CH 302 Spring 2009 Practice Quiz 1 Answer Key

1. Rank the following in order of decreasing vapor pressure:
Ar, NH_2, TiO_2, C_6H_6, CH_3OH, LiBr, CH_2Cl_2, C_2H_6.
   1. TiO_2 > LiBr > NH_2 > CH_3OH > CH_2Cl_2 > C_6H_6 > C_2H_6 > Ar.
   2. Ar > C_6H_6 > CH_2Cl_2 > C_2H_6 > CH_3OH > LiBr > NH_2 > TiO_2.
   3. Ar > C_2H_6 > C_6H_6 > CH_2Cl_2 > CH_3OH > NH_2 > LiBr > TiO_2. **correct**
   4. Ar > C_2H_6 > C_6H_6 > CH_2Cl_2 > NH_2 > CH_3OH > LiBr > TiO_2
Explanation: As intermolecular forces (instantaneous dipoles, dipole-dipole interactions, H-bonding and ionic bonding) for a given species increase, the vapor pressure decreases.

2. An unknown liquid is 2000 Pa at 25 °C and 7500 Pa at 50 °C. Based on the Clausius-Clapeyron equation which expression below could be used to solve for the enthalpy of vaporization (ΔH_{vap}) of the unknown liquid?
   1. [(8.314 J/mol*K)ln(7500 Pa /2000 Pa)] / [(1/50) – (1/25)] = ΔH_{vap}
   2. -[(8.314 J/mol*K)ln(7500 Pa /2000 Pa)] / [(1/323) – (1/298)] = ΔH_{vap} **correct**
   3. [(8.314 J/mol*K)ln(7500 Pa /2000 Pa)] / [(1/323) – (1/298)] = ΔH_{vap}
   4. -[(8.314 J/mol*K)ln(7500 Pa /2000 Pa)] / [(1/50) – (1/25)] = ΔH_{vap}
   5. -[(8.314 J/mol*K)ln(7500 Pa /2000 Pa)] / [(1/323) + (1/298)] = ΔH_{vap}
Explanation: Solve the Clausius-Clapeyron equation to express ΔH_{vap} in terms of the other variables. Plug in the given values, but remember to convert temperature to Kelvin.

3. For the process of ice sublimating to water vapor the sign of ΔH is (positive\negative) and the sign of ΔS is (positive\negative).
   1. positive, positive   **correct**
   2. positive, negative
   3. negative, positive
   4. negative, negative
Explanation: The signs of ΔH and ΔS are always the same for phase transitions. Ice must absorb heat to sublime and water vapor has a higher standard molar entropy than ice.

4. Consider the phase diagram below. A sample of water starts out at 298 K and 1 atm. It is compressed to 500 atm at constant temperature, and then heated to 750 K at constant pressure. Next, it is decompressed at 750 K back to 1 atm and finally cooled to 400 K at constant pressure.

What is the initial phase of the water (solid, liquid, gas, supercritical fluid), and does the water undergo any phase transition during the four steps described above (yes, no)?

(a) Argon   (b) Carbon dioxide   (c) Water
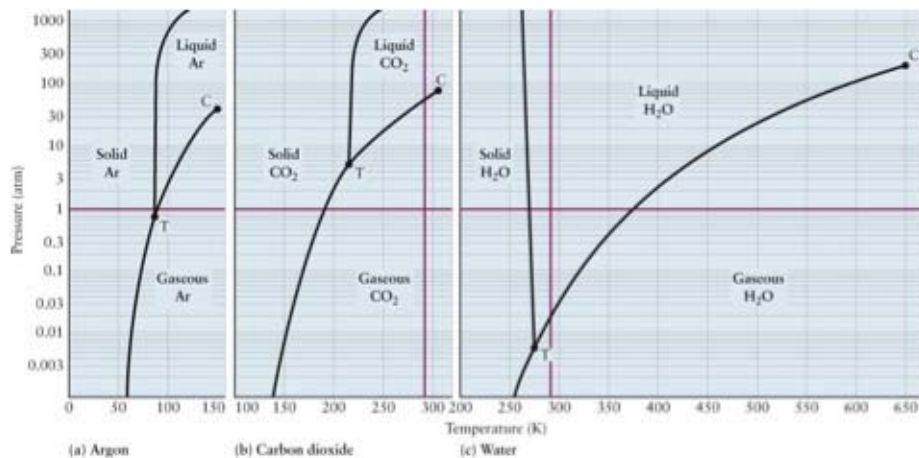
   1. liquid, yes
   2. solid, yes
   3. gas, yes

4. liquid, no   **correct**

5. solid, no

6. gas, no

Explanation: Use the phase diagram to determine the phase at the initial conditions (which are ambient conditions of room temperature and atmospheric pressure and thus liquid water).

