC Correctly defines Bose-Einstein Condensate as a state formed at near absolute zero temperature. 1 mark
Conditions for Formation States the correct condition needed for BEC formation (extremely low temperatures, near absolute zero). 1 mark
Key Property Describes one key property of BEC (e.g., superfluidity, particles behaving as a single quantum entity). 1 mark

Definition of BEC: A Bose-Einstein Condensate (BEC) is a state of matter formed when particles called bosons are cooled to temperatures close to absolute zero, causing them to occupy the same quantum state and behave as a single entity.

Conditions for Formation: BEC forms at extremely low temperatures, close to absolute zero, where thermal motion is nearly nonexistent, allowing the particles to clump together in the lowest quantum state.

Key Property: One key property of BEC is superfluidity, where the matter can flow without any resistance or viscosity.

Q3:What are liquid crystals? Provide one example of their use in everyday technology, and describe how their properties differ from traditional solids and liquids. (3 Marks)

Definition of Liquid Crystals (1 Mark): Example of Use in Technology (1 Mark): Differentiating Properties (1 Mark):

Definition of Liquid Crystals: Liquid crystals are a state of matter that possess properties between those of conventional liquids and solid crystals. They exhibit both fluidity like liquids and an ordered molecular arrangement like solids.(1 mark)

Example of Use in Technology: Liquid crystals are commonly used in Liquid Crystal Displays (LCDs) found in devices such as televisions, computer monitors, and digital watches.(1 mark)

Differentiating Properties: Unlike solids, which have a fixed shape, and liquids, which completely flow, liquid crystals flow like a liquid but maintain some structured molecular alignment, which allows them to change their optical properties in response to electric fields.(1mark)

Extended response question (ERQs)

"Draw a diagram to represent the particle arrangement of the three exotic states of matter: high-temperature states (plasma), low-temperature states (Bose-Einstein Condensate), and combined states (liquid crystals). Based on your diagrams, describe the conditions required for the formation of each state, their unique properties, and provide one example of where each state can be observed or used in everyday life."

Diagram (2 Marks): Draws and labels particle arrangements for plasma, Bose-Einstein Condensate (BEC), and liquid crystals.
Plasma (1.5 Mark): Explains formation and properties and provides an example.
BEC (1.5 Mark): Explains formation and properties and provides an example.
Liquid Crystals (1 Mark): Explains formation and properties and provides an example.

Diagrams (2 Marks):

- **Plasma:** A diagram showing randomly dispersed ions and free electrons, with arrows to indicate high mobility.
- **Bose-Einstein Condensate (BEC):** A diagram depicting tightly grouped particles, nearly stationary, labelled as "single quantum entity."
- **Liquid Crystals:** A diagram showing particles arranged in a partially ordered structure, demonstrating both alignment and fluidity.***(Total: 2 Marks)***

High-Temperature States (Plasma) (1.5 Mark):

- **Conditions for Formation:** Plasma forms at extremely high temperatures when gases are heated to the point where atoms lose electrons, creating a mixture of ions and free electrons.
- **Unique Properties:** Plasma conducts electricity, has an indefinite shape and volume, and strongly responds to electric and magnetic fields.
- **Example:** Plasma is naturally present in stars like the Sun and is artificially created in neon signs and plasma TVs.

Low-Temperature States (Bose-Einstein Condensate - BEC) (1.5 Mark):

- **Conditions for Formation:** BEC forms near absolute zero temperatures ($-273.15^\circ C$), where particles lose almost all their kinetic energy and behave as a single quantum entity**.**
- **Unique Properties:** BEC exhibits superfluidity (zero viscosity) and synchronised particle behaviour as if all particles act as one**.**
- **Example:** BEC is produced in laboratories using elements like rubidium cooled to near absolute zero.***(Total: 2 Mark)***

Combined States (Liquid Crystals) (1 Mark):

- **Conditions for Formation:** Liquid crystals form under intermediate temperatures, between solid and liquid states, depending on the type of material**.**
- **Unique Properties:** Liquid crystals flow like liquids but retain some structural order, similar to solids. They also respond to electric fields and temperature changes.
- **Example:** Liquid crystals are used in LCD (Liquid Crystal Display) screens for TVs, monitors, and digital watches.

