ChapterNotes

chapternotes.in · free NEET & JEE prep

CHAPTER NOTES

The Solid State Class 12 Notes — CBSE Chemistry Chapter 1

✓ 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-12-chemistry/the-solid-state-class-12-notes/

Scan to practice this chapter free in the app

The Solid State Class 12 Notes — CBSE Chemistry Chapter 1

Chapter 1 of Class 12 Chemistry introduces you to the fascinating world of **solid state chemistry**. Solids are all around us — from the salt in your kitchen to the silicon in your phone. Understanding how atoms, ions, and molecules arrange themselves in solids is key to understanding their properties. This chapter carries **5-7 marks** in CBSE Board exams and is essential for competitive exams like JEE and NEET.

Key Concepts

Classification of Solids

Solids are classified based on the arrangement of their constituent particles:

Property	Crystalline Solids	Amorphous Solids
Shape	Definite geometric shape	Irregular shape
Melting Point	Sharp melting point	Melt over a range
Cleavage	Clean cleavage along planes	Irregular cleavage
Heat of Fusion	Definite	Not definite
Anisotropy	Anisotropic	Isotropic
Nature	True solids	Pseudo solids / supercooled liquids
Examples	NaCl, Diamond, Quartz	Glass, Rubber, Plastics

Exam Tip: Remember — Amorphous = “without form” (Greek). Glass is the most commonly asked example of an amorphous solid. Quartz (crystalline) vs Glass (amorphous) — both are SiO_2 but differ in arrangement!

Types of Crystalline Solids

Type	Constituent Particles	Bonding	Properties	Examples
Ionic	Cations & Anions	Electrostatic (Coulombic)	Hard, brittle, high m.p., conduct in molten/solution	NaCl, KNO_3, ZnS
Molecular	Molecules	van der Waals / H-bonding	Soft, low m.p., poor conductors	Ice, I_2, CO_2
Covalent (Network)	Atoms	Covalent bonds	Very hard, very high m.p., poor conductors (except graphite)	Diamond, SiC, SiO_2
Metallic	Metal atoms (+ e^- sea)	Metallic bonding	Lustrous, malleable, ductile, good conductors	Fe, Cu, Au, Ag

Crystal Lattice and Unit Cell

A **crystal lattice** is a 3D arrangement of points representing the positions of constituent particles. The smallest repeating unit of this lattice is called the **unit cell**.

Seven Crystal Systems

There are 7 crystal systems and 14 Bravais lattices. The most important ones for your exam:

Crystal System	Axes	Angles	Example
Cubic	$a = b = c$	$\alpha = \beta = \gamma = 90°$	NaCl, Diamond
Tetragonal	$a = b \neq c$	$\alpha = \beta = \gamma = 90°$	SnO_2, TiO_2
Orthorhombic	$a \neq b \neq c$	$\alpha = \beta = \gamma = 90°$	$BaSO_4$, KNO_3
Hexagonal	$a = b \neq c$	$\alpha = \beta = 90°, \gamma = 120°$	Graphite, ZnO

Number of Atoms in a Unit Cell

This is one of the most important topics for numericals:

Contribution of atoms at different positions:

Corner atom: shared by 8 unit cells → contributes **1/8**

Edge atom: shared by 4 unit cells → contributes **1/4**

Face-centred atom: shared by 2 unit cells → contributes **1/2**

Body-centred atom: belongs entirely to 1 unit cell → contributes **1**

Unit Cell Type	Corners	Body	Face	Total Atoms
Simple Cubic (SCC)	8 × 1/8 = 1	0	0	**1**
Body-Centred Cubic (BCC)	8 × 1/8 = 1	1	0	**2**
Face-Centred Cubic (FCC)	8 × 1/8 = 1	0	6 × 1/2 = 3	**4**

Packing Efficiency

Packing Efficiency = (Volume occupied by atoms / Volume of unit cell) × 100

Simple Cubic: **52.4%** (coordination number = 6)

BCC: **68%** (coordination number = 8)

FCC / HCP: **74%** (coordination number = 12) — most efficient!

