

2. (a) The “normal” vapor pressure refers to vapor pressure exerted at 1 atmosphere of air pressure, 760 Torr. Both water and  $\text{CH}_3\text{OH}$  have the polar  $-\text{OH}$  group, but the non-polar  $-\text{CH}_3$  end limits the amount of hydrogen in bonding in  $\text{CH}_3\text{OH}$ . There is stronger hydrogen bonding between water molecules, resulting from these strong dipole-dipole attractions. Therefore, individual water molecules have a lower likelihood of overcoming these stronger attractions and evaporating. When evaporation is diminished, the vapor pressure exerted by the liquid is lower.

[LO 2.13 SP 1.4]

- (b) Both iodine and chlorine atoms have 7 valence electrons each and neither the  $\text{I}_2$  nor the  $\text{Cl}_2$  molecule is polar. The difference in melting points arises from the larger surface area in the  $\text{I}_2$  molecule, giving rise to greater likelihood of instantaneous attractions of outer electrons to nuclei in adjacent molecules

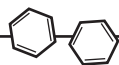


The nature of contact between  $\text{Cl}-\text{Cl}$  molecules is closer to tangent point contact than in the larger  $\text{I}-\text{I}$  molecule. The evidence for believing this is the fact that  $\text{Cl}_2$  is a gas at room temperature and iodine is a dark purple solid. Although the mass of iodine molecules is larger than the chlorine molecules, mass does NOT play any role in these electrons attractions to adjacent nuclei attractions. Mass arguments will not earn points in the AP assessment of points for a response.

[LO 2.16 SP 6.2]

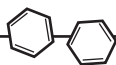
- (c) Both solid silver ( $\text{Ag}$ ) and molten  $\text{Ag}$  are good conductors of electricity. However, solid silver nitrate,  $\text{AgNO}_3$ , is a good conductor only when melted or dissolved in pure water; as a solid, it is a poor conductor. Silver is a metal, which means the crystal and melted liquid consist of metal atoms with delocalized valence electrons, often referred to as a sea of electrons. This phenomenon is the result of very low ionization energies (relative to the other elements) for metals. These mobile electrons readily lend themselves to being “pushed” across the surface when electricity is supplied via a wire. However, in the solid form, silver nitrate consists of alternating positive silver and negative nitrate ions whose electrons are firmly bonded in stable, octet configurations. Therefore migration of outer electrons does not occur, and no conductivity is detected in the solid form. However, when melted or dissolved in water, the ions are separated from one another and free to migrate towards charged terminals inserted into the vessel. This separation of charges accounts for why  $\text{AgNO}_3$  does conduct electricity in the molten state or in aqueous solutions.

[LO 2.20 SP 6.2, 7.1]



- (d) Water molecules exhibit “hydrogen bonding,” a higher form of dipole-dipole attractions because oxygen is more electronegative than is sulfur. These stronger attractions between  $\text{H}_2\text{O}$  molecules compared to between  $\text{H}_2\text{S}$  require greater energy to overcome. The higher required energy results in a higher boiling point. Note: although the mass of  $\text{H}_2\text{S}$  is higher, it does not play a role in outer electrons  $\rightarrow$  nuclei attractions.

[LO 2.16 SP 6.2]



4. (a) The boiling point is defined as the temperature at which the vapor pressure is equal to (cancels out) the air pressure above the liquid. When the pressure above the liquid is reduced, less vaporization is required in order for the liquid to boil. At the temperature of  $10^{\circ}\text{C}$ , the only liquid with a vapor pressure equal to or above 50 mm Hg is  $\text{CCl}_4$ . Therefore, the only liquid in which boiling will be observed will be the liquid  $\text{CCl}_4$ .
- (b) At  $25^{\circ}\text{C}$  three liquids will have vapor pressures equal to or greater than 50 mm Hg. Therefore, with vapor pressure of 59 mm, 114 mm and 94 mm, respectively, the ethyl alcohol, the  $\text{CCl}_4$ , and the benzene will all be observed to be boiling.

[LO 5.6 SP 2.2, 2,3]