SLO: C-09-B-04	***Explain the allotropic forms of solids (some examples may include diamond, graphite, and fullerenes)***

Cognitive Level: (U) **Type of assessment: Summative**

Multiple Choice Questions (MCQs):

1. Which property of diamond makes it suitable for use in cutting tools?
A) Electrical conductivity
B) High thermal expansion
c) Extreme hardness
d) Lubricating ability

2. What unique structural feature of graphite allows it to conduct electricity?
a) Tetrahedral arrangement of carbon atoms
b) Free movement of delocalised electrons between layers
c) Spherical shape of carbon rings
d) High density of carbon atoms

3. How do fullerenes differ from diamond and graphite in terms of molecular structure?
a) They form a flat sheet-like structure
b) They consist of layered hexagonal rings
c) They are composed of a network of carbon nanotubes
d**) They form a closed cage-like structure**

Short response Questions(SRQs)

Q1: Describe the structure of a diamond, how it impacts its properties, and give one use of diamond based on these properties. (3 Marks)

1mark: Describes the tetrahedral structure of diamond. 1mark: Describes properties like hardness or non-conductivity. 1mark: Provides a practical use, such as cutting tools.

Structure: Diamond has a three-dimensional tetrahedral structure where each carbon atom is bonded to four other carbon atoms through strong covalent bonds(1 mark)

Properties: This structure makes diamond extremely hard and unable to conduct electricity as all electrons are bonded.(1mark)

Use: Diamond is used in cutting and drilling tools due to its hardness.(1mark)

Q2: Describe the structure of graphite, explain why it is used as a lubricant, and mention one other application based on its properties. (3 Marks)

1 mark: Describes the layered structure of graphite. 1 mark: Explains why it is an effective lubricant. 1 mark: Mentions another use, like electrodes in batteries.

Structure: Graphite has a layered structure with carbon atoms arranged in hexagonal rings, held together by weak forces.

Lubricant Use: The layers can slide over each other easily, making graphite an effective lubricant.

Other Application: Graphite is also used as an electrode in batteries because of its electrical conductivity.

Q3: What are fullerenes, how is their structure different from diamond and graphite, and provide one application based on their properties? (3 Marks)

1mark: Defines fullerenes and their cage-like structure. **1mark**: Explains how fullerenes differ from diamond and graphite. **1mark**: Provides a practical application, like drug delivery systems.

Definition and Structure (1 Mark): Fullerenes are carbon allotropes where atoms are arranged in hexagons and pentagons, forming hollow, cage-like shapes like C_{60}, resembling a soccer ball**.**

Difference (1 Mark): Unlike diamond's rigid lattice or graphite's layered structure, fullerenes have a hollow, closed shape, making them chemically and physically unique.

Applications (1 Mark): Fullerenes are used in drug delivery systems, solar cells, and lubricants. Carbon nanotubes, a related form, are applied in making strong, lightweight materials and advanced electronics.

Q4: Compare the electrical conductivity of diamond, graphite, and fullerenes, and explain the reasons for these differences. (3 Marks)

1 mark: Explains why diamond does not conduct electricity. 1 mark: Explains why graphite conducts electricity.
1 mark: Mentions the conductivity properties of fullerenes and the reason for their conductivity.

Diamond Conductivity: Diamond does not conduct electricity because all its electrons are involved in covalent bonding, leaving no free electrons.

Graphite Conductivity: Graphite conducts electricity due to the presence of free, delocalised electrons that can move between its layers.

Fullerenes Conductivity: Fullerenes can conduct electricity due to their unique molecular structure that allows electron mobility across their spherical surfaces.

Extended response question(ERQs)

Q1: Compare and contrast the allotropic forms of carbon: diamond, graphite, and fullerenes. Discuss their structures, properties, and uses, and provide diagrams to illustrate their unique atomic arrangements?

2 marks: Detailed explanation of the structures of diamond, graphite, and fullerenes.
2 marks: Description of properties such as hardness, electrical conductivity, lubrication, and strength.
1 mark: Explanation of uses based on properties (e.g., cutting tools, lubricants, batteries, nanotechnology).
1 mark: Accurate and clearly labelled diagrams illustrating the structures of diamond, graphite, and fullerenes.

