Chapter 11 – focus points:

**Intermolecular forces and their effect on properties of liquids**

Intermolecular (or interparticle) forces are weak interactions between particles. They decrease as you go from solid → liquid → gas. Remember that in a gas the particles have the highest degree of freedom of movement and negligible or weak intermolecular forces.

As the intermolecular attraction increases,

- **The vapor pressure** (the pressure of the vapor that is in equilibrium with its liquid) decreases
- **The boiling point** (the temperature at which the vapor pressure becomes equal to the pressure exerted on the surface of the liquid) *increases*
- **Surface tension** (the resistance of a liquid to spread out and increase its surface area) *increases*
- **Viscosity** (the resistance of a liquid to flow) *increases*.

Higher the intermolecular forces between the liquid particles, harder it is for it to escape into the vapor phase, ie., you need more energy to convert it from liquid to the vapor phase, in other words, higher its boiling point.

If it is harder for a liquid to escape into vapor, because it is held back into the liquid by the neighboring particles attraction, you have less vapor and hence low vapor pressure.

**Three types of** intermolecular forces exist between **neutral molecules** which are known as **Van der Waals forces. They are:**

<table>
<thead>
<tr>
<th>Force Type</th>
<th>Details</th>
<th>Example</th>
<th>Bond Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dipole-dipole</td>
<td>between polar molecules</td>
<td>HCl</td>
<td>weak</td>
</tr>
<tr>
<td>Hydrogen bonding</td>
<td>between molecules containing H bound to small electronegative atoms such as O, N and F – strong</td>
<td>H$_2$O</td>
<td>strong</td>
</tr>
<tr>
<td>London Dispersion forces</td>
<td>between any two particles -tend to increase with increasing size and the molar mass resulting from the momentary nonsymmetrical electron distribution that produces temporary dipoles</td>
<td></td>
<td>weak</td>
</tr>
</tbody>
</table>

**Exercises:**

1. Identify the intermolecular forces in each of the following substances:
   a) HCl b) CH$_3$CH$_3$ c) CH$_3$NH$_2$ d) Kr
2. Write the following in the increasing order of boiling points:
   a) H$_2$S b) CH$_3$CH$_3$ c) CH$_3$OH d) Ar
3. Between CO$_2$ and SO$_2$, only ____ will have dipole-dipole interaction because ____________________.