a) Calculate the total pressure as well as the composition of the vapor phase.
b) To what temperature should you bring the system in order to increase the mol fraction of CO_2 in the liquid by a factor of 5, if the total pressure is to remain constant?
c) Calculate the composition of the vapor phase for the conditions of part (b).
Henry's constant of CO_2 is

+4 -2400

$$k_i^H = 9.12 \times 10^{-3} e^{2400/T} \text{ (bar kg/mol)}.$$

change to comma

with T in kelvin. Notice

~~Notice~~ that Henry's law constant is expressed in units of molality.

Problem 13.3: The fugacity coefficient of CO_2 in liquid n-pentane at 344.15 K, 2.93 bar approaches the value $\phi = \text{~~39.2~~}$. Use this information to calculate Henry's law constant for this system.

39.2, as the mol fraction of CO2 approaches zero.

Problem 13.4: A chemical process produces a waste stream that is mostly air but contains dimethlyamine (DMA) at a mol fraction of 0.01. To satisfy emission standards, the gas stream must be purified to contain no more than 100 ppm of DMA. To achieve this concentration, the gas is passed through a liquid scrubber in which water is sprayed from the top of the tank while the gas rises. During the contact between the drops and the gas, some DMA is transferred to the liquid phase. The inlet water contains no DMA and the exiting streams may be assumed to be in equilibrium with each other. The process is operated at 25 °C, 1 bar.
a) Calculate the required flow rate of water to achieved the desired purification. Report the result in kg of water per kg of air.
b) If the water flow rate must remain less than 50 kg water/kg of air, what is the required pressure?
c) Critique the assumption that the exit streams are at equilibrium.
Additional data: Henry's law constant for DMA at 25 °C is 1.84 bar.

Problem 13.5: A tank contains a mixture of water and carbon dioxide. The mol fraction of CO_2 in the liquid is 5.0E-04 and the temperature is 70 °C.
a) Calculate the total pressure as well as the composition of the vapor phase.
b) To what temperature should you bring the system in order to increase the mol fraction of CO_2 in the liquid by a factor of 5, if the total pressure is to remain constant?
c) Calculate the composition of the vapor phase for the conditions of part (b).
d) List and justify all your assumptions.
Henry's constant for CO_2 is given in Problem 13.2.

Problem 13.6: Pure water (stream A) and H_2S (stream B) are brought into contact in a bubbler where they reach equilibrium at 1 bar, 50 °C. The gas stream that leaves

the bubbler is then compressed to 5 bar and subsequently passes through a heat exchanger which cools the compressed stream to 25 °C.
a) Determine the composition of streams D and C.
b) Determine whether stream G contains any liquid and if so, calculate the fraction of the liquid.
Additional data: The saturation pressure of water (P_w) and Henry's law constant for H_2S in water (k^H) are given below as a function of T:

$$\ln P_w = -37.224 + 0.16686 \times T - 0.00017985 \times T^2,$$
$$\ln k^H = -14.13 + 0.11365 \times T - 0.00015146 \times T^2.$$

In the above, T is in kelvin while both P_w^{sat} and K are in bar.

Move to chapter 13

Problem 13.7: a) Calculate the solubility of ammonia in water at 25 °C if the partial pressure of ammonia in the gas phase is 2 bar.
b) Calculate Henry's law constant for ammonia in water at 25 °C.
Additional data:
ΔG°_{298} for NH_3(g) = −16450 J/mol,
ΔG°_{298} for NH_3(aq) = −26500 J/mol.

Problem 13.8: An air stream that contains 8% ammonia (by mol) is treated in absorption tower that removes 95% of the ammonia. In this unit, the gas stream is brought into contact with freshwater at 1 bar, 20 °C. In a simplified treatment of the process, assume that the liquid that exits the tower is in equilibrium with the exiting air stream. Determine the required flow rate of water per mol of the air stream entering the unit. The following equilibrium data are available:

x	0.0206	0.0310	0.0407	0.0502	0.0735	0.0962
y	0.0158	0.0240	0.0329	0.0418	0.0660	0.0920

Data from Wark, Warner, and Davis, *Air Pollution: Its Origin and Control*, 3rd ed., (Boston: Addison-Wesley, 1998), p. 329.

Problem 13.9: Water and normal heptane are essentially immiscible.
a) What is the bubble temperature of a liquid mixture that contains 50% by mol normal heptane at 1 bar?
b) What is the dew temperature of a vapor mixture with 50% normal heptane at 1 bar?
c) What is the dew pressure of an equimolar vapor mixture at 50 °C?