Structures (2 Marks):

- **Diamond:** Diamond has a rigid, three-dimensional tetrahedral structure where each carbon atom is covalently bonded to four other carbon atoms. This arrangement forms a strong and stable lattice.
- **Graphite:** Graphite consists of layers of carbon atoms arranged in hexagonal rings. The layers are held together by weak van der Waals forces, allowing them to slide over each other easily.
- **Fullerenes:** Fullerenes are spherical or cage-like molecules where carbon atoms are arranged in hexagons and pentagons. The most common fullerene, C_{60}, resembles a soccer ball.

Properties (2 Marks):

- **Diamond:** Extremely hard, non-conductive due to no free electrons, and has a very high melting point.
- **Graphite:** Good conductor of electricity because of delocalised electrons, slippery texture for lubrication, and softer than diamond.
- **Fullerenes:** Moderate electrical conductivity, lightweight, and chemically reactive due to their unique structure.

Uses (1 Mark):

- **Diamond:** Used in cutting tools and drilling equipment because of its hardness.
- **Graphite:** Used as a lubricant and in batteries as electrodes due to its conductivity.

- **Fullerenes:** Applied in nanotechnology, drug delivery systems, and the development of advanced materials.

Diagrams (1 Mark): Include accurate and clearly labelled diagrams for:

SLO: C-09-B-05	*Explain the differences between elements, compounds and mixtures.*
Cognitive Level: (k)	Type of assessment: Summative

Multiple Choice Questions (MCQs):

1. In an experiment, water is decomposed into hydrogen and oxygen gas using electrolysis. What does this demonstrate about the nature of water?

- A) Water is a mixture that can be separated by physical means.
- **B) Water is a compound that can be broken down into simpler substances by a chemical reaction**.
- C) Water is an element composed of hydrogen and oxygen.
- D) Water is a homogeneous mixture that cannot be separated.

2. Which property would help you differentiate between a homogeneous mixture and a compound?

- A) Both have uniform compositions.
- B) A homogeneous mixture can be separated into its components by chemical means, while a compound can be separated by physical means.
- **C) A homogeneous mixture has a uniform composition but its components can be separated by physical means, while a compound has a fixed composition and can only be separated by chemical means.**
- D) Both consist of two or more substances combined physically.

.3. Which scenario best illustrates a chemical change resulting in the formation of a compound?

- a) Mixing oil and water, and then separating them using filtration.
- b) Dissolving salt in water, forming a homogeneous mixture.

- **c) Burning hydrogen gas in oxygen to form water.**
- d) Crushing a piece of chalk into powder.

5. Why is a mixture of sand and salt considered heterogeneous, and how could you separate them?

a) It has a uniform appearance; use electrolysis to separate them.

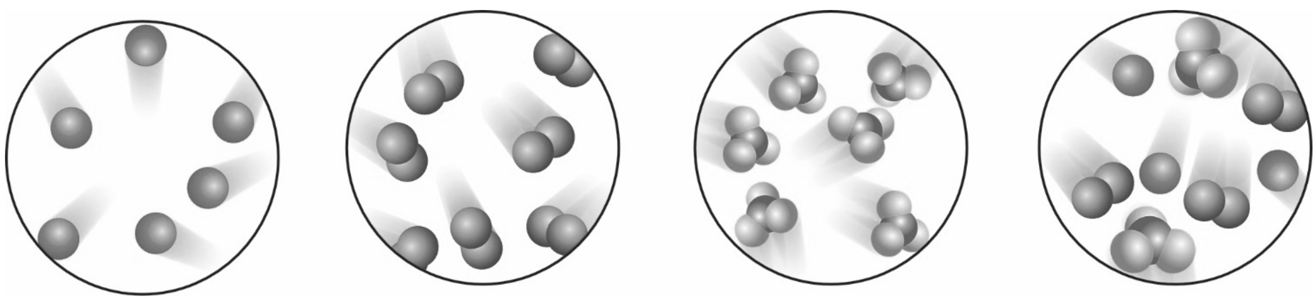
b) Its components are visibly different and can be separated by filtration or dissolving salt in water.

c) It is composed of chemically combined elements; heat is required for separation.

d) Its components are not uniformly distributed, and it requires a chemical reaction for separation

Short response Questions(SRQs)

Q1.Which of the following diagrams represents a compound, and why?How do the molecules of a compound differ from the molecules of an element?



