Exam 1
Chem 1142
Fall 2008

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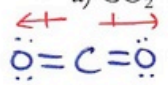
Name: KEY

Q1. List the intermolecular forces that exist between molecules of: (10 pts.)

a) CO_2

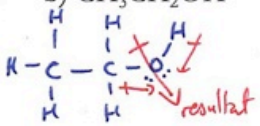


linear

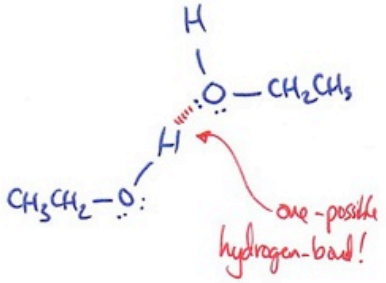
$\mu = 0$ (non-polar)

- London - Dispersion

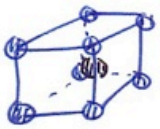
b) CH_3CH_2OH



- London
- Dipole-Dipole
- Hydrogen-Bonding!



Q2. Iron crystallizes in a body-centered cubic unit. The edge of this cell is 287 pm. Calculate the density of iron. (10 pts.)



8 atoms @ corners = $8 \times \frac{1}{8} = 1$ atom

1 atom in body = $1 \times 1 = 1$ atom

2 atoms in unit cell.

$d = m/V \Rightarrow$ need mass of 2 Fe atoms + Vol. of cell.

(i) $\frac{2 \text{ atoms Fe}}{6.022\times10^{23} \text{ atoms}} \left| \frac{1 \text{ mol Fe}}{1 \text{ mol Fe}} \right| \frac{55.85 \text{ g Fe}}{} = 1.855\times10^{-22} \text{ g}$

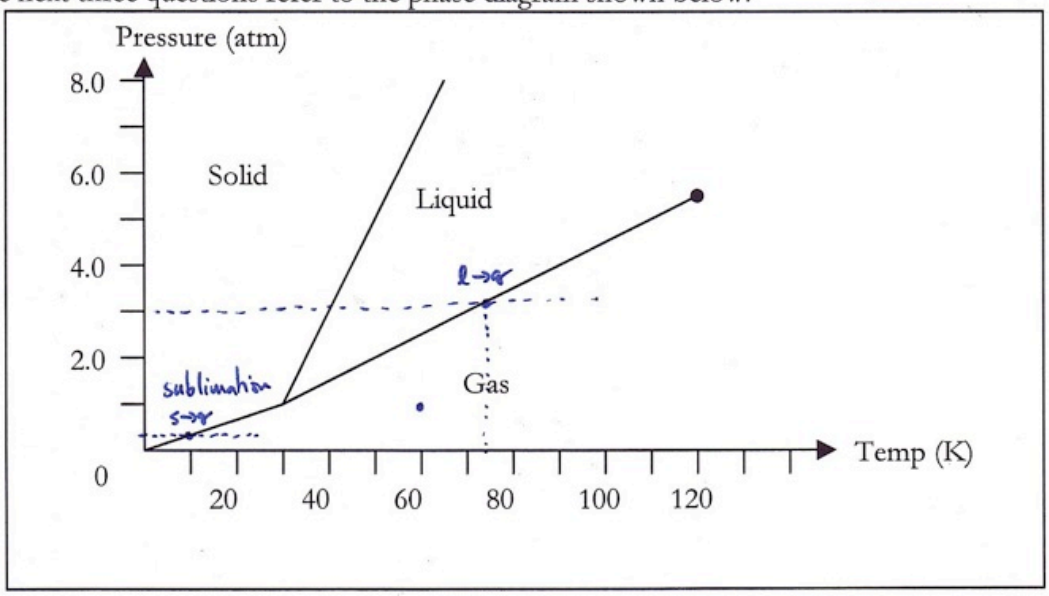
(ii) $V = \ell^3 = \left(\frac{287\times10^{-12} \text{ m}}{1 \text{ m}} \left| \frac{100 \text{ cm}}{} \right. \right)^3 = 2.36\times10^{-23} \text{ cm}^3$

(iii) $d = m/V = \frac{1.855\times10^{-22} \text{ g}}{2.36\times10^{-23} \text{ cm}^3} = 7.86 \text{ g/cm}^3$ (3 s.f.)

Q3. Name the following processes: (12 pts.)

a) Solid → Liquid fusion
b) Liquid → Gas vaporization
c) Gas → Solid deposition
d) Solid → Gas sublimation
e) Gas → Liquid condensation
f) Liquid → Solid freezing

The next three questions refer to the phase diagram shown below.



Q4. What phase will the substance be in at 60 K and 1.0 atm? (3 pts.)
a) Solid b) Liquid c) Gas d) Supercritical-fluid e) Triple-point

Q5. What is the freezing point at 0.25 atm? (3 pts.)
a) 10 K b) 20 K c) 30 K d) 40 K e) No freezing point exists

Q6. What is the boiling point at 3.0 atm? (3 pts.)
a) 70 K b) 20 K c) 120 K d) 0.05 K e) 35 K
closest!

