



ChapterNotes

chapternotes.in · free NEET & JEE prep

CHAPTER NOTES

Hydrogen Class 11 Notes | CBSE Chemistry Chapter 8

- ✓ Chapter-wise notes & important questions
- ✓ Free gamified practice app — streaks, levels, revision
- ✓ Free mock & prediction papers with answer keys

Source: <https://chapternotes.in/cbse/class-11-chemistry/hydrogen-class-11-notes/>



Scan to practice this
chapter free in the app

Hydrogen Class 11 Notes | CBSE Chemistry Chapter 8

Hydrogen is Chapter 8 of CBSE Class 11 Chemistry — and it is the simplest yet most fascinating element you will study, the very first entry on the periodic table with just one proton and one electron. From the water you drink to the rocket fuel that lifts spacecraft, hydrogen and its compounds are everywhere, and this chapter ties together periodicity, bonding, and redox in one neat package.

By the end of these notes you will be able to explain the unique position of hydrogen, write the preparation and properties of dihydrogen and hydrogen peroxide, classify hydrides, distinguish hard and soft water with their softening methods, and answer every board and entrance question on heavy water and hydrogen as a fuel. This is a scoring chapter carrying roughly 4–6 marks in boards and a guaranteed NEET/JEE question on H_2O_2 structure or hydrides.

Table of Contents

- Key Concepts — Position of hydrogen, dihydrogen, hydrides, water, H_2O_2 , heavy water, hydrogen as a fuel
 - Weightage in Board & Entrance Exams
 - Important Definitions
 - Solved Examples
 - Important Questions for Board Exams
 - Quick Revision Points
-

Key Concepts

1. Position of Hydrogen in the Periodic Table

Hydrogen has the electronic configuration $1s^1$ — just one electron. This single electron makes it behave like two completely different families, so its position is genuinely unique.

Like the **alkali metals (Group 1)**, hydrogen has one valence electron, forms a unipositive ion (H^+), and combines with halogens, oxygen, and sulphur. Like the **halogens (Group 17)**, it is one electron short of a noble-gas configuration, exists as a diatomic molecule (H_2), and forms the hydride ion (H^-).

Key idea: Because hydrogen resembles both Group 1 and Group 17 but matches neither perfectly, it is given a unique, isolated position at the top of the periodic table.

2. Isotopes of Hydrogen

Hydrogen has three isotopes that differ only in the number of neutrons. They have the same chemical properties but differ in physical properties such as rate of reaction.

Isotope	Symbol	Protons	Neutrons	Abundance
Protium	${}_1\text{H}^1$	1	0	99.985%
Deuterium	${}_1\text{H}^2$ (D)	1	1	0.015%
Tritium	${}_1\text{H}^3$ (T)	1	2	radioactive, trace

Note: Tritium is radioactive and emits β -particles with a half-life of about 12.3 years.

3. Dihydrogen — Occurrence and Preparation

Dihydrogen (H_2) is the most abundant element in the universe ($\approx 70\%$ by mass) but is rare in the free state on Earth, occurring mainly in combined form as water, acids, and hydrocarbons.

Laboratory Preparation

By the action of dilute hydrochloric acid or sulphuric acid on granulated zinc:



Commercial / Industrial Preparation

- **Electrolysis of water** (with a trace of acid/base) gives very pure dihydrogen: $2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$.
- **Water-gas / syngas:** steam passed over red-hot coke gives water gas: $\text{C} + \text{H}_2\text{O} \rightarrow \text{CO} + \text{H}_2$ (at 1270 K).
- **Water-gas shift reaction:** $\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2$, with CO_2 removed under pressure to leave pure H_2 .

4. Properties and Uses of Dihydrogen

Dihydrogen is a colourless, odourless, tasteless, highly combustible gas that is lighter than air and almost insoluble in water.

