Intermolecular Forces

Chapter 4
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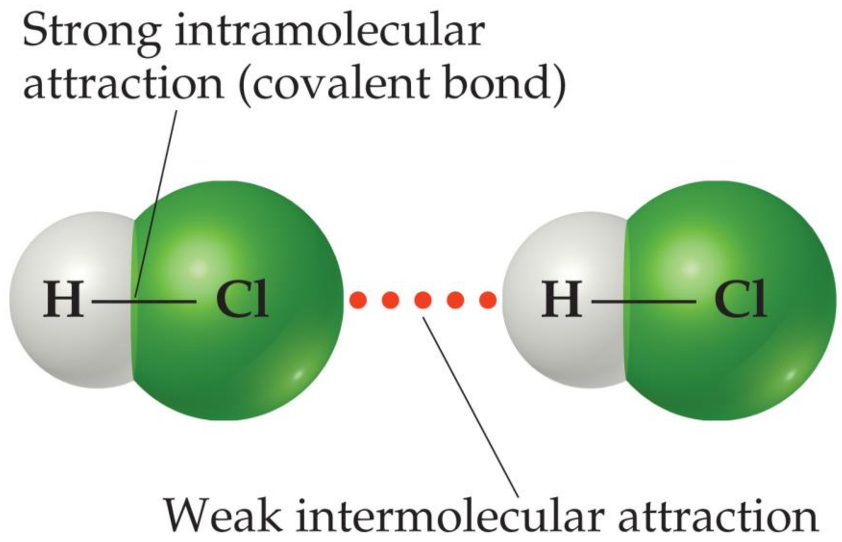
TYPES OF INTERMOLECULAR FORCE

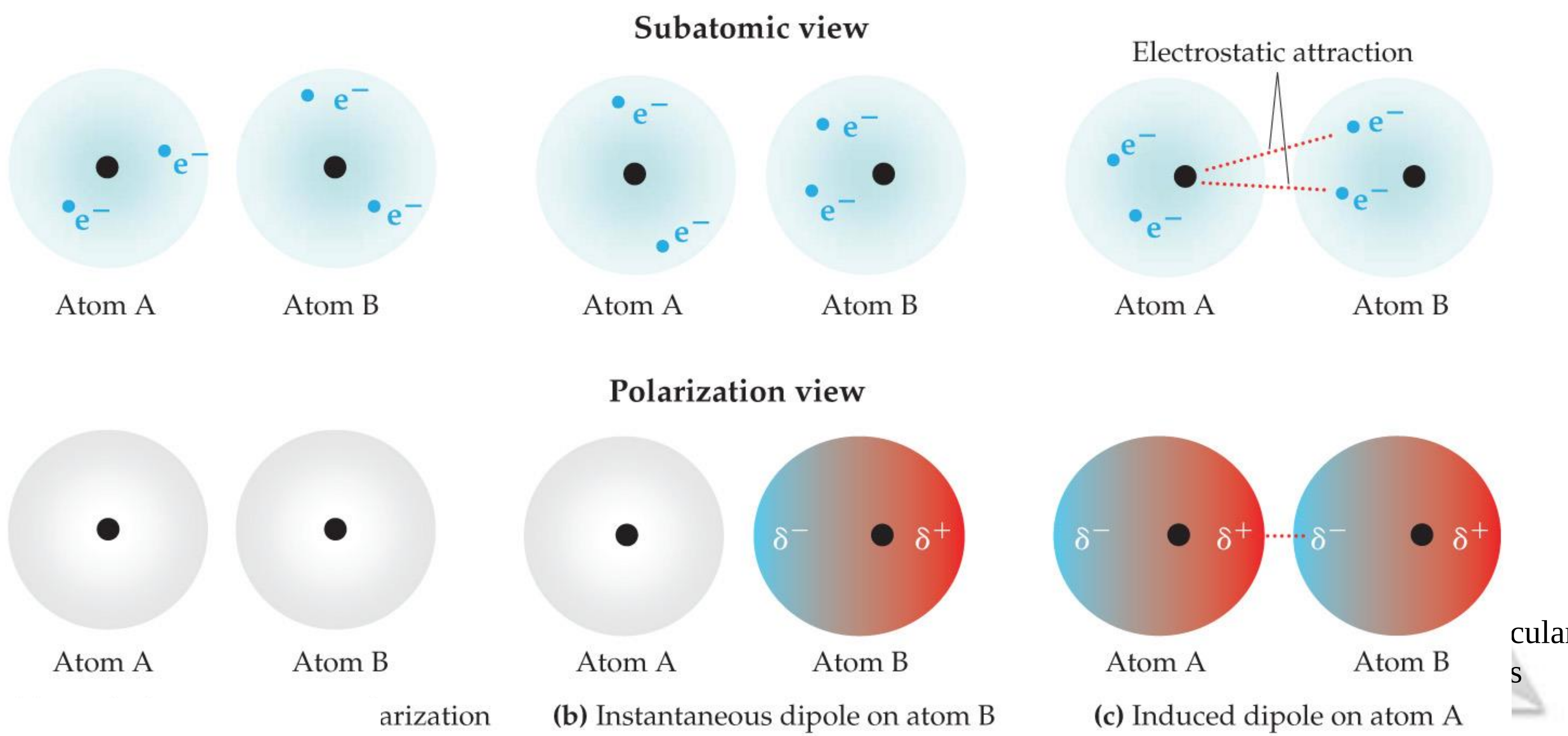
- van der Waals' forces (which are also called dispersion
- forces and temporary dipole–induced dipole forces)
- permanent dipole–dipole forces
- hydrogen bonding.



