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CHAPTER NOTES

Atomic Foundations of Matter Class 9 Notes | CBSE Science Chapter 9

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Your teacher for Atomic Foundations...



Hi, I am **Ira**. I teach this syllabus all day, so **Atomic Foundations of Matter** is very much my home ground.

Ask me anything from this chapter. A concept, a numerical, or that one doubt you did not want to raise in class. Pick one to start:

Explain Atomic Foundations of Matter simply

What can the board exam ask?

Most important formulas

Quiz me on this chapter

Ask Ira anything...



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Atomic Foundations of Matter Class 9 Notes | CBSE Science Chapter 9

Atomic Foundations of Matter is Chapter 9 of CBSE Class 9 Science (Exploration, 2026-27). It follows straight on from Chapter 8, Journey Inside the Atom, and asks how atoms behave when substances react and combine. It starts with two laws of chemical combination, the Law of Conservation of Mass and the Law of Constant Proportions, and shows how Dalton's Atomic Theory explains both. It then explains how atoms join by sharing electrons (covalent bonds) or transferring electrons (ionic bonds), how to name compounds and write their formulae, how ionic and covalent compounds differ in their properties, and how to calculate molecular mass and formula unit mass.

The chapter mixes reasoning with short calculations. School exams set mass-verification sums on the two laws, questions that ask you to show the formation of a molecule or an ion, formula writing by the criss-cross method, naming, or formula unit mass calculations. The same through every chemistry chapter you meet much easier.

Quick Answer - Atomic Foundations

In a chemical reaction the total mass of **Conservation of Mass**, Lavoisier). A ratio by mass, such as 1:8 for hydrogen **Proportions**, Proust). Dalton explained in reactions. Atoms become stable by H_2O) or by **transferring** electrons (ionic crossing valencies. Molecular mass and



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All Key Formulas at a Glance

Idea	Rule or formula	Example
Law of Conservation of Mass	Total mass of reactants = total mass of products	$4.0\text{ g} + 2.92\text{ g} = 1.76\text{ g} + 0.72\text{ g} + 4.44\text{ g} = 6.92\text{ g}$
Law of Constant Proportions	Mass ratio of elements in a compound is fixed	Water: hydrogen : oxygen = 1 : 8 by mass
Mass from a fixed ratio	Mass needed = (ratio part of B ÷ ratio part of A) × mass of A	Cl for 46 g Na = $(35.5 \div 23) \times 46 = 71\text{ g}$
Covalent bond	Sharing of electron pairs between atoms	H-H, Cl-Cl, O=O, H-Cl
Ionic bond	Electron transfer between cation and anion	
Criss-cross method	Swap valencies (or valence numbers) as subscripts and simplify	
Naming covalent compounds	Prefixes mono, di, tri, tetra, penta, hexa; second element starts with a prefix	
Molecular mass	Sum of atomic masses in a molecule	
Formula unit mass	Sum of atomic masses in a formula unit	



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Key Concepts

1. The Law of Conservation of Mass

Hydrogen and oxygen are gases; hydrogen peroxide is a liquid that puts out fire. The properties of these substances are different.

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formed equals the sum of the masses of hydrogen and oxygen that combined. The chapter tests this for a physical change and then for chemical changes.

Physical change (Activity 9.1): a beaker with about 50 mL of water and a spatula of common salt is weighed on a digital balance, then swirled until the salt dissolves and weighed again. The readings match: the mass of the solution equals the mass of water plus salt. There is practically no change in mass in a physical change. Tearing paper into pieces gives the same result.

Chemical change (Activity 9.2)

Vinegar + Baking soda (sodium hydrogencarbonate) → Carbon dioxide + Other substances

Feature	Set-up 1 (open)	Set-up 2 (closed)
Arrangement	Flask with about 20 mL vinegar; balloon with about 2 g baking soda kept beside it on the b	Balloon with the baking soda tied over the mouth of the flask
Observation	Brisk effervescence	
Final reading	Lower than the initial r	
Reason	Carbon dioxide escape weighed	

Set-up 2 shows that the total mass of vine
dioxide and the other substances formed.
digit, so a change only in the last digit of tl

Statement of the law

Matter can neither be created nor destroy
Conservation of Mass, proposed by Anto
Chemistry. In practice: **total mass of react**

Verification with a precipitate (Acti

About 10 mL of 1% m/v sodium sulfate sol
solution (flask B) are weighed together. B

Sodium sulfate + Barium chloride → Barium sulfate + Sodium chloride



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Both flasks are weighed again and the reading is unchanged. An open system works here because no gas is formed.

Open and closed systems: if a gaseous product escapes, the mass left behind falls. In a closed container the reading stays the same.