Identifying the diagram that represents a compound and justification: 1.5 Marks
Explaining the difference between molecules of a compound and an element: 1.5 Marks

Ans: The third diagram represents a compound. It shows clusters where different types of atoms are chemically bonded together. A compound is made up of two or more elements combined in fixed ratios through chemical bonds. (1.5 Marks)

Molecules of an element consist of only one type of atom bonded together (e.g., O_2 or N_2), as shown in the second diagram. Molecules of a compound consist of two or more different types of atoms bonded chemically (e.g., CO_2, H_2O), as shown in the third diagram.

- The difference lies in the composition: elements have identical atoms, while compounds combine atoms from different elements. (1.5 Marks)

Q2: Explain how the unique properties of compounds differ from the properties of the elements that make them up. Use the example of sodium chloride (NaCl) to support your explanation.

Identifies unique properties of compounds: 1 Mark
Describes the difference from elements: 1 Mark
Provides an example using sodium chloride (NaCl): 1 Mark

Unique Properties of Compounds: Compounds have properties that are entirely different from the elements they are made of. This happens because, during chemical bonding, the elements lose their individual characteristics and form a new substance with a fixed composition. (1 Mark)

Difference from Elements: Sodium is a soft, reactive metal, and chlorine is a poisonous yellow-green gas. However, when they combine chemically to form sodium chloride (NaCl), the resulting compound is a stable, non-toxic salt that is safe to eat. (1 Mark)

Example: Sodium chloride (NaCl) shows how new properties can emerge. Unlike sodium and chlorine, which are dangerous on their own, NaCl is widely used in food and is essential for life. (1 Mark)

Q3:Why is it important to know whether a substance is an element, a compound, or a mixture when choosing a method of separation? Provide one example where a specific method is used for separation.

Explains the importance of substance type: 1 Mark Gives reasoning for choosing the method: 1 Mark
Provide an example with a specific separation method: 1 Mark

Importance of Substance Type: It is important to know whether a substance is an element, compound, or mixture because it determines the method used for separation. Different types of substances require different techniques based on their nature. **(1 Mark)**

Reasoning: Elements cannot be separated. Further, compounds require chemical methods to break bonds, and physical methods can separate mixtures as their components are not chemically bonded. **(1 Mark)**

Example: A mixture of iron filings and sulphur can be separated using a magnet (physical method), while separating water into hydrogen and oxygen requires electrolysis, a chemical method. **(1 Mark)**

Q4: Explain how the formation of a compound demonstrates a chemical change while the formation of a mixture does not. Include an example of each to illustrate your answer.

Explains compound formation as a chemical change: 1 Mark
Explains mixture formation as not a chemical change: 1 Mark
Provides examples of both a compound and a mixture: 1 Mark

Compound Formation as Chemical Change: The formation of a compound involves a chemical change where the atoms of different elements chemically bond, resulting in a substance with entirely new properties.
Example: Water (H_2O) forms when hydrogen gas and oxygen gas chemically react, producing a liquid with properties different from its components**. (1 Mark)**

Mixture Formation as Physical Change: The formation of a mixture involves a physical change in which the components retain their original properties because no new substance is formed.
Example: Mixing salt and sand creates a mixture that can be separated physically using filtration or a solvent like water**. (1 Mark)**

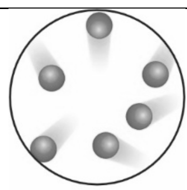
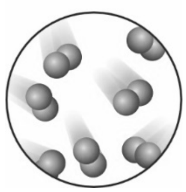
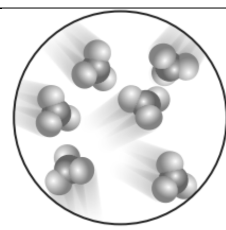
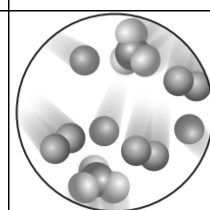
Examples: The compound water (H_2O) demonstrates chemical change, while the salt-sand mixture shows no chemical change**. (1 Mark)**

Extensive response questions:

Q1:Compare and contrast elements, compounds, and mixtures in terms of their composition, properties, methods of separation, and represent each with a diagram. Provide two examples for each and explain how their characteristics differ from one another?

