NCERT Archive

SOLUTIONS BOOK

CLASS 9

Science · Exploration

CHAPTER 9

Atomic Foundations of Matter

Complete Questions and Activities Solutions

In-text Questions | Worked Examples | Revise, Reflect, Refine | The Journey Beyond

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Every question is followed by its answer. Question numbers above are clickable and the PDF bookmarks panel lets you jump to any exercise set or question. Figures are reproduced from the NCERT textbook (© NCERT) for educational use.

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9.1

CLASS 9 SCIENCE · CHAPTER 9

In-text Questions

Solutions · 37 questions

Directions (Questions 1–37): These are the questions, activities and Pause and Ponder prompts that appear inside the chapter (Think It Over, Activities 9.1 to 9.4, Think as a Scientist, What if and Pause and Ponder), numbered in the order in which they appear. Activities that depend on your own observations give model answers.

QUESTION 1 *Think It Over · p. 162*

Water can be obtained from various sources. Are all these samples of water chemically identical?

ANSWER

Yes. Pure water from any source is chemically the same compound, H_2O.

a **Reason**

- If water from rivers, borewells, rain or the ocean is purified and analysed, it is always found to contain hydrogen and oxygen in the mass ratio 1:8.
- So 9 g of purified water from any source gives 1 g of hydrogen and 8 g of oxygen. This is the **Law of Constant Proportions**.
- Samples differ only in the substances dissolved or mixed in them (such as salts, gases and dirt). These are impurities and not part of the compound water.

Therefore, all purified samples of water are chemically identical because water always has hydrogen and oxygen in the fixed mass ratio 1:8.

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QUESTION 2 *Think It Over · p. 162*

Oxygen is sometimes represented as O and sometimes as O_2. What is the difference between these symbols?

ANSWER

O stands for one atom of oxygen, while **O_2** stands for a molecule made of two oxygen atoms.

a Difference

Point	O	O_2
Meaning	One atom of the element oxygen (its symbol)	One molecule of oxygen containing two atoms
Bonding	Single atom with 6 valence electrons, not stable	Two atoms joined by a double bond (O=O), each atom has a complete octet
Existence	Not found freely in air	The form in which oxygen exists as a gas in air

Therefore, O is a single atom and O_2 is a molecule of two oxygen atoms.

QUESTION 3 *Think It Over · p. 162*

Why does dissolved salt in water conduct electricity, but sugar does not?

ANSWER

Electricity is conducted in a solution only if it contains ions that are free to move.

a Reason

- Salt (sodium chloride) is an **ionic compound**. When it dissolves in water, the Na^+ and Cl^- ions become free to move and carry the current.
- Sugar is a **covalent compound**. It dissolves in water as neutral molecules and does not give ions in solution, so it does not conduct electricity.

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Therefore, salt solution conducts because it contains free ions, whereas sugar solution has no ions.

QUESTION 4 *Activity 9.1 · p. 163*

Activity 9.1: Let us investigate a physical change. Weigh water and salt in a beaker (Fig. 9.1a), then swirl until the salt dissolves and record your observations (Fig. 9.1b). What do you observe? Repeat by weighing a piece of paper before and after tearing it into pieces.

ANSWER

The mass of the solution is equal to the sum of the masses of the water and the salt taken.

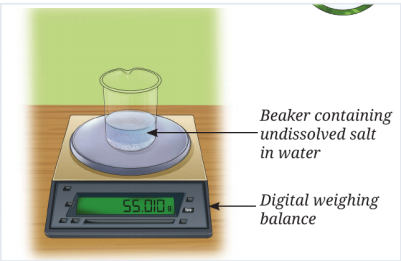


Fig. 9.1(a): Water and undissolved salt

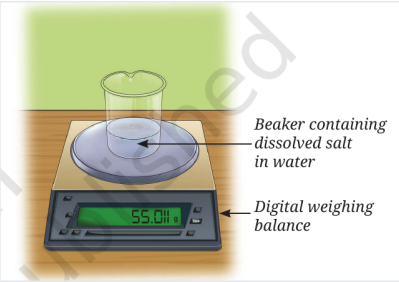


Fig. 9.1(b): Solution of salt and water

a Observation

- The balance reads about 55.01 g both before and after the salt dissolves (Fig. 9.1a and 9.1b). The tiny difference in the last digit is within the usual uncertainty of ±1 in a digital balance.
- Dissolving salt in water is a **physical change**, so there is practically no change in mass.
- Tearing paper into pieces is also a physical change. The pieces weigh the same as the paper before tearing.

Therefore, mass does not change during a physical change.

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QUESTION 5 *Activity 9.2 · pp. 163–164*

Activity 9.2: Let us investigate a chemical change. Experimental set-up 1: weigh a conical flask with vinegar and a balloon containing baking soda, then transfer the baking soda into the vinegar and weigh again. 8. What do you observe? 9. Are the initial and the final readings same? What can be the reason for this?

ANSWER

Vinegar reacts with baking soda (sodium hydrogencarbonate) to give carbon dioxide gas and other substances. In this open set-up the gas escapes.

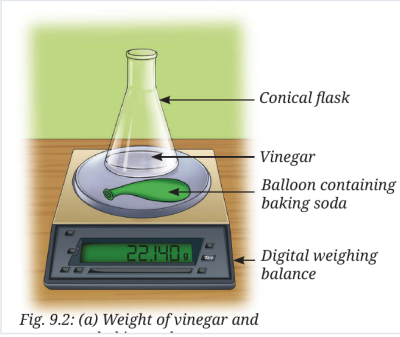


Fig. 9.2: (a) Weight of vinegar and

Fig. 9.2(a): Before mixing

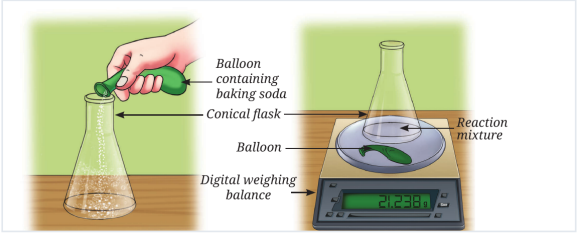


Fig. 9.2(b), (c): Pouring baking soda and the final reaction mixture

a Answers

- **8. Observation:** a brisk effervescence (bubbling) takes place as soon as the baking soda touches the vinegar.
- **9. Readings:** the final reading is **less** than the initial reading.
- **Reason:** the carbon dioxide gas produced escapes into the air because the flask is open, so the mass of the gas is not measured. The mass difference is the mass of the gas that left.

Therefore, the reading falls in set-up 1 because the gas formed escapes from the open flask.

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QUESTION 6 *Activity 9.2 · pp. 164–165*

Experimental set-up 2: fix the balloon containing baking soda to the mouth of the conical flask using a thread, weigh, and then let the baking soda fall into the vinegar. 8. What do you observe? 11. Are the initial and the final readings same in this case?

ANSWER

In this set-up the flask and the balloon form a closed system, so the gas cannot escape.

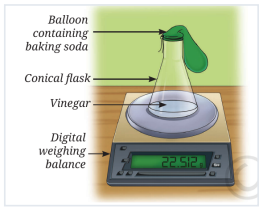


Fig. 9.3(a): Before mixing



Fig. 9.3(b): Pouring baking soda

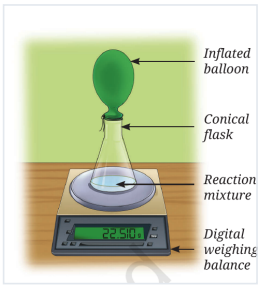


Fig. 9.3(c): Final mixture

a Answers

- **8. Observation:** a brisk effervescence occurs and the balloon is inflated by the carbon dioxide gas formed.
- **11. Readings:** the initial and final readings are the **same** (about 22.51 g in Fig. 9.3a and 9.3c).
- The total mass of vinegar and baking soda before the reaction equals the total mass of carbon dioxide and other substances formed after it.

Therefore, in a closed system the mass remains the same before and after a chemical reaction.

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QUESTION 7 *Activity 9.3 · p. 165*

Activity 9.3: Let us verify the law. Mix the sodium sulfate solution (flask A) and the barium chloride solution (flask B) and weigh them before and after mixing (Fig. 9.4). 7. What do you observe? 9. Do you observe any change in the reading after mixing the solutions?

ANSWER

Sodium sulfate reacts with barium chloride to form barium sulfate and sodium chloride.

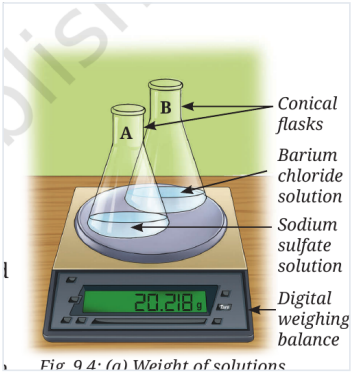


Fig. 9.4(a): Before mixing

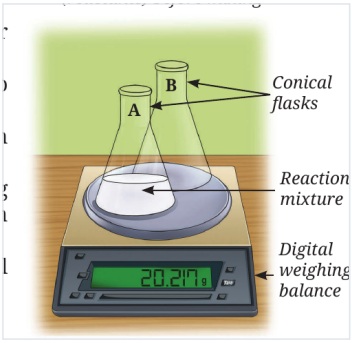


Fig. 9.4(b): After mixing

a Answers

- **7. Observation:** a white precipitate of barium sulfate is formed (sodium chloride stays in the solution).
- **9. Change in reading:** there is no change in the reading (about 20.22 g before and after). Any difference in the last digit is within experimental error.

