I. Multiple Choice

1. Which element is a liquid at 25 °C and 1 atm pressure?
   (A) Fluorine  (B) Chlorine
   (C) Bromine  (D) Iodine

2. A beaker containing 25 mL of liquid 1-aminopentane, CH₃(CH₂)₄NH₂, is placed on a hotplate and brought to a boil. As the 1-aminopentane boils,
   (A) the total energy of the system stays constant.
   (B) the hydrogen bonding between the 1-aminopentane molecules is disrupted.
   (C) the ion-dipole forces between the 1-aminopentane molecules are disrupted.
   (D) pentane and ammonia gas are formed.

3. What is the principal energetic factor in the lack of miscibility between C₆H₁₂(l) and H₂O(l)?
   (A) The strength of intermolecular forces of attraction between C₆H₁₂(l) molecules
   (B) The strength of intermolecular forces of attraction between H₂O(l) molecules
   (C) The difference between the molecular weights of the molecules
   (D) The difference in electronegativity between carbon and hydrogen

4. Which compound has the highest normal boiling point?
   (A) CH₃CH₂COOH  (B) CH₃CH₂OH
   (C) CH₃COOCH₃  (D) HCOOCH₂CH₃

5. Nitrogen, N₂, has the following properties:
   normal melting point: 63.2 K
   triple point: 0.127 atm, 63.1 K
   normal boiling point: 77.4 K
   critical point: 33.5 atm, 126.0 K

   Which statement about N₂ is correct?
   (A) Liquid N₂ is denser than solid N₂  F
   (B) At sufficiently high pressure, N₂ can be liquefied at 150 K.  F
   (C) Liquid N₂ and gaseous N₂ can coexist at 63.1 K and 1 atm.  F
   (D) If N₂ is heated from 60 K to 70 K at 0.100 atm, it sublimes.  F

*6. The vapor pressure of iodomethane, CH₃I (M = 141.9), is 110. mm Hg at 266 K. A 0.824 g sample of iodomethane is placed in a closed, evacuated 370. mL container at 266 K. At equilibrium, what will be the pressure in the container?
   (A) 96.4 mm Hg  (B) 110. mm Hg
   (C) 260. mm Hg  (D) 292. mm Hg

7. Which of the following properties is not typical of metallic solids?
   (A) High vapor pressure  F
   (B) High coordination number of atoms in the lattice  T
   (C) High electrical conductivity  T
   (D) High thermal conductivity  T

8. Which of the following substances experience London dispersion forces?
   I. CH₃CH₃  II. CH₃OH
   (A) I only  (B) II only
   (C) Both I and II  (D) Neither I nor II

\[
\frac{0.824 \text{ g CH}_3\text{I}}{1 \text{ mol CH}_3\text{I}} = \frac{141.9 \text{ g CH}_3\text{I}}{1 \text{ mol CH}_3\text{I}} = 0.00581 \text{ mol CH}_3\text{I}
\]

\[
P_{\text{CH}_3\text{I}} = \frac{(0.00581 \text{ mol})(266 \text{ K})}{0.370 \text{ L}} = 0.343 \text{ atm} = 261 \text{ mm Hg}
\]
9. According to the phase diagram of methanol shown below, which statement is correct?

(A) Solid methanol has a greater density than liquid methanol.
(B) Solid methanol sublimes at atmospheric pressure.
(C) Solid, liquid, and gaseous methanol can only coexist at pressures above 1 atm.
(D) At 200 °C and 1 atm pressure, methanol is a supercritical fluid.

10. Which of the following are ionic compounds?
   I. NH₄NO₂   II. NH₄NO₃
   (A) I only   (B) II only
   (C) Both I and II   (D) Neither I nor II

11. Which of the following statements is TRUE?
   A. Vapor pressure increases with temperature. T
   B. Hydrogen bonds are stronger than covalent bonds. F
   C. Intermolecular forces hold the atoms in molecules together. F
   D. Dispersion forces are generally stronger than dipole-dipole forces. F
   E. None of the above are true.

