Chapter 8: Nature of Matter: Elements, Compounds, and Mixtures

Exercises — Keep the Curiosity Alive

Q1 Consider the following reaction where two substances, A and B, combine to form a product C:

A + B → C

Assume that A and B cannot be broken down into simpler substances by chemical reactions. Based on this information, which of the following statements is correct?

(i) A, B, and C are all compounds and only C has a fixed composition.

(ii) C is a compound, and A and B have a fixed composition.

(iii) A and B are compounds, and C has a fixed composition.

(iv) A and B are elements, C is a compound, and has a fixed composition.

SOLUTION

A substance that cannot be broken down into simpler substances by chemical reactions is, by definition, an element.

Since both A and B cannot be broken down further, A and B are elements.

When two elements combine chemically, the product is a compound. Compounds are formed in a fixed ratio and have a fixed composition.

Therefore, C, formed by the chemical combination of A and B, is a compound with a fixed composition.

Evaluating the options:

(i) Incorrect — A and B are elements, not compounds.

(ii) Incorrect — It does not identify A and B as elements; elements do have fixed composition, but the statement omits classifying them correctly as elements.

(iii) Incorrect — A and B are elements, not compounds.

(iv) Correct — A and B are elements (cannot be broken down further); C is a compound formed from them and has a fixed composition.

Answer: (iv) A and B are elements, C is a compound, and has a fixed composition.

Q2 Assertion: Air is a mixture.
Reason: A mixture is formed when two or more substances are mixed, without undergoing any chemical change.
(i) Both Assertion and Reason are true and Reason is the correct explanation for Assertion.
(ii) Both Assertion and Reason are true, but Reason is not the correct explanation for Assertion.
(iii) Assertion is true, but Reason is false.
(iv) Assertion is false, but Reason is true.

SOLUTION

Assertion check: Air is a uniform mixture of nitrogen (~78%), oxygen (~21%), argon, carbon dioxide, water vapour, and other gases. The components of air retain their individual properties and can be separated by physical methods. Therefore, the Assertion — 'Air is a mixture' — is TRUE.

Reason check: The Reason states that a mixture is formed when two or more substances are mixed without undergoing any chemical change. This is the correct scientific definition of a mixture. Therefore, the Reason is also TRUE.

Does the Reason explain the Assertion? Yes — air fits this definition exactly: its components (nitrogen, oxygen, etc.) are physically combined without any chemical reaction between them, which is precisely why air is classified as a mixture. The Reason is the correct explanation for the Assertion.

Therefore, option (i) is correct.

Answer: (i) Both Assertion and Reason are true and Reason is the correct explanation for Assertion.

Q3 Water, a compound, has different properties compared to those of the elements oxygen and hydrogen from which it is formed. Justify this statement.

SOLUTION

Water (H_2O) is a compound formed by the chemical combination of hydrogen and oxygen in a fixed ratio of 2:1 (by number of atoms).

Properties of the constituent elements:
Hydrogen (H_2) — a colourless, odourless, highly flammable gas. It burns and is used as a fuel.
Oxygen (O_2) — a colourless, odourless gas that supports combustion. It is

necessary for burning.

Properties of water (H_2O):
Water is a colourless, odourless liquid at room temperature.
Water is neither flammable nor does it support combustion — it is widely used to extinguish fires.
Water is an excellent solvent and is essential for all living organisms.
Water conducts electricity when impure (due to dissolved ions).

This stark contrast — hydrogen burns, oxygen supports burning, yet water (made from both) puts out fire — demonstrates that when elements combine to form a compound, the resulting compound has entirely new and different properties. This is a key characteristic of compounds: their properties differ from those of the elements that formed them.

Answer: Water is neither flammable nor does it support combustion — it even extinguishes fires — whereas hydrogen is a fuel and oxygen supports burning. Water is a liquid at room temperature, while hydrogen and oxygen are gases. The compound has entirely new properties different from its constituent elements.

Q4 In which of the following cases are all the examples correctly matched? Give reasons in support of your answers.
(i) Elements — water, nitrogen, iron, air.
(ii) Uniform mixtures — minerals, seawater, bronze, air.
(iii) Pure substances — carbon dioxide, iron, oxygen, sugar.
(iv) Non-uniform mixtures — air, sand, brass, muddy water.