Sodium sulfate + Barium chloride → Barium sulfate + Sodium chloride

Therefore, the total mass of the reactants equals the total mass of the products, which verifies the Law of Conservation of Mass.

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QUESTION 8 *Think as a Scientist · p. 166*

Zinc reacts with dilute hydrochloric acid to form zinc chloride and hydrogen gas. Design and perform an experiment to test the hypothesis that mass is conserved during the chemical reaction. You may use a set-up different from the one shown in Activity 9.2.

ANSWER

Zinc + Hydrochloric acid (dilute) → Zinc chloride + Hydrogen. Since a gas is formed, the experiment should be done in a closed system. Do it under the teacher's supervision.

a Hypothesis

The total mass of the reactants (zinc and hydrochloric acid) is equal to the total mass of the products (zinc chloride and hydrogen).

b Procedure

- Take a clean, dry conical flask and pour about 20 mL of dilute hydrochloric acid into it.
- Put a few small zinc granules in a small test tube or place them in a balloon fixed to the mouth of the flask using a thread, without letting them touch the acid.
- Weigh the whole set-up (flask, acid, zinc and balloon) and note the initial reading.
- Let the zinc fall into the acid. Bubbles of hydrogen are formed and the balloon inflates.
- Weigh the whole set-up again after the reaction stops and note the final reading.

c Observation and conclusion

- The initial and final readings are the same (within experimental error), so the hypothesis is supported.
- If the same reaction is done in an open flask, the reading falls because the hydrogen gas escapes.
- **Safety:** use dilute acid, wear safety goggles, and keep flames away because hydrogen is combustible.

Therefore, a closed system shows that mass is conserved in the reaction of zinc with dilute hydrochloric acid.

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QUESTION 9 *Pause and Ponder 1 · p. 166*

A student burns 10 g of ethanol in an open beaker. After the reaction, no residue is left in the beaker. Does this mean the Law of Conservation of Mass is violated? Explain.

ANSWER

No. The Law of Conservation of Mass is not violated.

a Explanation

- Ethanol burns in oxygen of the air to form carbon dioxide and water vapour.
- Both products are gases at the temperature of burning. They escape into the air from the open beaker, so no residue remains.
- The total mass of ethanol and the oxygen used equals the total mass of the carbon dioxide and water vapour formed. If the gases were collected in a closed container, this would be seen on weighing.

Therefore, the mass is not lost; it is carried away by the gaseous products.

QUESTION 10 *Pause and Ponder 2 · p. 166*

When 20 g of hydrogen reacts completely with 160 g of oxygen, how much water is formed according to the Law of Conservation of Mass?

ANSWER

By the Law of Conservation of Mass, the mass of the product equals the total mass of the reactants.

a Solution

Step	Calculation
Mass of hydrogen	20 g
Mass of oxygen	160 g
Mass of water formed	20 g + 160 g = **180 g**

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Check: the mass ratio of hydrogen to oxygen is 20 : 160 = 1 : 8, which is the ratio in water.

Therefore, 180 g of water is formed.

QUESTION 11 *Pause and Ponder 3 · p. 167*

A compound consists of 40% sulfur and 60% oxygen by mass. In a sample of the same compound containing 20 g of sulfur, what mass of oxygen must be present to satisfy the Law of Constant Proportions?

ANSWER

The ratio of sulfur to oxygen by mass is fixed: 40 : 60 = 2 : 3.

a **Solution**

Step	Calculation
Mass ratio S : O	40 : 60 = 2 : 3
Oxygen for 20 g of sulfur	(3 ÷ 2) × 20 g = **30 g**
Check	Total = 20 + 30 = 50 g; S = 20/50 = 40%, O = 30/50 = 60%

Therefore, 30 g of oxygen must be present.

QUESTION 12 *Pause and Ponder 4 · p. 167*

Carbon monoxide (CO) contains carbon and oxygen in the mass ratio of 3:4. How much oxygen will combine with 9 g of carbon to form carbon monoxide?

ANSWER

Carbon and oxygen combine in the fixed mass ratio 3 : 4.

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a Solution

Step	Calculation
3 g of carbon combines with	4 g of oxygen
1 g of carbon combines with	4/3 g of oxygen
9 g of carbon combines with	(4/3) × 9 = **12 g** of oxygen

Therefore, 12 g of oxygen combines with 9 g of carbon.

QUESTION 13 *Pause and Ponder 5 · p. 167*

The Law of Definite Proportions holds true for compounds but not for mixtures. Give reason.

ANSWER

A compound and a mixture are formed in different ways.

a Reason

Point	Compound	Mixture
Formation	Elements combine chemically	Substances are only mixed physically
Composition	Elements are always in a fixed ratio by mass (for example, hydrogen : oxygen = 1 : 8 in water)	Components can be mixed in any ratio (for example, any amount of salt in water)

Therefore, the law holds for compounds, whose elements combine in a fixed ratio, but not for mixtures, whose components can be present in any proportion.

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QUESTION 14 *Pause and Ponder 6 · p. 167*

Students X and Y, both prepared an oxide of copper by combining copper and oxygen in the ratios of 4:1 and 8:2, respectively. Do their results justify the Law of Constant Proportions? Explain.

ANSWER

Yes. Compare the two ratios in their simplest form.

a Explanation

Student	Ratio of Cu : O	Simplest form
X	4 : 1	4 : 1
Y	8 : 2	8 ÷ 2 : 2 ÷ 2 = 4 : 1

Therefore, both students got the same ratio of 4 : 1, so their results justify the Law of Constant Proportions.

QUESTION 15 *What if ... · p. 168*

What if atoms could combine in any ratio and not in a fixed ratio? How would this affect the substances around us?

ANSWER

The substances around us would not have fixed composition or fixed properties.

a Effects

- The same compound could contain different amounts of its elements. Water from different places could have different amounts of hydrogen and oxygen, with different properties.
- The Law of Constant Proportions would not hold, and a compound could not be represented by a single chemical formula such as H_2O or NaCl.
- Medicines, fuels, foods and materials would be unpredictable, and chemical reactions could not be planned reliably.

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Therefore, fixed ratios of atoms are why each substance has definite composition and properties.

QUESTION 16 *Pause and Ponder 7 · p. 168*

Assertion (A): 2 g of hydrogen combines with 16 g of oxygen to form 18 g of water.
Reason (R): According to Dalton's Atomic Theory, atoms combine in a simple whole number ratio by mass to form compounds.
Choose the correct option: (i) Both A and R are true, and R is the correct explanation of A. (ii) Both A and R are true, but R is not the correct explanation of A. (iii) A is true, but R is false. (iv) A is false, but R is true.

ANSWER

Correct option: (iii) A is true, but R is false.

a Checking A

2 g + 16 g = 18 g, and the ratio of hydrogen to oxygen is 2 : 16 = 1 : 8, the ratio found in water. So the Assertion is **true**.

b Checking R

Dalton's postulate says that atoms combine in a ratio of **simple whole numbers** (numbers of atoms), not by mass. Masses of atoms are different, so the mass ratio need not be a simple whole number (for example, sodium and chlorine combine in the mass ratio 23 : 35.5). So the Reason is **false** as stated.

Therefore, the answer is (iii).

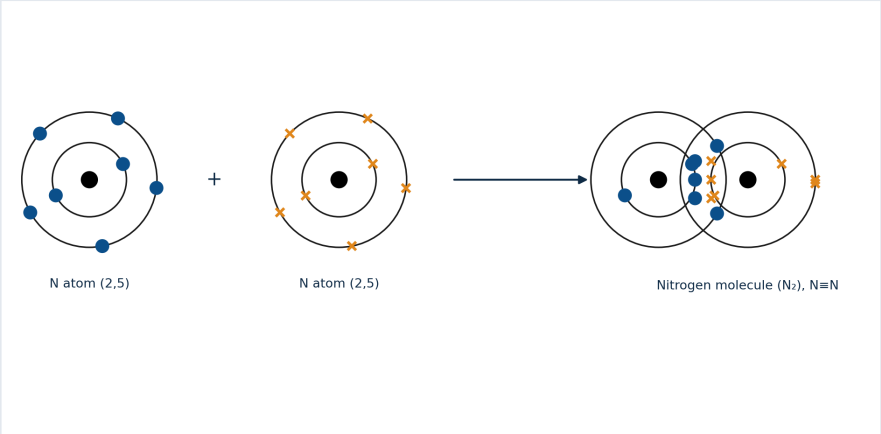
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QUESTION 17 *Pause and Ponder 8 · p. 170*

Nitrogen has five valence electrons. Draw the structure of the nitrogen molecule (N_2).