12. The strongest intermolecular interactions between hydrogen sulfide (H₂S) molecules arise from
   A. dipole-dipole forces.
   B. London Dispersion forces
   C. Hydrogen bonding

13. The two strands in DNA are held together by
   A. dispersion forces   B. dipole-dipole forces
   C. hydrogen bonding   D. ion-dipole forces
   E. Elmer's glue

14. Place the following compounds in order of increasing strength of intermolecular forces.

   CH₄   CH₃CH₂CH₃   CH₃CH₂CH₃

   A. CH₃CH₂CH₃ < CH₄ < CH₃CH₂CH₃   B. CH₃CH₂CH₃ < CH₃CH₂CH₃ < CH₄
   C. CH₃CH₂ < CH₄ < CH₃CH₂CH₃   D. CH₄ < CH₃CH₂CH₃ < CH₃CH₂CH₃
   E. CH₄ < CH₃CH₂ < CH₃CH₂CH₃

15. In a liquid, the energy required to increase the surface of the area by a unit amount is called
   A. viscosity   B. surface tension
   C. capillary action   D. hydrogen bonding
   E. Stark energy

16. Identify the term used to describe the ability of a liquid to flow against gravity up a narrow tube.
   A. capillary action   B. viscosity   C. surface tension
17. Place the following substances in order of decreasing vapor pressure at a given temperature.

- \( \text{nonpolar} \): \( \text{PF}_3 \), \( \text{BrF}_3 \), \( \text{CF}_4 \)
- \( \text{polar} \):

  \( \text{BrF}_3 \) > \( \text{PF}_3 \) > \( \text{CF}_4 \)

- \( \text{smaller molar mass than} \): \( \text{PF}_3 \)

A. \( \text{BrF}_3 \) > \( \text{PF}_3 \) > \( \text{CF}_4 \)  
B. \( \text{BrF}_3 \) > \( \text{CF}_4 \) > \( \text{PF}_3 \)  
C. \( \text{PF}_3 \) > \( \text{BrF}_3 \) > \( \text{CF}_4 \)  
D. \( \text{CF}_4 \) > \( \text{BrF}_3 \) > \( \text{PF}_3 \)  
E. \( \text{CF}_4 \) > \( \text{PF}_3 \) > \( \text{BrF}_3 \)

18. What mass of ice at 0.0 °C must be added to 200. g \( \text{H}_2\text{O} \) at 25.0 °C to cool it to 0.0 °C?

(A) 2.50 g  (B) 15.0 g  (C) 62.6 g  (D) 200. g

\( q_{\text{melt}} = q_{\text{cooling water}} \)

\( \Delta H = (334 \text{J/g})(0.184 \text{ J/g°C})(0 - 25°C) \)

II. Short Answer

1. Draw a picture of two He atoms and use words to describe the dispersion forces between the two atoms.

   For \( \frac{1}{1000} \)th of a second, the 2 e- of He are on one side of the atom...

   ...which induces a dipole in a neighboring atom. The attraction b/w these atoms is the dispersion force.

2. Draw a picture of two acetone molecules and use words to describe the dipole-dipole forces between the two molecules.

   The dipole-dipole force is the attraction b/w the positive part of one molecule's dipole to the negative part of a molecule's dipole on a neighboring molecule...
3. Draw a picture of two ammonia molecules and use words to describe the hydrogen bonding forces between the two molecules.

4. For each of the following pairs of molecules, list the dominant IMF for each molecule and circle the one with the higher boiling point:

   - A. Ne
     - LDF
     - LDF
   - B. CF₃
     - LDF
     - dipole-dipole
   - C. MgO
     - ion-ion
   - MgS
     - ion-ion
   - D. H₂-bonding
     - dipole-dipole

5. For each of the following pairs of molecules, list the dominant IMF for each molecule and circle the one with the higher boiling point:

   - A. NF₃
     - dipole-dipole
     - Na₂O
     - ion-ion
   - B. PF₅
     - LDF
     - ClF₃
     - dipole-dipole
   - C. heptane
     - 3,3-dimethylpentane
     - LDF
   - D. dipole-dipole
     - LDF
     - LDF

6. Draw a heating curve for water with “Heat Added” on the x-axis and “Temperature” on the y-axis. Label the regions according to their phases (solid, liquid, and gas) and phase transitions (solid to liquid and liquid to gas).