For the second part, although the water starts out as a liquid and ends as a gas, no phase transition occurs. Why? Because the water is taken to the supercritical region. The change from liquid to supercritical fluid is smooth and gradual, as is the subsequent change from supercritical fluid to gas. Since there is no abrupt change in density or other physical properties, there is no phase transition.

For extra practice, answer and think about the same for Ar and CO2.

5. 10g of steam at 200°C is cooled to ice at -100°C. Assuming the following constants:

$c_{ice} = A$ J/g °C

$c_{water} = B$ J/g °C

$c_{steam} = C$ J/g°C

$\Delta H_{fusion} = D$ J/g

$\Delta H_{vaporization} = E$ J/g

express ΔH_{total} in terms of A, B, C, D and E.

1. $1000(A+B+C+D+E)$ J
2. $10(A+B+C+D+E)$ J
3. $1000(A+B+C) + 10(D+E)$ J   **correct**
4. $10(A+B+C) + 1000(D+E)$ J
5. $1000(A+B) + 10(C+D+E)$ J

Explanation:Cooling steam from 200°C to 100°C, $\Delta H = m\ c_{steam}\ \Delta T = 10g \times C \times 100°C = 1000C$ J.

Changing steam to water at 100°C (the boiling point of water), $\Delta H = m\ \Delta H_{vaporization} = 10g \times E = 10\ E$ J. Cooling water at 100°C to water at 0°C, $\Delta H = m\ c_{water}\ \Delta T = 10g \times B \times 100$ °C $= 1000\ B$ J.

Changing water to ice at 0°C (the freezing point of water), $\Delta H = m\ \Delta H_{fusion} = 10g \times D = 10\ D$ J.

Finally, cooling ice from 0°C to -100°C, $\Delta H = m\ c_{ice}\ \Delta T = 10g \times A \times 100°C = 1000A$ J. Adding everything together, the ΔH_{sys} for the entire process is $(1000C + 10E + 1000B + 10D + 1000A)$ J.

6. Which of the following statements regarding the dissolution of salt is true?
1. The greater the charge density of the ions in the salt, the more favorable dissolution is.
2. The stronger the intermolecular forces of the salt, the less favorable dissolution is.   **correct**
3. The solubility of salts generally decreases as temperature increases.
4. The salt's lattice energy is irrelevant to its solubility.
5. None of these are true.

Explanation: The greater the charge density, the harder it is to separate the ions and the harder it is to dissolve the salt. Likewise, the greater the intermolecular force, the harder it is to separate the ions and dissolve the salt. With the exceptions of sodium sulfate and lithium carbonate, every other salt has an increasing solubility at a higher temperature. Finally, the greater the lattice energy of a salt, the lower the solubility of the salt.

7. Dissolving gases in water is always an (endothermic\exothermic) process because the gas molecules must (lose\gain) kinetic energy in the form of heat in order to enter the aqueous phase.
1. endothermic, lose
2. endothermic, gain
3. exothermic, lose   **correct**
4. exothermic, gain

Explanation: Kinetic molecular theory states that molecules in the gas phase possess an amount of kinetic energy proportional to their temperature. When they collide with a water surface, they can either bounce off that surface and remain in the gas phase or stick to that surface and enter the aqueous phase. Because these aqueous molecules move much more slowly than their gaseous counterparts they also have less kinetic energy. This difference in kinetic energy was lost (as heat) by the gas molecules to their surroundings, making dissolution of gases an exothermic process.

8. Rank the following liquids in terms of increasing miscibility in water: H_2O_2 (hydrogen peroxide), CH_3OH (methanol), C_8H_{18} (octane), C_2H_7Cl (chloroethane).

   1. $CH_3Cl < CH_3OH < H_2O_2 < C_8H_{18}$

   2. $C_8H_{18} < CH_3Cl < CH_3OH < H_2O_2$ **correct**

   3. $H_2O_2 < C_8H_{18} < CH_3Cl < CH_3OH$

   4. $CH_3OH < H_2O_2 < C_8H_{18} < CH_3Cl$

Explanation: In obedience to the maxim that "like dissolves like," and considering that water exhibits hydrogen bonding, the species with the most hydrogen bonding potential will be the most miscible - in this case hydrogen peroxide. Behind that is methanol, with one hydrogen bonding partner. Then chloroethane, which is polar, and finally octane which is non-polar.