2. The Law of Constant Proportions

Joseph Proust found that in any compound formed by two or more elements, the elements combine in a **fixed ratio by mass**, whatever the source. He showed that copper carbonate always contains copper, carbon and oxygen in the same proportion by mass, however it was prepared. This is the **Law of Constant Proportions**, also called the **Law of Definite Proportions** or **Proust's Law**.

Water: purified water from a river, a borewell or the ocean always contains hydrogen and oxygen in a mass ratio of **1 : 8**. Decomposing 9 g of it always gives 1 g of hydrogen and 8 g of oxygen. So 18 g of water contains 2 g of hydrogen and 16 g of oxygen.

Cinnabar: the red pigment called hingu is made of mercury and sulfur on heating, in mass ratio of 1 : 8.

Calculations: sodium chloride has sodium and chlorine in the ratio of 23 : 35.5. So 117 g of sodium chloride contains 46 g of sodium, chlorine = $(35.5 \div 23) \times 46 = 71$ g

Compounds and mixtures: the law holds for compounds. Mixtures can be made in any proportion, so it has no fixed ratio and both obey the law.

3. Dalton's Atomic Theory

John Dalton, who taught in Manchester from 1800 to 1844, gave three postulates. A **postulate** is a fundamental idea from which further ideas are formed or derived.

1. All matter is made up of very tiny particles called atoms. Atoms cannot be created or destroyed in a chemical reaction.
2. Atoms are indivisible particles, which cannot be created or destroyed.
3. Atoms of a given element are identical in mass and chemical properties.
4. Atoms of different elements have different masses and chemical properties.
5. Atoms combine in the ratio of simple whole numbers to form compounds.



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

Law	Postulates	Reasoning
Conservation of Mass	2 and 3	In a reaction the same atoms are only rearranged, each with its fixed mass, so the total mass cannot change.
Constant Proportions	3, 5 and 6	A compound always has the same kinds of atoms in the same relative numbers, each with a fixed mass, so the mass ratio is fixed.

When magnesium burns in air, a white powder of magnesium oxide forms: magnesium atoms have combined with oxygen atoms, and no atom is destroyed. You learnt in Chapter 8 that atoms contain electrons, protons and neutrons. For this chapter the key point still holds: atoms are neither created nor destroyed in a chemical reaction.

4. Molecules and Covalent Bonds

A **molecule** is an electrically neutral entity of independent existence and shows all the properties of the substance. For example, two hydrogen atoms; a hydrogen chloride molecule. Some elements, such as **helium**, exist only as single atoms.

Why atoms combine: an atom with 8 electrons in its outermost shell (K) holds 2 electrons. Atoms with 1 or 2 electrons. When atoms combine, the total number of electrons is conserved, so the arrangement is more stable. **covalent bond.** Sharing electrons gives a covalent bond.

Molecules of elements

H₂: hydrogen has one electron in its K-shell. Two hydrogen atoms share one electron each. The shared pair attracts both nuclei, forming a bond. A shared pair of electrons is a **covalent bond**.

Cl₂: chlorine (2, 8, 7) needs one electron. Two chlorine atoms share one electron each, forming a single bond. Fluorine (2, 7) forms F₂ the same way.

O₂: oxygen (2, 6) needs two electrons. Two oxygen atoms share two electrons each, forming a **double bond**, O=O.



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N₂: nitrogen (2, 5) needs three electrons. The two atoms share three electrons each, so three pairs are shared: a **triple bond**, $\text{N}\equiv\text{N}$.

Molecules of compounds

Write both configurations, then count what each atom needs. In **HCl**, hydrogen needs one electron for a duplet and chlorine one for an octet, so they share one electron each: H-Cl. Bonded by sharing, HCl is a **covalent compound**. In **H₂O**, oxygen needs two electrons and each hydrogen one, so two hydrogen atoms each share an electron with one oxygen atom: H-O-H.

Molecule	Electrons shared	Bonds
CO ₂	C shares 4, each O shares 2	Two double bonds, O=C=O
NH ₃	N shares 3, each H shares 1	Three single N-H bonds
H ₂ S	S shares 2, each H shares 1	Two single S-H bonds

Neon (2, 8) already has a complete octet,

Naming covalent compounds

Prefixes give the number of atoms: mono- the first element keeps its name and the second element gets a prefix. The second element but used for the second. If a prefix ends in 'o' drop that vowel (monoxide, pentoxide); a prefix ending in 'a' as the first element takes no prefix. H₂O is water, not dihydrogen monoxide. ammonia.

Formula	Name
CO	carbon monoxide
CO ₂	carbon dioxide
CS ₂	carbon disulfide
PCl ₃	phosphorus trichloride



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5. Ions and Ionic Bonds (Transfer of Electrons)

An atom with fewer than four valence electrons generally gives them away to become stable. Atoms with more than four usually gain or share electrons.

