Chem 1B Discussion

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Office Hours?
Thurs. 1-2
• Intermolecular Forces
  – 11.9, 11.12, 11.14, 11.13, 11.18

• Properties of Liquids
  – 11.26, 11.31

• Crystal Structure and Types of Crystals
  – 11.34, 11.37, 11.49, 11.54, 11.42, 11.43, 11.132

• Phase Change
  – 11.59, 11.63, 11.67, 11.84, 11.78, 11.86, 11.128

• Phase Diagrams
  – 11.94, 11.91, 11.93
11.9 The binary hydrogen compounds of the Group 4A elements and their boiling points are: CH$_4$ -162°C; SiH$_4$ -112°C; GeH$_4$ -88°C; and SnH$_4$ -52°C. Explain the increase in boiling points from CH$_4$ to SnH$_4$.

Answer:

Melting point depends on strength of intermolecular forces.

- CH$_4$: Dispersion
- SiH$_4$: Dispersion
- GeH$_4$: Dispersion
- SnH$_4$: Dispersion

Strength depends on polarizability

C < Si < Ge < Sn
11.12 Which of the following species are capable of hydrogen-bonding among themselves?

a) $C_2H_6$
b) HI
c) KF
d) BeH$_2$
e) CH$_3$COOH

**Answer:**

Hydrogen bonding needs to have a N, O, or F bonded to an H.
Diethyl ether has a boiling point of 34.5°C, and 1-butanol has a boiling point of 117 °C.

Both of these compounds have the same numbers and types of atoms. Explain the difference in their boiling points.

**Answer:**
Strength of intermolecular forces affect boiling point.
Arrange the following in order of increasing boiling point: RbF, CO$_2$, CH$_3$OH, CH$_3$Br. Explain your reasoning.

**Answer:**

Determine intermolecular forces, use the strength of those to determine boiling point rankings.

- RbF: Dispersion, Ionic
- CO$_2$: Dispersion
- CH$_3$OH: Dispersion, Dipole-Dipole, Hydrogen Bonding
- CH$_3$Br: Dispersion, Dipole-Dipole

CO$_2$ < CH$_3$Br < CH$_3$OH < RbF
11.18 What kind of attractive forces must be overcome in order to
a) melt ice
b) boil molecular bromine
c) melt solid iodine
d) dissociate $F_2$ into F atoms
11.26 Draw diagrams showing the capillary action of a) water and b) mercury in three tubes of different radii.

**Answer:**
See Figure 11.10.
Modify the diagram to have 3 tubes of different radii. Consider the two things that affect capillary action: cohesion (attraction to itself) and adhesion (attraction to anything else i.e. glass walls).
Predict which of the following liquids has greater surface tension: ethanol \((C_2H_5OH)\) or dimethyl ether \((CH_3OCH_3)\).

**Answer:**

Strength of intermolecular forces affect surface tension.

Ethanol: Dispersion, Dipole-Dipole, Hydrogen Bonding

Dimethyl ether: Dispersion, Dipole-Dipole

Ethanol > Dimethyl ether
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 is the lowest?

**Answer:** Figure 11.17
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.

Answer: CN = nearest neighbors
Face centered cubic = cubic close-packed structure

Figure 11.21 (b): 

Exploded view  

Cubic close-packed structure
11.49 Describe and give examples of the following types of crystals: a) ionic crystals, b) covalent crystals, c) molecular crystals, d) metallic crystals.

**Answer:**

Ionic = nonmetal & metal; NaCl
Covalent = nonmetal only; Diamond, graphite, or quartz
Molecular = nonmetal only; I₂
Metallic = metal only; Au
11.54 Which of the following are molecular solids and which are covalent solids? Se$_8$, HBr, Si, CO$_2$, C, P$_4$O$_6$, SiH$_4$.

Answer:
Molecular: Se$_8$, HBr, Si, CO$_2$, P$_4$O$_6$, SiH$_4$
Covalent: C
11.42 Europium crystallizes in a body-centered cubic lattice (the Eu atoms occupy on the lattice points). The density of Eu is 5.26 g/cm³. Calculate the unit cell edge length in pm.

**Answer:**

See example 11.3

Density of unit cell → volume of unit cell → edge length
11.43 Crystalline silicon has a cubic structure. The unit cell edge length is 543 pm. The density of the solid is 2.33 g/cm$^3$. Calculate the number of Si atoms in one unit cell.

**Answer:**

See example 11.3

Edge length of unit cell $\rightarrow$ volume $\rightarrow$ mass $\rightarrow$ atoms
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.

**Answer:**

See example 11.3

Radius $\rightarrow$ edge length $\rightarrow$ volume

Atoms $\rightarrow$ mass

Mass & volume $\rightarrow$ density
What is a phase change? Name all possible changes that can occur among the vapor, liquid, and solid phases of a substance.

**Answer:**

Condensation: vapor → liquid
Deposition: vapor → solid
Freezing: liquid → solid
Evaporation/vaporization: liquid → vapor
Melting/fusion: solid → liquid
Sublimation: solid → vapor
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?

Answer:

$$\Delta H_{\text{sub}} = \Delta H_{\text{fus}} + \Delta H_{\text{vap}}$$

Hess’s law: energy change of physical and chemical process is independent of path.
11.67 As a liquid is heated at a 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.

**Answer:**

The added heat is going towards breaking the bonds.
Steam at 100°C causes more serious burns than water at 100°C. Why?

Answer:

Steam (gas) at that temperature is able to collide more with your skin than water at that temperature because of the nature of the phase.

More collisions = more serious burns
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.)

**Answer:** Example 11.8

-10°C to 0°C + Melting + 0°C to 100°C + Vaporization + 100°C to 126°C
The vapor pressure of benzene, C\textsubscript{6}H\textsubscript{6}, 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.

**Answer:**

Clausius-Clapeyron equation:

\[
\ln \frac{P_1}{P_2} = \frac{\Delta H_{vap}}{R} \left( \frac{T_1}{T_1T_2} - \frac{T_2}{T_1T_2} \right)
\]

See Example 11.7
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.
A phase diagram of water is below. 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.
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 100°C.
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 X 10^{-3} atom, 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.