- The attractions between molecules are not nearly as strong as the intramolecular attractions (bonds) that hold compounds together.
- Many physical properties reflect intermolecular forces, like boiling points, melting points, viscosity, surface tension, and capillary action.

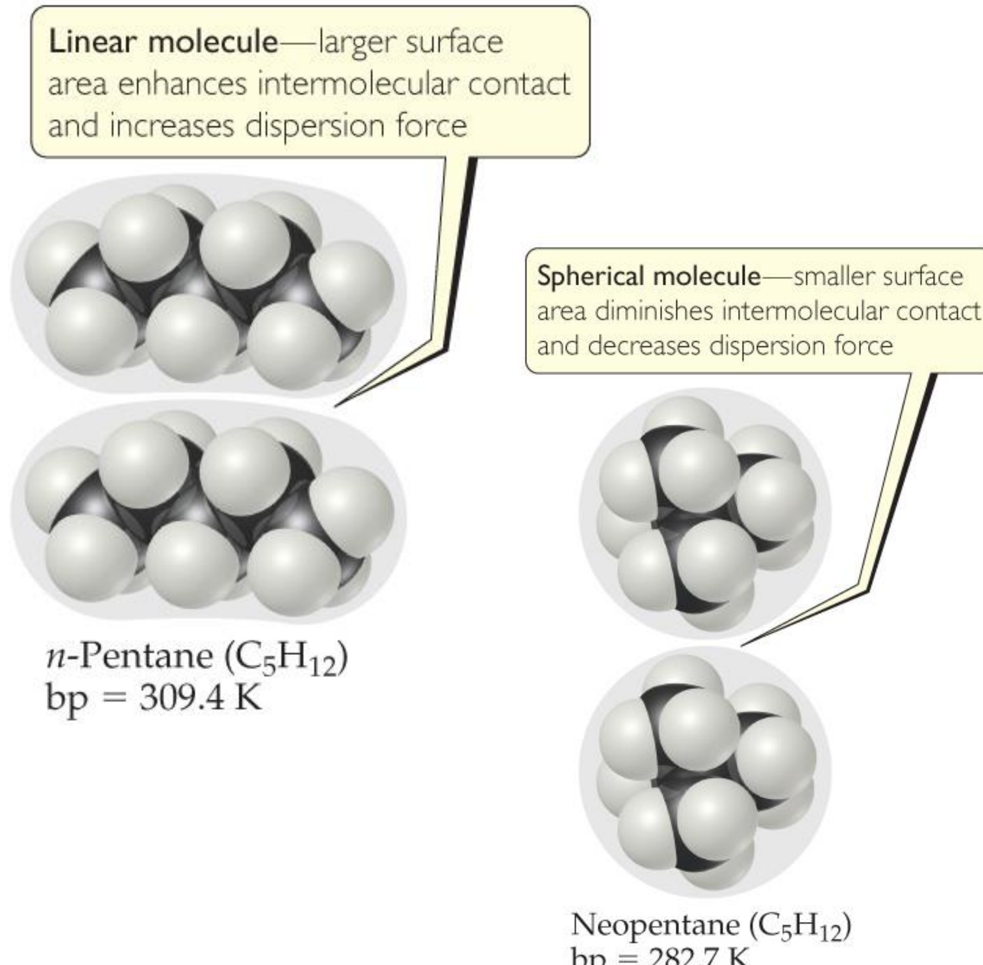
DISPERSION FORCES

- The figure below shows how a nonpolar particle (in this case a helium atom) can be temporarily polarized to allow dispersion force to form.
- The tendency of an electron cloud to distort is called its **polarizability**.



