

# Class 12 Chemistry – Solid State | Study Guide

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## 1. Theory in Simple Words with Visuals

### 1.1 What is a Solid?

- **Definition:** A solid is a state of matter in which **particles are closely packed** in a fixed arrangement and can **vibrate but cannot move freely**.
- **Analogy:** Think of a solid like a **tightly packed box of marbles** – they can jiggle, but they can't move around.
- **Visual:**

Particles in Solid: (Fixed arrangement)



- **Characteristics of solids:**
  1. Definite shape and volume
  2. High density
  3. Low compressibility
  4. Rigid structure

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### 1.2 Types of Solids

Type	Particles	Bonding	Example	Properties
Crystalline	Regular, repeating	Ionic, covalent, metallic	NaCl, Diamond	Sharp melting point, definite geometry
Amorphous	Random arrangement	Weak intermolecular forces	Glass, Rubber	No sharp melting point, soft

- **Mnemonic: "Crazy Angry Raccoons" → Crystalline, Amorphous, Random**

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### 1.3 Crystal Lattices

- **Definition:** 3D repeating arrangement of particles in a crystal.
- **Unit cell:** The smallest repeating unit that represents the entire lattice.
- **Types of Unit Cells:**
  - **Simple cubic (SC):** 1 atom per cell

- Body-centered cubic (BCC): 2 atoms per cell
- Face-centered cubic (FCC): 4 atoms per cell

Visual:

SC: Corner atoms only

0-----0

|       |

0-----0

BCC: Corner + center

0-----0

|   0   |

0-----0

FCC: Corner + face centers

0--0--0

|   0   |

0--0--0

Tips:

- SC → 1 atom
- BCC → 2 atoms
- FCC → 4 atoms

## 1.4 Close Packing in Crystals

- Hexagonal close packing (hcp) → ABAB stacking
- Cubic close packing (ccp/fcc) → ABCABC stacking
- Packing efficiency: % of space occupied by particles
  - SC → 52%, BCC → 68%, FCC/HCP → 74%

## 1.5 Imperfections in Solids

1. Point defects: Vacancy, interstitial, substitutional
2. Line defects: Dislocations
3. Surface defects: Grain boundaries

Example: NaCl crystals can have missing Na<sup>+</sup> ions (Schottky defect)

## 1.6 Electrical and Magnetic Properties

- Ionic solids conduct electricity **only in molten/aqueous state**

- Metals conduct in solid & molten states
- Diamond: non-conductor, Graphite: conductor
- Magnetism: Paramagnetic (unpaired electrons), Diamagnetic (all paired)

## 1.7 Properties of Solids

- **Mechanical:** Hardness, elasticity, brittleness
- **Thermal:** Melting point, specific heat
- **Optical:** Transparency, color (due to band gap)

## 2. Key Concepts & Formulas

Concept	Formula / Fact	Tip / Mnemonic
Density of unit cell	$\rho = (Z \times M) / (a^3 \times N_A)$	$Z$ = #atoms/unit cell, $a$ = edge length, $N_A$ = Avogadro
Edge length (SC)	$a = 2r$	$r$ = atomic radius
Edge length (BCC)	$a = 4r/\sqrt{3}$	Remember: "BCC = 4 over root 3"
Edge length (FCC)	$a = 2\sqrt{2} r$	FCC $\rightarrow 2\sqrt{2} r$
Packing efficiency	$\% = (\text{Volume of atoms in cell} / \text{Volume of cell}) \times 100$	SC $\rightarrow 52\%$ , BCC $\rightarrow 68\%$ , FCC $\rightarrow 74\%$
Vacancy defect	$\Delta\rho/\rho = 1/N$	$N$ = total atoms
Schottky defect	Equal # cations & anions missing	NaCl

**Memory trick for packing efficiency:**

"Silly Bunnies Fly"  $\rightarrow$  SC 52%, BCC 68%, FCC/HCP 74%

## 3. Solved Numerical Problems

### Example 1: Density of a crystal

**Problem:** Density of a NaCl crystal with edge 564 pm. Find  $\rho$ . ( $Z = 4$ ,  $M = 58.5$  g/mol,  $N_A = 6.022 \times 10^{23}$ )

**Solution:**

Step 1: Convert edge:  $a = 564 \text{ pm} = 564 \times 10^{-12} \text{ m} = 5.64 \times 10^{-8} \text{ cm}$

Step 2: Density formula:  $\rho = Z \times M / (a^3 \times N_A)$

$$\rho = (4 \times 58.5) / ((5.64 \times 10^{-8})^3 \times 6.022 \times 10^{23})$$
$$\rho \approx 2.16 \text{ g/cm}^3$$

**Tips:** Always convert pm  $\rightarrow$  cm for  $\text{g/cm}^3$ .

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## Example 2: Atomic radius in FCC

**Problem:** Edge length of FCC copper = 361 pm. Find radius.

**Solution:**

$$\text{FCC} \rightarrow a = 2\sqrt{2} r \rightarrow r = a / 2\sqrt{2}$$

$$r = 361 / (2 \times 1.414) \approx 127.5 \text{ pm}$$

**Shortcut:** Remember FCC  $\rightarrow$  divide edge by  $2\sqrt{2}$

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## 4. Previous Years' Board Questions (Solved)

1. Define Schottky and Frenkel defects (2018)

**Answer:** Schottky  $\rightarrow$  missing equal cation & anion; Frenkel  $\rightarrow$  cation goes to interstitial site.

2. Calculate density of BCC solid (2020)

Use  $\rho = ZM/(a^3 N_A)$ ,  $Z = 2$  for BCC

3. Types of unit cells and coordination number (2017)

SC: 1 atom, CN = 6

BCC: 2 atoms, CN = 8

FCC: 4 atoms, CN = 12

**Pattern noticed:** Questions mostly focus on defects, unit cells, density calculations, and packing efficiency.

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## 5. Quick Revision Notes / Important Points

- **Types of solids:** Crystalline & amorphous
- **Unit cells:** SC(1,6), BCC(2,8), FCC(4,12)
- **Packing efficiency:** SC 52%, BCC 68%, FCC/HCP 74%
- **Defects:** Schottky, Frenkel, vacancy
- **Formulas:** Density, edge length, packing efficiency

**Flowchart:**

Solids  $\rightarrow$  Crystalline  $\rightarrow$  (Ionic, Metallic, Covalent, Molecular)  
 $\rightarrow$  Amorphous  $\rightarrow$  Glass, Rubber

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## 6. Predicted / Likely Questions

1. Density calculation problems (BCC/FCC/SC)
  2. Schottky & Frenkel defects definition
  3. Packing efficiency & coordination number questions
  4. Graphite vs Diamond properties
  5. Unit cell diagrams & labeling
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## 7. Exam Tips & Tricks

- **Always remember formulas first:** density, edge length, packing efficiency
- **Unit conversion is crucial:** pm  $\rightarrow$  cm or nm  $\rightarrow$  m
- **Shortcuts:** FCC  $\rightarrow$  4 atoms, BCC  $\rightarrow$  2 atoms, SC  $\rightarrow$  1 atom
- **Common mistakes:** Confusing SC/BCC/FCC, forgetting CN

Visual mnemonic:

SC: **Single** Cube  $\rightarrow$  **1** atom

BCC: **Body Center**  $\rightarrow$  **2** atoms

FCC: **Faces Covered**  $\rightarrow$  **4** atoms

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## 8. Visual & Kid-Friendly Learning Style

- **Use colors:** Red = cations, Blue = anions
- **Sketch unit cells** while studying
- **Mental image:** FCC like stacking oranges in a pyramid (ABCABC stacking)