Chemical Properties

- **With metals:** forms ionic hydrides, e.g. $2\text{Na} + \text{H}_2 \rightarrow 2\text{NaH}$.
- **With non-metals:** $3\text{H}_2 + \text{N}_2 \rightarrow 2\text{NH}_3$ (Haber process); $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$.
- **Reducing agent:** $\text{CuO} + \text{H}_2 \rightarrow \text{Cu} + \text{H}_2\text{O}$ — reduces metal oxides to metals.
- **Hydrogenation:** adds across $\text{C}=\text{C}$ bonds to convert oils into fats (vanaspati ghee) using a Ni catalyst.

Uses

- Manufacture of ammonia (Haber process) and hence fertilisers.
- Hydrogenation of vegetable oils into vanaspati.

- Manufacture of methanol and HCl.
- As rocket fuel and in fuel cells; in oxy-hydrogen and atomic-hydrogen torches for welding.

5. Hydrides

When dihydrogen combines with other elements it forms **hydrides**. Based on bonding, hydrides are of three types.

Type	Formed with	Nature	Examples
Ionic (saline)	s-block metals (Group 1, 2)	Crystalline, conduct on melting, liberate H ₂ at anode	NaH, CaH ₂
Covalent (molecular)	p-block non-metals	Volatile, low m.p./b.p., poor conductors	CH ₄ , NH ₃ , H ₂ O, HF
Metallic (interstitial)	d- and f-block metals	Non-stoichiometric, metallic, conduct heat/electricity	TiH _{1.73} , PdH _{0.6}

Note: Elements of groups 7, 8, and 9 (the middle of the d-block) generally do not form hydrides — this is called the **hydride gap**.

6. Water — Structure and Properties

A water molecule (H₂O) has a bent (angular) shape with an H–O–H bond angle of about **104.5°** and two lone pairs on oxygen. Oxygen is sp³ hybridised.

[DIAGRAM: Bent H₂O molecule — central O with two O–H bonds at 104.5°, two lone pairs on O, dipole pointing from H toward O.]

Because oxygen is far more electronegative than hydrogen, water is a highly **polar molecule** and an excellent solvent. Extensive **hydrogen bonding** gives water its high boiling point, high specific heat, high surface tension, and the unusual fact that ice is less dense than liquid water.

Amphoteric Nature

Water can act both as an acid and as a base (it is amphoteric):

- As an acid with NH₃: $\text{H}_2\text{O} + \text{NH}_3 \rightarrow \text{NH}_4^+ + \text{OH}^-$
- As a base with H₂S: $\text{H}_2\text{O} + \text{H}_2\text{S} \rightarrow \text{H}_3\text{O}^+ + \text{HS}^-$

7. Hard and Soft Water

Soft water lathers readily with soap. **Hard water** does not give lather easily because it contains dissolved calcium and magnesium salts.

Type of hardness	Cause	Removal method
Temporary hardness	Bicarbonates of Ca^{2+} and Mg^{2+}	Boiling; Clark's method (slaked lime)
Permanent hardness	Chlorides and sulphates of Ca^{2+} and Mg^{2+}	Washing soda; ion-exchange resins; Calgon

Softening Methods

- **Clark's method:** calculated slaked lime removes temporary hardness: $\text{Ca}(\text{HCO}_3)_2 + \text{Ca}(\text{OH})_2 \rightarrow 2\text{CaCO}_3\downarrow + 2\text{H}_2\text{O}$.
- **Washing soda:** Na_2CO_3 removes both kinds: $\text{CaCl}_2 + \text{Na}_2\text{CO}_3 \rightarrow \text{CaCO}_3\downarrow + 2\text{NaCl}$.
- **Calgon method:** sodium hexametaphosphate $\text{Na}_6\text{P}_6\text{O}_{18}$ forms a soluble complex with $\text{Ca}^{2+}/\text{Mg}^{2+}$.
- **Ion-exchange (permutit):** hydrated sodium aluminium silicate exchanges Na^+ for $\text{Ca}^{2+}/\text{Mg}^{2+}$.

8. Hydrogen Peroxide (H_2O_2)

Hydrogen peroxide is a pale-blue, syrupy liquid (almost colourless when dilute) and an important oxidising and bleaching agent.