Explains the composition of elements, compounds, and mixtures: 2 Marks
Describes the properties of each, highlighting key differences: 2 Marks
Provides two examples of each, explains the methods of separation, and includes a representative diagram: 2
Answer:

Aspect	**Elements**	**Compounds**	**Mixtures**

Composition	Made of only one type of atom; pure substances.	Formed by the chemical combination of two or more types of atoms in a fixed ratio.	Physical combination of two or more substances (elements or compounds); can be homogeneous or heterogeneous.
Properties	Unique properties defined by atomic structure (e.g., iron is magnetic, oxygen supports combustion).	Different properties from the constituent elements (e.g., water is a liquid, unlike hydrogen and oxygen gases).	Retain the properties of their components (e.g., in a mixture of sand and salt, both retain their original properties).
Examples	Oxygen (O_2), Gold (Au).	Sodium chloride (NaCl), Carbon dioxide (CO_2).	Air (a mixture of gases), Salad (a mixture of vegetables).
Separation	Cannot be separated into simpler substances by physical or chemical means.	Can only be separated into elements by chemical reactions (e.g., electrolysis for water).	Can be separated by physical methods like filtration (solid-liquid), distillation (liquids), or magnetic separation (iron filings and sulfur).
Diagram	 		

SLO: C-09-B-06	***Identify solutions, colloids, and suspensions as mixtures and give an example of each***

Cognitive Level: (u) **Type of assessment: Summative**

Multiple Choice Questions (MCQs):

1. Which of the following statements correctly describes the behaviour of a colloid under the light?

a) It allows light to pass through completely without scattering.

b) It scatters light due to the presence of larger particles, showing the Tyndall effect.

c) It blocks light entirely, making the mixture appear opaque.

d) It contains particles too small to be seen, making the mixture appear clear and uniform.

2. Which characteristic is most likely observed in a suspension but not in a solution or colloid?

a) Particles are evenly distributed throughout and do not settle over time.

b) Particles are visible and settle at the bottom when the mixture is undisturbed.

c) The mixture appears clear and uniform, with particles too small to scatter light.

d) Particles scatter light but do not settle due to constant motion (Brownian motion).

3. Which of the following examples represents a colloid?

a) Sugar dissolved in water

b) Sand mixed with water

c) Mayonnaise d) Copper sulfate solution

SHORT RESPONSE QUESTION (SRQs)

Q1: Identify and explain the main characteristics that differentiate a solution from a colloid. Provide one example of each.

Identifies the key characteristic of a solution: **1 Mark** Identifies the key characteristic of a colloid: **1 Mark** Provides one example of each (solution and colloid): **1 Mark**

Solution Characteristics: A solution is a homogeneous mixture where the solute is completely dissolved in the solvent, forming a single phase. Particles in a solution are too small (less than 1 nm) to scatter light or be seen under a microscope. *(1 Mark)* Example: Saltwater, where salt is completely dissolved in water.

Colloid Characteristics: A colloid is a heterogeneous mixture where particles are larger than in a solution (1–1000 nm) but small enough to remain suspended. These particles scatter light, showing the Tyndall effect, but do not settle over time. *(1 Mark)* Example: Milk, where fat droplets are dispersed in water.

Q2: Describe the main difference between a colloid and a suspension in terms of particle size and behaviour. Provide one example of each?

Describes the particle size and behavior of a colloid: 1 Mark Describes the particle size and behavior of a suspension: 1 Mark
Provides one example of each (colloid and suspension): 1 Mark

Colloid: In a colloid, particles are intermediate in size (1 to 1000 nm) and remain dispersed in the medium without settling due to constant Brownian motion. These particles scatter light, displaying the Tyndall effect. *(1Mark)* **Example: Gelatine, where solid particles are dispersed in liquid.**

Suspension: A suspension has larger particles (greater than 1000 nm) that are visible to the naked eye. These particles do not remain uniformly dispersed and settle down over time when left undisturbed. *(1Mark)***Example: Muddy water, where soil particles settle at the bottom after some time.**

Extended response Question

Q1: Compare and contrast solutions, colloids, and suspensions in terms of their particle size, appearance, stability, behavior under light, and diagram representation. Provide two examples for each and explain how these characteristics help distinguish one type of mixture from another**.**