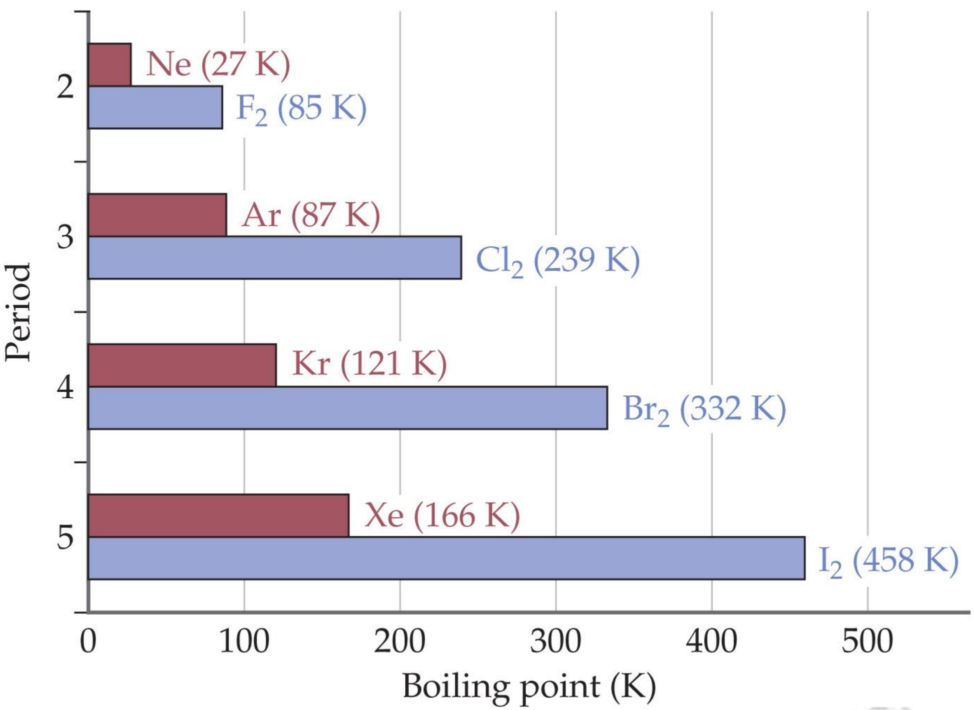
FACTORS WHICH AFFECT AMOUNT OF DISPERSION FORCE IN A MOLECULE

- number of electrons in an atom (more electrons, more dispersion force)
- size of atom or molecule/molecular weight
- shape of molecules with similar masses (more compact, less dispersion force)



POLARIZABILITY & BOILING POINT

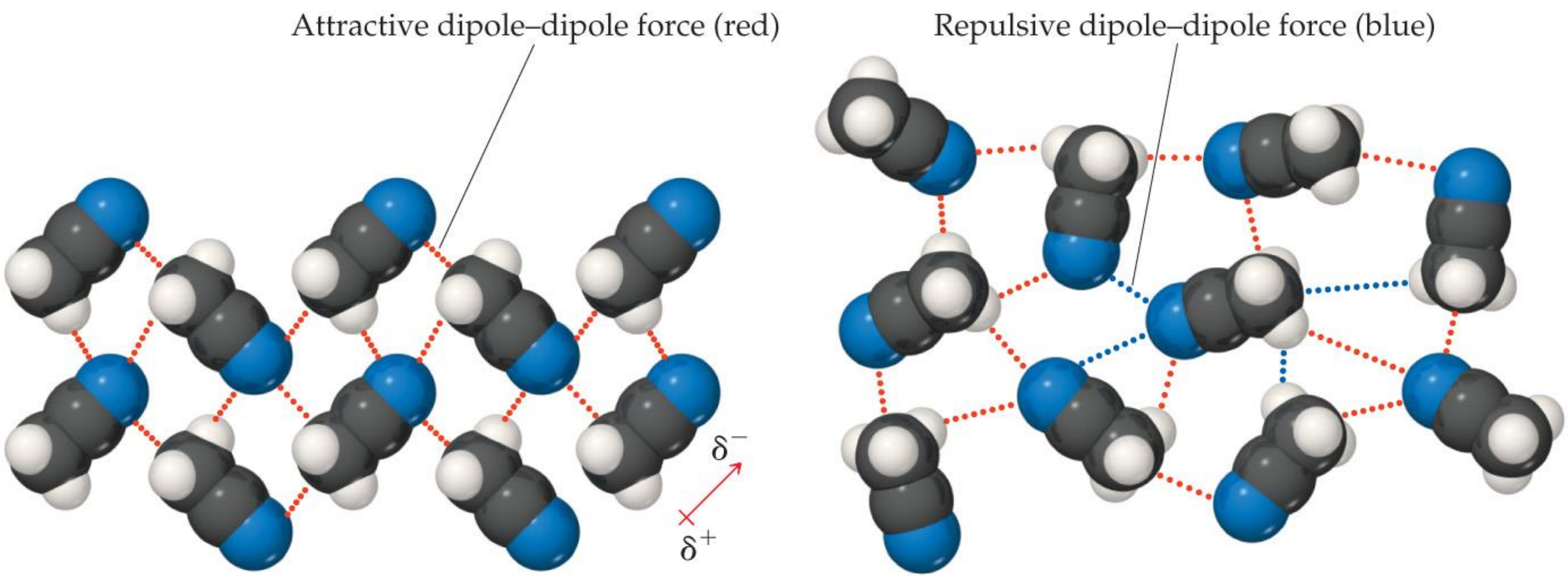
- If something is easier to polarize, it has a *lower* boiling point.
- Remember: This means *less* intermolecular force (smaller molecule: lower molecular weight, fewer electrons).