Cation: sodium (11; 2, 8, 1) loses its one valence electron. With 11 protons and 10 electrons it carries one positive charge: the **sodium cation**. $\text{Na} \rightarrow \text{Na}^+ + \text{e}^-$

Anion: chlorine (2, 8, 7) gains one electron. With 17 protons and 18 electrons it carries one negative charge: the **chloride anion**. $\text{Cl} + \text{e}^- \rightarrow \text{Cl}^-$

Bond: cations and anions are together called **ions**. The electrostatic force of attraction between oppositely charged ions that holds them together is the **ionic bond**. $\text{Na} + \text{Cl} \rightarrow \text{Na}^+ + \text{Cl}^- \rightarrow \text{NaCl}$

Crystals: ionic compounds form 3-D crystals. In sodium chloride each Na^+ is surrounded by six Cl^- ions and each Cl^- by six Na^+ ions. This repeating arrangement is the crystal structure; drawn with ions as points it is a crystal lattice. Ionic compounds form crystals.

Larger charges: sulfur (six outer electrons) gives two electrons the same way. Magnesium gives two electrons. Mg^{2+} combines with two Cl^- to give MgCl_2 . One electron from one sulfur atom to one sulfur atom: Na_2S .

Naming ionic compounds

Name the cation first, then the anion. Simple metals and non-metals anions, so ionic compounds are sodium chloride, calcium oxide, magnesium sulfide. **polyatomic ions**; their names generally do not change.

Valency	Cations
1	Na^+ , Li^+ , K^+ , Ag^+ , cuprous Cu^+ , ammonium NH_4^+
2	Ca^{2+} , Ba^{2+} , ferrous Fe^{2+} , cupric Cu^{2+} , Mg^{2+} , Zn^{2+}
3	ferric Fe^{3+} , Al^{3+}



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"-ous" goes with the lower charge and "-ic" with the higher: ferrous Fe^{2+} , ferric Fe^{3+} , cuprous Cu^+ , cupric Cu^{2+} .

6. Properties of Ionic and Covalent Compounds

Activity 9.4 tests camphor, sodium chloride, copper sulfate, sugar and naphthalene for solubility in water, kerosene and petrol, and for electrical conductivity. Two carbon or metal electrodes pushed through a piece of cardboard are connected to a 9 V battery and a bulb; a glowing bulb means the sample conducts. Do not touch the electrodes, and keep kerosene and petrol away from flames.

- Ionic compounds do not conduct as solids because their ions are held in fixed positions by strong forces. Dissolved in water, the ions are free to move and the compound conducts. Melting also frees the ions, so a molten ionic compound conducts.
- Sugar dissolves in water but gives no ions, so its solution does not conduct. Camphor and naphthalene also do not conduct: covalent compounds are made of neutral molecules.
- Strong attraction between ions gives ionic compounds high melting and boiling points; covalent compounds usually have low melting and boiling points.



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Property	Ionic compounds	Covalent compounds
How formed	Transfer of electrons	Sharing of electrons
Particles	Cations and anions in a 3-D crystal	Separate neutral molecules
Solubility in water	Generally soluble	Mostly insoluble (sugar is an exception)
Solubility in kerosene, petrol	Insoluble	Mostly soluble
Conductivity as a solid	Do not conduct	Do not conduct
Conductivity in water solution	Conduct	Do not conduct
Melting and boiling points	Generally high	Generally low
Examples	Sodium chloride, Magnesium sulfate	Water, Carbon dioxide

7. Writing Chemical Formulae

The quick route to a formula is the **criss-cross** method.

Covalent compounds

1. Write the symbols of the elements.
2. Write the valency of each element below the symbol.
3. Cross over the valencies and write the formula. Do not write the signs.



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Compound	Symbols	Valencies	Formula
Hydrogen chloride	H, Cl	1, 1	HCl
Hydrogen sulfide	H, S	1, 2	H ₂ S
Carbon tetrachloride	C, Cl	4, 1	CCl ₄

Ionic compounds

1. Write the symbol of the cation first and the anion second.
2. Write the charges under the symbols.
3. Cross over only the numbers of the charges, not the signs.
4. The formula shows the simplest ratio, so divide the subscripts by any common factor.
Subscripts 2 and 4 become 1 and 2.

The charges on the ions are not shown in the formula, but the total positive charge must equal the total negative charge, so the compound is electrically neutral.

Compound	Ions and charges
Calcium chloride	Ca ²⁺ , Cl ¹⁻
Aluminium oxide	Al ³⁺ , O ²⁻
Magnesium oxide	Mg ²⁺ , O ²⁻
Calcium carbonate	Ca ²⁺ , CO ₃ ²⁻
Magnesium hydroxide	Mg ²⁺ , OH ¹⁻
Aluminium hydroxide	Al ³⁺ , OH ¹⁻
Aluminium sulfate	Al ³⁺ , SO ₄ ²⁻

Brackets for polyatomic ions

Use brackets when two or more polyatomic ions are present in a formula. The bracket with subscript 3 means three of the polyatomic ion.