Describes the particle size of solutions, colloids, and suspensions: 1 Mark Explains the appearance of each mixture type: 1 Mark
Discusses the stability of solutions, colloids, and suspensions: 1 Mark
Describes behavior under light (Tyndall effect) for each type of mixture: 1 Mark
Provides two examples of each type of mixture (solution, colloid, suspension): 1 Mark

Aspect	Solution	Colloid	Suspension
Particle Size	Particles are very small, typically less than 1 nanometer (nm); they are fully dissolved in the solvent and cannot be seen even under a microscope.	Particles are intermediate in size, ranging from 1 to 1000 nanometers (nm); they are small enough to remain suspended but large enough to scatter light.	Particles are large, generally greater than 1000 nanometers (nm); they are visible to the naked eye and tend to settle over time if left undisturbed.
Appearance	Clear and transparent with no visible particles; the mixture looks uniform throughout.	Appears cloudy or translucent; particles are not visible individually but cause the mixture to appear hazy or milky.	Opaque or cloudy; particles are visibly distinct and tend to form a sediment at the bottom if left standing.
Stability	Very stable; particles do not settle out over time,	Relatively stable; particles do not settle due to constant motion (Brownian motion)	Unstable; particles settle out quickly when the mixture is

	and the mixture remains uniform.	but may separate slowly over a long period.	at rest, forming layers or sediment.
Behavior Under Light	Does not scatter light; passes through completely, hence no Tyndall effect.	Scatters light due to the size of dispersed particles, showing the Tyndall effect (e.g., light beam is visible in a foggy room).	May block or scatter light significantly; larger particles cause a shadow or block light entirely, making the mixture appear more opaque.
Examples	Saltwater: Salt completely dissolves in water to form a uniform, clear mixture. Sugar solution: Sugar fully dissolves in water, resulting in a clear, sweet-tasting liquid.	Milk: Fat droplets dispersed in water, giving a white, cloudy appearance. Fog: Tiny water droplets suspended in air, scattering light and reducing visibility.	Muddy water: Soil particles suspended in water, creating a cloudy appearance, and settling over time. Sand in water: Sand particles are clearly visible and settle quickly.
Diagram	Particles are too small to be seen or scatter light, appearing uniformly clear.	Particles dispersed throughout; light beam scatters, creating a cloudy or milky look.	Large particles settle at the bottom, creating distinct layers; the mixture looks heterogeneous.

SLO: C-09-B-07	***Explain the effect of temperature on solubility and formation of unsaturated and saturated solutions.***

Cognitive Level: (U) **Type of assessment: Summative**

1. What happens to the solubility of most solid solutes in water as the temperature increases?

A) It decreases
C) It increases
B) It remains constant
D) It fluctuates randomly

2.A saturated solution is formed when?

A) The solvent can dissolve more solute
B) The solute and solvent are mixed in equal proportions
C) No more solute can dissolve in the solvent at a given temperature
D) The solution has a lower concentration of solute

3.What happens to a saturated solution of sugar in water if the temperature is increased

A) The solution remains saturated
C) Sugar starts precipitating out of the solution
B) More sugar dissolves in the solution
D) The water evaporates immediately

4.If a solution contains less solute than the maximum amount it can dissolve at a given temperature, it is called.

A) A saturated solution
C) A supersaturated solution
B) An unsaturated solution
D) A concentrated solution

5. How does the solubility of gases in liquids generally change as the temperature increases?

A) It increases
C) It decreases
B) It remains constant
D) It fluctuates

6. A solution becomes supersaturated when:

A) A saturated solution is cooled, and excess solute remains dissolved
B) Solute particles are visible in the solution
C) The solvent can dissolve additional solute
D) The temperature of the solution decreases

7. Which of the following will happen if you add more solute to a saturated solution at a constant temperature?
A) The solute will dissolve completely.
B) The solute will form crystals or precipitate
C) The solution becomes unsaturated
D) The temperature of the solution increases

8. Why does the solubility of salts like NaCl increase with temperature?

A) **The kinetic energy of particles increases, allowing more solute to dissolve**
B) The solvent evaporates quickly
C) The solute decomposes
D) The density of water decreases

SHORT RESPONCE QUESTIONS (SRQS)

Q1: Explain how an increase in temperature affects the solubility of a substance when heat is absorbed during dissolution. Refer to a specific example from the text.