ANSWER

Nitrogen (atomic number 7) has the electronic configuration 2, 5. Each atom needs three more electrons to complete its octet.



Formation of a nitrogen molecule (dots = electrons of one atom, crosses = electrons of the other)

a Explanation

- Each nitrogen atom shares **three** electrons with the other, forming three shared pairs.
- After sharing, each atom has 8 electrons in its valence shell.
- The atoms are joined by a **triple bond**, written N≡N.

Therefore, the nitrogen molecule N_2 has a triple covalent bond (N≡N).

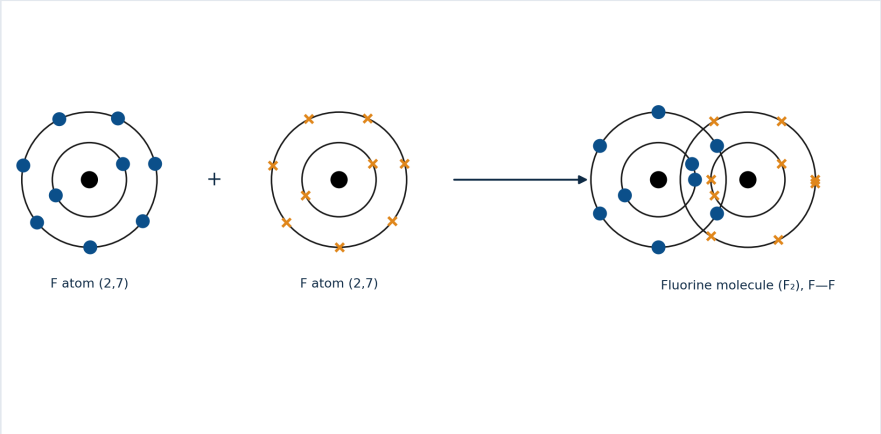
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QUESTION 18 *Pause and Ponder 9 · p. 170*

The atomic number of fluorine is 9. Explain the formation of the fluorine molecule (F_2).

ANSWER

Fluorine (atomic number 9) has the electronic configuration 2, 7, so it has seven valence electrons and needs one more to complete its octet.



Formation of a fluorine molecule

a Explanation

- Two fluorine atoms share one electron each, forming one shared pair.
- Each atom now has 8 electrons in its valence shell.
- The atoms are joined by a **single covalent bond**, written F—F.

Therefore, F_2 is formed by a single covalent bond between two fluorine atoms.

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QUESTION 19 *Pause and Ponder 10 · p. 171*

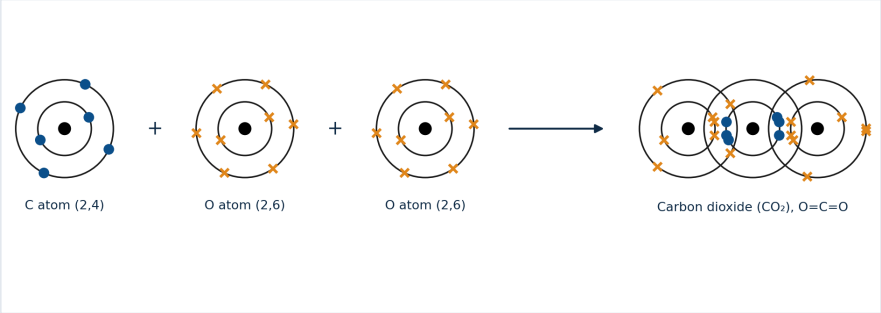
Show the formation of the following molecules: (i) Carbon dioxide (CO_2) (ii) Hydrogen sulfide (H_2S) (iii) Ammonia (NH_3)

ANSWER

In each molecule the atoms share electrons so that every atom completes its octet (hydrogen completes its duplet).

a (i) Carbon dioxide (CO_2)

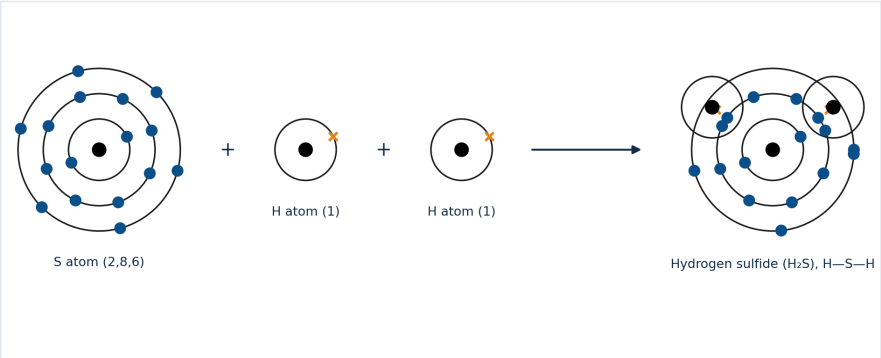
Carbon (2, 4) needs 4 electrons and each oxygen (2, 6) needs 2. Carbon shares two electrons with each oxygen atom, forming two double bonds: O=C=O.



Formation of a carbon dioxide molecule

b (ii) Hydrogen sulfide (H_2S)

Sulfur (2, 8, 6) needs 2 electrons and each hydrogen (1) needs 1. Sulfur shares one electron with each hydrogen atom, forming two single bonds: H—S—H.

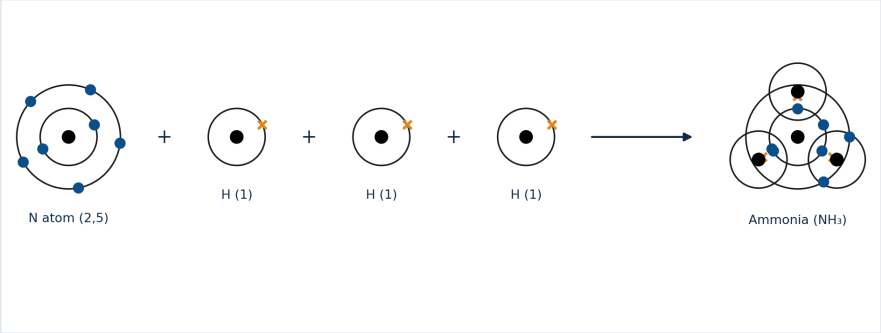


Formation of a hydrogen sulfide molecule

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c (iii) Ammonia (NH_3)

Nitrogen (2, 5) needs 3 electrons and each hydrogen needs 1. Nitrogen shares one electron with each of three hydrogen atoms, forming three single bonds.



Formation of an ammonia molecule

Therefore, CO_2 has two double bonds, H_2S has two single bonds and NH_3 has three single bonds.

QUESTION 20 *Pause and Ponder 11 · p. 171*

Neon (atomic number 10) neither transfers nor shares its valence electrons. Explain.

ANSWER

Neon already has a stable electronic configuration.

a Explanation

- The electronic configuration of neon is 2, 8. Its valence shell has 8 electrons, which is a complete octet.
- Atoms combine only to complete their valence shell. Neon already has a complete octet, so it does not need to lose, gain or share electrons.
- That is why neon exists as single atoms (like helium) and not as molecules.

Therefore, neon neither transfers nor shares electrons because its octet is already complete.

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QUESTION 21 *Section 9.4.2 · p. 172*

Identify four such elements (valence shell with less than four electrons) among the first 18 elements using Table 8.4. Will sodium still be neutral after losing one electron? If not, what charge would it carry and why?

ANSWER

Atoms with fewer than four valence electrons generally donate them to attain a stable configuration.

a Four such elements

Element	Electronic configuration	Valence electrons
Lithium (Li)	2, 1	1
Sodium (Na)	2, 8, 1	1
Magnesium (Mg)	2, 8, 2	2
Aluminium (Al)	2, 8, 3	3

Other examples are beryllium (2, 2) and hydrogen (1).

b Charge on sodium after losing one electron

No, it will not be neutral. Sodium has 11 protons (11+) and, after losing one electron, 10 electrons (10−). The net charge is 11 − 10 = **+1**, so it becomes the sodium cation Na^{+}.

Therefore, Li, Na, Mg and Al donate electrons, and Na becomes Na^{+} after losing one electron.

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QUESTION 22 *Pause and Ponder 12 · p. 174*

What kind of ion will oxygen (O) form?

ANSWER

Oxygen (atomic number 8) has the configuration 2, 6.

a **Explanation**

Oxygen has six valence electrons and needs two more to complete its octet, so it **gains two electrons**. It then has 8 protons and 10 electrons, giving two units of negative charge: the oxide anion **O^{2-}**.

Therefore, oxygen forms the anion O^{2-}.

QUESTION 23 *Pause and Ponder 13 · p. 174*

Fill in the blanks. Among magnesium and chlorine, magnesium atom can give two electrons to become Mg^{2+}. However, chlorine can take only one electron to become _____. Now, _____ ion of magnesium and _____ ions of chlorine combine to give magnesium chloride.

