[TP] Which of the following are associated with intramolecular forces (forces within a molecule)?

13% 1. Fog forms on a cold morning
13% 2. Wet clothes are hung out to dry
13% 3. Ice melts
13% 4. 1 and 2
13% 5. 1 and 3
13% 6. 2 and 3
13% 7. All of the above
13% 8. None of the above

Response Counter 10

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# Lecture 14 CH101 A2 (MWF 11:15 am)

Tuesday, October 10, 2017

For today ...

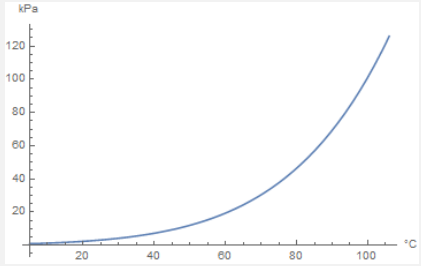
- Review: Vapor pressure and "boiling"
- Intermolecular forces
- Hydrogen bonding
- Polarity

Next lecture: Dipole-dipole interaction versus temporary dipole attraction (dispersion); Relative boiling points



## Vapor pressure and boiling

Vapor pressure rises with temperature.

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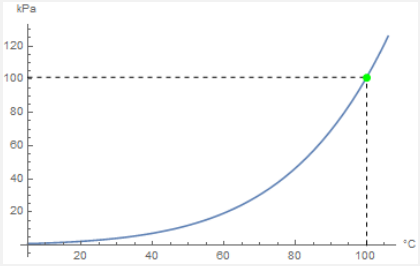
## Vapor pressure and boiling

Bubbles appear when vapor pressure = applied pressure

"Normal" boiling point is when vapor pressure is exactly 1 atm = 101.325 kPa

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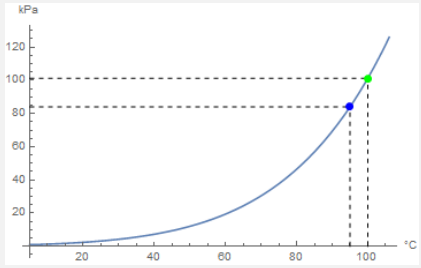
## Vapor pressure and boiling

Bubbles appear when vapor pressure = applied pressure

A vacuum pump allows boiling at lower temperature.

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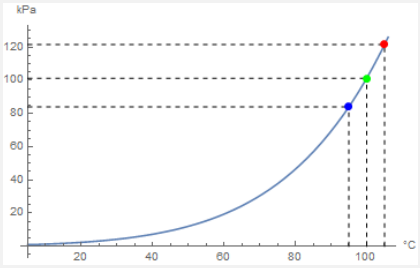
## Vapor pressure and boiling

Bubbles appear when vapor pressure = applied pressure

A pressure cooker delays boiling to higher temperature.

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## Intramolecular and intermolecular forces

Intermolecular forces are forces of attraction between molecules

Chemical changes are related to breaking and formation of covalent bonds due to intramolecular forces within molecules.

Physical changes are governed by intermolecular forces

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[TP] Which of the following are associated with intramolecular forces (forces within a molecule)?

13% 1. Fog forms on a cold morning
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13% 4. 1 and 2
13% 5. 1 and 3
13% 6. 2 and 3
13% 7. All of the above
13% 8. None of the above

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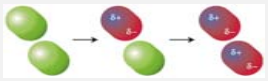
## Intermolecular forces: stickiness!

A molecules attract one another, because of the attraction of opposite electrical charges.

Most specific and strongest is "hydrogen bonding": X—H · · · Y

More common and intermediate strength is "dipole-dipole attraction":

Always present and weakest is "temporary dipole attraction" ("dispersion interaction"):



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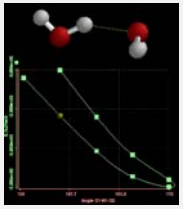
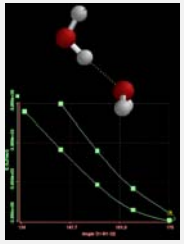
## Hydrogen bond angle is 180°

| | | |
|---|---|---|
| N—H - - - :N— | O—H - - - :N— | F—H - - - :N— |
| N—H - - - :O— | O—H - - - :O— | F—H - - - :O— |
| N—H - - - :F— | O—H - - - :F— | F—H - - - :F— |





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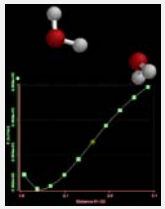
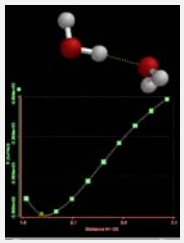
## Hydrogen bonds are longer than typical bonds

| | | |
|---|---|---|
| N—H - - - :N— | O—H - - - :N— | F—H - - - :N— |
| N—H - - - :O— | O—H - - - :O— | F—H - - - :O— |
| N—H - - - :F— | O—H - - - :F— | F—H - - - :F— |





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## Which of the following cannot form H bonds?

- Ammonia, $NH_3$
- Methanol, $CH_3OH$
- Ethanol, $CH_3CH_2OH$
- Dimethyl ether, $CH_3OCH_3$

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[Quiz] Which of the following cannot form hydrogen bonds with themselves?

