Winter 2012 Chem 1B Discussion Worksheet

Chapter 11: Intermolecular Forces and Liquids and Solids

The assignments are from: Chemistry by Raymond Chang; McGraw Hill Higher Education, 10th Edition, 2010

Goals

• Understand different types of intermolecular forces
• Understand how intermolecular forces affect various properties of gases, liquids, and solids
• Understand the difference between liquids, crystals and amorphous solids
• Learn about different types of crystal structures
• Learn about different types of phase changes
• Learn how to interpret phase diagrams

(for your convenience, copies of the problems are provided on the next page if you do not have your book with you)

If you have no time to solve all of the, do only the underlined ones

Intermolecular Forces

Easier problems: 11.9, 11.12, 11.14
Harder problems: 11.13, 11.18

Properties of Liquids

Easier problems: 11.26, 11.31

Crystal Structure and Types of Crystals

Easier problems: 11.34, 11.37, 11.49, 11.54
Harder problems: 11.42, 11.43, 11.132

Phase Change

Easier problems: 11.59, 11.63, 11.67, 11.84,
Harder problems: 11.78, 11.86, 11.128

Phase Diagrams

Easier problems: 11.94, 11.91
Harder problems: 11.93

11.9 The binary hydrogen compounds of the Group 4A elements and their boiling points are: CH₄, -162°C; SiH₄, -112°C; GeH₄, -88°C; and SnH₄, -52°C. Explain the increase in boiling points from CH₄ to SnH₄.

11.12 Which of the following species are capable of hydrogen-bonding among themselves? (a) C₂H₆, (b) HI, (c) KF, (d) BeH₂, (e) CH₃COOH

11.13 Arrange the following in order of increasing boiling point: RbF, CO₂, CH₃OH, CH₃Br. Explain your reasoning.
11.14 Diethyl ether has a boiling point of 34.5°C, and 1-butanol has a boiling point of 117°C.

\[ \text{H}_3\text{C}\text{H}_2\text{O\text{C}\text{H}_3} \quad \text{H}_3\text{C}\text{H}_2\text{O\text{C}\text{H}_3} \]

[Diethyl ether, 1-butanol]

11.18 What kind of attractive forces must be overcome in order to (a) melt ice, (b) boil molecular bromine, (c) melt solid iodine, and (d) dissociate F₂ into F atoms?

11.26 Draw diagrams showing the capillary action of (a) water and (b) mercury in three tubes of different radii.

11.31 Predict which of the following liquids has greater surface tension: ethanol (C₂H₅OH) or dimethyl ether (CH₃OCH₃).

11.34 Describe the geometries of the following cubic cells: simple cubic, body-centered cubic, face-centered cubic. Which of these structures would give the highest density for the same type of atoms? Which the lowest?

11.37 What is the coordination number of each sphere in a (a) simple cubic cell, (b) a body-centered cubic cell, and (c) a face-centered cubic cell? Assume the spheres are all the same.

11.42 Europium crystallizes in a body-centered cubic lattice (the Eu atoms occupy only the lattice points). The density of Eu is 5.26 g/cm³. Calculate the unit cell edge length in pm.

11.43 Crystaline silicon has a cubic structure. The unit cell edge length is 543 pm. The density of the solid is 2.33 g/cm³. Calculate the number of Si atoms in one unit cell.

11.49 Describe and give examples of the following types of crystals: (a) ionic crystals, (b) covalent crystals, (c) molecular crystals, (d) metallic crystals.

11.54 Which of the following are molecular solids and which are covalent solids? Se₂, HBr, Si, CO₂, C, P₂O₅, SiH₄

11.59 What is a phase change? Name all possible changes that can occur among the vapor, liquid, and solid phases of a substance.

11.63 How is the molar heat of sublimation related to the molar heats of vaporization and fusion? On what law are these relationships based?

11.67 As a liquid is heated at constant pressure, its temperature rises. This trend continues until the boiling point of the liquid is reached. No further rise in temperature of the liquid can be induced by heating. Explain.

11.78 How much heat (in kJ) is needed to convert 866 g of ice at −10°C to steam at 126°C? (The specific heats of ice and steam are 2.03 J/g °C and 1.99 J/g °C, respectively.)

11.84 Steam at 100°C causes more serious burns than water at 100°C. Why?

11.86 The vapor pressure of benzene, C₆H₆, is 40.1 mmHg at 7.6°C. What is its vapor pressure at 60.6°C? The molar heat of vaporization of benzene is 31.0 kJ/mol.

11.91 The phase diagram of sulfur is shown here. (a) How many triple points are there? (b) Monoclinic and rhombic are two allotropes of sulfur. Which is more stable under atmospheric conditions? (c) Describe what happens when sulfur at 1 atm is heated from 80°C to 200°C.

![Phase diagram of sulfur](image)

11.93 The boiling point and freezing point of sulfur dioxide are −10°C and −72.7°C (at 1 atm), respectively. The triple point is −75.5°C and 1.65 × 10⁻³ atm, and its critical point is at 157°C and 78 atm. On the basis of this information, draw a rough sketch of the phase diagram of SO₂.

11.94 A phase diagram of water is shown at the end of this problem. Label the regions. Predict what would happen as a result of the following changes: (a) Starting at A, we raise the temperature at constant pressure. (b) Starting at C, we lower the temperature at constant pressure. (c) Starting at B, we lower the pressure at constant temperature.

![Phase diagram of water](image)

11.128 A 1.20-g sample of water is injected into an evacuated 5.00-L flask at 65°C. What percentage of the water will be vapor when the system reaches equilibrium? Assume ideal behavior of water vapor and that the volume of liquid water is negligible. The vapor pressure of water at 65°C is 187.5 mmHg.

11.132 Argon crystallizes in the face-centered cubic arrangement at 40 K. Given that the atomic radius of argon is 191 pm, calculate the density of solid argon.