ANSWER

The charges must balance: one Mg^{2+} (2+) needs two Cl^{-} (2−).

a **Completed statement**

Among magnesium and chlorine, magnesium atom can give two electrons to become Mg^{2+}. However, chlorine can take only one electron to become **Cl^{-}**. Now, **one** ion of magnesium and **two** ions of chlorine combine to give magnesium chloride ($MgCl_2$).

Therefore, the blanks are Cl^{-}, one and two.

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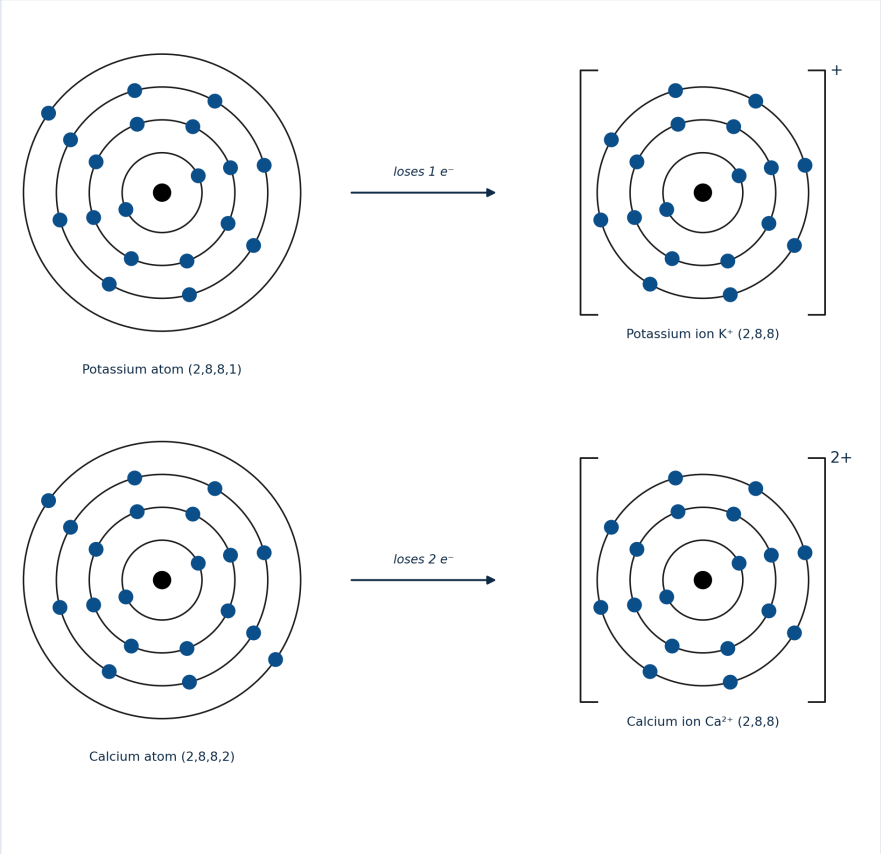
QUESTION 24 *Pause and Ponder 14 · p. 174*

Show the formation of cations of potassium (K) and calcium (Ca) atoms, and the formation of their corresponding chlorides using diagrams.

ANSWER

Potassium (atomic number 19) is 2, 8, 8, 1 and calcium (atomic number 20) is 2, 8, 8, 2. Each loses its valence electrons to reach the stable configuration 2, 8, 8.

a Formation of the cations

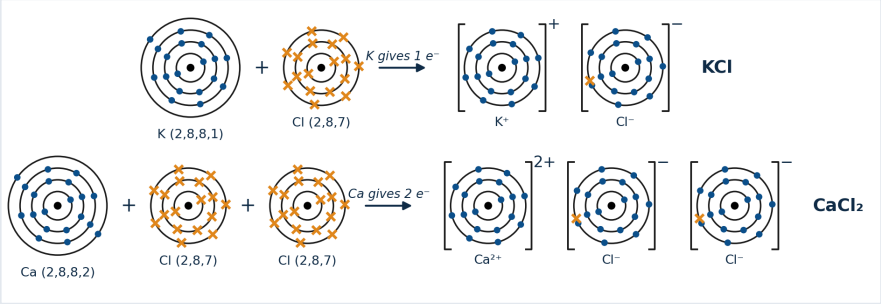


Formation of K^+ and Ca^{2+}

b Formation of the chlorides

Chlorine (2, 8, 7) gains one electron to become Cl^- (2, 8, 8). One K^+ combines with one Cl^- to give KCl. One Ca^{2+} needs two Cl^- to balance charge and gives $CaCl_2$. Crosses show the electrons received by chlorine.

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Formation of potassium chloride and calcium chloride

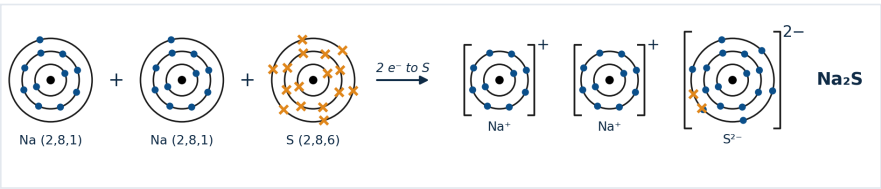
Therefore, K and Ca form K^+ and Ca^{2+}, which combine with Cl^- to form KCl and $CaCl_2$.

QUESTION 25 *Pause and Ponder 15 · p. 174*

Illustrate how sodium sulfide (Na_2S) is formed.

ANSWER

Sodium (2, 8, 1) loses one electron, and sulfur (2, 8, 6) needs two electrons. So two sodium atoms are needed for one sulfur atom.



Formation of sodium sulfide

a Steps

- Each sodium atom transfers one electron and becomes Na^+ (2, 8).
- The sulfur atom accepts the two electrons and becomes S^{2-} (2, 8, 8).
- Two Na^+ (2+) balance one S^{2-} (2−). The ions are held by an ionic bond, giving Na_2S.

Therefore, two sodium atoms transfer two electrons to one sulfur atom to form Na_2S.

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QUESTION 26 *What if ... · p. 174*

What if we could see atoms directly? How would it help scientists and what challenges would it cause?

ANSWER

Atoms are far too small to be seen with ordinary light.

a How it would help

- Scientists could see how atoms are arranged and bonded in molecules and crystals, and check models such as Dalton's theory and the electron shells directly.
- It would help in designing new materials and medicines, and in understanding chemical reactions.

b Challenges

- Atoms are extremely small and in constant motion, so they are very hard to observe.
- Special and costly instruments would be needed, and the images may be difficult to interpret.

Therefore, seeing atoms would help in understanding matter, but it needs very advanced instruments.

QUESTION 27 *Pause and Ponder 16 · p. 177*

Name the following: (i) CO_2 (ii) NO_2 (iii) SF_6 (iv) PCl_3

ANSWER

Covalent compounds are named with prefixes (mono-, di-, tri-, tetra-, penta-, hexa-) for the number of atoms. The second element ends in -ide.

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a Names

Formula	Name	Reason
CO_2	**Carbon dioxide**	One carbon (no prefix) and two oxygen (di-)
NO_2	**Nitrogen dioxide**	One nitrogen and two oxygen (di-)
SF_6	**Sulfur hexafluoride**	Six fluorine atoms (hexa-)
PCl_3	**Phosphorus trichloride**	Three chlorine atoms (tri-)

Therefore, the names are carbon dioxide, nitrogen dioxide, sulfur hexafluoride and phosphorus trichloride.

QUESTION 28 *Pause and Ponder 17 · p. 177*

Write the formula for the following: (i) Sodium hydrogencarbonate (ii) Sulfur dioxide (iii) Ferric chloride (iv) Cuprous oxide

ANSWER

The charges (valencies) from Table 9.1 are criss-crossed to get the formula.

a Formulae

Compound	Ions / valencies	Criss-cross	Formula
Sodium hydrogencarbonate	Na^+ (1), HCO_3^- (1)	$Na_1(HCO_3)_1$	**$NaHCO_3$**
Sulfur dioxide	Covalent: two oxygen atoms	Prefix di- gives 2 oxygen	**SO_2**
Ferric chloride	Fe^{3+} (3), Cl^- (1)	Fe_1Cl_3	**$FeCl_3$**
Cuprous oxide	Cu^+ (1), O^{2-} (2)	Cu_2O_1	**Cu_2O**

Therefore, the formulae are $NaHCO_3$, SO_2, $FeCl_3$ and Cu_2O.

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QUESTION 29 *Pause and Ponder 18 · p. 177*

Write the formulae for the compounds formed from the following pairs of ions: (i) Fe^{3+} and OH^{-} (ii) K^{+} and CO_3^{2-}

ANSWER

Criss-cross the charges (only the numbers). Use brackets when more than one polyatomic ion is needed.

a **Formulae**

Pair of ions	Criss-cross	Formula
Fe^{3+} and OH^{-}	$Fe_1(OH)_3$	**$Fe(OH)_3$**
K^{+} and CO_3^{2-}	$K_2(CO_3)_1$	**K_2CO_3**

Therefore, the formulae are $Fe(OH)_3$ and K_2CO_3.

