TABLE 7 *Boiling Points and Bonding Types*

Bonding type	Substance	bp (1 atm, °C)
Nonpolar-covalent (molecular)	H_2	–253
	O_2	–183
	Cl_2	–34
	Br_2	59
	CH_4	–164
	CCl_4	77
	C_6H_6	80
Polar-covalent (molecular)	PH_3	–88
	NH_3	–33
	H_2S	–61
	H_2O	100
	HF	20
	HCl	–85
	ICl	97
Ionic	NaCl	1413
	MgF_2	2239
Metallic	Cu	2567
	Fe	2750
	W	5660

Molecular Polarity and Dipole-Dipole Forces

The strongest intermolecular forces exist between polar molecules. Polar molecules act as tiny dipoles because of their uneven charge distribution. *A* **dipole** *is created by equal but opposite charges that are separated by a short distance.* The direction of a dipole is from the dipole's positive pole to its negative pole. A dipole is represented by an arrow with a head pointing toward the negative pole and a crossed tail situated at the positive pole. The dipole created by a hydrogen chloride molecule, which has its negative end at the more electronegative chlorine atom, is indicated as follows.

$$\overset{+\!\!\longrightarrow}{\text{H}-\text{Cl}}$$

The negative region in one polar molecule attracts the positive region in adjacent molecules, and so on throughout a liquid or solid. The forces of attraction between polar molecules are known as *dipole-dipole forces.* These forces are short-range forces, acting only between nearby molecules. The effect of dipole-dipole forces is reflected, for example, by the significant difference between the boiling points of iodine chloride, I—Cl, and bromine, Br—Br. The boiling point of polar iodine chloride is 97°C, whereas that of nonpolar bromine is only 59°C. The dipole-dipole forces responsible for the relatively high boiling point of ICl are illustrated schematically in **Figure 25.**

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