Extra Exercise:

Linking Crystal Bonding with the Periodic Table

Consider the following elements from the periodic table:

- Aluminum (Al)
- Silicon (Si)
- Sodium (Na)
- Chlorine (Cl)

Part A: Bonding Type Identification

1. For each element (or compound formed), determine the **dominant type of bonding** in the solid state:
    - Metallic
    - Covalent (network)
    - Ionic
2. Identify which combination forms a compound and state its bonding type.

Part B: Periodic Table Reasoning

Using their positions in the periodic table:

1. Explain how **valence electrons** influence the type of bonding.
2. Discuss how **metallic vs nonmetallic character** determines:
    - Electron loss (metals)
    - Electron sharing (metalloids)
    - Electron gain (nonmetals)

Part C: Crystal Structure Connection

1. Describe the expected **crystal structure** for:
    - Al (metallic lattice)
    - Si (covalent network)
    - NaCl (ionic crystal)
2. Explain how bonding type affects:
    - Electrical conductivity
    - Mechanical properties (brittle vs ductile)

◆ Part D: Trend Analysis (Higher Thinking)

1. Moving from left to right across the periodic table:
   - How does bonding change?
   - Why does metallic bonding decrease and covalent/ionic increase?
2. Predict the bonding type of:
   - Magnesium
   - Phosphorus
   Justify your answer using periodic trends.

◆ Question

Why does Aluminum have stronger metallic bonding than Sodium even though both are metals?

Solution:

Linking Crystal Bonding with the Periodic Table

◆ Part A: Bonding Type Identification

1. Individual Elements

- **Sodium (Na):**
  Metallic bonding
  ➤ Na is a metal with 1 valence electron → forms a **metallic lattice with delocalized electrons**
- **Aluminum (Al):**
  Metallic bonding
  ➤ Al has 3 valence electrons → stronger **metallic bonding (electron sea)**
- **Silicon (Si):**
  Covalent (network) bonding
  ➤ Si shares electrons → forms a **giant covalent network**
- **Chlorine (Cl):**
  Molecular covalent (Cl_2 gas), but **ionic when combined with metals**

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2. Compound Formation

- **Na + Cl → NaCl**
  ➤ Bonding type: **Ionic bonding**
  ➤ Na loses 1 electron → Na^+
  ➤ Cl gains 1 electron → Cl^-

◆ Part B: Periodic Table Reasoning

1. Role of Valence Electrons

- Na (1 valence electron) → easily **loses electron**
- Al (3 valence electrons) → forms stronger **metallic bonding**
- Si (4 valence electrons) → prefers **sharing (covalent bonding)**
- Cl (7 valence electrons) → tends to **gain electrons**

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2. Metallic vs Nonmetallic Behavior

Type	Behavior	Example
Metals	Lose electrons	Na, Al
Metalloids	Share electrons	Si
Nonmetals	Gain electrons	Cl

◆ Part C: Crystal Structure Connection

1. Structures

- **Al (metallic lattice):**
  Positive ion cores + delocalized electrons (electron sea)
- **Si (covalent network):**
  Each atom bonded to 4 neighbors → **tetrahedral structure**
- **NaCl (ionic crystal):**
  Alternating Na^+ and Cl^- ions → **cubic lattice**

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2. Properties vs Bonding

Property	Metallic (Al)	Covalent (Si)	Ionic (NaCl)
Conductivity	High	Low (semiconductor)	Low (solid)
Mechanical	Ductile	Hard & brittle	Brittle

Melting Point	Moderate–high	Very high	High

🔹 Part D: Trend Analysis

1. Across a Period (Left → Right)

- Metallic → Covalent → Ionic (with compounds)
- Reason:
  - Increase in **electronegativity**
  - Decrease in **metallic character**
  - Increase in **electron attraction**

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2. Predictions

- **Magnesium:**
  Metallic bonding
  ➤ 2 valence electrons → stronger metallic bond than Na
- **Phosphorus:**
  Covalent bonding
  ➤ Nonmetal → shares electrons

🔹 Question

Why is Al stronger than Na in metallic bonding?

- Al provides **3 delocalized electrons per atom**
- Na provides only **1 electron per atom**

➡️ More electrons → stronger attraction between:

- Positive ion cores
- Electron sea

➡️ Therefore:

Aluminum has stronger metallic bonding than sodium