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AlOH_3 would wrongly mean one oxygen and three hydrogen atoms. Brackets are not needed when only one polyatomic ion is present: NaOH , CaCO_3 , NH_4Cl .

What a formula tells you

- The formula of a **covalent compound** shows the elements and the number of atoms of each element present in one molecule.
- The formula of an **ionic compound** shows the simplest whole number ratio of the atoms of the different elements present.

8. Molecular Mass and Formula Unit Mass

Once the formula is known, the mass of one unit of the substance is found by adding up the masses of the atoms in it. Atomic masses are in atomic mass units, u.

Molecular mass (covalent compounds)

Molecular mass is the total mass of a molecule, calculated by adding up the masses of all the atoms in it.

- H_2O : $(1 \text{ u} \times 2) + (16 \text{ u} \times 1) = 18 \text{ u}$
- CO_2 : $(12 \text{ u} \times 1) + (16 \text{ u} \times 2) = 44 \text{ u}$
- HNO_3 : $(1 \text{ u} \times 1) + (14 \text{ u} \times 1) + (16 \text{ u} \times 3) = 63 \text{ u}$
- CH_4 : $(12 \text{ u} \times 1) + (1 \text{ u} \times 4) = 16 \text{ u}$

Formula unit mass (ionic compounds)

Ionic compounds form 3-D crystals and hence the concept of molecular mass does not suit them. In an ionic compound, the mass of one unit of ions is called a **formula unit**. Its mass is calculated by adding up the masses of all the atoms in one formula unit.

- Na_2O : $(23 \text{ u} \times 2) + (16 \text{ u} \times 1) = 62 \text{ u}$
- $\text{Ca}(\text{NO}_3)_2$: $(40 \text{ u} \times 1) + \{(14 \text{ u} \times 1) + (16 \text{ u} \times 3) \times 2\} = 200 \text{ u}$
- KCl : $39 \text{ u} + 35.5 \text{ u} = 74.5 \text{ u}$
- $\text{Mg}(\text{OH})_2$: $24 \text{ u} + (16 \text{ u} + 1 \text{ u}) \times 2 = 58 \text{ u}$

Method for brackets: find the mass of the group in the brackets and multiply it by the number outside.



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Formula and Reaction Sheet

Item	Formula, rule or reaction	When to use it
Law of Conservation of Mass	Total mass of reactants = total mass of products	Verification sums; finding a missing product mass
Law of Constant Proportions	Mass of B = (ratio part of B ÷ ratio part of A) × mass of A	Fixed-ratio sums on a compound
Activity 9.2 reaction	Vinegar + Baking soda (sodium hydrogencarbonate) → Carbon dioxide + Other substances	Open versus closed system
Activity 9.3 reaction	Sodium sulfate + Barium chloride → Barium sulfate (w Sodium chloride	
Cation formation	$\text{Na} \rightarrow \text{Na}^+ + \text{e}^-$; M	
Anion formation	$\text{Cl} + \text{e}^- \rightarrow \text{Cl}^-$; S +	
Criss-cross (ionic)	Cation with charge b- gives Cation _b	
Molecular mass	Sum of (atomic m over all elements	
Formula unit mass	Sum of atomic m unit	



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Important Definitions

Term	Definition
Law of Conservation of Mass	Matter (mass) can neither be created nor destroyed in a chemical reaction. Proposed by Antoine Lavoisier in 1789.
Law of Constant Proportions	In any compound formed by two or more elements, the elements combine in a fixed ratio by mass, irrespective of the source. Also called the Law of Definite Proportions or Proust’s Law.
Postulate	A fundamental assumption accepted as truth without formal proof, from which further ideas are formed or developed.
Molecule	An electrically neutral entity consisting of more than one atom that is capable of independent existence as that substance.
Chemical bond	The force that holds atoms together in a molecule.
Covalent bond	The interaction between two atoms by sharing of electrons.
Cation	A positively charged ion, formed by loss of electrons, such as Na^+ and Ca^{2+} .
Anion	A negatively charged ion, formed by gain of electrons, such as Cl^- and SO_4^{2-} .
Ions	Cations and anions.
Ionic bond	The electrostatic attraction between oppositely charged ions that holds them together in a crystal lattice.
Polyatomic ion	An ion formed by two or more atoms, such as SO_4^{2-} and NH_4^+ .
Crystal structure	The regular, repeating arrangement of ions in an ionic solid. Dr



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Term	Definition
Molecular mass	The total mass of a molecule, calculated by adding the atomic masses of all the atoms in it.
Formula unit	In an ionic compound, the collection of the simplest whole number ratio of ions.
Formula unit mass	The mass of a formula unit: the sum of the atomic masses of all the atoms in it.