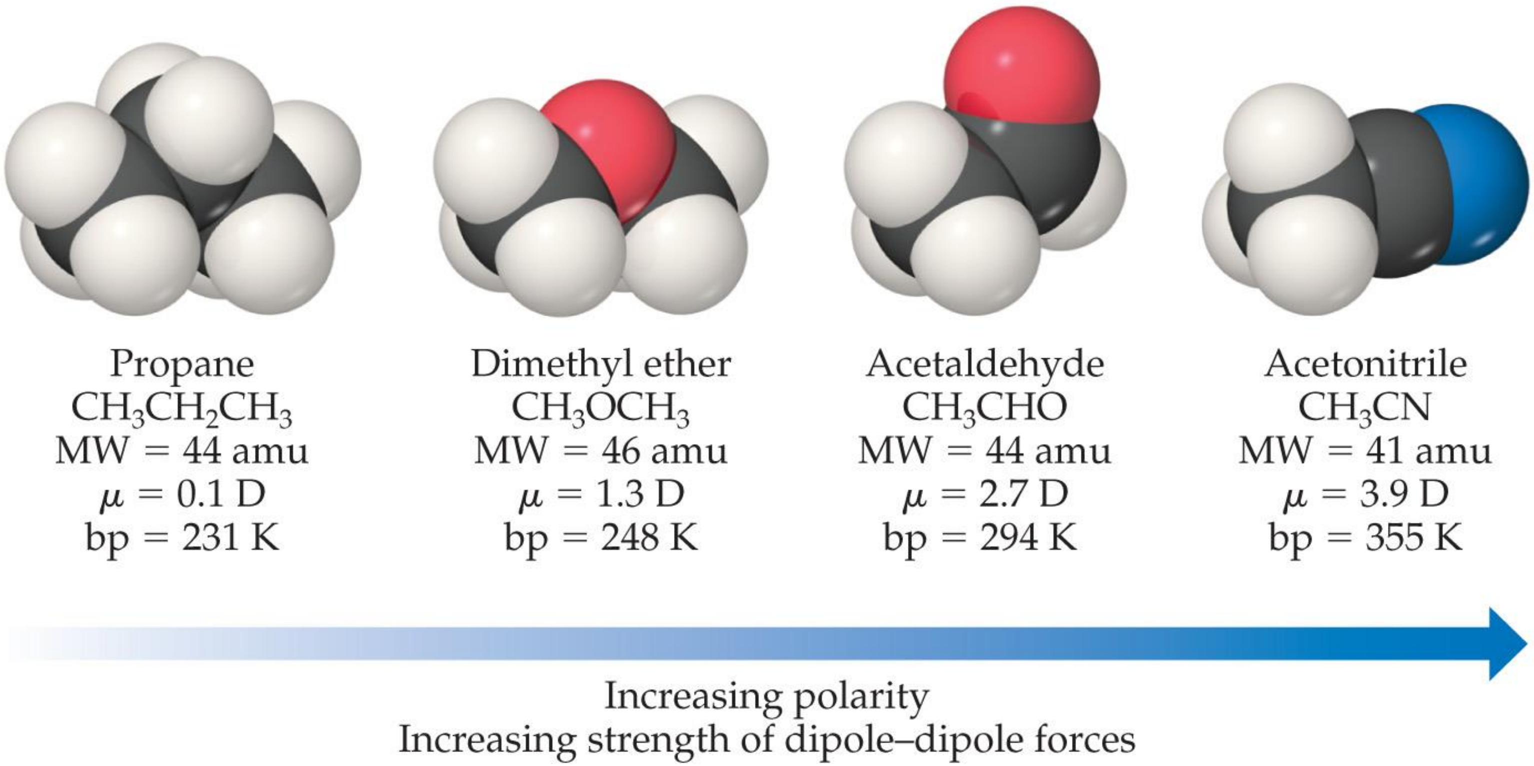
Intermolecular Forces

DIPOLE–DIPOLE INTERACTIONS

- Polar molecules have a more positive and a more negative end–a dipole (two poles, δ^{+} and δ^{-}).
- The oppositely charged ends attract each other.



