1. [7 Points] In which of the following substances are dipole-dipole forces present, but hydrogen bonding absent?

CF_4 SF_6 SF_4 HCl NH_3

(a) CF_4, SF_6, SF_4 and HCl
(b) HCl and NH_3
(c) CF_4, SF_6 and SF_4
(d) SF_4 and HCl
(e) SF_4, HCl and NH_3

2. [7 Points] In each of the following pairs determine the substance that has the highest boiling point.

PH_3 or NH_3 Br_2 or ICl GeH_4 or CH_4 LiF or HF

(a) Highest boiling point of each pair = PH_3, ICl, GeH_4 and HF
(b) Highest boiling point of each pair = NH_3, ICl, GeH_4 and HF
(c) Highest boiling point of each pair = NH_3, ICl, GeH_4 and LiF
(d) Highest boiling point of each pair = NH_3, Br_2, GeH_4 and LiF
(e) Highest boiling point of each pair = PH_3, ICl, CH_4 and HF

3. [7 Points] Which of the following liquids would you expect to have the highest viscosity at room temperature?

(a) propyl alchohol, $CH_3CH_2CH_2OH$
(b) ethylene diamine, $NH_2CH_2CH_2NH_2$
(c) ethyl alchohol, CH_3CH_2OH
(d) propyl amine, $CH_3CH_2CH_2NH_2$

4. [7 Points] Which property of a liquid decreases as the strength of the intermolecular forces increases?

(a) Normal boiling point
(b) Viscosity
(c) Surface tension
(d) Vapor pressure
(e) All of the above

5. [7 Points] For a given substance rank the relative magnitudes of the heat of fusion, ΔH_{fus}, heat of vaporization, ΔH_{vap}, and heat of sublimation, ΔH_{sub}.

(a) $\Delta H_{fus} < \Delta H_{vap} < \Delta H_{sub}$
(b) $\Delta H_{sub} < \Delta H_{vap} < \Delta H_{fus}$
(c) $\Delta H_{fus} < \Delta H_{sub} < \Delta H_{vap}$
(d) $\Delta H_{vap} < \Delta H_{sub} < \Delta H_{fus}$
(e) $\Delta H_{vap} < \Delta H_{fus} < \Delta H_{sub}$

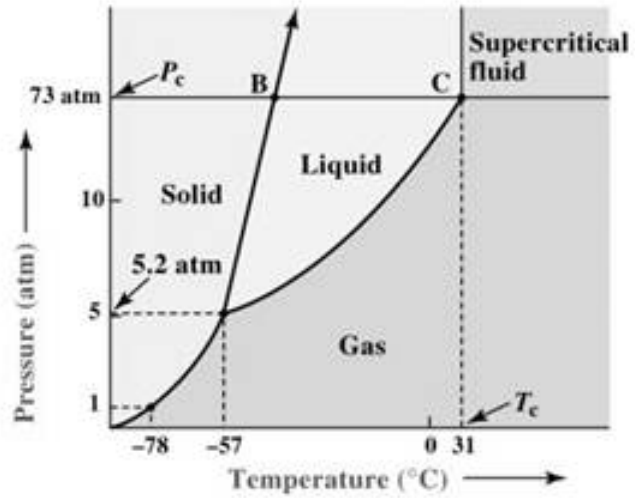
6. [7 Points] At a temperature of 63 °C ethanol, CH_3CH_2OH, has a vapor pressure of 400 torr and water, H_2O, has a vapor pressure of 200 torr. Given this observation which of the following statements is false?

(a) Increasing the temperature will increase the vapor pressure of both liquids
(b) The intermolecular forces in water are stronger than they are in ethanol
(c) The normal boiling point of ethanol will be higher than the normal boiling point of water
(d) At any temperature where both substances are liquids water will always have the higher vapor pressure

7. [7 Points] Ethanol, CH_3CH_2OH melts at 159 K and boils at 351 K. The heat of fusion is 5.02 kJ/mol and the heat of vaporization is 38.56 kJ/mol. The specific heats of solid, liquid and gaseous ethanol are 0.97, 2.3 and 1.9 J/g·K, respectively. How much heat must be added to a 115.5 g sample of solid ethanol initially at 77 K to raise the temperature to 300 K.

(a) 46.7 kJ
(b) 59.2 kJ
(c) 626 kJ
(d) 13.6 kJ
(e) 143 kJ

The phase diagram for CO_2 is shown below. Use this diagram to answer the following two questions. Note that the x- and y-axes are not drawn to scale.



8. [7 Points] What is the normal boiling point of CO_2?

(a) −78 °C (b) −57 °C (c) −50 °C (d) 31 °C

(e) CO_2 does not have a normal boiling point

9. [7 Points] What is the minimum pressure that liquid CO_2 can exist? What is the maximum temperature that liquid CO_2 can exist?

(a) Minimum pressure = 73 atm, Maximum temperature = 31 °C

(b) Minimum pressure = 5.2 atm, Maximum temperature = −57 °C

(c) Minimum pressure = 5.2 atm, Maximum temperature = 31 °C

(d) Minimum pressure = 73 atm, Maximum temperature = −57 °C

(e) Minimum pressure = 73 atm, Maximum temperature = −50 °C

10. [7 Points] Which of the following statements is false.

(a) Ionic liquids are ionic compounds that are liquids at room temperature

(b) Most ionic liquids contain polyatomic ions

(c) The presence of irregularly shaped ions tends to favor the formation of ionic liquids because they do not pack well in the solid state

(d) The presence of small, light ions tends to favor the formation of ionic liquids because the dispersion forces holding ions together tend to be relatively weak

(e) Ionic liquids typically have low vapor pressures