Solved Examples (NCERT-Based)

Example 1: Verifying conservation of mass

In a group activity, students place 4.0 g of calcium carbonate in a closed container. After the reaction is over, they find 1.76 g of water, and 4.44 g of calcium chloride. Verify the law of conservation of mass or not.

Solution: Total mass of reactants = 4.0 g

Total mass of products = 1.76 g + 0.72 g + 1.52 g = 4.0 g

Mass of reactants = mass of products, so the law of conservation of mass is verified.

Example 2: A second verification of the law of conservation of mass

5.3 g of sodium carbonate and 6.0 g of acetic acid are mixed in a closed container. After the reaction is over, they find 2.2 g of water, and 8.2 g of sodium acetate. Verify the law of conservation of mass or not.

Solution: Total mass of reactants = 5.3 g + 6.0 g = 11.3 g

Total mass of products = 2.2 g + 0.9 g + 8.2 g = 11.3 g

The two totals are equal, so the law is valid.



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Example 3: Scaling a product mass (NCERT Example 9.2)

12 g of carbon combines with 32 g of oxygen to form 44 g of carbon dioxide as per the given equation: Carbon + Oxygen $\rightarrow$ Carbon dioxide. If 2.4 g of carbon reacts completely with oxygen, how much carbon dioxide will be produced?

Solution: 12 g of carbon gives 44 g of carbon dioxide.

So 1 g of carbon gives $44/12$ g of carbon dioxide.

2.4 g of carbon gives $(44/12) \times 2.4$ g = 44×0.2 g = **8.8 g of carbon dioxide.**

Example 4: Using a fixed mass ratio (NCERT Example 9.3)

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?

Solution: Mass of chlorine required = $(35.5/23) \times 46$ g = 71 g

The mass of NaCl formed is $46 + 71 = 117$ g

Example 5: Percentage composition (Ponder 2, 3 and 4)

(a) When 20 g of hydrogen reacts completely with 160 g of oxygen according to the Law of Conservation of Mass, 180 g of water is formed. In a sample of the same water, how much oxygen must be present to satisfy the Law of Conservation of Mass if it contains carbon and oxygen in the mass ratio of 3:8? How much carbon to form carbon monoxide?

Solution (a): Mass of water = 20 g + 160 g = 180 g
Since water has a fixed composition of water.

Solution (b): Sulfur : oxygen = 40 : 60 = 2 : 3

Solution (c): Oxygen = $(4 \div 3) \times 9$ g = 12 g

Example 6: Predicting ions, bond formation

A particular element (A) has one electron in its outermost shell. (i) How many electrons does A tend to give or take to become stable?



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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?

Solution: A has one electron in its third shell, so its configuration is 2, 8, 1 (sodium, atomic number 11). B has six electrons in its second shell, so its configuration is 2, 6 (oxygen, atomic number 8).

(i) A tends to **give 1 electron**. (ii) It forms a **cation with charge 1+**, A^+ .

(iii) B tends to **take 2 electrons**. (iv) It forms an **anion with charge 2-**, B^{2-} .

(v) Electrons are transferred from A to B, so an **ionic bond** forms.

(vi) Criss-cross the charges 1 and 2: the formula is **A_2B** . Two A atoms each give one electron to one B atom. With the real elements this is Na_2O , sodium oxide.

Example 7: Formulae from pairs of Ponder 18)

Write the formulae of the compounds formed by:
 (i) Al^{3+} and CO_3^{2-} (ii) K^+ and SO_4^{2-} (iii) NH_4^+ and Cl^-

Solution: Criss-cross the charge numbers

Pair	
Ca^{2+}, Br^-	2, 1
Al^{3+}, CO_3^{2-}	3, 2
K^+, SO_4^{2-}	1, 2
NH_4^+, Cl^-	1, 1
Fe^{3+}, OH^-	3, 1
K^+, CO_3^{2-}	1, 2



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(ii)

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Example 8: Formula unit masses (NCERT Exercise 8)

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.

Solution: Atomic masses: H = 1 u, C = 12 u, N = 14 u, O = 16 u, Na = 23 u, and P = 31 u (the standard value; the chapter does not list phosphorus).

(i) NH_4NO_3 : N appears twice, H four times, O three times. $(14 \times 2) + (1 \times 4) + (16 \times 3) = 28 + 4 + 48 = \mathbf{80 \text{ u}}$.

(ii) H_3PO_4 : $(1 \times 3) + (31 \times 1) + (16 \times 4) = 3 + 31 + 64 = \mathbf{98 \text{ u}}$.

(iii) NaHCO_3 : $23 + 1 + 12 + (16 \times 3) = 23 + 1 + 12 + 48 = \mathbf{84 \text{ u}}$.