(a) Solid CH_3CN **(b)** Liquid CH_3CN



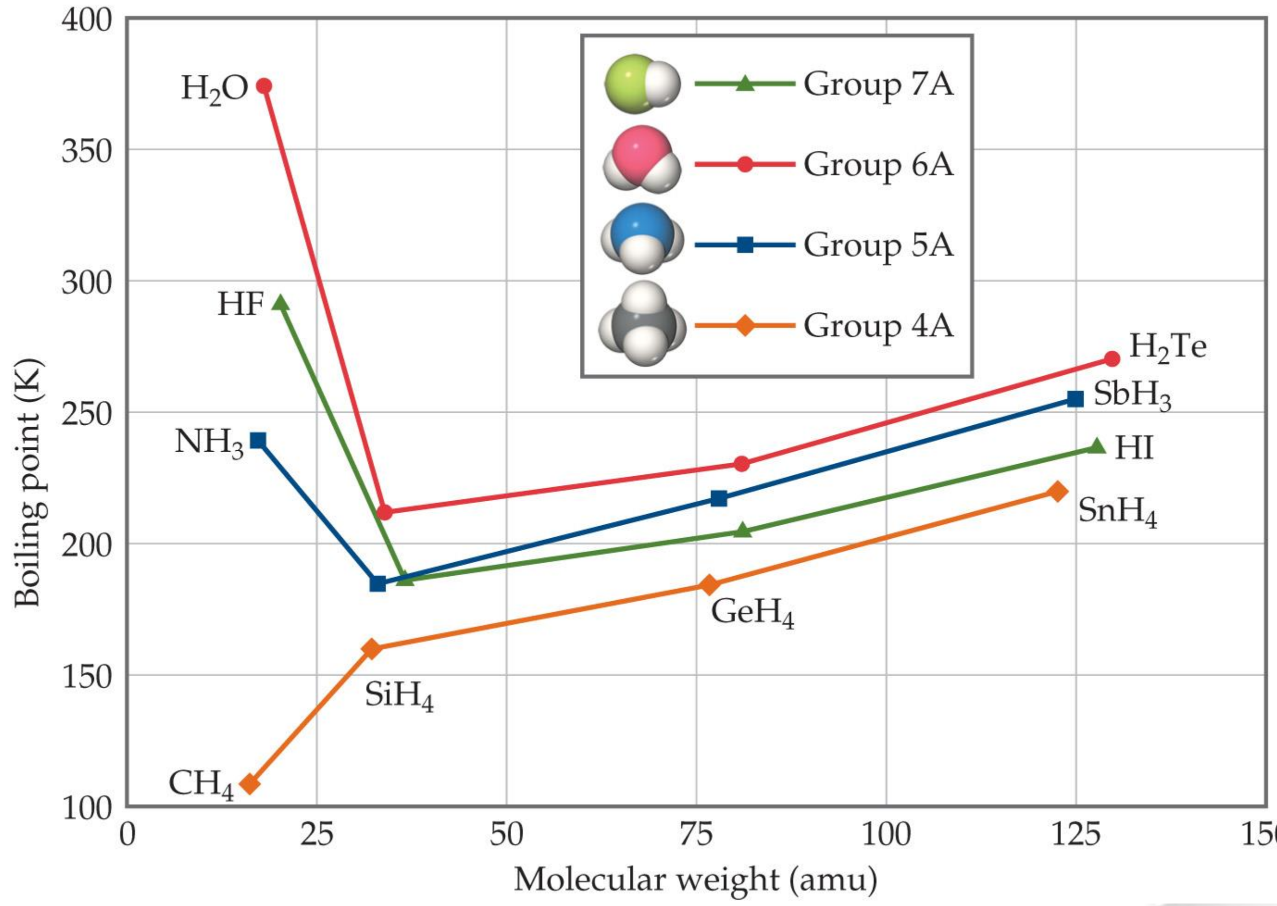
For molecules of approximately equal mass and size, the more polar the molecule, the higher its boiling point.

WHICH HAVE A GREATER EFFECT: DIPOLE–DIPOLE INTERACTIONS OR DISPERSION FORCES?

- If two molecules are of comparable size and shape, dipole–dipole interactions will likely be the dominating force.
- If one molecule is much larger than another, dispersion forces will likely determine its physical properties.

WHAT DOES THIS GRAPH SHOW US?

- In a group, the period 3/4/5 elements have higher boiling points as the group member gets larger.
- What happens with the period 2 elements?
- For group 4A, the trend is continued. What about for the other groups?



