

Intermolecular Attractive Forces

Name _____

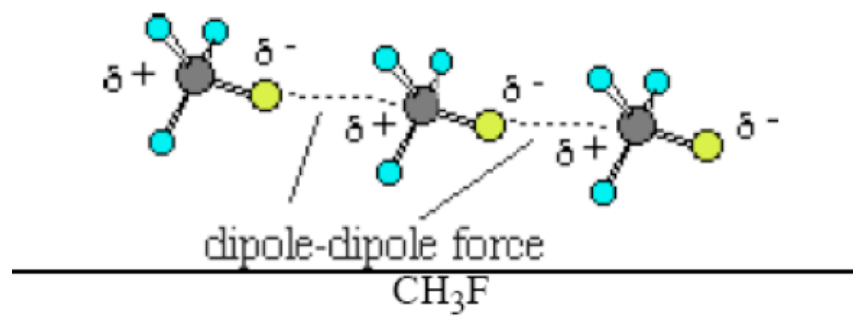
Sec _____

- Sketch the orientations of molecules and/or ions involved in the following intermolecular attractive forces. Include at least one specific example where each attractive force is important. For each one, tell what causes the force and describe its strength relative to the others.

a. Ion-dipole forces

	<p>This figure shows the ion-dipole interaction between the chloride ion and the water molecules. There are two more water molecules that could have been drawn. These are located in front and behind the chloride ion. Notice the orientation of the water molecules. The $\delta+$ end of the dipole is oriented towards the negatively charged chloride ion.</p> <p>This figure shows the ion-dipole interaction between the potassium ion and the water molecules. There are two more water molecules which could have been drawn. These are located in front and behind the potassium ion. Notice the orientation of the water molecules. The $\delta-$ end of the dipole is oriented towards the positively charged potassium ion.</p>
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b. Dipole-dipole forces



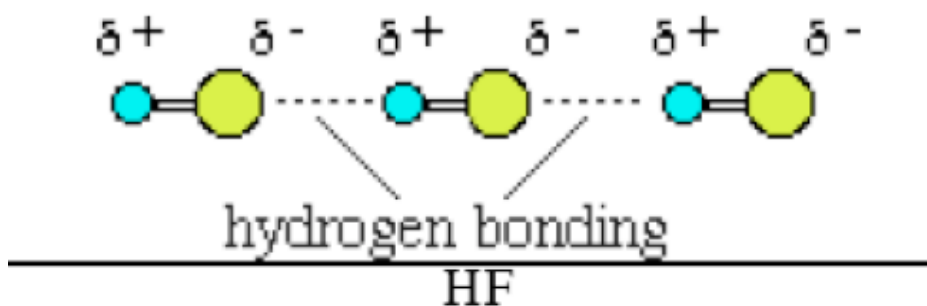
The figure above shows the dipole-dipole intermolecular attractive force in liquid CH_3F . CH_3F is a polar molecule, so both dispersion forces and dipole-

dipole forces are present. Since all of the atoms in CH_3F are in the first or second period dipole-dipole forces are the strongest IMAF.