0% 1. Ammonia, $NH_3$
0% 2. Methanol, $CH_3OH$
0% 3. Ethanol, $CH_3CH_2OH$
0% 4. Dimethyl ether, $CH_3OCH_3$
0% 5. 1 and 3
0% 6. 1 and 4
0% 7. 2 and 4
0% 8. All of the above can form hydrogen bonds with themselves





## Dipole-dipole attraction

Molecules must be "polar"


What makes a molecule polar is unequal sharing of electron clouds.

Sharing tendency is proportional to electronegativity difference.

The greater the difference of electronegativities,
the more unequal the sharing,
the more polar the shared electron cloud.





## Electronegativity χ: Relative pull

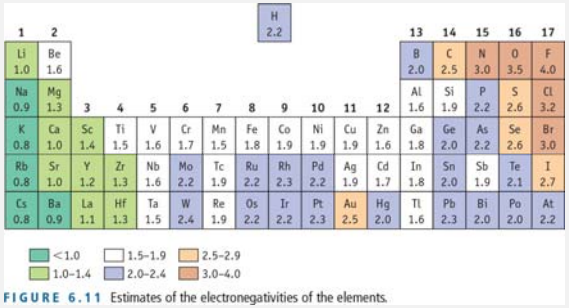


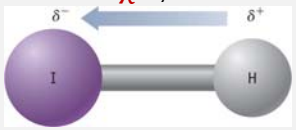

FIGURE 6.11 Estimates of the electronegativities of the elements.

The larger χ the more piggish the atom





## The more different the χ's, the more polar the bond

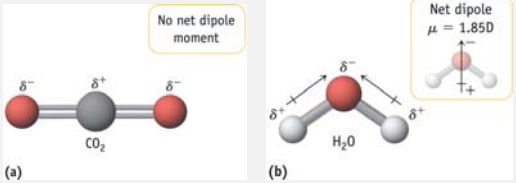



- If two bonded atoms are different, the one with larger χ gets more of the shared electron cloud
- Atom with larger χ has net negative charge; atom with smaller χ has net positive charge
- The larger the difference in χ, the greater the charge separation (unequal sharing of electron cloud)
- Result is a polar bonds

## Molecular polarity

- If bond dipoles cancel, molecule is nonpolar
- If bond dipoles do not cancel, molecule is polar




Let's illustrate, for $BF_3$ and $BH_2F$

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## Consider polarity of the following

- $BFCl_2$, whose shape is trigonal-planar, like that of $BF_3$
- $SCl_2$, which is a bent molecule, like $H_2O$
- $NH_2Cl$, whose shape is trigonal-pyramidal, like that of $NH_3$
- OCS, which is a linear molecule, like $CO_2$

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[TP] Which of the following molecules are not polar?

17% 1. $BFCl_2$, whose shape is trigonal-planar, like that of $BF_3$
17% 2. $SCl_2$, which is a bent molecule, like $H_2O$
17% 3. $NH_2Cl$, whose shape is trigonal-pyramidal, like that of $NH_3$
17% 4. OCS, which is a linear molecule, like $CO_2$
17% 5. All of the above are nonpolar
17% 6. All of the above are polar

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[Quiz] Which of the following statements is true about carbon dioxide, O=C=O?

25% 1. $CO_2$ contains polar bonds and is a polar molecule
25% 2. $CO_2$ contains polar bonds, but is not a polar molecule
25% 3. $CO_2$ does not contain polar bonds and is not a polar molecule
25% 4. $CO_2$ does not contain polar bonds but is a polar molecule

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Dipole-dipole versus dispersion

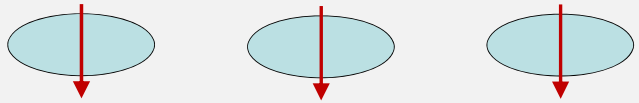


## Permanent dipoles

Sketch a second molecule arranged so that it ...

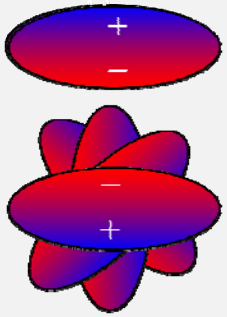
attracts maximally repels maximally neither attracts nor repels





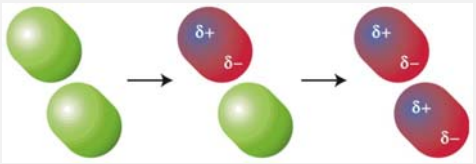
## Dipole can be attractive or repulsive





## Dispersion forces are due to induced dipoles



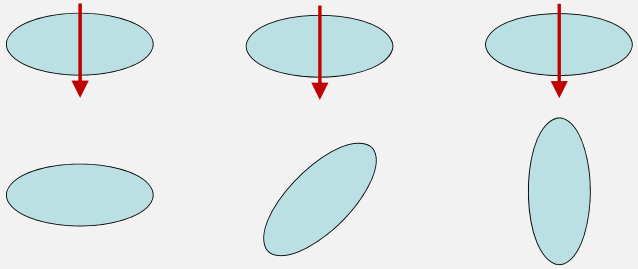


## Induced dipoles

Sketch the induced dipole in each case:



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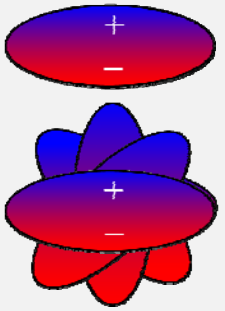
## Dispersion always attractive

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