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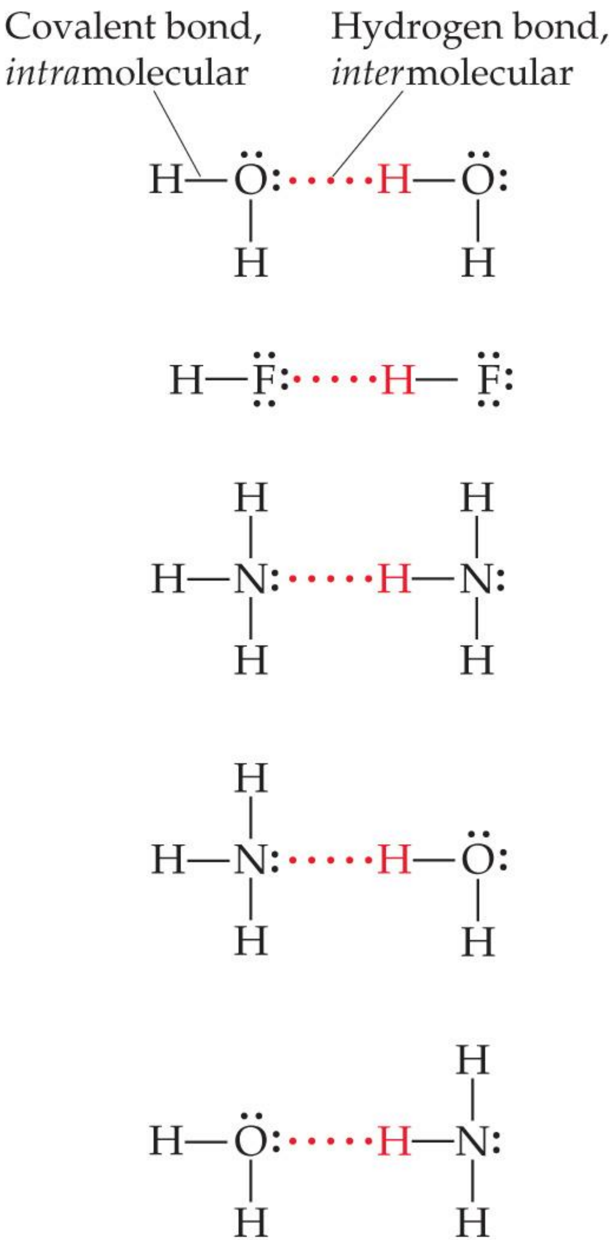
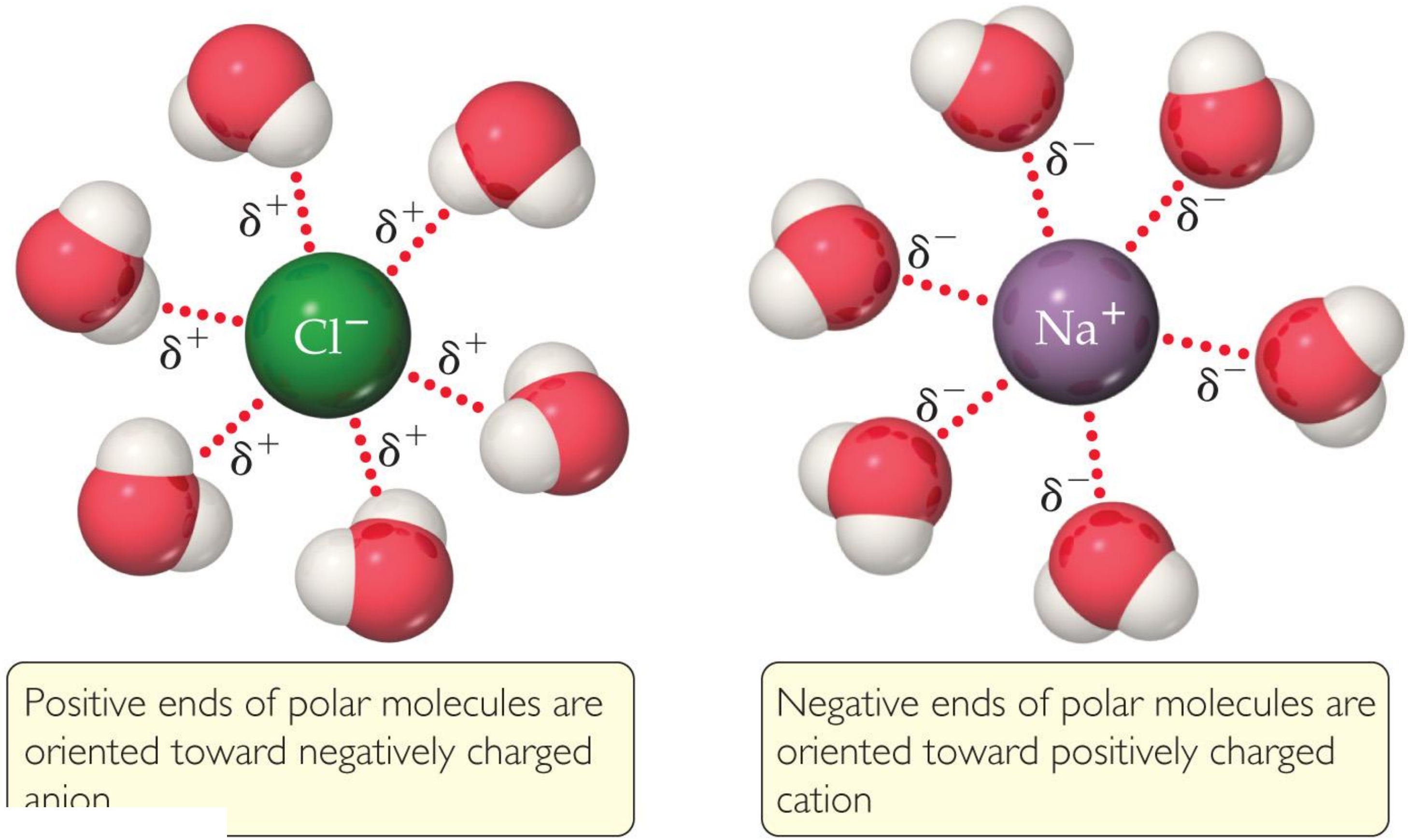
- The dipole–dipole interactions experienced when H is bonded to N, O, or F are unusually strong.
- We call these interactions **hydrogen bonds**.
- A hydrogen bond is an attraction between a hydrogen atom attached to a highly electronegative atom and a nearby small electronegative atom in another molecule or chemical group.