QUESTION 30 *Activity 9.4 · pp. 177–178*

Activity 9.4: Let us experiment. Test the solubility of camphor, sodium chloride, copper sulfate, sugar and naphthalene in water, kerosene and petrol, and the electrical conductivity of each in the solid state and in water (Fig. 9.15). Record your observations in Table 9.2 and group the compounds showing similar properties.

ANSWER

Typical observations are given below. Handle kerosene and petrol with care as they are flammable.

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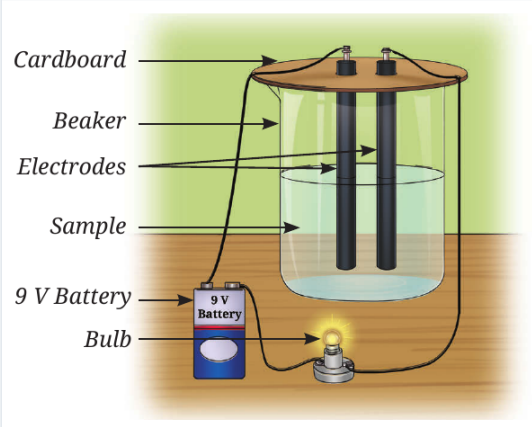


Fig. 9.15: Experimental set-up for electrical conductivity of a solution

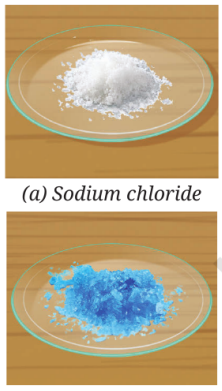


Fig. 9.16: Ionic compounds ($NaCl$, $CuSO_4$)

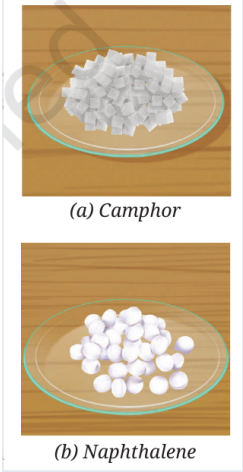


Fig. 9.17: Covalent compounds (camphor, naphthalene)

a Table 9.2: Solubility and electrical conductivity

Compound	Water	Kerosene	Petrol	Solid state conducts	In water conducts
Camphor	Insoluble	Soluble	Soluble	No	No
Sodium chloride	Soluble	Insoluble	Insoluble	No	Yes
Copper sulfate	Soluble	Insoluble	Insoluble	No	Yes
Sugar	Soluble	Insoluble	Insoluble	No	No
Naphthalene	Insoluble	Soluble	Soluble	No	No

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b Grouping

Group	Compounds	Properties
Ionic	Sodium chloride, copper sulfate	Soluble in water, insoluble in kerosene and petrol; conduct electricity in water but not in solid state
Covalent	Camphor, naphthalene, sugar	Do not conduct electricity. Camphor and naphthalene dissolve in kerosene and petrol but not in water; sugar dissolves in water but gives no ions

Therefore, ionic compounds dissolve in water and conduct in solution, while covalent compounds generally do not conduct electricity.

QUESTION 31 *Section 9.6 · p. 178*

Camphor and naphthalene, covalent compounds, also do not conduct electricity. Can you give a reason? Predict whether ionic and covalent compounds would conduct electricity in the molten state.

ANSWER

Conduction of electricity needs charged particles that are free to move.

a Reason for camphor and naphthalene

They are made of neutral molecules in which atoms share electrons. They contain no ions or free electrons to carry charge, in the solid state or when dissolved.

b Molten state

Compound	Conducts in molten state?	Reason
Ionic	**Yes**	On melting, the ions are no longer held in fixed positions and are free to move
Covalent	**No**	They have only neutral molecules and no ions

Therefore, ionic compounds conduct in the molten state but covalent compounds do not.

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QUESTION 32 *Pause and Ponder 19 · p. 179*

What type of chemical bond is present in a solid compound that does not conduct electricity in the solid state but conducts electricity when dissolved in water?

ANSWER

The compound conducts only when ions are free to move.

a Reasoning

- In the solid state, the ions are held in fixed positions, so it does not conduct.
- In water, the ions become free to move, so the solution conducts.

Therefore, the compound has an ionic bond.

QUESTION 33 *Pause and Ponder 20 · p. 179*

Metal M, with two electrons in its valence shell (M shell), reacts with oxygen to form a compound that is slightly soluble in water. Predict its: (i) formula (ii) type of bond (iii) electrical conductivity of its aqueous solution.

ANSWER

M has the configuration 2, 8, 2 (like magnesium). It loses two electrons to form M^{2+}. Oxygen gains two electrons to form O^{2-}.

Part	Prediction	Reason
(i) Formula	**MO**	M^{2+} and O^{2-} criss-cross to M_2O_2, simplified to MO
(ii) Type of bond	**Ionic**	Electrons are transferred from the metal to oxygen
(iii) Conductivity of aqueous solution	**Conducts**	The ions that dissolve are free to move (the solution is weak since it is only slightly soluble)

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Therefore, the compound is MO, ionic in nature, and its aqueous solution conducts electricity.

QUESTION 34 *Pause and Ponder 21 · p. 179*

Find the molecular mass of nitric acid (HNO_3). Atomic mass — H = 1 u; N = 14 u; O = 16 u.

ANSWER

Molecular mass is the sum of the atomic masses of all the atoms in the molecule.

Atom	Number	Mass
H	1	1 u × 1 = 1 u
N	1	14 u × 1 = 14 u
O	3	16 u × 3 = 48 u

Molecular mass of HNO_3 = 1 + 14 + 48 = **63 u**

Therefore, the molecular mass of nitric acid is 63 u.

QUESTION 35 *Pause and Ponder 22 · p. 179*

Find the molecular mass of methane (CH_4). Atomic mass — C = 12 u; H = 1 u.

ANSWER

Add the masses of one carbon atom and four hydrogen atoms.

Atom	Number	Mass
C	1	12 u × 1 = 12 u
H	4	1 u × 4 = 4 u

Molecular mass of CH_4 = 12 + 4 = **16 u**

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Therefore, the molecular mass of methane is 16 u.

QUESTION 36 *Pause and Ponder 23 · p. 180*

Find the formula unit mass of potassium chloride (KCl). Atomic mass — K = 39 u; Cl = 35.5 u.

ANSWER

Formula unit mass is the sum of the atomic masses in one formula unit.

Formula unit mass of KCl = (39 u × 1) + (35.5 u × 1) = **74.5 u**

Therefore, the formula unit mass of KCl is 74.5 u.

QUESTION 37 *Pause and Ponder 24 · p. 180*

Find the formula unit mass of magnesium hydroxide, $Mg(OH)_2$. Atomic mass — Mg = 24 u; O = 16 u; H = 1 u.

ANSWER

$Mg(OH)_2$ has one Mg and two OH groups, so it has 1 Mg, 2 O and 2 H atoms.

Formula unit mass of $Mg(OH)_2$ = (24 u × 1) + {(16 u × 1) + (1 u × 1)} × 2 = 24 + 34 = **58 u**

Therefore, the formula unit mass of $Mg(OH)_2$ is 58 u.

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CLASS 9 SCIENCE · CHAPTER 9

9.2 Worked Examples

Solutions · 7 examples

Directions (Questions 1–7): These are the solved examples of the chapter (Examples 9.1 to 9.7). Each question is followed by a step-by-step solution in which every calculation has been checked again.

QUESTION 1 *Example 9.1 · p. 166*

In a group activity, students place 4.0 g of calcium carbonate with 2.92 g of hydrochloric acid in a closed container. After the reaction is over, they measured 1.76 g of carbon dioxide, 0.72 g of water, and 4.44 g of calcium chloride. Verify whether the Law of Conservation of Mass is obeyed or not.

ANSWER

Compare the total mass of the reactants with the total mass of the products.

Substance	Mass
Calcium carbonate (reactant)	4.0 g
Hydrochloric acid (reactant)	2.92 g
Total mass of reactants	4.0 g + 2.92 g = **6.92 g**
Carbon dioxide (product)	1.76 g
Water (product)	0.72 g
Calcium chloride (product)	4.44 g
Total mass of products	1.76 g + 0.72 g + 4.44 g = **6.92 g**

Mass of reactants = Mass of products = 6.92 g.

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Therefore, the Law of Conservation of Mass is obeyed.

QUESTION 2 *Example 9.2 · p. 166*

12 g of carbon combines with 32 g of oxygen to form 44 g of carbon dioxide (Carbon + Oxygen → Carbon dioxide). If 2.4 g of carbon reacts completely with oxygen, how much carbon dioxide will be produced?

ANSWER

The mass of carbon dioxide produced is proportional to the mass of carbon used.

Step	Calculation
12 g of carbon gives	44 g of carbon dioxide
1 g of carbon gives	44/12 g of carbon dioxide
2.4 g of carbon gives	(44/12) × 2.4 g = 105.6/12 g = **8.8 g**

Check: 12 + 32 = 44, so the data are consistent with the Law of Conservation of Mass. Also, 2.4 g is one-fifth of 12 g, and one-fifth of 44 g is 8.8 g.

