

# Chemistry Assessment: Molecular Structure and Bulk Properties

## Stimulus: The Mystery of Salt and Sugar

Imagine you are a scientist studying two common white powders: **Table Salt (Sodium Chloride, NaCl)** and **Table Sugar (Sucrose, C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>)**. Your goal is to figure out why these two substances, which look so similar, behave so differently when heated or dissolved.

You conduct an investigation and find the following bulk properties:

Property	Table Salt (NaCl)	Table Sugar (C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> )
<b>Melting Point</b>	Very High ~806 C	Relatively Low ~186 C
<b>Solubility in Water</b>	Very High	Very High
<b>Electrical Conductivity (as a solid)</b>	None	None
<b>Electrical Conductivity (dissolved in water)</b>	<b>High</b>	None

## Using Molecular Models:

Scientists use models to explain these differences by looking at the particles that make up each substance:

- **Table Salt (NaCl):** This substance is made of alternating positive **Sodium ions** (Na<sup>+</sup>) and negative **Chloride ions** (Cl<sup>-</sup>) held together by very strong **ionic bonds** in a large, repeating **networked structure**. The strong **electrical forces** between these oppositely charged ions must be overcome to melt the salt.
- **Table Sugar (C<sub>12</sub>H<sub>22</sub>O<sub>11</sub>):** This substance is made of neutral, individual **C<sub>12</sub>H<sub>22</sub>O<sub>11</sub> molecules**. While the atoms *inside* each molecule are held by strong covalent bonds, the individual molecules are only held to *each other* by much **weaker intermolecular forces**. Only these weaker forces need to be broken for the sugar to melt.

Name \_\_\_\_\_

**Multiple Choice: Circle the BEST answer.**

- 1. When Table Salt melts, a very high temperature (~801 °C) is required to turn it from a solid to a liquid. This high temperature is needed because:**
- A. The salt particles are held together by very strong electrical forces (ionic bonds).
  - B. The salt particles are very large.
  - C. Salt has many water molecules trapped inside it.
  - D. The salt particles are individual molecules.
- 2. Table Sugar is made of individual neutral molecules held together by weak forces. Table Salt is a network of charged ions held together by strong forces. Which model best explains the difference in the strength of the forces?**
- A. Both substances have high solubility in water.
  - B. Sugar dissolves in water; salt conducts electricity in water.
  - C. Sugar uses individual molecules; salt uses a repeating network of ions.
  - D. Sugar is a white powder; salt is a white powder.
- 3. When salt is dissolved in water, the liquid conducts electricity, but when sugar is dissolved, the liquid does not. This is because:**
- A. Salt's particles separate into mobile, charged ions in water, and sugar's particles are neutral.
  - B. Salt's particles are larger than sugar's particles.
  - C. Sugar melts at a lower temperature than salt.
  - D. Water cannot break the bonds in the sugar molecule.
- 4. The difference in the forces that hold the particles of salt and sugar together is huge. Which choice correctly describes the forces?**
- A. Salt: Strong forces between ions; Sugar: Weak forces between molecules.
  - B. Salt: Weak forces between molecules; Sugar: Strong forces between ions.
  - C. Salt: Weak forces between atoms; Sugar: Strong forces between atoms.
  - D. Both substances are held together by very strong forces of the same type.
- 5. Table Sugar melts at a low temperature (~186) because the forces between its particles are weak. If you compared sugar to salt, the weaker forces in sugar also mean that when a liquid, it would turn into a gas more easily. This property is called:**
- A. Electrical Conductivity.
  - B. Melting Point.
  - C. Vaporization.
  - D. Solubility.