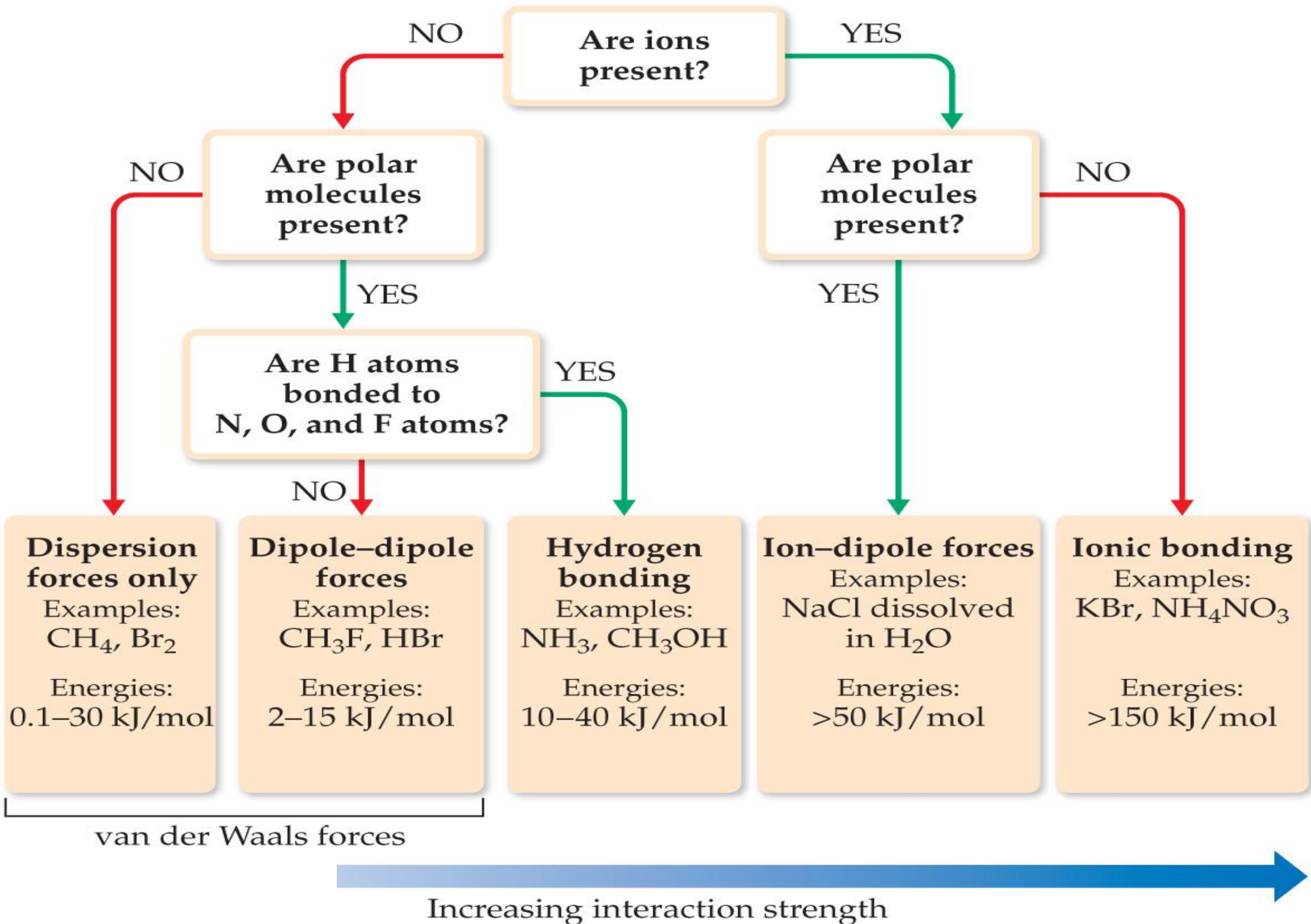
WHAT FORMS HYDROGEN BONDS?

