CHAPTER 2 CHEMICAL BONDING

Reflect on your Learning

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1. Atoms form compounds to become stable. When forming compounds, the individual atoms gain, lose, or share electrons. For example, both sodium and chlorine are highly reactive. Atoms of these elements combine by transferring electrons from one to another to form stable ions. The compound formed is sodium chloride, also known as common table salt. Other compounds that have been formed by transferring electrons are calcium fluoride, magnesium chloride, and aluminum fluoride.
2. There are two classes of forces present between atoms in substances. One force is responsible for the creation of crystalline ionic compounds, and the other is responsible for the "clumping" of molecular compounds (intermolecular forces). An ionic compound is made up of positive and negative ions that have resulted from the transfer of electrons from a metal to a nonmetal. The positive and negative ions are attracted to each other because they have opposite charges. This is known as an ionic bond. Students will learn that one cause of intermolecular forces is polarity within a molecule, caused by uneven sharing of electrons in a covalent bond. In general, intermolecular forces are not as strong as ionic bonds, and so molecular substances tend to have lower melting and boiling points than ionic compounds. However, covalent bonds are at least as strong as ionic bonds, as many molecular compounds do not readily decompose.
3. Use sodium chloride (table salt) as an example. Sodium chloride is a compound that is held together with ionic forces. The strong ionic bonds are responsible for the solid state, hardness, and brittleness of ionic compounds like sodium chloride. The strong ionic bonds result in a crystalline structure of hard, flat surfaces that make characteristic angles with one another. Crystals of table salt exhibit this property and are cubic in shape. If enough force is applied, ionic compounds will cleave (break apart) along these lines of smooth, flat surfaces. The high melting point of solid sodium chloride results from the strong attractions that occur in the crystal structure. And because the ionic bonds often break down in water, the resulting ions are free to move in solution and conduct electricity.

Try This Activity: Making Models of Compounds

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Chlorine: the dark-green coloured piece.
Bromine: the orange coloured piece.
Carbon: the black coloured piece.
Nitrogen: the blue coloured piece.
Oxygen: the red coloured piece.
Iodine: the purple coloured piece.
Hydrogen: the white coloured piece.
Group the different pieces according to the number of holes present.

(a)
- Chlorine, bromine, and iodine have one hole, are nonmetals, and belong to Group 17, the halogens, of the representative elements.
- Hydrogen also has one hole, and belongs to Group 1 (hydrogen is sufficiently different to be in a class by itself).
- Oxygen has two holes, is a nonmetal, and belongs to Group 16, of the representative elements.
- Nitrogen has three holes, is a nonmetal, and belongs to Group 15, of the representative elements.
- Carbon has four holes, is a nonmetal, and belongs to Group 14, of the representative elements.

(b) The holes in the pieces represent the number of single valence (bonding) electrons available on each atom.
(c) The sticks represent the chemical bonds between the atoms.
(d) The students are to construct as many different compounds as possible using the pieces in the kit, and to the best of their ability, name the compounds modelled. For example, O_2 — oxygen, H_2O — water, CO_2 — carbon dioxide, etc.
(e) Some models show atoms with single bonding connections and others show atoms with two, three, or four bonding connections.
(f) Two groups that might be used are: single bonding connected models (HCl), and multiple bonding connected models (CH_4). The rationale for this classification is that a clear distinction can be made between single bonding elements and multiple bonding elements.

(g) Two more classification schemes that might be used are: models that have the same elements bonding (O_2), and models that have different elements bonding (HCl); models with a carbon atom (CH_4), and models without a carbon atom (H_2O). (Students are likely to discover quickly the variety of compounds that can be formed using carbon atoms.) The rationale for this classification is that once again, clear distinctions can be made between such bonding arrangements.

2.1 CLASSIFYING COMPOUNDS

PRACTICE

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Understanding Concepts

1. (a) A metal element and a nonmetal element combine to form an ionic compound.
   (b) A nonmetal element and a nonmetal element combine to form a molecular compound.
2. Electrical conductivity can be used as a diagnostic test for an ionic compound. Ionic compounds (many of which dissolve readily in water) form solutions that conduct electricity.

Applying Inquiry Skills

3. **Experimental Design**
   Solubility: Obtain a small amount of the unknown substance. Observe and record its state at the ambient temperature. Add a small quantity of the substance to about 10 mL of distilled water. Stir the mixture with a stirring rod and note whether the chemical dissolves. Many ionic compounds readily dissolve in water.
   Conductivity: Obtain a small sample of distilled water in a beaker. Use a low-voltage conductivity apparatus to test the electrical conductivity of the sample. The apparatus should indicate a reading of zero. Test the electrical conductivity of the mixture from the above solubility procedure and record observations. Ionic compounds form solutions that conduct electricity.
4. • Compound A is ionic — its solution conducts electricity.
   • Compound B is molecular — it is a liquid at SATP, and its solution does not conduct electricity.
   • Compound C is molecular — it is a gas at SATP.
   • Compound D is ionic — its solution conducts electricity.
   • Compound E is molecular — its solution does not conduct electricity.

2.2 IONIC BONDING

PRACTICE

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Understanding Concepts

1. The properties of ionic compounds that suggest ionic bonds are strong are: they are solids at SATP, they have hard surfaces, and they have high melting and boiling points.
2. Metal elements and nonmetal elements form ionic bonds with each other.
3. Groups 1, 2, and 3 (13), tend to lose electrons to become positive ions. Groups 15, 16, and 17 tend to gain electrons to form negative ions.
4. The minimum number of different ions in the formula of an ionic compound is 2. This is because the smallest unit of an ionic compound that would still have the properties of the compound is a 1:1 ratio of the different ions, with the general formula MX.
5. (a) S^{2-}
   (b) Ba^{2+}
   (c) Br^{-}
   (d) Cl^{-}
   (e) Ca^{2+}
   (f) K^{+}
   (g) P^{3-}
   (h) Rb^{+}
   (i) Be^{2+}

