CHAPTER 11: ANSWERS TO ASSIGNED PROBLEMS
Hauser- General Chemistry I
revised 12/02/08

11.15 Describe the intermolecular forces that must be overcome to convert each of the following from a liquid or solid to a gas:
(a) I₂  
LONDON FORCES ONLY (linear geo)
(b) CH₃CH₂OH  
LONDON, DIPOLE-DIPOLE, HYDROGEN-BONDING
(c) H₂Se  
LONDON FORCES, DIPOLE-DIPOLE (bent geo)

11.19 Which member of the following pairs has the larger London dispersion forces?
CONSIDER GEOMETRY AND MOLECULAR WEIGHT FOR LONDON FORCES.
(a) H₂O or H₂S  
H₂S  (same bent geo, higher MW)
(b) CO₂ or CO  
CO₂  (same linear geo, higher MW)
(c) SiH₄ or GeH₄  
GeH₄  (same tetrahedral geo, higher MW)

11.21 Butane and 2-methylpropane, whose space-filling models are shown, are both nonpolar and have the same molecular formula, yet butane has the higher boiling point (-0.5 °C compared to -11.7 °C). Explain.

CONSIDER GEOMETRY AND MOLECULAR WEIGHT FOR LONDON FORCES. MW IDENTICAL HERE, BUT BUTANE HAS A MORE LINEAR SHAPE, SO IT CAN INTERACT MORE WITH (AND HOLD TO) OTHER BUTANES. MORE HEAT WILL BE REQUIRED TO SEPARATE BUTANE MOLECULES.

11.23 (a) What atoms must a molecule contain to participate in hydrogen bonding with other molecules of the same kind?
A HYDROGEN ATOM MUST BE DIRECTLY ATTACHED TO F, O, or N.
(b) Which of the following molecules can form hydrogen bonds with other molecules of the same kind? EXAMINE THE LEWIS STRUCTURES!

CH₃F   NO Hydrogen-bonding (Lewis structure shows H's attached to C, not F)
CH₃NH₂    YES Hydrogen-bonding
CH₃OH    YES Hydrogen-bonding
CH₃Br   NO Hydrogen-bonding (Br does not cause H-bonding))

11.31 Explain the following observations:
(a) The surface tension of CHBr₃ is greater than that of CHCl₃.

**BOTH MOLECULES HAVE TETRAHEDRAL GEOMETRIES AND HAVE BOTH LONDON AND DIPOLE-DIPOLE FORCES. CHBr₃ HAS HIGHER MW, SO GREATER LONDON FORCES. CHBr₃ MOLECULES WOULD ATTRACT MORE STRONGLY TO EACH OTHER AND FORM A STRONGER "SURFACE."

(b) As temperature increases, oil flows faster through a narrow tube.
**TEMP. INCREASE CAUSES HIGHER KINETIC ENERGY AND MOVEMENT, SO VISCOSITY WILL DECREASE.**

11.11 If you mix olive oil with water, the olive oil will float on top of the water. The density of water is 1.00 g/cm³ at room temperature.
(a) Is the density of olive oil more or less than 1.00 g/cm³?
**THE FLOATING OLIVE OIL MUST BE LESS DENSE THAN THE 1.00 g/cm³ WATER.**

(b) The density of olive oil in its liquid phase does vary with temperature. Do you think olive oil would be more dense or less dense at higher temperatures? Explain. **THE OIL SHOULD BE LESS DENSE AT HIGHER TEMPS. INCREASED MOLECULAR MOVEMENT WILL INCREASE VOLUME, BUT NOT MASS OF OIL. SINCE DENSITY IS MASS / VOLUME, THE DENSITY VALUE WILL DECREASE.**

11.33 Name the phase transition in each of the following situations, and indicate whether it is exothermic or endothermic:

(a) When ice is heated, it turns to water.
**SOLID TO LIQUID = MELTING or FUSION  (ENDOTHERMIC)**

(b) Wet clothes dry on a warm summer day.
**LIQUID TO GAS = VAPORIZATION (ENDOTHERMIC)**

(c) Frost appears on a window on a cold winter day.
**GAS TO SOLID = DEPOSITION (EXOTHERMIC)**

(d) Droplets of water appear on a cold glass of beer.
**GAS TO LIQUID = CONDENSATION (EXOTHERMIC)**
ADDITIONAL EXERCISE #13

Calculate the kJ of heat required to convert 746 gram of water at 100 °C to steam. HEAT OF VAPORIZATION (ΔH_vap) FOR WATER IS 40.7 kJ/mol. NOTE: THE WATER IS ALREADY AT 100 °C SO THIS CALC. SHOWS HOW MUCH HEAT NEEDED FOR THE PHASE TRANSITION.

