# 🌟 1. Common Types of Cubic Unit Cells

The main cubic unit cells in crystallography are:

1. **Simple Cubic (SC)**
2. **Body-Centered Cubic (BCC)**
3. **Face-Centered Cubic (FCC)**

There are also other unit cells in different crystal systems (tetragonal, hexagonal, etc.), but we'll focus on cubic cells first.

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## A. Simple Cubic (SC)

### 🍑 Easy Example

Think of SC as a **stack of small marbles in a box**:

- 1 marble at each corner
- No center or face marbles

**Counting marbles (atoms):**

$$8 \text{ corners} \times \frac{1}{8} = 1$$

**Total atoms per SC unit cell = 1**

**Packing efficiency analogy:** Only 52% of the box is filled, the rest is empty space.

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### 🔹 Theory / Formulas

1. **Atoms in SC:**

$$N_{\text{atoms}} = 8 \times \frac{1}{8} = 1$$

2. **Edge length (a) vs. atomic radius (r):**

$$a = 2r$$

3. **Packing efficiency (APF):**

$$\text{APF} = \frac{1 \cdot \frac{4}{3}\pi r^3}{(2r)^3} = 0.52 = 52\%$$

4. **Examples:** Polonium (Po), some simple metals

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## B. Body-Centered Cubic (BCC)

### 🍊 Easy Example

Think of BCC as a **cube-shaped gift box**:

- 1 gift at each corner → shared with 8 neighboring boxes → counts as 1/8 each
- 1 gift in the center → belongs entirely to your box

**Counting gifts (atoms):**

$$8 \times \frac{1}{8} + 1 = 2$$

**Total atoms per BCC unit cell = 2**

**Packing efficiency analogy:** 68% of the box is filled.

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### 🔹 Theory / Formulas

1. **Atoms in BCC:**

$$N_{\text{atoms}} = 8 \times \frac{1}{8} + 1 = 2$$

2. **Edge length (a) vs. atomic radius (r):**
   Atoms touch along the **body diagonal**:

$$4r = a\sqrt{3} \quad \Rightarrow \quad a = \frac{4r}{\sqrt{3}}$$

3. **Packing efficiency (APF):** 68%
4. **Examples:** Fe, Cr, W

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## C. Face-Centered Cubic (FCC)

### 🍊 Easy Example

Think of FCC as **stacking oranges in a grocery box**:

- 1 orange at each corner → shared with 8 boxes → counts as 1/8 each
- 1 orange in the center of each face → shared with 2 boxes → counts as 1/2 each

**Counting oranges (atoms):**

$$8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4$$

**Total atoms per FCC unit cell = 4**

**Packing efficiency analogy:** 74% of the cube is filled with atoms, the rest is empty space.

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### 🔹 Theory / Formulas

1. **Atoms in FCC:**

$$N_{\text{atoms}} = 8 \times \frac{1}{8} + 6 \times \frac{1}{2} = 4$$

2. **Edge length (a) vs. atomic radius (r):**
   Atoms touch along the **face diagonal**:

$$4r = a\sqrt{2} \quad \Rightarrow \quad a = 2\sqrt{2}r$$

3. **Packing efficiency (APF):** 74%
4. **Examples:** Cu, Al, Ag

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## 🌟 2. Quick Comparison Table

| Unit Cell | Atoms per Cell | Packing Efficiency | Touching Direction | Everyday Analogy | Examples |
|---|---|---|---|---|---|
| SC | 1 | 52% | Edge | Single marbles | Po |
| BCC | 2 | 68% | Body diagonal | Gift in box | Fe, Cr, W |
| FCC | 4 | 74% | Face diagonal | Oranges in box | Cu, Al, Ag |

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## 🌟 3. Additional Theory

1. **Packing Efficiency (APF):**

$$\text{APF} = \frac{\text{Volume of atoms in the unit cell}}{\text{Volume of the unit cell}} \times 100$$

2. **Relationship between edge length (a) and atomic radius (r):**

| Unit Cell | Formula |
|---|---|
| SC | $a = 2r$ |
| BCC | $a = \frac{4r}{\sqrt{3}}$ |
| FCC | $a = 2\sqrt{2}r$ |

3. **Atoms sharing rules**:

- Corner atom → 1/8th per cell
- Face atom → 1/2 per cell

- Body-center atom → 1 per cell

4. **Packing efficiency significance**:

- Higher APF → atoms are tightly packed → more stable structure
- FCC > BCC > SC in packing efficiency and stability

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## 🌟 4. Everyday Analogies Recap

- **SC** → 1 marble in a box → 52% filled
- **BCC** → gift in the center of a box → 68% filled
- **FCC** → oranges stacked tightly → 74% filled

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## ✅ FCC Unit Cell Summary

- 8 corners × 1/8 = 1 atom
- 6 faces × 1/2 = 3 atoms
- Total = 4 atoms per unit cell
- Packing efficiency = 74%
- Example analogy: oranges stacked tightly

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## ✅ BCC Unit Cell Summary

- 8 corners × 1/8 = 1 atom
- 1 body-center atom = 1 atom
- Total = 2 atoms per unit cell
- Packing efficiency = 68%
- Example analogy: gift in a box