Chapter 11 + 9: Polarity, Binding Forces, Noncovalent Interactions, and Dependent Physical Properties

Types of Binding Forces

1) Covalent bonds (between nonmetals)
2) Ionic bonds (between metal and nonmetal)
3) Metallic bonds (within pure metals)
4) Noncovalent Interactions (in decreasing strength)
   - Hydrogen Bonds (O-H, N-H, or F-H bonds)
   - Dipole-dipole Attractions (for polar molecules, but lacking any O-H, N-H, or F-H bonds)
   - London Forces (only binding force between nonpolar molecules, but also applies in polar and H-bonding molecules. Increases with increasing molecular weight.)

Network vs Molecular Substances

- Network (usually identifiable by presence of a metal!)
  - Ionic
  - Metallic
  - Network Covalent (diamond…)
- Molecular (usually identifiable by absence of a metal)

Network binding forces are strong, molecular binding forces are relatively weak

Recognizing Polarity

1. AB_m	Nonpolar	If no lone pairs on central, and all outside atoms same.
2. AB_mL_N	Polar.	If lone pairs on central atom.
3. AB_mL_n	Weakly polar	No lone pairs on central atom, but attached atoms not same.
4. Hydrocarbons	Nonpolar	
5. Halocarbons	Very weakly polar	

Ranking substances in terms of relative binding forces:

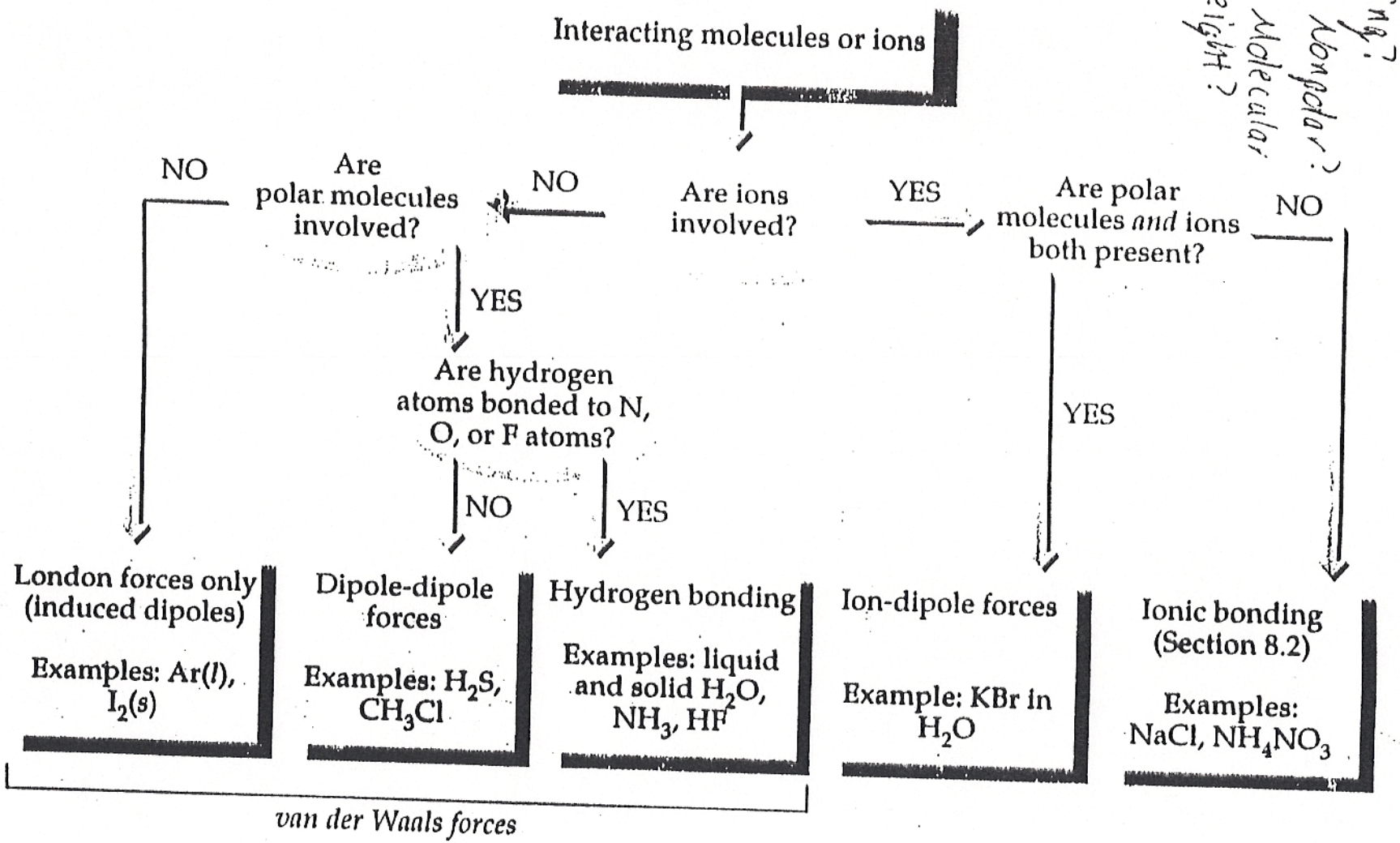
1. Identify network substances versus molecular substances
2. For molecular substances
   a. H-bonding?
   b. polar?
3. For molecular substances, what is the molecular weight? Greater molecular weight gives greater binding force.