746 g H₂O (1 mole H₂O / 18.02 g) (40.7 kJ / mol) = 1684.9 kJ = 1680 kJ (3 SF)

11.47 (a) Two pans of water are on different burners of a stove. One pan of water is boiling vigorously, while the other is boiling gently. What can be said about the temperature of the water in the two pans?

THE TEMPERATURE IS THE SAME IN BOTH PANS! DURING A PHASE CHANGE, THE TEMP OF A SYSTEM IS CONSTANT.

(b) A large container of water and a small one are at the same temperature. What can be said about the relative vapor pressures of the water in the two containers?

VAPOR PRESSURE DOES NOT DEPEND ON VOLUME OR SURFACE AREA. Note: The larger container WILL go dry sooner, though.

ADDITIONAL EXERCISE #14

Death Valley is the lowest point in the United States (280 feet below sea level). Would you expect the atmospheric pressure in Death Valley to be greater or less than the atmospheric pressure in St. Louis? EXPLAIN how the pressure in Death Valley would affect the boiling point of a liquid.

ATMOSPHERIC PRESSURE IS GREATER IN A VALLEY. BOILING OCCURS AT THE TEMP. WHEN VAPOR PRESSURE OF A LIQUID EQUALS THE ATMOSPHERIC PRESSURE. MORE VAPOR PRESSURE (THROUGH MORE HEATING) WILL BE NEEDED TO EQUAL THIS GREATER ATMOS PRESSURE. THE LIQUID WILL BOIL AT A HIGHER TEMP.
11.6 The phase diagram of a hypothetical substance is shown below.

(a) Estimate the normal boiling point and freezing point of the substance.
"NORMAL" INDICATES BEHAVIOR AT 1 ATMOSPHERE OF PRESSURE.
FIRST AREA ON LEFT IS SOLID, THEN LIQUID, THEN GAS.
BOILING POINT: about 360 K (the liquid/gas transition @ 1 atm)
FREEZING POINT: about 260 K (the solid/liquid transition @ 1 atm)

(b) What is the physical state of the substance under the following conditions?
   (i) T = 150 K, P = 0.2 atm   GAS
   (ii) T = 100 K, P = 0.8 atm  SOLID
   (iii) T = 300 K, P = 1.0 atm LIQUID

(c) What is the triple point of the substance?
ALL THREE PHASES ARE IN EQUILIBRIUM AT ~185 K AND 0.45 ATM FOR THIS SUBSTANCE.

ADDITIONAL EXERCISE #15
Methyl alcohol (CH$_3$OH) has a much higher boiling point than methane (CH$_4$).
Use intermolecular forces to explain this large difference in boiling point.

EXAMINE INTERMOLECULAR FORCES.
CH$_4$ HAS A TETRAHEDRAL AND SYMMETRIC GEOMETRY. IT WILL HAVE ONLY LONDON FORCES HOLDING IT TO NEIGHBORING CH$_4$ MOLECULES.

CH$_3$OH HAS LONDON, DIPOLE-DIPOLE, AND HYDROGEN-BONDING FORCES HOLDING IT TO NEIGHBORS. MUCH MORE HEAT REQUIRED TO SEPARATE METHYL ALCOHOL MOLECULES FROM EACH OTHER.
ADDITIONAL EXERCISE #16

Which would you expect to have the higher boiling point, carbon dioxide (CO₂) or acetonitrile (CH₃CN)? The acetonitrile has the basic backbone of C - C - N; you should draw the Lewis Structure. Use intermolecular forces to explain your answer.

\[ \text{LONDON ONLY \hspace{1cm} LONDON, DIPOLE} \]

THE ACETONITRILE HAS MORE IM FORCES, SHOULD REQUIRE MORE HEAT TO SEPARATE THESE MOLECULES.