Preparation

- **Laboratory:** acidified hydrogen peroxide from barium peroxide — $\text{BaO}_2 \cdot 8\text{H}_2\text{O} + \text{H}_2\text{SO}_4 \rightarrow \text{BaSO}_4 + \text{H}_2\text{O}_2 + 8\text{H}_2\text{O}$.
- **Industrial:** 2-ethylantraquinol is oxidised by air (auto-oxidation), then H_2O_2 is extracted with water.

Structure

H_2O_2 has a **non-planar, open-book structure**. The two O–H bonds lie in different planes joined at the O–O bond, like the two pages of a half-open book.

[DIAGRAM: Open-book structure of H_2O_2 — O–O single bond as the spine, each O carrying one H; dihedral angle 111° in gas phase (90.2° in solid).]

- O–O bond length: 147.5 pm; O–H bond length: 95 pm
- Dihedral angle: 111.5° in the gas phase (90.2° in the solid)

Properties and Uses

- Acts as both an **oxidising and reducing agent** in acidic and basic media.
- Decomposes on standing: $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$ — stored in coloured plastic bottles, away from light.
- Used as a mild antiseptic, hair bleach, in restoring old paintings, and as a propellant.

9. Heavy Water (D₂O)

Heavy water is deuterium oxide, D₂O, where ordinary hydrogen is replaced by its heavier isotope deuterium. It is obtained by the prolonged electrolysis of ordinary water.

- It is denser (1.106 g/cm³) and has a higher boiling point (101.4 °C) than ordinary water.
- Its main use is as a **moderator** in nuclear reactors, where it slows down fast neutrons.
- It is also used to prepare deuterated compounds for studying reaction mechanisms.

10. Hydrogen as a Fuel

Dihydrogen releases a large amount of energy per gram on combustion and produces only water as the by-product, making it a clean, pollution-free fuel.

- **Energy released** on combustion is about 143 kJ/g — far higher than petrol or LPG by mass.
- Used in **hydrogen fuel cells**, which convert chemical energy directly into electricity: $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{electricity}$.
- **5% dihydrogen blended with CNG** (called Hydrogen-CNG) is used as a cleaner automobile fuel.

Important: The main challenges are the safe storage and transport of a highly inflammable gas.

Weightage in Board & Entrance Exams

Exam	Typical Weightage	Most-Tested Areas
CBSE Board (Class 11)	4–6 marks	Hydrides, H ₂ O ₂ structure & reactions, hard/soft water, heavy water
JEE Main	1 question	H ₂ O ₂ structure, redox behaviour, hydrides classification
NEET	1–2 questions	Isotopes, hydrides, H ₂ O ₂ as oxidising/reducing agent, hard water

[TABLE: Question-type split — VSA (1 mark): isotopes, definitions, formulae; SA (2–3 marks): preparation of H₂/H₂O₂, hardness removal; LA (5 marks): structure of H₂O₂, classification of hydrides with examples.]

Important Definitions

Term	Definition
Dihydrogen	The diatomic molecular form of hydrogen, H_2 — most abundant element in the universe
Isotopes of hydrogen	Protium (${}_1H^1$), deuterium (${}_1H^2$), tritium (${}_1H^3$) — same protons, different neutrons
Ionic hydride	Hydride of s-block metals containing the H^- ion, e.g. NaH , CaH_2
Interstitial hydride	Non-stoichiometric hydride of d/f-block metals, e.g. $PdH_{0.6}$
Hard water	Water containing dissolved Ca^{2+} and Mg^{2+} salts that does not lather with soap
Temporary hardness	Hardness due to bicarbonates of Ca/Mg , removed by boiling
Permanent hardness	Hardness due to chlorides/sulphates of Ca/Mg , removed by washing soda
Hydrogen peroxide	H_2O_2 — pale-blue liquid with an open-book structure; oxidising and reducing agent
Heavy water	Deuterium oxide, D_2O — used as a moderator in nuclear reactors
Calgon	Sodium hexametaphosphate, used to soften water by forming soluble complexes

Solved Examples

Example 1

Why is hydrogen placed separately in the periodic table?

