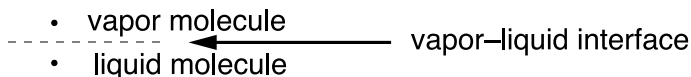


Vapor Liquid Equilibrium: Here's a little bit of a tangent but it's prompted because this is one of those times when you are being taught something but in an over simplified way. You're only responsible for understanding a few little things about VLE but if you're interested I'll explain it in a little more detail. (If you're not interested you can skip down to "shut up and leave me alone.")

- VLE looks at equilibrium at an interface between the liquid and vapor phase.



Mathematically, equilibrium is achieved when a specific quantity, the chemical potential, for each species is equal in both the vapor and liquid phases. Physically, you can envision the natural tendency toward equilibrium by considering a molecular picture of the interface between the phases. First, recall that pressure, at a specific temperature, is determined by the rate of collisions of the gas molecules with the walls of their container. Now if the pressure above the liquid is less (greater) than the vapor pressure of the liquid, then the rate of molecules hitting (and sticking to) the liquid will be less (greater) than the rate of molecules escaping from the liquid. This will increase (decrease) the rate of vapor molecules hitting all the surfaces (including the liquid). Eventually, the pressure above the liquid will become equal to the vapor pressure of the liquid.

Raoult's Law <----- shut up and leave me alone

Raoult's Law allows you to calculate the partial pressure that a species will exert when it is a component of a solution. We know that a pure liquid exerts a vapor pressure. This equation allows you to find the pressure exerted by all members in a solution

$$P_A = X_A P^{\text{sat}}$$

This just says that the partial pressure of species A (P_A) is equal to the mole fraction of species A in the solution (X_A) times the vapor pressure of pure A (P^{sat}) at the specified temperature.

Raoult's Law is an idealization of how solutions behave in the real world, and there are two types of deviations from it that you should be familiar with (familiar enough to explain them in an essay).

Positive Deviations: These are when you get a higher vapor pressure than predicted by Raoult's Law. It means that the attractive forces between the molecules of the solution are weaker than they would be for a pure solution of any component of the mixture. As a result, it is easier for molecules to jump into the vapor phase.

Negative Deviations: When the attractive forces between molecules in the solution are greater than those in pure solutions, you get negative deviations from Raoult's Law. The vapor pressure of the solution is lower than that predicted by Raoult's law.

Remember, the vapor pressure of the solution will be the sum of the partial pressures (calculated by Raoult's Law) for all species in the solution.

Henry's Law

Henry's Law is less emphasized than Raoult's Law but you should still know what it is. Henry's Law says that the solubility of a gas in a liquid is directly proportional to the partial pressure of the gas over the solution:

$$C_g = k P_g$$

You often have to solve for k , the Henry's law constant, at one set of conditions and then calculate the solubility (C_g) at another pressure (P_g).

Student Packet: 2.6: Vapor Liquid Equilibrium: AssessMe questions

- 1) Which of the following is insoluble in water?
- A) KI B) CO₂ C) NaBr D) Mg(OH)₂ E) I'm clueless
- 2) Which of the following will be most soluble in water?
- A) C₈H₁₀ B) Br₂ C) NaI D) SiC E) I'm clueless
- 3) Which of these solvents will dissolve the salt NaCl?
- A) carbon tetrachloride
B) acetone, (CH₃)₂CO
C) benzene, C₆H₆
D) methanol, CH₃OH
E) I'm clueless
- 4) Which of these tests would best distinguish between sodium chloride and diamond dust, both of which are finely divided clear crystals?
- A) volatility — NaCl is volatile while diamond is not.
B) solubility in benzene — NaCl will dissolve in a nonpolar solvent.
C) conductivity — NaCl is ionic and will conduct electricity in the solid form.
D) solubility in water — only NaCl will dissolve.
E) I'm clueless
- 5) Which of the following will have the highest melting point?
- A) benzene, C₆H₆ B) CF₄ C) Hg D) silicon E) I'm clueless
- 6) Which of the following substances melts far below room temperature and is held together by dispersion forces?
- A) potassium B) quartz C) magnesium oxide D) argon E) I'm clueless

Student Packet: 2.6: Vapor Liquid Equilibrium: ShowMe questions

- 1) What mass of water will condense in a 500 mL beaker filled with 0.075 g of water if the temperature is 50°C and the vapor pressure of H₂O at 50°C is 0.122 atm?

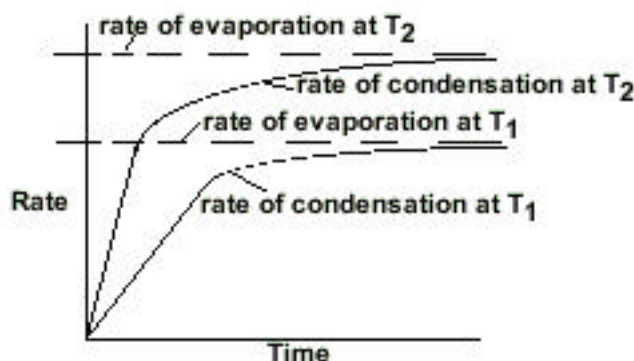
- 2) What is the relative humidity for a day when the partial pressure of water vapor in the air is 30.5 torr and the temperature of the air is 40°C? The equilibrium vapor pressure of H₂O at 40°C is 55.3 torr.

- 3) Estimate the vapor pressure of water at 70°C. Note the normal boiling point of water is 100°C and that the heat of vaporization is 40.7 kJ/mol. At the normal boiling point, the vapor pressure is 760 mm Hg.

- 4) Calculate the heat of vaporization of water from the following water vapor pressures: 760 mm Hg at 100°C and 233.7 mm Hg at 70°C.

Student Packet: 2.6: Vapor Liquid Equilibrium: TestMe questions

1)



Which of the following statements are true?

- I. Vapor pressure is lower at T_2
- II. $T_2 > T_1$
- III. $T_1 > T_2$
- IV. Vapor pressure is higher at T_2

- A) II, IV B) III, I C) II D) III E) II, I

2) What is the dew point for a day when the partial pressure of water vapor in the air is 118.0 torr and the temperature of the air is 80°C? Use the following chart.

Temp/°C	35	50	55	70	80
P/Torr	42.2	92.5	118.0	233.7	355.1

- A) 355.1 torr B) 55 torr C) 35°C D) 55°C E) None of the above

3) How do the following changes affect the vapor pressure of a liquid?

increased surface area
smaller volume of a liquid
increased temperature

- A) no effect, decrease, decrease B) no effect, no effect, increases
C) increase, decrease, increase D) increase, no effect, increase
E) decrease, no effect, decrease

4) What is the vapor pressure of mercury at 80°C? The vapor pressure of Hg at 60°C is 0.02524 mm Hg and the heat of vaporization is 60.3 kJ/mol.

- A) .08 mm Hg B) 349 mm Hg C) .08 torr D) 349 atm E) None of the above

5) Which of the following statements are true about boiling points of liquids?

- I. During the process of boiling, the temperature increases.
- II. Occurs when the vapor pressure of a liquid equals the pressure exerted on the liquid.
- III. Defined as the partial pressure of the vapor over the liquid measured at equilibrium.
- IV. The boiling point of a liquid can vary.

- A) I, II, IV B) I, III, IV C) III, IV D) I, III, IV E) II, IV