Therefore, 8.8 g of carbon dioxide will be produced.

QUESTION 3 *Example 9.3 · p. 167*

Sodium chloride (NaCl) contains sodium and chlorine in the mass ratio of 23:35.5. If 46 g of sodium reacts completely, how much chlorine is needed to form NaCl?

ANSWER

Use the fixed mass ratio of sodium to chlorine (Law of Constant Proportions).

Step	Calculation
23 g of sodium needs	35.5 g of chlorine
46 g of sodium is 2 × 23 g, so needs	(35.5 ÷ 23) × 46 = 35.5 × 2 = **71 g** of chlorine

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Therefore, 71 g of chlorine is needed.

QUESTION 4 *Example 9.4 · p. 179*

Find the molecular mass of water (H_2O). Atomic mass — H = 1 u; O = 16 u.

ANSWER

Molecular mass = sum of the atomic masses of all the atoms in the molecule.

Molecular mass of H_2O = (1 u × 2) + (16 u × 1) = 2 u + 16 u = **18 u**

Therefore, the molecular mass of water is 18 u.

QUESTION 5 *Example 9.5 · p. 179*

Find the molecular mass of carbon dioxide (CO_2). Atomic mass — C = 12 u; O = 16 u.

ANSWER

CO_2 has one carbon atom and two oxygen atoms.

Molecular mass of CO_2 = (12 u × 1) + (16 u × 2) = 12 u + 32 u = **44 u**

Therefore, the molecular mass of carbon dioxide is 44 u.

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QUESTION 6 *Example 9.6 · p. 179*

Find the formula unit mass of sodium oxide (Na_2O). Atomic mass — Na = 23 u; O = 16 u.

ANSWER

A formula unit of Na_2O has two sodium and one oxygen.

Formula unit mass of Na_2O = (23 u × 2) + (16 u × 1) = 46 u + 16 u = **62 u**

Therefore, the formula unit mass of sodium oxide is 62 u.

QUESTION 7 *Example 9.7 · p. 180*

Find the formula unit mass of calcium nitrate, $Ca(NO_3)_2$. Atomic mass — Ca = 40 u; N = 14 u; O = 16 u.

ANSWER

$Ca(NO_3)_2$ has one calcium and two nitrate (NO_3) groups.

Step	Calculation
One nitrate group (NO_3)	(14 u × 1) + (16 u × 3) = 14 + 48 = 62 u
Two nitrate groups	62 u × 2 = 124 u
Calcium	40 u × 1 = 40 u
Formula unit mass	40 u + 124 u = **164 u**

Therefore, the formula unit mass of calcium nitrate is 164 u.

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CLASS 9 SCIENCE · CHAPTER 9

9.3 Revise, Reflect, Refine

Solutions · 15 questions

Directions (Questions 1–15): These are the exercise questions at the end of the chapter (page 181 onwards). For multiple-choice questions the correct option is given first, followed by the reason.

QUESTION 1 *Revise, Reflect, Refine*

A particular element (A) has one electron in its third shell. There is another element (B) with six electrons in its second shell.
(i) How many electrons does A tend to give or take to become stable?
(ii) What kind of ion would it form?
(iii) How many electrons does B tend to give or take to become stable?
(iv) What kind of ion would it form?
(v) If A and B were to combine, what kind of bond would be formed?
(vi) What would be the formula for the compound thus formed?

ANSWER

Element A has the configuration 2, 8, 1 (sodium-like) and element B has 2, 6 (oxygen-like).

Part	Answer	Reason
(i)	A gives **1 electron**	Losing the single valence electron leaves a stable octet (2, 8)
(ii)	Cation, A^{+}	11 protons and 10 electrons give a charge of +1
(iii)	B takes **2 electrons**	Six valence electrons need two more for an octet
(iv)	Anion, B^{2-}	It gains two electrons and gets a charge of 2−
(v)	**Ionic bond**	Electrons are transferred from A to B and the opposite charges attract
(vi)	**A_2B**	Criss-cross of A^{+} and B^{2-} gives A_2B_1, written A_2B

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Therefore, A loses 1 electron to form A^{+}, B gains 2 electrons to form B^{2-}, the bond is ionic and the formula is A_2B.

QUESTION 2 *Revise, Reflect, Refine*

An element X has six electrons in its outer shell and forms a diatomic molecule.
(i) Why would that be so?
(ii) What kind of bond would it form?
(iii) Draw the structure of the molecule it would form.
(iv) A certain other element Y has two electrons in its second shell. Draw the structure of the molecule that X would form with Y.

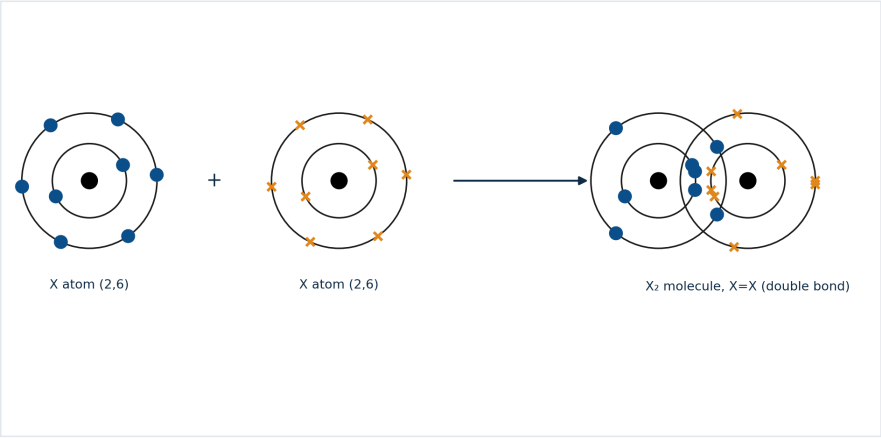
ANSWER

X has six valence electrons (configuration 2, 6, like oxygen) and needs two more to complete its octet.

a (i) and (ii) Reason and bond

Two atoms of X share two electrons each, so that each gets a complete octet. This gives the diatomic molecule X_2. The atoms share two pairs of electrons, so the bond is a **covalent double bond** (X=X).

b (iii) Structure of X_2

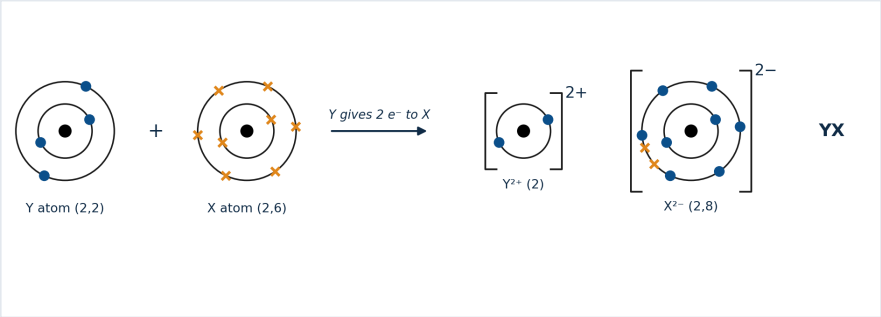


Formation of the X_2 molecule

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c (iv) X with Y

Y has the configuration 2, 2 (two electrons in its second shell). It has fewer than four valence electrons, so it gives up two electrons to X. Y becomes Y^{2+} (2) and X becomes X^{2-} (2, 8). They are held by an ionic bond, and the formula is YX.



Formation of YX by transfer of two electrons

Therefore, X forms X_2 with a double covalent bond, and with Y it forms the ionic compound YX.

QUESTION 3 *Revise, Reflect, Refine*

You want to design a new ionic compound, where the total positive charge is 6+ and the total negative charge is 6−. Which of the following combinations gives the correct number of ions?
(i) 2 Al^{3+} and 3 Cl^{-} (ii) 3 Mg^{2+} and 1 PO_4^{3-} (iii) 2 Fe^{3+} and 3 O^{2-} (iv) 3 Ca^{2+} and 2 SO_4^{2-}

ANSWER

Correct option: (iii) 2 Fe^{3+} and 3 O^{2-}.

Option	Positive charge	Negative charge	Verdict
(i) 2 Al^{3+}, 3 Cl^{-}	2 × 3 = 6+	3 × 1 = 3−	Incorrect
(ii) 3 Mg^{2+}, 1 PO_4^{3-}	3 × 2 = 6+	1 × 3 = 3−	Incorrect
(iii) 2 Fe^{3+}, 3 O^{2-}	2 × 3 = 6+	3 × 2 = 6−	**Correct**
(iv) 3 Ca^{2+}, 2 SO_4^{2-}	3 × 2 = 6+	2 × 2 = 4−	Incorrect

Therefore, the answer is (iii); this compound is Fe_2O_3.

NCERT ARCHIVE

QUESTION 4 *Revise, Reflect, Refine*

Choose the correct statement(s) and correct the false statement(s).
(i) Elements are made up of molecules and compounds are made up of atoms.
(ii) The molecule of a compound is always made up of two or more atoms of the same kind.
(iii) One molecule of nitrogen gas contains three nitrogen atoms.
(iv) Water is made of two hydrogen atoms, covalently bonded with one oxygen atom.