Note: when molecular weight effects counteract H-bonding or polar effects (such as methanol versus acetone versus hexane!) you are not expected to be able to predict which has stronger binding forces, except for special cases like H_2O.

Predictable Properties that Depend on Binding Forces

1. mp	Higher binding force –> higher mp
2. ΔH_f	Higher binding force –> higher ΔH_f
3. bp	Higher binding force –> higher bp
4. ΔH_v	Higher binding force –> higher ΔH_v
5. evaporation rate/volatility	Higher binding force –> lower evaporation rate
6. vapor pressure	Higher binding force –> lower vapor pressure
7. viscosity	Higher binding force –> higher viscosity
8. surface tension	Higher binding force –> higher surface tension
9. solubility	higher solute/solvent binding force –> higher solubility

Fig. 11.12 Flowchart of Intermolecular Forces



Questions
① Ionic or Molecular? (Network or Molecular)
② H-bonding?
③ Polar or Nonpolar?
④ What is Molecular weight?

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Figure 11.7

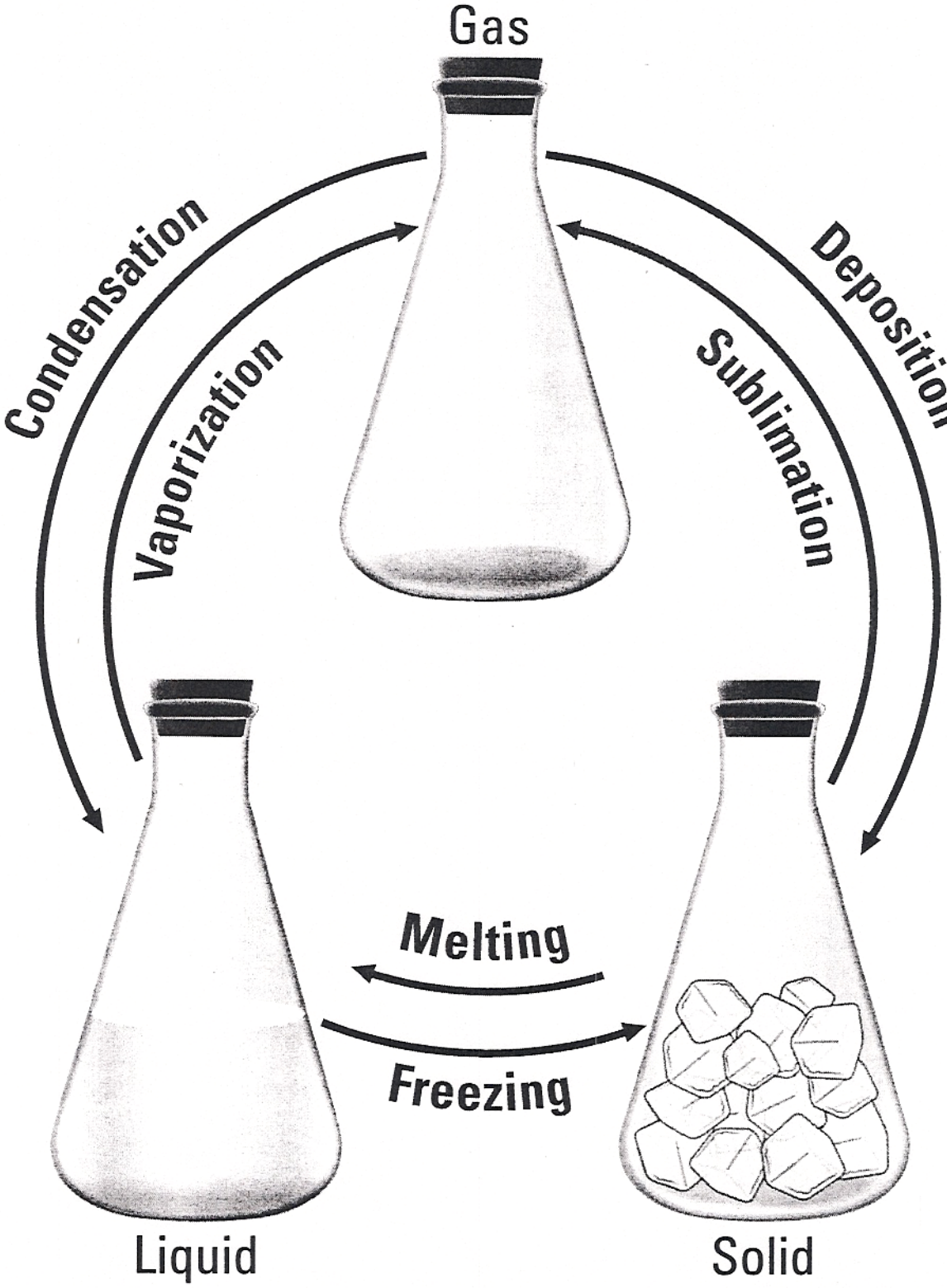

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Figure 11.12

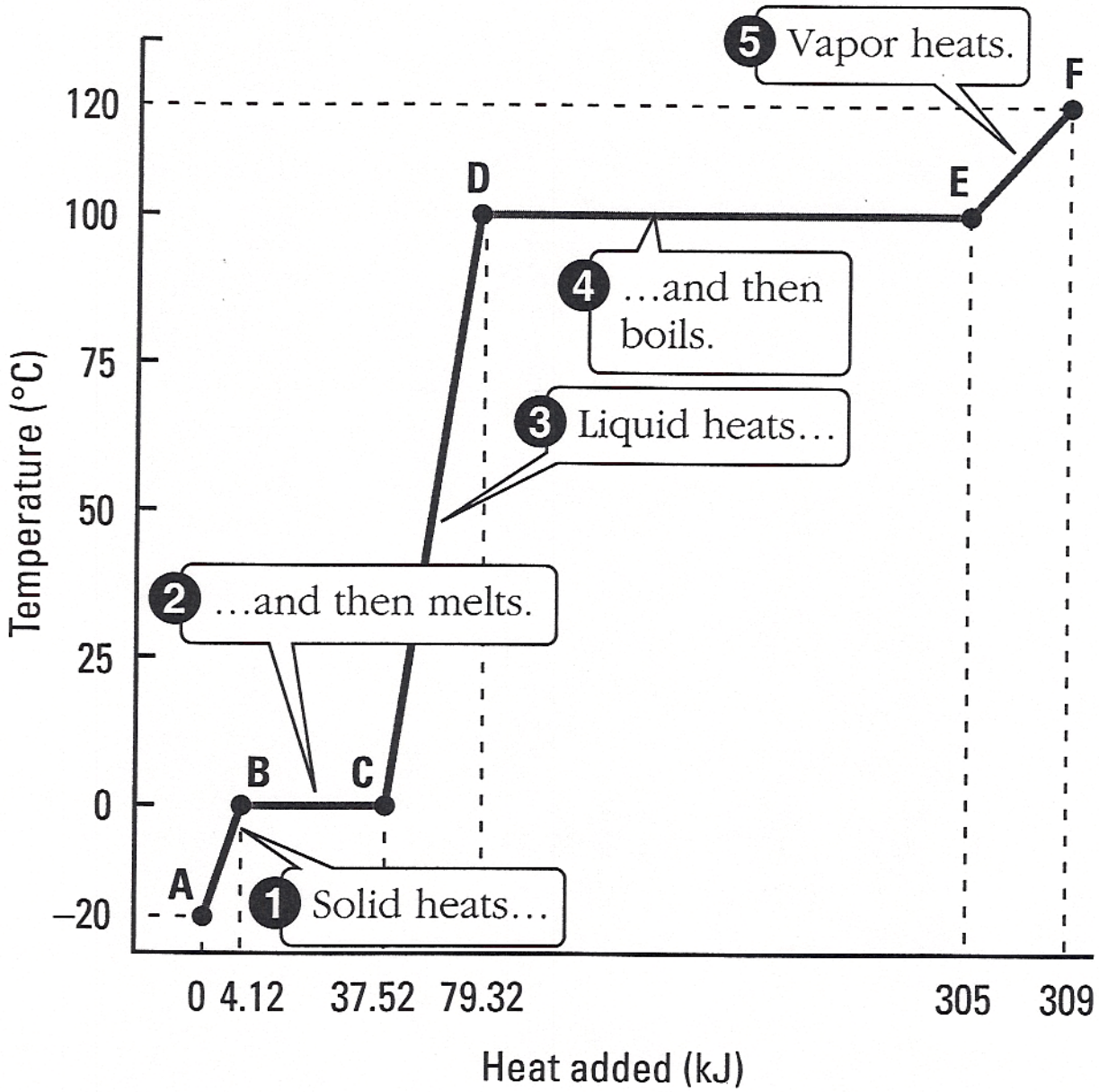

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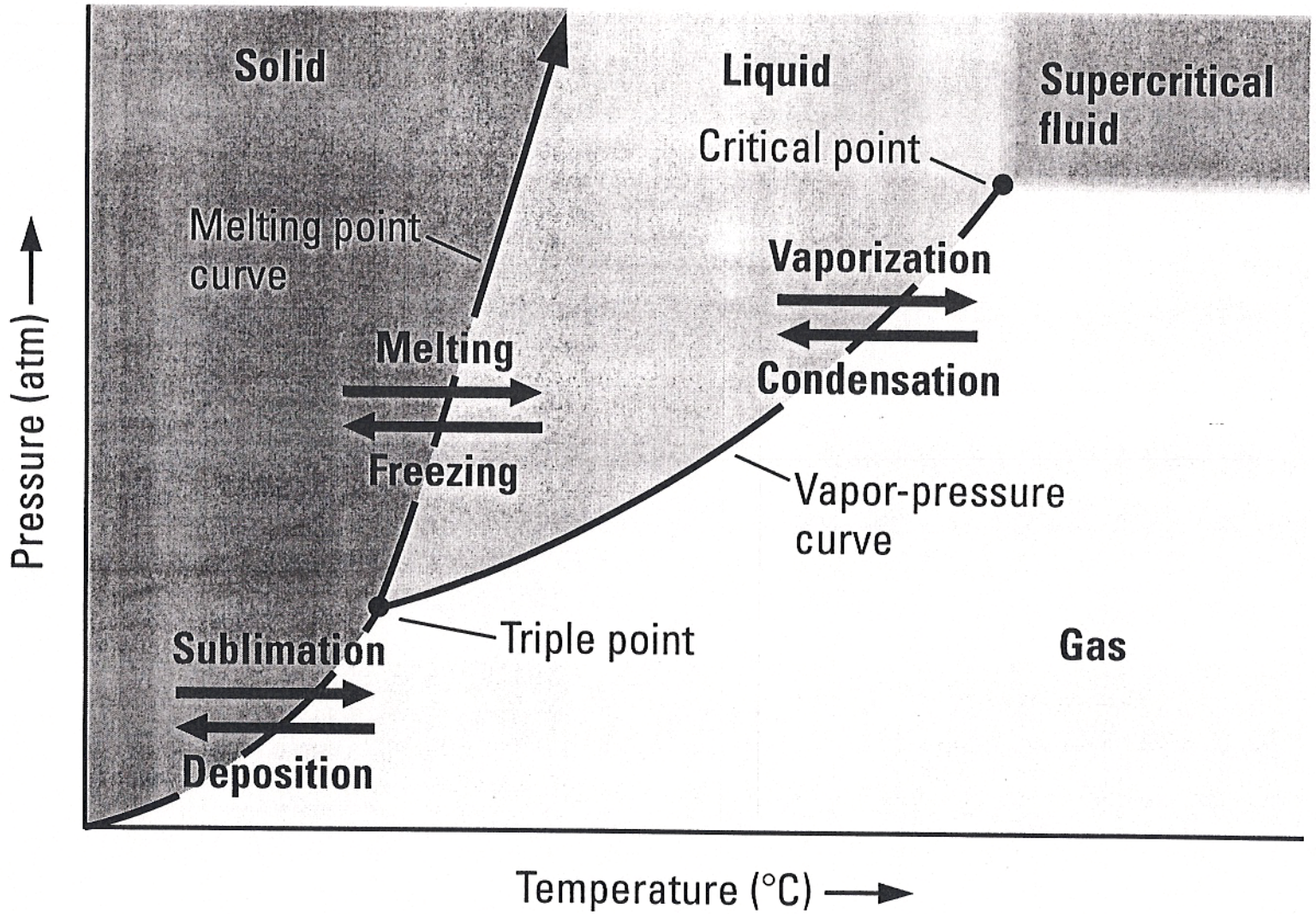
Figure 11.13