Answer: With configuration $1s^1$ it resembles both alkali metals (one valence electron, forms H^+) and halogens (one electron short of a noble gas, forms H^- and a diatomic molecule), but matches neither completely — so it is given a **unique isolated position**.

Example 2

Write the reaction for the laboratory preparation of dihydrogen.

Answer: Granulated zinc with dilute HCl : $Zn + 2HCl \rightarrow ZnCl_2 + H_2\uparrow$. Dilute H_2SO_4 may also be used.

Example 3

How is temporary hardness of water removed by Clark's method?

Answer: A calculated amount of slaked lime is added, precipitating insoluble carbonate: $Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2CaCO_3\downarrow + 2H_2O$.

Example 4

Give the structure of hydrogen peroxide and state its dihedral angle in the gas phase.

Answer: H_2O_2 has a **non-planar open-book structure** with the two O–H bonds in different planes joined at the O–O bond. The dihedral angle is **111.5°** in the gas phase (90.2° in the solid).

Example 5

Why is hydrogen peroxide stored in coloured plastic bottles?

Answer: H_2O_2 decomposes in the presence of light: $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$. Coloured bottles cut out light and the smooth plastic surface avoids catalytic decomposition, so it stays stable.

Example 6

Distinguish between ionic and covalent hydrides with one example each.

Answer: **Ionic hydrides** form with reactive s-block metals, contain the H^- ion, and are crystalline solids that conduct on melting — e.g. **NaH**. **Covalent hydrides** form with p-block non-metals, are volatile with low melting points, and are poor conductors — e.g. **CH_4** .

Important Questions for Board Exams

1-Mark Questions (VSA)

1. Name the three isotopes of hydrogen.
2. What is the hybridisation of oxygen in a water molecule?
3. Write the formula of Calgon.
4. Why is heavy water used in nuclear reactors?
5. Name the by-product formed when hydrogen is burnt as a fuel.

2–3-Mark Questions (SA)

1. Explain why hydrogen resembles both alkali metals and halogens.
2. Distinguish between temporary and permanent hardness of water and give one method to remove each.
3. Describe the industrial preparation of dihydrogen by the water-gas shift reaction.
4. Why does H_2O_2 act both as an oxidising and a reducing agent? Give one example of each.

5-Mark Questions (LA)

1. Classify hydrides into three types based on bonding, giving their characteristics and examples.

2. Draw and explain the structure of hydrogen peroxide and discuss its preparation and uses.
 3. Explain hard and soft water. Describe Clark's method, washing-soda method, and the ion-exchange method of softening water.
-

Quick Revision Points

- Hydrogen ($1s^1$) has a unique position — resembles both Group 1 and Group 17
 - Three isotopes: protium ${}_1\text{H}^1$, deuterium ${}_1\text{H}^2$, tritium ${}_1\text{H}^3$ (radioactive)
 - Lab prep of H_2 : $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$; pure H_2 by electrolysis of water
 - Hydrides: ionic (NaH), covalent (CH_4 , H_2O), metallic/interstitial ($\text{PdH}_{0.6}$); hydride gap in groups 7–9
 - Water: bent, sp^3 , bond angle 104.5° , polar, amphoteric, extensive H-bonding
 - Temporary hardness = bicarbonates (boiling/Clark's); permanent = chlorides/sulphates (washing soda, Calgon, ion-exchange)
 - H_2O_2 : open-book structure, dihedral angle 111.5° (gas); oxidising + reducing agent; stored in coloured bottles
 - Heavy water D_2O : moderator in nuclear reactors; denser and higher b.p. than H_2O
 - Hydrogen as fuel: $\sim 143 \text{ kJ/g}$, only water as by-product, used in fuel cells and H-CNG
-

Next Chapter: Chapter 9 — The s-Block Elements



Got this PDF from a friend?

Everything here is free at **chapternotes.in** — 134 chapters of notes, a gamified practice app, and full NEET mock & prediction papers.



Scan to practice this chapter free in the app