ANSWER

Only statement (iv) is correct.

Statement	Verdict	Correct statement
(i)	False	Elements are made up of atoms (or molecules of the same kind of atoms), and compounds are made up of molecules or ions formed by atoms of different elements.
(ii)	False	The molecule of a compound is made up of two or more atoms of **different** kinds (for example, H_2O).
(iii)	False	One molecule of nitrogen gas (N_2) contains **two** nitrogen atoms.
(iv)	**True**	Water (H_2O) has two hydrogen atoms covalently bonded to one oxygen atom.

Therefore, (iv) is correct and (i), (ii) and (iii) are false, with the corrections given above.

NCERT ARCHIVE

QUESTION 5 *Revise, Reflect, Refine*

Write the chemical formulae for the following compounds.
(i) Aluminium nitrate (ii) Calcium oxide (iii) Ferric oxide

ANSWER

Write the cation first, then the anion, and criss-cross the charges (use Table 9.1).

Compound	Ions	Criss-cross	Formula
(i) Aluminium nitrate	Al^{3+}, NO_3^-	$Al_1(NO_3)_3$	**$Al(NO_3)_3$**
(ii) Calcium oxide	Ca^{2+}, O^{2-}	Ca_2O_2, divided by 2	**CaO**
(iii) Ferric oxide	Fe^{3+}, O^{2-}	Fe_2O_3	**Fe_2O_3**

Therefore, the formulae are $Al(NO_3)_3$, CaO and Fe_2O_3.

QUESTION 6 *Revise, Reflect, Refine*

Write the formulae of the compounds formed from the following pairs of ions.
(i) Ca^{2+} and Br^- (ii) Al^{3+} and CO_3^{2-} (iii) K^+ and SO_4^{2-} (iv) NH_4^+ and Cl^-

ANSWER

Criss-cross the numbers of the charges and simplify if there is a common factor.

Pair of ions	Criss-cross	Formula
(i) Ca^{2+}, Br^-	Ca_1Br_2	**$CaBr_2$**
(ii) Al^{3+}, CO_3^{2-}	$Al_2(CO_3)_3$	**$Al_2(CO_3)_3$**
(iii) K^+, SO_4^{2-}	$K_2(SO_4)_1$	**K_2SO_4**
(iv) NH_4^+, Cl^-	NH_4Cl	**NH_4Cl**

Therefore, the formulae are $CaBr_2$, $Al_2(CO_3)_3$, K_2SO_4 and NH_4Cl.

NCERT ARCHIVE

QUESTION 7 *Revise, Reflect, Refine*

Which of the following, in Fig. 9.18, correctly represents Cl^- ion (Atomic number of chlorine = 17).

ANSWER

Correct option: (ii)

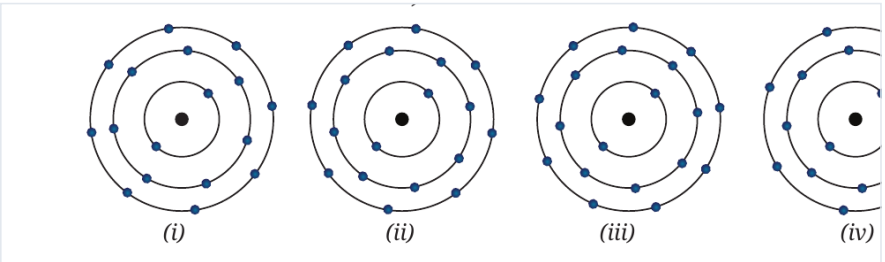


Fig. 9.18

a **Counting the electrons**

Option	Electrons in shells	Total	Represents
(i)	2, 7, 8	17	Not a stable arrangement for Cl or Cl^-
(ii)	2, 8, 8	18	**Cl^- ion**
(iii)	2, 9, 8	19	Not possible (a shell cannot hold 9 here)
(iv)	2, 8, 7	17	Neutral chlorine atom

Chlorine has 17 protons. The chloride ion has gained one electron, so it has 17 + 1 = 18 electrons arranged as 2, 8, 8.

Therefore, option (ii) represents the Cl^- ion.

NCERT ARCHIVE

QUESTION 8 *Revise, Reflect, Refine*

Determine the formula unit mass of the following substances.
(i) Ammonium nitrate (NH_4NO_3), used as a nitrogen fertiliser, which is essential for plant growth.
(ii) Phosphoric acid (H_3PO_4), used to make phosphate fertiliser and detergents.
(iii) Sodium hydrogencarbonate ($NaHCO_3$), used to relieve acidity and helps in digestion.

ANSWER

Atomic masses used: H = 1 u, C = 12 u, N = 14 u, O = 16 u, Na = 23 u and P = 31 u (the atomic mass of phosphorus is not given in the chapter, so the standard value is used).

Substance	Calculation	Mass
(i) NH_4NO_3	2 N = 28; 4 H = 4; 3 O = 48; total = 28 + 4 + 48	**80 u**
(ii) H_3PO_4	3 H = 3; 1 P = 31; 4 O = 64; total = 3 + 31 + 64	**98 u**
(iii) $NaHCO_3$	Na = 23; H = 1; C = 12; 3 O = 48; total = 23 + 1 + 12 + 48	**84 u**

Note: phosphoric acid is a covalent compound, so its mass is strictly a molecular mass; it is found in the same way.

Therefore, the masses are 80 u, 98 u and 84 u.

NCERT ARCHIVE

QUESTION 9 *Revise, Reflect, Refine*

Write the formulae for the compounds formed by the reaction of: (i) Magnesium and nitrogen (ii) Lithium and nitrogen (iii) Sodium and sulfur (iv) Aluminium and oxygen

ANSWER

Metals form cations and non-metals form anions. The charges are criss-crossed.

Reaction	Ions	Formula
(i) Magnesium and nitrogen	Mg^{2+} (2, 8, 2 loses 2); N^{3-} (2, 5 gains 3)	$\mathbf{Mg_3N_2}$
(ii) Lithium and nitrogen	Li^{+} (2, 1 loses 1); N^{3-}	$\mathbf{Li_3N}$
(iii) Sodium and sulfur	Na^{+}; S^{2-} (2, 8, 6 gains 2)	$\mathbf{Na_2S}$
(iv) Aluminium and oxygen	Al^{3+} (2, 8, 3 loses 3); O^{2-}	$\mathbf{Al_2O_3}$

Therefore, the formulae are Mg_3N_2, Li_3N, Na_2S and Al_2O_3.

QUESTION 10 *Revise, Reflect, Refine*

Complete the Table 9.3 by writing the formulae of the compounds formed by the cations on the left and the anions at the top. $LiNO_3$ is given as an example.

ANSWER

Criss-cross the charges for each pair. Brackets are used when two or more polyatomic ions are needed.

NCERT ARCHIVE

a **Table 9.3**

	NO_3^-	SO_4^{2-}	PO_4^{3-}
NH_4^+	NH_4NO_3	$(NH_4)_2SO_4$	$(NH_4)_3PO_4$
Li^+	$LiNO_3$	Li_2SO_4	Li_3PO_4
Al^{3+}	$Al(NO_3)_3$	$Al_2(SO_4)_3$	$AlPO_4$
Cu^{2+}	$Cu(NO_3)_2$	$CuSO_4$	$Cu_3(PO_4)_2$

Therefore, the table is completed using the criss-cross method.

QUESTION 11 *Revise, Reflect, Refine*

5.3 g of sodium carbonate and 6.0 g of acetic acid react to produce 2.2 g of carbon dioxide, 0.9 g of water, and 8.2 g of sodium acetate. Verify whether the law of conservation of mass is valid.

ANSWER

Compare the total mass of reactants and products.

Substance	Mass
Sodium carbonate (reactant)	5.3 g
Acetic acid (reactant)	6.0 g
Total mass of reactants	5.3 + 6.0 = **11.3 g**
Carbon dioxide (product)	2.2 g
Water (product)	0.9 g
Sodium acetate (product)	8.2 g
Total mass of products	2.2 + 0.9 + 8.2 = **11.3 g**

Therefore, the mass of reactants equals the mass of products (11.3 g), so the law of conservation of mass is valid.

NCERT ARCHIVE

QUESTION 12 *Revise, Reflect, Refine*

If a species has 11 protons, 12 neutrons and 10 electrons then
(i) what is its atomic number and mass number?
(ii) is it neutral, a cation or an anion? Explain.
(iii) write its electronic configuration.
(iv) name the species.

ANSWER

The atomic number is the number of protons and the mass number is the number of protons plus neutrons.

Part	Answer	Reason
(i)	Atomic number = **11**; mass number = **23**	Protons = 11; mass number = 11 + 12 = 23
(ii)	**Cation**	Protons (11+) are more than electrons (10−), so the net charge is +1
(iii)	**2, 8**	10 electrons fill K shell (2) and L shell (8)
(iv)	**Sodium ion (Na^+)**	Atomic number 11 is sodium, and it has lost one electron

Therefore, the species is the sodium cation, $^{23}Na^+$.