Example 9: Identifying a species

If a species has 11 protons, 12 neutrons and mass number? (ii) is it neutral, a cation or anion? (iii) write its electronic configuration. (iv) name the species.

Solution: (i) Atomic number = number of protons = 11. Mass number = 11 + 12 = 23.

(ii) It has 11 positive protons and only 10 negative electrons, so it has a net positive charge of +1, so it is a **cation**.

(iii) Electronic configuration of the 10 electrons is $1s^2 2s^2 2p^6 3s^1$.

(iv) Atomic number 11 is sodium, so the species is Na^+ .



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Competency-Based Questions

1. Case-based: Burning in an open

A student burns 10 g of ethanol in an open beaker. A friend says the Law of Conservation of Mass is violated.

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of magnesium ribbon in air and finds that the white powder collected weighs more than the ribbon did.

(a) Is the law violated in the ethanol case? No. Burning ethanol produces gases (carbon dioxide and water vapour) that escape from the open beaker. The mass of ethanol plus the oxygen used equals the mass of these gases.

(b) Why does the magnesium product weigh more? The white powder is magnesium oxide. Oxygen from the air combined with the magnesium, and its mass is now part of the product.

(c) How would you redesign either experiment to verify the law? Carry out the reaction in a closed system on the balance, as in set-up 2 of Activity 9.2, so that no gas enters or leaves and the balance reading can be compared before and after.

2. Case-based: Water from many sources

Samples of water are collected from a river, a well, and a lake. The water is decomposed completely.

(a) Which law predicts that all three samples will have the same mass ratio of hydrogen to oxygen? Proportions (Law of Definite Proportions, Law of Conservation of Mass).

(b) A purified sample of 36 g is decomposed. 4 g of hydrogen is obtained. How much oxygen is obtained? Hydrogen : oxygen = 1 : 8, so 1 g of hydrogen requires 8 g of oxygen. Oxygen = $36 \times \frac{8}{9} = 32$ g. Check: 4 + 32 = 36 g.

(c) Why must the water be purified first? Natural water contains salts and other substances in varying amounts, which affect the composition.

3. Assertion-Reason (NCERT Exercise)

Assertion (A): Copper sulfate conducts electricity in the molten state.

Reason (R): Copper and sulfate ions are free to move in the molten state; they can move freely.

(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.

Answer: (iii) A is true, but R is false. The ions of copper sulfate are fixed in the lattice; in the molten state they are free to move.



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4. Assertion-Reason

Assertion (A): A solution of sugar in water does not conduct electricity. **Reason (R):** Sugar is a covalent compound that does not provide ions in solution.

(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: (i) Both A and R are true, and R is the correct explanation of A. Conduction in a solution needs free ions. Sugar dissolves as neutral molecules, so there is nothing to carry charge.

5. Assertion-Reason

Assertion (A): Helium exists only as single atoms and does not form He_2 molecules. **Reason (R):** A helium atom has two electrons in its K-shell, which is its only shell, as its valence shell is complete and stable.

(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: (i) Both A and R are true, and R is the correct explanation of A. Helium has two electrons in its K-shell, which is its only shell, as its valence shell is complete and stable, so helium exists only as single atoms and does not form He_2 molecules.

6. Source-based: Reading Activity

A student tests three unlabelled white solids P, Q and R. P does not dissolve in water, but kerosene, and its water solution lights the bulb. Q dissolves in water, but does not light the bulb. R dissolves in water, not in kerosene, and its water solution lights the bulb. None of the solids lights the bulb.

(a) Which solid is ionic? P. It dissolves in water, but does not light the bulb. When dissolved, because its ions become free to move, it conducts electricity.

(b) Which of the chapter's compounds could be P? Naphthalene (a covalent compound soluble in kerosene but not in water, no ions in solution).

(c) Why does none of the solids conduct electricity in solid state? Q and R contain no ions at all.



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7. Case-based: Designing a neutral ionic compound (NCERT Exercise 3)

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 Al³⁺ and 3 Cl⁻ (ii) 3 Mg²⁺ and 1 PO₄³⁻ (iii) 2 Fe³⁺ and 3 O²⁻ (iv) 3 Ca²⁺ and 2 SO₄²⁻

Answer: (iii). Work out both totals for each option.

Option	Total positive	Total negative	Balanced for 6+ and 6-
(i)	2 × 3 = 6+	3 × 1 = 3-	No
(ii)	3 × 2 = 6+	1 × 3 = 3-	No
(iii)	2 × 3 = 6+	3 × 2 = 6-	Yes: Fe ₂ O ₃
(iv)	3 × 2 = 6+	2 × 3 = 6-	Yes: Ca ₃ (SO ₄) ₂

8. Case-based: The unknown metal

Metal M, with two electrons in its valence shell, is a metal that is slightly soluble in water. Predict its formula and the nature of its aqueous solution.