c. London dispersion forces

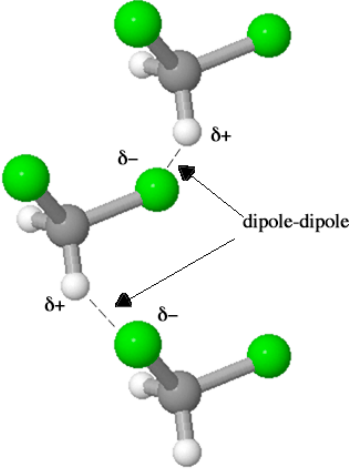
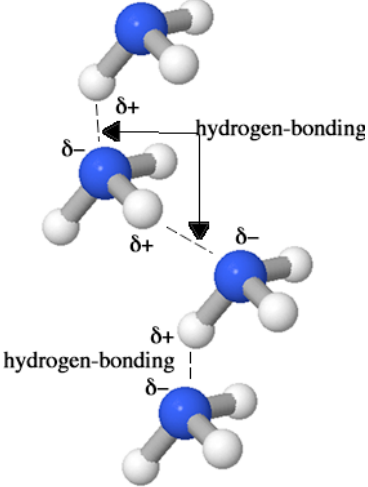
London dispersion forces are difficult to represent pictorially, but a description can be used. LD forces are only present in nonpolar atoms or molecules. For a nonpolar atom or molecule, for most of the time, the electrons are symmetrically distributed. However, there are instances when the electrons in a nonpolar molecule are not symmetrically distributed, and the result is to produce an instantaneous dipole (a dipole that is present for a very brief period of time). The instantaneous dipole can induce a dipole on another atom or molecule very close to it. The result is a small electrostatic attraction. However, an instant later the instantaneous dipole will be gone as the electrons in the atom or molecule find a more symmetric arrangement. So London dispersion forces are the result of instantaneous dipoles that briefly form in nonpolar atoms or molecules. For substances containing atoms in the first or second period LD forces are weak. However, if a molecule contains atoms from the third or higher periods the LD forces can be very strong. Stronger than dipole-dipole forces (if present). Since LD forces are due to arrangements of electrons all molecules, whether polar or nonpolar exhibit LD forces.

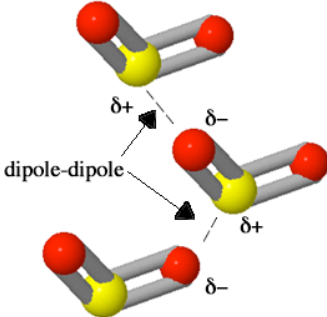
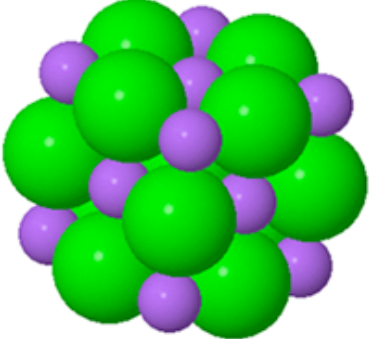
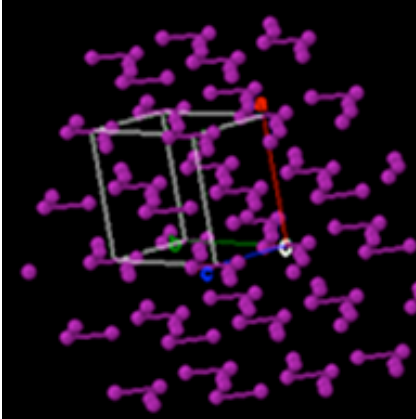
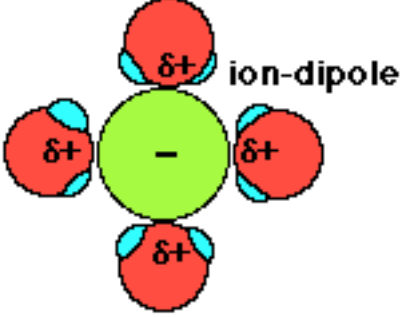
d. Hydrogen-bonding forces

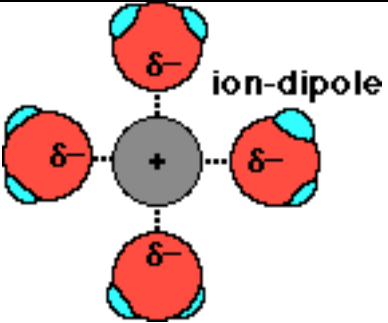
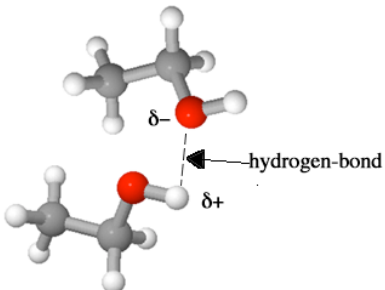


The figure above shows the hydrogen bonding intermolecular attractive force between HF molecules in liquid HF. HF is a polar molecule so both dispersion forces and dipole-dipole forces are present. However because a hydrogen atom is covalently bonded to a fluorine atom, and the same hydrogen atom interacts with a fluorine atom on another HF molecule, hydrogen bonding is possible. So all three NMAF are present in HF.