SOLUTION

(i) Elements — water, nitrogen, iron, air: INCORRECT.
Water is a compound (hydrogen + oxygen chemically combined in 2:1 ratio), not an element.
Air is a mixture of gases, not an element.
Nitrogen and iron are correctly classified as elements.
Since water and air are wrongly listed, this case is not correctly matched.

(ii) Uniform mixtures — minerals, seawater, bronze, air: INCORRECT.
Minerals are mostly compounds (e.g., quartz, calcite), not mixtures.
Seawater (water + dissolved salts) and air (mixture of gases) are uniform mixtures.

Bronze (copper + tin alloy) is a uniform mixture (alloy).
Since minerals are wrongly listed, this case is not correctly matched.

(iii) Pure substances — carbon dioxide, iron, oxygen, sugar: CORRECT.
Carbon dioxide (CO_2) is a compound — a pure substance.
Iron (Fe) is an element — a pure substance.
Oxygen (O_2) is an element — a pure substance.
Sugar (sucrose, $C_{12}H_{22}O_{11}$) is a compound — a pure substance.
All four are pure substances (they each have a definite, fixed composition and cannot be separated by physical means). This case is correctly matched.

(iv) Non-uniform mixtures — air, sand, brass, muddy water: INCORRECT.
Air is a uniform mixture (components are evenly distributed and cannot be seen separately).
Brass (copper + zinc alloy) is a uniform mixture (alloy).
Muddy water is a non-uniform mixture (mud particles visible and unevenly distributed).
Sand is a non-uniform mixture (a mix of silicon dioxide with other minerals and particles) — correctly listed here.
However, air is a uniform mixture and brass is a uniform mixture (alloy) — both are wrongly listed as non-uniform. Since air and brass are incorrectly classified, this case is not correctly matched.

Answer: Only (iii) is correctly matched — carbon dioxide, iron, oxygen, and sugar are all pure substances (compounds or elements with fixed composition, not separable by physical means).

Q5 Iron reacts with moist air to form iron oxide, and magnesium burns in oxygen to form magnesium oxide. Classify all the substances involved in the above reactions as elements, compounds or mixtures, with justification.

SOLUTION

Reaction 1: Iron + Moist air → Iron oxide

Iron (Fe): Element — a pure substance made of only one type of atom (iron atoms); cannot be broken down into simpler substances by chemical means.

Moist air: Mixture — air is a uniform mixture of nitrogen, oxygen, argon, carbon dioxide, and water vapour. The components retain their individual properties and are physically combined (no chemical change). 'Moist air' additionally contains

water vapour, confirming its nature as a mixture.

Iron oxide (rust, Fe_2O_3): Compound — formed by the chemical combination of iron and oxygen in a fixed ratio. It has properties different from iron (not metallic, not magnetic) and cannot be separated into its elements by physical methods.

Reaction 2: Magnesium + Oxygen → Magnesium oxide

Magnesium (Mg): Element — a pure substance made of only magnesium atoms; a metal that cannot be broken down into simpler substances chemically.

Oxygen (O_2): Element — a pure substance made of only oxygen atoms; a non-metal that cannot be broken down further chemically.

Magnesium oxide (MgO): Compound — formed by the chemical combination of magnesium and oxygen in a fixed 1:1 ratio. It is a white powder with properties entirely different from those of magnesium (a shiny metal) and oxygen (a gas that supports combustion); cannot be separated by physical methods.

Answer: Iron — element; Moist air — mixture; Iron oxide — compound; Magnesium — element; Oxygen — element; Magnesium oxide — compound.

Q6 Classify the following as elements, compounds, or mixtures in Table 8.3.
Carbon dioxide, sand, seawater, magnesium oxide, muddy water, aluminium, gold, oxygen, rust, iron sulfide, glucose, air, water, fruit juice, nitrogen, sodium chloride, sulfur, hydrogen, baking soda.
Also identify pure substances amongst these and list them.

SOLUTION

Elements (pure substances made of one type of atom, cannot be broken down chemically):
Aluminium, Gold, Oxygen, Nitrogen, Sulfur, Hydrogen.

Compounds (pure substances formed by chemical combination of two or more elements in a fixed ratio):
Carbon dioxide (CO_2 — carbon + oxygen), Magnesium oxide (MgO — magnesium + oxygen), Rust (Fe_2O_3 — iron + oxygen), Iron sulfide (FeS — iron + sulfur), Glucose ($C_6H_{12}O_6$ — carbon + hydrogen + oxygen), Water (H_2O — hydrogen + oxygen), Sodium chloride (NaCl — sodium + chlorine), Baking soda ($NaHCO_3$ — sodium + hydrogen + carbon + oxygen).