Answer: The M shell is the third shell, so M has 19 electrons to form M²⁺, and oxygen gains 2 electrons to form O²⁻. The formula is M₂O₂, which simplifies to MO. The part that dissolves releases ions, so it is an ionic compound.

(i) Criss-cross gives M₂O₂, which simplifies to MO. The part that dissolves releases ions, so it is an ionic compound.

Important Questions for

1-Mark Questions

- 1. State the Law of Conservation of Mass in a chemical reaction; the total mass of reactants is equal to the total mass of products.
- 2. Who proposed the Law of Constant Proportions?



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- What is a formula unit?** In an ionic compound, the collection of the simplest whole number ratio of ions.
- Name N_2O_5 and CS_2 .** Dinitrogen pentoxide and carbon disulfide.
- What kind of ion will oxygen (O) form?** An anion, the oxide ion O^{2-} , by gaining two electrons.

2-Mark Questions

- The Law of Definite Proportions holds true for compounds but not for mixtures. Give reason.** In a compound the elements combine in fixed numbers of atoms, so the mass ratio is fixed whatever the source. A mixture can be made with its components in any proportion, so it has no fixed composition.
- Neon (atomic number 10) neither transfers nor shares its valence electrons. Explain.** Neon's configuration is 2, 8. Its valence shell already has a complete octet, so it is stable and has no tendency to lose, gain or share electrons.
- Why is the formula of aluminium hydroxide written as $\text{Al}(\text{OH})_3$ and not AlOH_3 ?** The formula has three hydroxide ions for each aluminium ion. The formula AlOH_3 applies to the whole OH group.
- Find the formula unit mass of KCl and $\text{Mg}(\text{OH})_2$.**
 $\text{KCl} = 39 + 35.5 = 74.5 \text{ u}$
 $\text{Mg}(\text{OH})_2 = 24 + 2(16 + 1) = 58 \text{ u}$
- Write the formulae: (i) Sodium hydrogencarbonate (ii) Cuprous oxide.** (i) NaHCO_3 (ii) Cu_2O



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3-Mark Questions

- Explain the formation of sodium chloride.** Sodium (2, 8, 1) loses its one valence electron to become Na^+ . Chlorine (2, 8, 7) gains that electron to become Cl^- . The oppositely charged ions are held by electrostatic forces of attraction to form sodium chloride.
- Choose the correct statement(s) and correct the wrong ones.**
 (i) All molecules are made up of two or more atoms. **Correct.**
 (ii) All compounds are made up of two or more atoms. **Correct.**
 (iii) Water contains three nitrogen atoms. **Wrong.** Water contains three hydrogen atoms and one oxygen atom.
 (iv) A molecule is bonded with one oxygen atom. **Wrong.** A molecule can be bonded with one or more oxygen atoms.
 (v) Helium is made up of single atoms. **Correct.**
 (vi) Some molecules are made up of two or more different elements combined. **Correct.**
 (vii) All compounds are made up of two or more different kinds of atoms. **Correct.**
 (viii) All molecules are made up of two or more different kinds of atoms. **Wrong.** Some molecules are made up of two or more different kinds of atoms, but some are made up of single atoms of the same element.
 (ix) All compounds are made up of two or more different kinds of atoms. **Correct.**
 (x) All molecules are made up of two or more different kinds of atoms. **Wrong.** Some molecules are made up of two or more different kinds of atoms, but some are made up of single atoms of the same element.

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3. 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. (i) B. It needs to gain only one electron to complete its octet, while A needs three, so B reacts more readily. (ii) Both have more than four valence electrons, so both tend to gain electrons; neither gives electrons away easily. They complete their octets by sharing, so the bonds are covalent. (iii) A needs three electrons and B needs one, so one A atom shares one electron with each of three B atoms. Formula: AB_3 . (A is phosphorus and B is chlorine; the compound is PCl_3 , phosphorus trichloride.)

5-Mark Questions

- Describe an activity with vinegar and baking soda to show that mass is conserved in a chemical reaction. Explain why an open set-up gives a different result from a closed one, and state the law with its proposer. Set-up 1: pour the baking soda into the open flask. There is brisk effervescence and the final reading is lower, because carbon dioxide escapes. Set-up 2: tie the balloon over the mouth of the flask. Effervescence inflates the balloon, the gas is trapped and weighed. Conclude that mass is conserved. Law of Conservation of Mass. Chemical reaction, proposed by Antoine Lavoisier.
- Differentiate between ionic and covalent compounds (i) solubility in water and kerosene (iii) electrical conductivity in water but not as a solid. (i) Ionic: generally soluble in water, mostly insoluble in kerosene; covalent: no conduction in water; covalent: usually insoluble in water. Ionic: generally high; covalent: usually low. Naphthalene (covalent). In the solid, ions are free to move and carry charge.