2. Complete the following table.

System	Primary IMAF	Sketch of Interaction between particles	Comments
$\text{CH}_2\text{Cl}_2(l)$	LDF and dipole-dipole†		<p>CH_2Cl_2 is polar. The hydrogen atoms have partial positive charge and the chlorine has a partial negative. However, no hydrogen bonding since the hydrogen atom is covalently bonded to a carbon atom. So dipole-dipole and LD forces are present. The LD forces will be the primary IMAF, because chlorine is in the 3rd period. When a molecule has an element in the 3rd or higher period LD forces are the most important.</p>
$\text{NH}_3(l)$	LDF, dipole-dipole and hydrogen-bonding†		<p>NH_3 is polar. The hydrogen atoms have partial positive charge and the nitrogen has a partial negative. Since the hydrogen atom is covalently bonded to a nitrogen, hydrogen-bonding can occur between molecules.</p>

SO ₂ (l)	LDF and dipole-dipole†		SO ₂ is polar. The sulfur atom has a partial positive charge and the oxygen atoms have a partial negative. The primary IMAF is dipole-dipole, or it could be LDF.
KBr(s)	Ionic bonding		KBr is an ionic compound so the primary IMAF is ionic bonding. Ionic bonding is always stronger than LDF, dipole-dipole or hydrogen-bonding IMAFs.
I ₂ (s)	LDF		I ₂ is nonpolar. The only IMAF is dispersion forces. The image shows the arrangement of I ₂ molecules in I ₂ (s).
NaCl(aq)	Ion-dipole		This figure shows the ion-dipole interaction between the chloride ion and the water molecules. There are two more water molecules that could have been drawn. These are located in front and behind the chloride ion. Notice the orientation of the water molecules. The $\delta+$ end of the dipole is oriented towards the

		 <p>The diagram shows a central grey sphere with a '+' sign representing a potassium ion. It is surrounded by four water molecules, each represented by a red sphere (oxygen) with two blue spheres (hydrogen). The oxygen atoms are labeled with a partial negative charge (δ^-). Dotted lines connect the potassium ion to the oxygen atoms of the water molecules. The text 'ion-dipole' is written to the right of the diagram.</p>	<p>negatively charged chloride ion.</p> <p>This figure shows the ion-dipole interaction between the potassium ion and the water molecules. There are two more water molecules which could have been drawn. These are located in front and behind the potassium ion. Notice the orientation of the water molecules. The δ^- end of the dipole is oriented towards the positively charged potassium ion.</p>
$\text{CH}_3\text{CH}_2\text{OH}(l)$	<p>LDF, dipole-dipole and hydrogen-bonding†</p>	 <p>The diagram shows two ethanol molecules ($\text{CH}_3\text{CH}_2\text{OH}$) in ball-and-stick representation. The oxygen atoms are red and the hydrogen atoms are white. A dashed line connects the oxygen atom of one molecule to the hydrogen atom of another molecule, labeled 'hydrogen-bond'. The oxygen atom is labeled with a partial negative charge (δ^-) and the hydrogen atom with a partial positive charge (δ^+).</p>	<p>$\text{CH}_3\text{CH}_2\text{OH}$ is polar. The presence of the O-H group means that hydrogen-bonding can occur between molecules of $\text{CH}_3\text{CH}_2\text{OH}$.</p>