Describes the effect of increased temperature on solubility with heat absorption: 1 Mark
Provides a reason related to the dissolution process: 1 Mark
Uses an example from the text to illustrate this effect: 1 Mark

Effect on Solubility: When heat is absorbed during dissolution, increasing the temperature generally raises the solubility of the substance (1 Mark).

Reason: This happens because the process is endothermic. The additional heat provides energy required to overcome the attractive forces between solute particles and the solvent, facilitating dissolution (1 Mark).

Example: The solubility of potassium nitrate (KNO_3) increases significantly with temperature, as heat is absorbed during the dissolving process, allowing more KNO_3 to dissolve in water (1 Mark).

Q2: Describe how a saturated solution can become unsaturated when the temperature changes. Use an example from the content provided to explain your answer.

Explains how a saturated solution can become unsaturated with temperature changes: 1 Mark
Discusses the role of temperature in this process: 1 Mark
Provide an example from the text to demonstrate this change: 1 Mark

Concept: A saturated solution can become unsaturated if the temperature increases because higher temperatures allow more solute to dissolve in the solvent (1 Mark).

Role of Temperature: Increased temperature raises the solubility of most solutes, reducing saturation and enabling additional solutes to dissolve (1 Mark).

Example: For sodium chloride (NaCl), an increase in temperature slightly increases its solubility, turning a previously saturated solution into an unsaturated one as more NaCl dissolves in the warmer water (1 Mark).

Q3: Explain why the solubility of certain substances decreases with an increase in temperature, and discuss how this affects the formation of saturated and unsaturated solutions. Include a specific example from the text.

Describe why some substances decrease in solubility with rising temperature: 1 Mark
Explains the effect on saturated and unsaturated solutions: 1 Mark
Use a specific example from the text to support the explanation: 1 Mark

Decreased Solubility: For some substances, dissolving releases heat (an exothermic process), and increasing temperature reduces their solubility as it opposes the heat released from dissolution (1 Mark).

Effect on Solutions: When temperature rises, these substances quickly reach saturation, limiting their ability to form unsaturated solutions, as less solute can dissolve in the solvent (1 Mark).

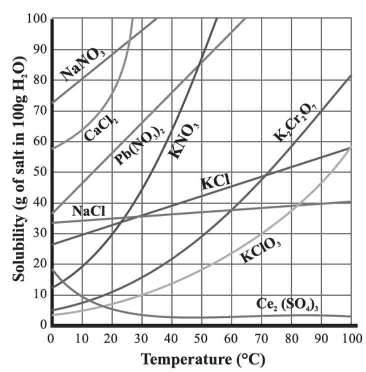
Example: Cerium(III) sulfate ($Ce_2(SO_4)_3$) becomes less soluble at higher temperatures due to its exothermic dissolution process, leading to rapid saturation and a decrease in solubility (1 Mark).

Extended response question (ERQs)

Q1: Analyze the solubility curves for KNO_3, $NaNO_3$, KCl, and $Ce_2(SO_4)_3$ in the graph provided. Explain how temperature influences the solubility of these substances, identify which substance shows the most significant change, and discuss why some substances decrease in solubility?

Describes the general trend of solubility changes with temperature: 2 Marks
Identifies which substance has the most significant change in solubility: 2 Marks
Explains why some substances decrease in solubility and discusses the graph's details: 2 Marks

General Trend: The solubility curves demonstrate that KNO_3, NaNO, and KCl have increasing solubility with rising temperature, which is typical for most salts because higher temperatures provide energy for solute particles to dissolve. In contrast, $Ce_2(SO_4)_3$ decreases in solubility as temperature increases due to its exothermic dissolution process (2 Marks).



Most Significant Change: Potassium nitrate (KNO_3) exhibits the most significant change in solubility. The graph shows a steep curve for KNO_3, indicating that its solubility increases dramatically with temperature. For example, at 20°C, its solubility is much lower compared to its solubility at 80°C (2 Marks).

Explanation and Graph Details: Substances like $Ce_2(SO_4)_3$ release heat when dissolving, so their solubility decreases with rising temperature as the system tries to counteract the added heat (Le Chatelier's Principle). The graph reflects this behavior with $Ce_2(SO_4)_3$'s downward curve, while KCl and $NaNO_3$ show moderate increases. The steep slope for KNO_3 highlights its temperature sensitivity, while NaCl has a relatively flat line, indicating minimal changes (2 Marks).