- Hydrogen bonding arises in part from the high electronegativity of nitrogen, oxygen, and fluorine.
- These atoms interact with a nearly bare nucleus (which contains one proton).

- Ion–dipole interactions are found in solutions of ions.
- The strength of these forces is what makes it possible for ionic substances to dissolve in polar solvents.



SUMMARIZING INTERMOLECULAR FORCES



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LIQUID PROPERTIES AFFECTED BY INTERMOLECULAR FORCES

- boiling point (previously discussed) and melting point
- viscosity
- surface tension
- capillary action

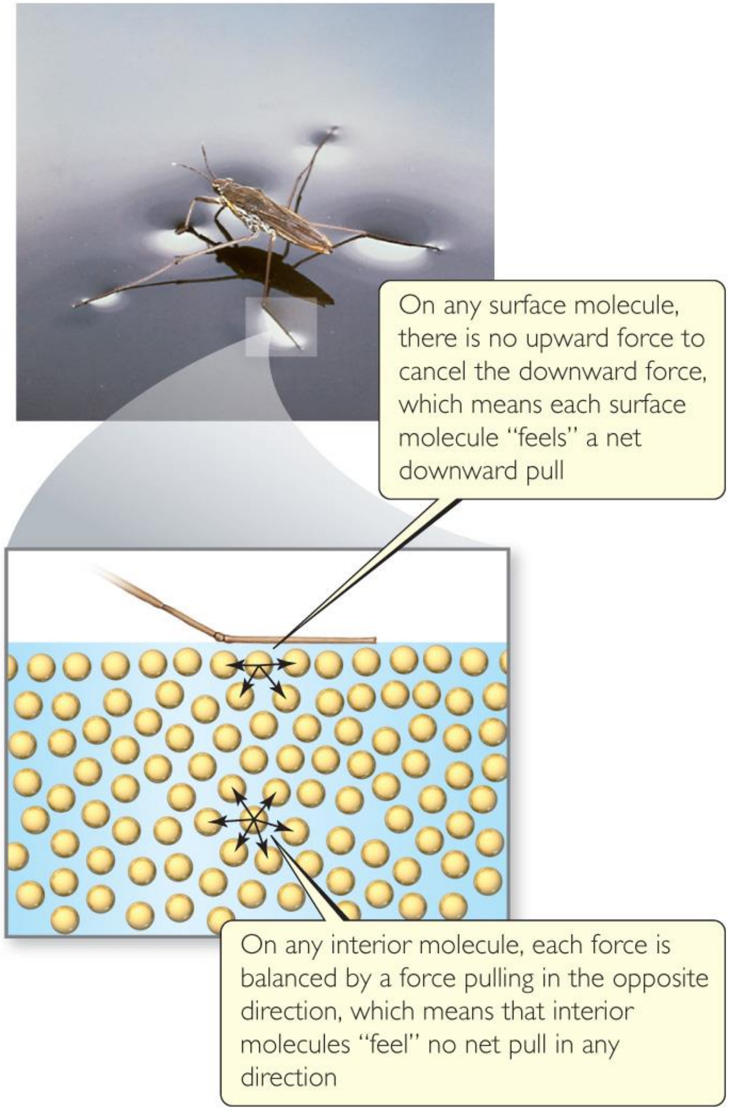
- Resistance of a liquid to flow is called **viscosity.**
- It is related to the ease with which molecules can move past each other.
- Viscosity increases with stronger intermolecular forces and decreases with higher temperature.

SAE 40
higher number
higher viscosity
slower pouring

SAE 10
lower number
lower viscosity
faster pouring

Table 11.5 Viscosities of a Series of Hydrocarbons at 20 °C

Substance	Formula	Viscosity (kg/m-s)
Hexane	$CH_3CH_2CH_2CH_2CH_2CH_3$	3.26×10^{-4}
Heptane	$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$	4.09×10^{-4}
Octane	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	5.42×10^{-4}
Nonane	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	7.11×10^{-4}
Decane	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	1.42×10^{-3}



- Water acts as if it has a "skin" on it due to extra inward forces on its surface. Those forces are called the **surface tension**.