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Common Mistakes and Explanations

- Saying the law "fails" when a gas escapes. The law is not violated because the gaseous product left the system. The law is only valid in a closed system.
- Adding only some of the products. In a chemical reaction, if only one product is listed, then write "mass of reactants = mass of products + mass of water in Example 9.1 breaks the balance."

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3. **Scaling the wrong way in a ratio sum.** For "46 g of sodium, ratio 23 : 35.5", the factor is $46 \div 23 = 2$, applied to 35.5. Dividing 46 by 35.5 is the usual slip.
4. **Drawing O₂ with a single bond.** Oxygen shares two electrons each, so O=O is a double bond. Nitrogen shares three each, a triple bond. Count the electrons each atom still needs.
5. **Using mono- for the first element.** CO₂ is carbon dioxide, never monocarbon dioxide. CO is carbon monoxide, never monooxide. H₂S is hydrogen sulfide, never dihydrogen sulfide.
6. **Criss-crossing the signs.** Only the numbers cross over, and charges are not written in the final formula. Write CaCl₂, never Ca²⁺Cl₂⁻.
7. **Forgetting to simplify.** Mg₂O₂ must become MgO, and Ca₂(CO₃)₂ must become CaCO₃. An ionic formula shows the simplest ratio.
8. **Missing brackets on polyatomic ions.** Write Al(OH)₃, Mg(OH)₂, Al₂(SO₄)₃. Do not add brackets when there is only one polyatomic ion: NaOH, K₂SO₄.
9. **Mixing up ferrous and ferric, cuprous and cupric.** -ous is the lower charge (Fe²⁺, Cu⁺) and -ic the higher (Fe³⁺, Cu²⁺). Ferric oxide is Fe₂O₃; cuprous oxide is Cu₂O.
10. **Using "molecular mass" for an ionic compound.** Na₂CO₃ and Ca(NO₃)₂ have formula unit masses, not molecular masses. Multiply by 2 before adding calcium.

Quick Revision Points

- Law of Conservation of Mass: matter can neither be created nor destroyed in a chemical reaction; Antoine Lavoisier, 1789, the Father of Modern Chemistry.
- Activity 9.2: open set-up loses mass because it is not closed; closed set-up stays the same.
- Law of Constant Proportions (Definite Proportions): elements combine in a fixed ratio by mass, whatever the source of the compound.
- Water: hydrogen : oxygen = 1 : 8 by mass.
- Dalton, 1808: atoms are tiny, indivisible, cannot be created or destroyed, identical atoms; combine in simple whole number ratios; relative atomic masses are constant in a compound.
- Molecule: electrically neutral, more than one atom; shows chemical properties of the substance. Helium exists as single atoms.
- Chemical bond = force holding atoms together in a molecule.



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- H-H, Cl-Cl, H-Cl: single bonds. O=O: double bond. N≡N: triple bond. Water: H-O-H.
- Prefixes: mono 1, di 2, tri 3, tetra 4, penta 5, hexa 6; no mono- on the first element; monoxide, pentoxide, tetroxide drop a vowel.
- Fewer than four valence electrons: usually lose them. More than four: usually gain or share.
- Na (2, 8, 1) → Na⁺ (11 p, 10 e); Cl (2, 8, 7) → Cl⁻ (17 p, 18 e). Ionic bond = electrostatic attraction between them.
- Ionic compounds: generally soluble in water, insoluble in kerosene and petrol, conduct in water and when molten, not as solids, high melting points.
- Covalent compounds: mostly insoluble in water, soluble in kerosene and petrol, do not conduct, low melting points; sugar dissolves in water but gives no ions.
- Criss-cross: swap valency numbers as subscripts, divide by any common factor, bracket repeated polyatomic ions.
- Molecular mass: H₂O 18 u, CO₂ 44 u, HNO₃ 63 u, CH₄ 16 u.
- Formula unit mass: Na₂O 62 u, Ca(NO₃)₂ 164 u.



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Weightage and Exam Pattern

Class 9 has no board exam. This chapter is important for (term and annual papers), and the NCERT source

Question type	What this chapter typically supplies
MCQ and one-word	Proposers of the laws, naming compounds with prefixes, charges of common ions, choosing the neutral combination of ions
Assertion-Reason	Conductivity of ionic compounds in solid and molten states, sugar solution, stability of noble gases, Dalton's postulates
Short answer (2 to 3 marks)	Mass verification sums, fixed-ratio sums, formulae from pairs of ions, molecular mass and formula unit mass, forming a cation or an anion
Long answer (5 marks)	Describing Activity 9.2 or 9.3, formation of NaCl or H ₂ O with explanation, comparing ionic and covalent compounds
Case-based	Open versus closed reactions, water from different sources, designing an ionic compound, Activity 9.4 observation tables

This chapter is the foundation for Class 10 chemistry. It is used in every later chemistry chapter.



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