Mixtures (two or more substances physically combined, components retain their

properties):
Sand (mainly silicon dioxide mixed with other minerals), Seawater (water + dissolved salts and minerals), Muddy water (water + mud particles — non-uniform), Air (nitrogen + oxygen + other gases — uniform), Fruit juice (water + sugars + minerals + organic compounds — non-uniform).

Pure substances (elements + compounds — fixed composition, cannot be separated by physical means):
Aluminium, Gold, Oxygen, Nitrogen, Sulfur, Hydrogen, Carbon dioxide, Magnesium oxide, Rust, Iron sulfide, Glucose, Water, Sodium chloride, Baking soda.

Answer: Elements: Aluminium, Gold, Oxygen, Nitrogen, Sulfur, Hydrogen. Compounds: Carbon dioxide, Magnesium oxide, Rust, Iron sulfide, Glucose, Water, Sodium chloride, Baking soda. Mixtures: Sand, Seawater, Muddy water, Air, Fruit juice. Pure substances = all elements + all compounds (14 substances total).

Q7 What new substance is formed when a mixture of iron filings and sulfur powder is heated, and how is it different from the original mixture? Also, write the word equation for the reaction.

SOLUTION

When a mixture of iron filings and sulfur powder is heated, a new black substance called iron sulfide is formed.

Word equation: Iron + Sulfur → Iron sulfide

Differences between the mixture (Sample A) and the new compound iron sulfide (Sample B):

Appearance: The original mixture shows the yellow colour of sulfur and the grey-black colour of iron particles (non-uniform). Iron sulfide is uniformly black throughout.

Magnetic properties: In the original mixture, iron filings are attracted by a magnet and can be separated. Iron sulfide is not attracted by a magnet — it has lost the magnetic property of iron.

Separation: The components of the mixture (iron and sulfur) can be separated by physical means (e.g., using a magnet or dissolving sulfur in carbon disulfide). Iron sulfide cannot be separated into iron and sulfur by any physical method.

Reaction with dilute hydrochloric acid: The iron in the original mixture reacts with dilute HCl to produce colourless, odourless hydrogen gas (burns with a 'pop' sound). Iron sulfide reacts with dilute HCl to produce hydrogen sulfide gas, which has a rotten egg-like odour — a completely different gas.

These differences confirm that iron sulfide is a compound with new properties, not merely a mixture of iron and sulfur.

Answer: Iron sulfide (a black compound) is formed. Unlike the original mixture, it is not attracted by a magnet, cannot be separated into iron and sulfur by physical means, and reacts with dilute HCl to produce hydrogen sulfide (rotten egg odour) instead of hydrogen gas. Word equation: Iron + Sulfur → Iron sulfide.

Q8 Is it possible for a substance to be classified as both an element and a compound? Explain why or why not.

SOLUTION

No, it is not possible for a substance to be classified as both an element and a compound. The two categories are mutually exclusive.

An element is a pure substance that cannot be broken down into simpler substances by any chemical reaction. It is made up of only one type of atom.

A compound is a pure substance formed by the chemical combination of two or more different elements in a fixed ratio. It can be broken down into its constituent elements by chemical means.

By definition:
An element consists of only one kind of atom — it cannot contain a second type of element chemically bonded within it.
A compound must contain at least two different elements chemically combined — it is always more complex than an element.

Therefore, if a substance is an element, it contains only one type of atom and is not made from other elements — so it cannot simultaneously be a compound. Conversely, if a substance is a compound, it is made of two or more elements and can be chemically broken down — so it cannot simultaneously be an element.

The two definitions are contradictory and cannot both apply to the same substance.

Answer: No. An element consists of only one type of atom and cannot be broken down further. A compound is made of two or more elements chemically combined. These definitions are mutually exclusive — a substance cannot be both simultaneously.

Q9 How would our daily lives be changed if water were not a compound but a mixture of hydrogen and oxygen?

SOLUTION

If water were a mixture of hydrogen and oxygen (rather than a compound), several fundamental changes would occur:

1. Variable composition: A mixture does not have a fixed composition — the ratio of hydrogen to oxygen could vary. We could not rely on water having consistent properties every time.

2. Flammable and explosive: Hydrogen gas is highly flammable, and oxygen strongly supports combustion. A mixture of both would be extremely hazardous — it would burn or explode rather than extinguish fires. Water would be unusable for firefighting.

