

Exercise 10.3

Intermolecular Forces

Name: _____

Date: _____ Per: _____

<i>Types of Solids*</i>	<i>Intermolecular Force(s) Between Particles</i>
1. Metallic Crystals (Metals) Ex: Na, Cu, Fe, Mn	<i>Metallic bonding:</i> Valence electrons form mobile sea of electrons which comprise the metallic bond.
2. Ionic Crystals (Ionic Solids) Ex: NaCl, MgCl ₂ , MgO	<i>Ionic Bonding/Ion-dipole:</i> Attraction of charged ions for one another. Lattice energy is a measure of ionic bond strength. Attractive force between an ion and an oppositely charged end of a permanent dipole possessed by a neutral molecule.
3. Network Covalent Crystals Ex: C _(diamond) , SiC(s), SiO ₂ (quartz)	<i>Network covalent bonding.</i> Network solids are extremely hard compounds with very high melting and boiling points due to their endless 3-dimensional network of covalent bonds.
4. Molecular Crystals (a) Need H bonded to O, N or F: Ex: H ₂ O, HF, NH ₃ . (b) CHF ₃ , CH ₃ COCH ₃ (acetone) and H ₂ O, HF, NH ₃ . (c) C ₆ H ₆ (benzene), polyethylene, I ₂ , F ₂ , and all the compounds from (a) and (b) above.	One or more of the following: (a) <i>Hydrogen bonding:</i> Hydrogen bonds are weaker than covalent bonds, but stronger than (b) or (c) below. A hydrogen atom attached to one of these three elements possesses a substantial partial positive charge. The positive end of each of the bond dipoles (H atom) is capable of strongly interacting with an unshared electron pair possessed by N, O, or F atom of an adjacent molecule. (b) <i>Dipole-dipole forces:</i> these forces act between <i>polar</i> molecules. They are much weaker than hydrogen bonding. Positive end of permanent dipole on one molecule aligns itself with negative end of permanent dipole on another molecule. Only significant in effect when molecules are close together. They usually dominate over (c) below. (c) <i>Dispersion forces</i> (induced dipole – induced dipole or London dispersion forces): universal force of attraction between instantaneous dipoles. These forces are weak for small, low-molecular weight molecules, but greater for heavy, long, and/or highly <i>polarizable</i> molecules with increasing molecular volume. Short-range attractive forces between molecules resulting from momentary mutual distortion (polarization) of electron clouds.
5. Atomic Crystals Ex: He, Ne, Ar, Kr, Xe	<i>Dispersion forces:</i> See Section 4(c) above.

*Note: Many of the compounds given as examples are *not* solids at room temperature. But if you cool them down to a low enough temperature, eventually they will become solids.

- The physical properties of a substance depend on its intermolecular forces. The stronger the forces between particles,
 - the higher / lower the melting point.
 - the higher / lower the boiling point.
 - the higher / lower the vapor pressure.
 - the higher / lower the viscosity (resistance to flow).
 - the higher / lower the surface tension (resistance to an increase in surface area).
- What type of crystal will each of the following substances form in its solid state? Choices to consider are metallic, ionic, covalent, or molecular crystals.

(a) C ₂ H ₆ _____	(d) CO ₂ _____	(g) Al _____
(b) Na ₂ O _____	(e) N ₂ O ₅ _____	(h) C(diamond) _____
(c) SiO ₂ _____	(f) NaNO ₃ _____	(i) SO ₂ _____
- Circle **all** the compounds in the following list which would be expected to form intermolecular hydrogen bonds in the liquid state:

(a) CH ₃ OCH ₃ (dimethyl ether)	(b) CH ₄	(c) HF	(d) CH ₃ CO ₂ H	(e) Br ₂	(f) CH ₃ OH (methanol)
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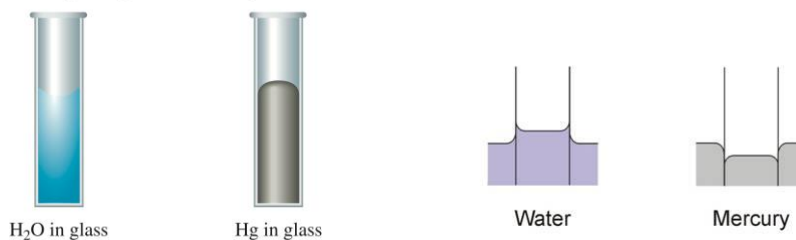
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4. Identify the most important types of intermolecular forces present in the solids of each of the following substances.
- a. Ar: _____ d. CaCl_2 : _____ g. NaNO_3 : _____
- b. HCl: _____ e. CH_4 : _____ h. I_2 : _____
- c. HF: _____ f. CO: _____ i. H_2O_2 : _____
5. Predict which substance in each of the following pairs would have the greater intermolecular forces. Explain.
- a. CO_2 or OCS: _____
- b. SeO_2 or SO_2 : _____
- c. $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$ or $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$: _____
- d. CH_3CH_3 or H_2CO : _____
- e. CH_3OH or H_2CO : _____
6. The shape of the meniscus of water in a glass tube is different from that of mercury in a glass tube? Why?



7. Hydrogen peroxide (H_2O_2) is a syrupy liquid with a relatively low vapor pressure and a normal boiling point of 152.2°C . Rationalize the differences of these physical properties from those of water.
- _____
- _____
- _____
8. Specify the *predominant intermolecular force* involved for each substance in the space immediately following the substance. *Then in the last column, indicate which member of the pair you would expect to have the higher boiling point.*

Substance #1	Predominant Intermolecular Force	Substance #2	Predominant Intermolecular Force	Substance with Higher Boiling Point
(a) HCl(g)		I_2		
(b) CH_3F		CH_3OH		
(c) H_2O		H_2S		
(d) SiO_2		SO_2		
(e) Fe		Kr		
(f) CH_3OH		CuO		
(g) NH_3		CH_4		
(h) HCl(g)		NaCl		
(i) SiC		Cu		