- 6. The ball-and-stick model for sugar shows a large, complicated molecule. The weak forces between these individual molecules (that must be broken to melt the sugar) are a key example of a weaker electrical force known as:**
- A. Ionic bonds.
  - B. Covalent bonds.
  - C. Intermolecular forces.
  - D. Networked forces.
- 7. A student wants to plan an investigation to compare the properties of ice (water) and dry ice (solid CO<sub>2</sub>). Which comparison would best meet the goal of relating a bulk property to the strength of electrical forces between particles?**
- A. Comparing the color and texture of the two solids.
  - B. Comparing the melting point of each substance to see which has stronger forces between particles.
  - C. Comparing the mass and volume of both solids.
  - D. Comparing how much of each substance can dissolve in gasoline.
- 8. When you heat Table Sugar, it melts quickly. This observation at the macroscopic (bulk) scale is a direct result of the weak forces that hold the sugar particles together at the microscopic (molecular) level. This is an example of relating:**
- A. Mass to Volume.
  - B. A bulk property (melting point) to a molecular structure/force (weak forces).
  - C. Color to Solubility.
  - D. A chemical change to a physical change.
- 9. The stimulus says scientists use models like Lewis dot structures to explain forces. A Lewis dot model for a Sodium atom (Na) shows that it easily gives up one electron. This is important because:**
- A. It explains why solid salt is a white powder.
  - B. It allows the Sodium atom to share electrons with a Chlorine atom.
  - C. Giving up an electron makes the Sodium particle a neutral atom.
  - D. It causes the Sodium particle to become a positive ion (Na<sup>+</sup>) that is attracted to a negative ion.
- 10. Which statement is the best conclusion that links the molecular structure of salt and sugar to the properties you observed?**
- A. Very strong electrical forces between ions (salt) lead to a very high melting point, while weak forces between neutral molecules (sugar) lead to a low melting point.
  - B. All substances that dissolve in water conduct electricity when dissolved.
  - C. Molecular structure only determines how a substance looks, not how it behaves.
  - D. Substances that are white powders are always made of individual molecules.



Question	Correct Answer	Rationale (Microscopic → Macroscopic Link)
1	A. The salt particles are held together by very strong electrical forces (ionic bonds).	High melting points (macroscopic) require a lot of energy to overcome the very strong electrical forces (microscopic) holding the ionic network together.
2	C. Sugar uses individual molecules; salt uses a repeating network of ions.	The structural difference (neutral molecules vs. charged ion network) explains the massive difference in the strength of the electrical forces between the particles.
3	A. Salt's particles separate into mobile, charged ions in water, and sugar's particles are neutral.	Electrical conductivity requires mobile charged particles (ions) at the molecular level. Sugar's neutral molecules cannot carry a current.
4	A. Salt: Strong forces between ions; Sugar: Weak forces between molecules.	The high melting point of salt and the low melting point of sugar are direct evidence of the strength of the forces holding their particles together.
5	C. Vapor Pressure.	Weak forces (microscopic) allow particles to escape the liquid more easily as a gas, thereby increasing the gas's vapor pressure (a macroscopic property).
6	C. Intermolecular forces.	These are the weaker electrical forces that exist between separate molecules (like sugar), which cause them to have low melting and boiling points.
7	B. Comparing the melting point of each substance to see which has stronger forces between particles.	Melting point is a measurable bulk property that directly relates to the energy needed to overcome the internal forces of attraction between particles.
8	B. A bulk property (melting point) to a molecular structure/force (weak forces).	This is the core skill: connecting an observable property (low melting point, macroscopic) to the unobservable cause (weak intermolecular forces, microscopic).
9	D. It causes the Sodium particle to become a positive ion (Na <sup>+</sup> ) that is attracted to a negative ion.	Giving up an electron creates a positive charge (Na <sup>+</sup> ). This charge is necessary to create the strong, attractive electrical force (ionic bond) with the negative ion.
10	A. Very strong electrical forces between ions (salt) lead to a very high melting point, while weak forces between neutral molecules (sugar) lead to a low melting point.	This is the most complete statement, effectively summarizing the link between the differences in microscopic structure/forces and the resulting macroscopic behavior.

Framed sentence for essay for lower students: **Sentence Frame for Question 11**

Your conclusion is incorrect because the data table shows salt and sugar behave very differently. For example, salt has a very (1) \_\_\_\_\_ melting point, while sugar's melting point is (2) \_\_\_\_\_. Also, salt (3) \_\_\_\_\_ electricity when dissolved, but sugar does not.

These differences are caused by their microscopic structures. Salt is made of (4) \_\_\_\_\_ held together by strong (5) \_\_\_\_\_ bonds. Sugar is made of neutral (6) \_\_\_\_\_ held together by weak (7) \_\_\_\_\_ forces.