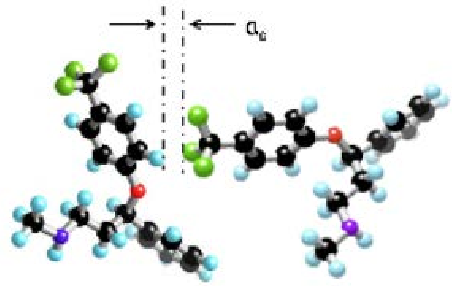
QUIZ on Lecture P1_Wk1_L4

1. It's a good idea to have a distance in mind which specifies the smallest separation possible between two small neutral molecules. Call this "touching distance" distance a_o. A reasonable estimate for a_o might be

a) ~0.05 nm
b) ~0.3 nm
c) ~1.5 nm
d) ~5.0 nm



2. Suppose you have a small atomic system in thermal equilibrium with a large reservoir at temperature T. Assume the small system can have three discrete energies E_1, E_2, and E_3. Also assume there is only one way of populating each energy level (ie. All the energy states have equal weight). The thermal average of E might best be described by

d) $$\langle E \rangle = \frac{E_1 e^{-E_1/kBT} + E_2 e^{-E_2/kBT} + E_3 e^{-E_3/kBT}}{e^{-E_1/kBT} + e^{-E_2/kBT} + e^{-E_3/kBT}}$$

3. A molecule with a permanent dipole moment

a) cannot electrostatically interact with a non-polar molecule
b) can interact with the dipole moment it induces in a nearby non-polar molecule
c) requires an electric field produced by a nearby ion before it can interact with a non-polar molecule
d) can only interact with the non-polar molecule at temperatures near 0K

4. If an ion interacts with a molecule having a permanent electric dipole moment that is thermally free to rotate, the electrostatic interaction energy

a) is constant, independent of temperature
b) increases linearly with increasing temperature
c) is always zero
d) decreases with increasing temperature as 1/T

5. Suppose under certain circumstances, electric fields between molecules can approach 5 x10^9 V/m. Estimate the induced dipole moment (in Debye) for an argon atom with an electronic polarizability volume of 1.66 x 10^{-30} m^3 if the atom encounters such an intermolecular electric field.

a) 0.10 D
b) 0.28 D
c) 0.68 D
d) 1.62 D

Solution:

$$p = \alpha_0 E = (4\pi\varepsilon_0 \alpha)E$$
$$= 4\pi\left(8.85\times10^{-12}\,C^2/Nm^2\right)\left(1.66\times10^{-30}\,m^3\right)\left(5\times10^{9}\,V/m\right)$$
$$= 9.23\times10^{-31}\,Cm \times \frac{1D}{3.33\times10^{-30}\,Cm} = 0.28D$$

units: $$C^2/Nm^2 \times m^3 \times V/m = \frac{C^2 m^3\, J/C}{Nm^3} = \frac{CNm}{N} = Cm$$