3. Gaseous state: Hydrogen and oxygen are both gases at room temperature. A mixture of these two gases would not exist as a liquid under normal conditions. There would be no liquid water available for drinking, cooking, irrigation, or any biological process.

4. No solvent properties: Water's remarkable ability to dissolve a vast range of substances (making it the 'universal solvent') arises from its compound nature — the polar H_2O molecule. A mixture of H_2 and O_2 gases would not have this property.

5. Life would be impossible: All biochemical reactions in living cells depend on liquid water as a medium. Without it as a stable liquid compound, life as we know it could not exist.

6. Physical separation possible: The 'water' could be easily separated back into hydrogen and oxygen by physical means, making it unstable and unreliable as a resource.

In summary, daily life as we know it — from drinking and cooking to biological survival — would be completely impossible if water were a mixture instead of a compound.

Answer: If water were a mixture of H_2 and O_2 gases: it would be flammable/explosive (not a liquid for drinking or firefighting), would have no fixed composition, could not act as a universal solvent, and could not support life. All biology depends on water being a stable liquid compound.

Q10 Analyse Fig. 8.24. Identify Gas A. Also, write the word equation of the chemical reaction.
(Fig. 8.24 shows iron filings reacting with dilute hydrochloric acid, producing a gas collected above.)

SOLUTION

Fig. 8.24 shows iron filings placed in dilute hydrochloric acid. A gas (Gas A) is being produced and collected.

From the chapter (Activity 8.5 / Sample A discussion), we know that iron reacts with dilute hydrochloric acid to produce iron chloride and hydrogen gas. The hydrogen gas is colourless, odourless, and burns with a characteristic 'pop' sound when a burning candle is brought near it.

Therefore, Gas A = Hydrogen.

Word equation of the chemical reaction:
Iron + Dilute hydrochloric acid → Iron chloride + Hydrogen

Answer: Gas A is hydrogen. Word equation: Iron + Dilute hydrochloric acid → Iron chloride + Hydrogen.

Q11 Write the names of any two compounds made only from non-metals, and also mention two uses of each of them.

SOLUTION

Compound 1: Carbon dioxide (CO_2)
Made from: Carbon (non-metal) + Oxygen (non-metal).
Use 1: Used in fire extinguishers to smother fires — it does not support combustion and is heavier than air, cutting off the oxygen supply.
Use 2: Used in the carbonation of beverages (soft drinks, soda water) to give them their fizz.

Compound 2: Water (H_2O)
Made from: Hydrogen (non-metal) + Oxygen (non-metal).

Use 1: Essential for drinking and for all biological processes — it is the medium in which biochemical reactions in living cells take place.
Use 2: Used as a coolant in industrial processes and power plants, and for irrigation in agriculture.

(Alternative acceptable compound: Hydrogen chloride/HCl — hydrogen + chlorine, both non-metals. Uses: manufacturing of PVC plastics; used as a laboratory acid and in industrial cleaning.)

Answer: Carbon dioxide (CO_2): used in fire extinguishers and carbonated beverages. Water (H_2O): used for drinking/biological processes and as a coolant/for irrigation.

Q12 How can gold be classified as both a mineral and a metal?

SOLUTION

Gold can be classified as a mineral because:
Minerals are natural, solid substances found in the Earth's crust with a definite chemical composition. Gold occurs naturally as a pure element (Au) in the Earth — it is a native mineral. It has a fixed composition (100% gold atoms), a definite crystalline structure, and is found in nature without being combined with other elements. This qualifies it as a native mineral.

Gold can be classified as a metal because:
Gold exhibits all the characteristic properties of metals — it has a lustrous (shiny) appearance, is malleable (can be beaten into thin sheets), ductile (can be drawn into wires), and is an excellent conductor of electricity and heat. It also has a high density and a high melting point. These properties place it firmly in the category of metals.

Therefore, gold is simultaneously a mineral (naturally occurring pure element with definite composition, found in Earth's crust) and a metal (possessing metallic properties such as lustre, malleability, ductility, and conductivity). These two classifications are not contradictory — they describe different aspects of the same substance.

Answer: Gold is a mineral because it is a naturally occurring solid with a definite composition (pure Au), found in Earth's crust — a native mineral. It is a metal because it is lustrous, malleable, ductile, and a good conductor of electricity and heat. Both classifications apply simultaneously as they describe different characteristics.