NCERT ARCHIVE

QUESTION 13 *Revise, Reflect, Refine*

Two elements, A and B, have the following configurations: A: 2, 8, 5 and B: 2, 8, 7.
(i) Which element is more reactive?
(ii) Will A and B form ionic or covalent bonds when they combine? Explain using electron transfer or sharing.
(iii) Predict the formula of the compound they would form.

ANSWER

A has 5 valence electrons (needs 3) and B has 7 valence electrons (needs 1).

Part	Answer	Reason
(i)	**B** is more reactive	B needs only one electron to complete its octet, so it gains it more readily than A needs three
(ii)	**Covalent**	Both are non-metals with more than four valence electrons; neither can easily lose electrons, so they share. A shares its 3 electrons with three B atoms (one each)
(iii)	**AB_3**	Valencies A = 3 and B = 1; criss-cross gives A_1B_3

Therefore, B is more reactive, the bond is covalent and the formula is AB_3 (like PCl_3).

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QUESTION 14 *Revise, Reflect, Refine*

Assertion (A): Copper sulfate conducts electricity in the molten state but not in the solid state.
Reason (R): Copper and sulfate ions are fixed in the lattice in molten state, while in solid state they can move freely.
Choose the correct option: (i) Both A and R are true, and R is the correct explanation of A. (ii) Both A and R are true, but R is not the correct explanation of A. (iii) A is true, but R is false. (iv) A is false, but R is true.

ANSWER

Correct option: (iii) A is true, but R is false.

a **Explanation**

- **A is true:** copper sulfate is an ionic compound. In the solid state, its ions are held in fixed positions, so it does not conduct. In the molten state the ions move freely, so it conducts.
- **R is false:** it states the opposite. The ions are fixed in the lattice in the **solid** state and free to move in the **molten** state.

Therefore, the answer is (iii).

QUESTION 15 *Revise, Reflect, Refine*

The species ^{27}Al, $^{80}Br^{-}$ and $^{201}Hg^{2+}$ have 13, 35 and 80 protons, respectively. How many electrons and neutrons do they have?

ANSWER

Neutrons = mass number − protons. Electrons = protons − charge (a negative charge means extra electrons).

Species	Protons	Electrons	Neutrons
^{27}Al (neutral)	13	13	27 − 13 = **14**
$^{80}Br^{-}$	35	35 + 1 = **36**	80 − 35 = **45**

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Species	Protons	Electrons	Neutrons
$^{201}Hg^{2+}$	80	80 − 2 = **78**	201 − 80 = **121**

For Al the electrons are 13 because the atom is neutral.

Therefore, Al has 13 electrons and 14 neutrons, Br^- has 36 electrons and 45 neutrons, and Hg^{2+} has 78 electrons and 121 neutrons.

NCERT ARCHIVE

9.4

CLASS 9 SCIENCE · CHAPTER 9

The Journey Beyond

Solutions · 5 activities

Directions (Questions 1–5): These are the activities of “The Journey Beyond” and the question of “The Quest Continues...” at the end of the chapter (page 183). Model answers are given; add your own observations.

QUESTION 1 *The Journey Beyond · p. 183*

Design and perform an experiment to show and compare that water always contains hydrogen and oxygen in the same ratio, regardless of its source.

ANSWER

This is an experiment to be done under the teacher’s supervision. A model design using electrolysis of water is given.

a Design

- Collect samples of water from different sources, for example tap water, borewell water, river water and rainwater. Purify each by distillation so that dissolved salts are removed.
- Take an equal volume of each purified sample, add a small amount of dilute acid or a pinch of salt so that it conducts, and pass a low-voltage current through it in an electrolysis (water decomposition) set-up with test tubes to collect the gases.
- Collect hydrogen at one electrode and oxygen at the other. Measure the volume of each gas for the same time and note the ratio for every sample.

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b Expected result

In every sample the volume of hydrogen is twice the volume of oxygen (2 : 1). Equal volumes of gases contain the same number of molecules, so hydrogen : oxygen = 2 molecules of H_2 : 1 molecule of O_2, which is a mass ratio of (2 × 2) : 32 = 4 : 32 = **1 : 8**.

Safety: use low voltage, do not use flames near the hydrogen collected, and wear safety goggles.

Therefore, water from every source gives hydrogen and oxygen in the same ratio, which supports the Law of Constant Proportions.

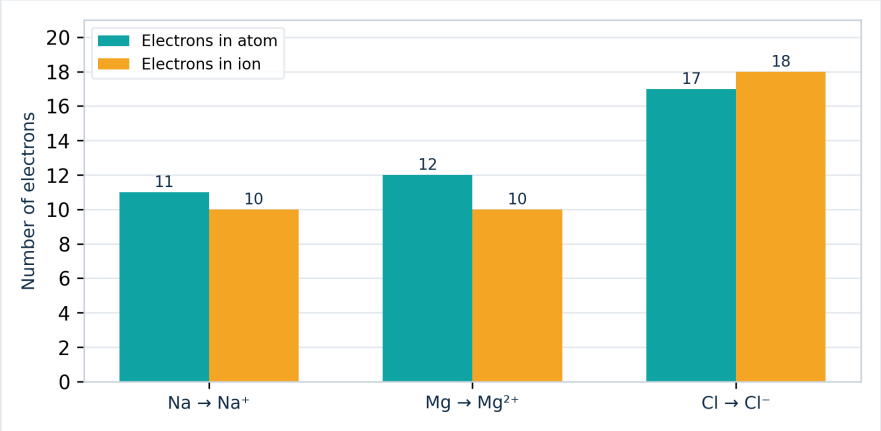
QUESTION 2 *The Journey Beyond · p. 183*

Compare atoms and ions of any three elements. Show the number of electrons before and after ion formation using bar graphs.

ANSWER

Sodium, magnesium and chlorine are taken as examples. The number of protons does not change; only the number of electrons changes.

Element	Protons	Electrons in atom	Change	Ion	Electrons in ion
Sodium	11	11 (2, 8, 1)	loses 1	Na^+	10 (2, 8)
Magnesium	12	12 (2, 8, 2)	loses 2	Mg^{2+}	10 (2, 8)
Chlorine	17	17 (2, 8, 7)	gains 1	Cl^-	18 (2, 8, 8)



Bar graph: electrons in atoms and in the ions formed from them

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Therefore, metal atoms lose electrons to form cations and non-metal atoms gain electrons to form anions, with the number of protons unchanged.

QUESTION 3 *The Journey Beyond · p. 183*

Make a card game with cations and anions. Possible ideas may include: pick cards from the pile or from open cards and match them with cards in your hand to form compounds, and you may discard any unwanted cards; ask other players for cards and form compounds using the cards they already have.

ANSWER

This is a creative activity. A model design of the game is given.

a Cards

- Make cards for cations (Na^+, K^+, Ca^{2+}, Mg^{2+}, Al^{3+}, NH_4^+) and anions (Cl^-, O^{2-}, S^{2-}, OH^-, NO_3^-, SO_4^{2-}), with several copies of each.

b Rules

- Each player gets 7 cards. A player picks a card from the pile or from the open cards and may discard one card.
- A player can also ask another player for a card needed to make a compound.
- A compound is formed by one or more cation cards and anion cards whose total positive and negative charges are equal. The player writes the formula (for example, 2 Na^+ and 1 S^{2-} give Na_2S).
- A correct formula scores points; a wrong formula loses points. The player with the most points wins.

Therefore, the game helps to practise ions, their charges and writing chemical formulae.

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QUESTION 4 *The Journey Beyond · p. 183*

To learn more about molecules you can explore the link given below: https://phet.colorado.edu/sims/html/build-a-molecule/latest/build-a-molecule_all.html

ANSWER

This is an online activity using the “Build a Molecule” simulation from PhET Interactive Simulations (it needs an internet connection).

a **Suggested way to use it**

- Open the link and build simple molecules such as H_2, O_2, H_2O, CO_2 and NH_3 from the atoms provided.
- Write the formula and name of each molecule you build, and count the bonds (single, double or triple).
- Compare your results with what you have learnt in this chapter, for example the double bond in O_2 and CO_2.

Therefore, the simulation helps you to see how atoms combine to form molecules.

QUESTION 5 *The Quest Continues... · p. 183*

Are there any chemical changes that do not obey the Law of Conservation of Mass?

ANSWER

In ordinary chemical changes, no. The Law of Conservation of Mass holds for every chemical reaction.

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a Why it may seem to fail

- If a gas escapes from an open container (as in Activity 9.2, set-up 1), or a gas is taken in from the air, the measured mass seems to change. In a closed system the mass is the same.

b Beyond chemical changes

In nuclear reactions, in which nuclei split or combine, a small amount of mass is changed into a very large amount of energy. The total of mass and energy is conserved, which is why atomic energy is so large. Such changes are nuclear changes and not chemical changes.

Therefore, all chemical changes obey the Law of Conservation of Mass; apparent exceptions are due to escaping gases or to nuclear changes.

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