Relationship Between Edge Length and Atomic Radius

SCC: $a = 2r$

BCC: $a = 4r/\sqrt{3}$

FCC: $a = 2\sqrt{2} \cdot r$

Density of Unit Cell

$\boldsymbol{\rho = (Z \times M) / (a^3 \times N_a)}$

Where: Z = atoms per unit cell, M = molar mass, a = edge length, N_a = Avogadro’s number

Voids (Interstitial Sites)

In close-packed structures, there are spaces between atoms called **voids**:

Void Type	Coordination Number	Number of Voids (for N atoms)	Location
Tetrahedral	4	2N	Body diagonal, at 1/4 distance
Octahedral	6	N	Body centre + edge centres

Quick Memory Aid: “Tetra = 2N, Octa = N” — the one with fewer sides has MORE voids!

Defects in Solids (Imperfections)

Point Defects in Ionic Solids

Defect	What Happens	Effect on Density	Example
Schottky Defect	Equal number of cations & anions missing	Density decreases	NaCl, KCl, AgBr
Frenkel Defect	Smaller ion displaced to interstitial site	Density unchanged	AgCl, AgBr, ZnS

Remember: AgBr shows BOTH Schottky and Frenkel defects — a favourite exam question!

Non-stoichiometric Defects

Metal Excess Defect:

- **F-centres:** Anion vacancies trapped with electrons → colour (NaCl = yellow, KCl = violet, LiCl = pink)
- Extra cation in interstitial site (e.g., ZnO turns yellow on heating)

Metal Deficiency Defect: Cation missing, charge balanced by adjacent cation having higher charge (e.g., FeO often found as $Fe_{0.93}O$ to $Fe_{0.96}O$)

Electrical Properties — Band Theory

Type	Band Gap	Conductivity	Temp Effect	Examples
Conductors (Metals)	No gap / overlapping bands	10^2 – 10^8 S/m	Decreases with temp	Cu, Ag, Al
Semiconductors	Small gap (< 3 eV)	10^{-6} – 10^4 S/m	Increases with temp	Si, Ge, GaAs
Insulators	Large gap (> 3 eV)	10^{-20} – 10^{-10} S/m	—	Diamond, wood

Types of Semiconductors

- **n-type:** Doped with Group 15 element (P, As) → extra electron → negative charge carrier
- **p-type:** Doped with Group 13 element (B, Al, Ga) → electron hole → positive charge carrier

Magnetic Properties

Type	Behaviour in Magnetic Field	Examples
Diamagnetic	Weakly repelled, all electrons paired	NaCl, C_6H_6, TiO_2
Paramagnetic	Weakly attracted, unpaired electrons	O_2, Cu^{2+}, Fe^{3+}
Ferromagnetic	Strongly attracted, domains align	Fe, Co, Ni, CrO_2
Antiferromagnetic	Domains align anti-parallel, cancel out	MnO, MnO_2
Ferrimagnetic	Domains anti-parallel but unequal, net moment	Fe_3O_4, ferrites

Important Definitions

Term	Definition
Crystal Lattice	Regular 3D arrangement of constituent particles in a crystalline solid
Unit Cell	Smallest repeating portion of a crystal lattice
Coordination Number	Number of nearest neighbours surrounding a particle
Packing Efficiency	Percentage of total space filled by constituent particles
Interstitial Void	Empty space between close-packed atoms
Schottky Defect	Point defect where equal cation-anion pairs are missing from lattice
Frenkel Defect	Point defect where smaller ion is displaced to an interstitial site
F-centre	Anion vacancy with trapped electron, responsible for colour
Doping	Adding impurity atoms to a semiconductor to modify conductivity

Solved Examples — NCERT Based

Example 1: Calculating Density of Unit Cell

Q: Silver crystallises in FCC structure. If the edge length of the unit cell is 408.6 pm, calculate the density of silver. (Molar mass of Ag = 108 g/mol)