Generic Phase Diagram

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11.4 Wonderful Water: Special Properties

① Given small size/mass, amazing that its liquid!

	Mass	bp		Mass	bp
N_2	28	−196	HF	20	−164
O_2	32	−183	H_2S	34	−60
CO_2	44	−78	NH_3	17	−33
CH_4	18	−161	H_2O	18	+100 liqu

② "Universal Solvent"
- far more substances dissolve in water than any other liquid ⇒ both ionic + molecula

③ Density (unique phase diagram)
- other solids more dense than liquids ⇒ sink!
- solid water (ice) unique in that it floats ⇒ impact on water life
- "turnover" (4° water sinks ⇒ O_2, nutrients exchan

④ Earth's "Air Conditioner" (+Body)
- exceptional heat capacity
- coolant in summer, heater in winter
- sweat/evaporation keeps us from overheating

⑤ High surface tension
- bugs, [redacted] ships

H-bonding special reason

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Table 11.5

TABLE 11.5 Structures and Properties of Various Types of Solid Substances

Type	Examples	Structural units	Forces holding units together	Typical properties
Ionic (⇐ *p. 86*)	$NaCl$, K_2SO_4, $CaCl_2$, $(NH_4)_3PO_4$	Positive and negative ions (some polyatomic); no discrete molecules	Ionic bonding; attractions among charges on positive and negative ions	Hard; brittle; high melting point; poor electrical conductivity as solid, good as liquid; often water-soluble
Metallic (Section 11.8)	Iron, silver, copper, other metals and alloys	Metal atoms (or positive metal ions surrounded by an electron sea)	Metallic bonding; electrostatic attraction among metal ions and electrons	Malleability; ductility; good electrical conductivity in solid and liquid; good heat conductivity; wide range of hardness and melting points
Molecular (⇐ *p. 75*)	H_2, O_2, I_2, H_2O, CO_2, CH_4, CH_3OH, CH_3COOH	Molecules with covalent bonds	London forces, dipole-dipole forces, hydrogen bonds	Low to moderate melting points and boiling points; soft; poor electrical conductivity in solid and liquid
Network (Section 11.10)	Graphite, diamond, quartz, feldspars, mica	Atoms held in an infinite one-, two-, or three-dimensional network	Covalent bonds; directional electron-pair bonds	Wide range of hardnesses and melting points (three-dimensional bonding > two-dimensional bonding > one-dimensional bonding); poor electrical conductivity, with some exceptions
Amorphous (glassy)	Glass, polyethylene, nylon	Covalently bonded networks of atoms or collections of large molecules with no long-range regularity in their arrangement	Covalent; directional electron-pair bonds	Noncrystalline; wide temperature range for melting; poor electrical conductivity, with some exceptions

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