Q7. What's the definition of a saturated solution? (4 pts.)
Solution with Max. amount of solute that can dissolve in a given amount of solvent

Q8. How many grams of solute are present in 125 g of a 4.5% (w/w) solution? (8 pts.)

$$125\text{g soln} \times \frac{4.5\text{g solute}}{100\text{g soln}} = 5.6\text{g solute (2s.f.)}$$

Q9. A 4.53 M solution of CsBr(aq) has a density of 1.38 g/mL. Calculate its molal concentration. (10 pts.)

molal conc = $\frac{\#\text{mol solute}}{\#\text{kg solvent}}$.

Assume 1-L soln (Since conc. is intensive, amount doesn't matter)

$\Rightarrow$ 4.53 mol CsBr

Mass of solution = $1000\text{mL} \times \frac{1.38\text{g}}{1\text{mL}} = 1380\text{g}$

but mass of solvent = mass of solution $\ominus$ mass of solute!

$4.53\text{mol CsBr} \times \frac{212.8\text{g CsBr}}{1\text{mol CsBr}} \rightarrow 963.98\text{g CsBr} = 964\text{g CsBr}$ (3 s.f.)

$\Rightarrow 1380\text{g} - 964\text{g} = 416\text{g}$ solvent (H_2O)

$= 0.416\text{kg}$ $\Rightarrow$ molal conc $= \frac{4.53\text{mol}}{0.416\text{kg}} = 10.9 \frac{\text{mol}}{\text{kg}}$ or m

Q10. Calculate the van't Hoff factor, *i*, for a 2.45 m aqueous solution of NaBr if the boiling point of the solution is 102.34 °C at 1 atm. Comment on the value you obtain. Explain why it deviates from the ideal value. (k_b = 0.512 °C/m) (10 pts.)

$\Delta T_b = i \cdot K_b \cdot m \Rightarrow i = \Delta T_b / K_b \cdot m$

$\Delta T_b = 102.34^\circ\text{C} - 100.00^\circ\text{C} = 2.34^\circ\text{C}$ (elevation)

$\Rightarrow i = \frac{2.34^\circ\text{C}}{0.512^\circ\text{C/m} \times 2.45\text{m}} = 1.87$

ideal: $NaBr(s) \xrightarrow{H_2O} \underbrace{Na^+(aq) + Br^-(aq)}_{\text{2 ions/formula unit}}$

$\Rightarrow$ ideally, $i = 2$

reality: ion-pairing (coming together of +/− ions) reduces # particles in soln. At higher concs, this becomes more prevalent!

Q11. Calculate the osmotic pressure of a 0.050 M solution of Na_2SO_4(aq) at 23 °C. Comment on any assumptions you are making. (8 pts.)

$Na_2SO_4 \xrightarrow{H_2O} 2Na^+(aq) + SO_4^{2-}(aq)$

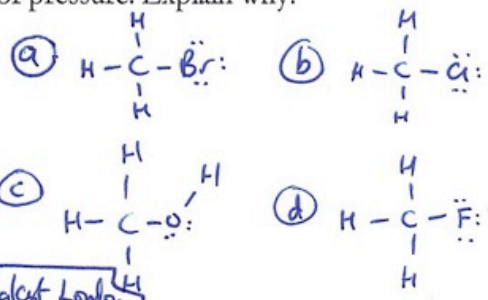
$i = 3$ (assume 100% dissoc.) no ion-pairing

$T = 23 + 273.15 = 296\ K$

$\Pi = iMRT = 3 \times 0.050 \frac{mol}{L} \times 0.08206 \frac{atm \cdot L}{mol \cdot K} \times 296\ K = 3.6\ atm$ (2 s.f.)

Q12. Which of the following compounds will have the highest vapor pressure. Explain why. (6 pts.)

a) CH_3Br b) CH_3Cl c) CH_3OH d) CH_3F



high v.p. = weak IMF. usually more important than

(c) H-Bonds, (a),(b),(d) have London + Dipole-Dipole IMF

London $\propto$ #e⁻s $\Rightarrow$ CH_3F would be weakest London

Q13. Acetic acid is a polar molecule and can form hydrogen bonds with water molecules. Therefore, it has a high solubility in water. Yet acetic acid is also soluble in benzene (C_6H_6), a non-polar solvent that lacks the ability to form hydrogen bonds. A solution of 3.8 g of CH_3COOH in 80. g C_6H_6 has a freezing point of 3.5 °C. Calculate the molar mass of the solute and explain your result. (13 pts.)

fp(C_6H_6) = 5.5 °C. k_f (C_6H_6) = 5.12 °C/m.

$\Delta T_f = i \cdot K_f \cdot m$

$\Delta T_f = 5.5°C - 3.5°C = 2.0°C$

$m = \frac{\#\ mol\ CH_3COOH}{\#\ kg\ solvent}$

since acetic acid's not ionic, we expect $i = 1$

$\Rightarrow m = \frac{\Delta T_f}{K_f} = \frac{2.0°C}{5.12°C/m} = 0.39\ mol/kg$

$\Rightarrow 0.080\ kg \times \frac{0.39\ mol}{kg} = 0.03125\ mol$ solute

$\Rightarrow$ molar mass of solute $= \frac{3.8\ g}{0.03125\ mol} = 121.6\ g/mol$

However, CH_3COOH has a molar mass of 60.05 g/mol.

$\Rightarrow$ Our "solute" is twice as heavy as expected!

WHY?

- 2 molecules H-Bond + act as one!
- DIMERIZATION!