Solution:

For FCC: $Z = 4$

$a = 408.6 \text{ pm} = 408.6 \times 10^{-10}$ cm

$\rho = (Z \times M) / (a^3 \times N_a)$

$\rho = (4 \times 108) / ((408.6 \times 10^{-10})^3 \times 6.022 \times 10^{23})$

$\rho = 432 / (6.83 \times 10^{-23} \times 6.022 \times 10^{23})$

$\rho = 432 / 41.13 =$ **10.5 g/cm³**

Example 2: Calculating Number of Atoms in Unit Cell

Q: A compound forms HCP structure. What is the number of atoms per unit cell? Also find the number of tetrahedral and octahedral voids if the structure contains 8 atoms.

Solution:

HCP has same packing as FCC → **Z = 4 atoms per unit cell** (but for the full HCP unit cell consideration, it's 6).

For N = 8 atoms:

Tetrahedral voids = 2N = 2 × 8 = **16**

Octahedral voids = N = **8**

Example 3: Edge Length from Atomic Radius

Q: Iron has BCC structure with atomic radius 124 pm. Find the edge length of its unit cell.

Solution:

For BCC: $a = 4r/\sqrt{3}$

$a = (4 \times 124) / 1.732$

$a = 496 / 1.732 =$ **286.4 pm**

Example 4: Identifying Defect Type

Q: In a sample of NaCl, some Na^+ ions are missing from their lattice sites. The same number of Cl^- ions are also missing. What type of defect is this? What will be the effect on density?

Solution:

Since equal numbers of cations (Na^+) and anions (Cl^-) are missing → this is a **Schottky defect**.

Effect: Number of ions decreases but volume remains same → **density decreases**.

Important Questions for Board Exams

1 Mark Questions

1. What is the coordination number of atoms in BCC structure?
2. What type of defect is shown by NaCl?
3. What is the packing efficiency of FCC structure?
4. Name one substance that shows both Schottky and Frenkel defects.
5. What type of semiconductor is formed when Si is doped with Boron?

2 Mark Questions

1. Distinguish between tetrahedral and octahedral voids.
2. What are F-centres? How do they impart colour to crystals?
3. Differentiate between n-type and p-type semiconductors.
4. Why does Frenkel defect not change the density of a solid?

3 Mark Questions

1. Explain Schottky and Frenkel defects with examples. How do they affect density?
2. Derive the relationship between edge length and atomic radius for FCC unit cell.
3. Calculate the packing efficiency of BCC structure.
4. Classify the following as ionic, molecular, covalent or metallic solids: SiC, Ice, NaCl, Iron, Diamond.

5 Mark Questions

1. What is a unit cell? Describe the three types of cubic unit cells. Calculate the number of atoms in each.
2. Explain band theory. Distinguish between conductors, semiconductors and insulators on its basis. What are n-type and p-type semiconductors?

Quick Revision Points

- Crystalline solids: definite shape, sharp m.p., anisotropic | Amorphous: irregular, range of m.p., isotropic
- 4 types of crystalline solids: Ionic, Molecular, Covalent (network), Metallic
- 7 crystal systems, 14 Bravais lattices
- SCC: Z=1, CN=6, PE=52.4% | BCC: Z=2, CN=8, PE=68% | FCC: Z=4, CN=12, PE=74%
- Density formula: $\rho = ZM / a^3N_a$

- Tetrahedral voids = 2N, Octahedral voids = N
- Schottky: both ions missing → density decreases | Frenkel: ion displaced → density same
- AgBr shows both Schottky and Frenkel defects
- F-centres: anion vacancy + trapped electron → colour
- n-type: Group 15 dopant (extra e^-) | p-type: Group 13 dopant (hole)
- Ferro > Ferri > Para > Dia (in terms of magnetic response)

Next Chapter: Solutions →