1. Explain/show the structure of a hydrogen bond.
2. Write the Lewis structures and give the shapes of each of the following molecules; predict which substance of each pair has the higher boiling point. Explain your reasoning.
   1. Ethanol, CH3CH2OH or dimethyl ether, CH3-O-CH3?
   2. Butane, C4H10 or octanol, C8H18?
   3. PF3 or PCl3?
   4. SO2 or CO2?
3. The phase diagram of an unknown substance is shown below:

P

R

E

S

S

U

R

E

1 atm

TEMPERATURE

* 1. Label the solid liquid and gas regions of the phase diagram.
  2. Label the triple point and the critical point.
  3. Label the normal freezing and boiling points.
  4. Which phase is more dense the liquid or the solid? Explain your reasoning.

1. Explain why CH3OH is completely soluble in water but not completely soluble in toluene, C6H5CH3.
2. A room in which the humidity has been lowered feels cooler. Yet the dehumidifier has not “cooled” the room. Why is that?
3. How might one go about establishing whether a solution of sodium sulfate in water is saturated, unsaturated, or supersaturated?
4. A 10.7 m solution of NaOH has a density of 1.33 g/mL at 20oC. Calculate
   1. The mole fraction of NaOH
   2. The mass percentage of NaOH
   3. The molarity of the solution
5. A solution of glucose (C6H12O6) is prepared by dissolving 100.0 g of glucose in 1000. g of water. The density of the resultant solution is 1.050 g/mL. Kb for water is 0.52 oC/m and kf for water is –1.86 oC/m.
   1. What is the vapor pressure of the solution at 100.0oC?
   2. What is the boiling point of the solution?
   3. What is the osmotic pressure of the solution at 25oC?
6. A compound of carbon, hydrogen, and oxygen was burned in oxygen, and 1.000 g of the compound produced 1.434 g CO2 and 0.783 g H2O. In another experiment, 0.1107 g of the compound was dissolved in 25.0 g of water. This solution had a freezing point of -0.0894oC. What is the molecular formula of the compound?
7. The osmotic pressure of blood at 37oC is 7.7 atm. A solution that is given intravenously must have the same osmotic pressure as the blood. What should be the molarity of a glucose solution to give an osmotic pressure of 7.7 atm at 37oC?
8. For the equilibrium C(s) + 2 H2(g) <==> CH4(g) + heat
   1. Write the equilibrium constant expression as Kc.
   2. What are the units of the equilibrium constant Kp?
   3. How is Kc related to Kp (specify quantitatively)
   4. For each of the following changes to the system at equilibrium, predict the direction of the shift and explain why it occurs:

|  |  |  |
| --- | --- | --- |
| Change | Shift (left or right) | Reason |
| The volume of the reaction vessel is doubled. |  |  |
| The temperature is increased. |  |  |
| The pressure of H2(g) is increased. |  |  |
| C(s) is added to the system. |  |  |
| Adding a catalyst |  |  |

1. The equilibrium constant for the reaction N2O4(g) <==> 2 NO2(g) is 0.212 mol/L at 100o C. What is the value of Kc at 100oC for:
   1. 2 NO2(g) <==> N2O4(g)
   2. NO2(g) <==> 1/2 N2O4(g)
2. For the reaction NO(g) + NO2(g) + H2O(g) <==> 2 HNO2(g), occurring at 28oC, [NO]*i* = [NO2]*i* = 44.1 torr and [H2O]*i* = 17.5 torr. If the total pressure at equilibrium is 95.6 torr.
   1. What are the equilibrium pressures of all species?

P(NO) =

P(NO2) =

P(H2O) =

P(HNO2) =

* 1. Calculate Kp for the reaction.

1. At some temperature the system 2 SO2(g) + O2(g) <==> 2 SO3(g) is at equilibrium when [SO2] = 0.0100 M, [O2] = 0.200 M and [SO3] = 0.100 M. What is the value of Kc at this temperature?
2. The reaction 2 NO(g) + Br2(g) <==> 2 NOBr(g) has a Kp = 1.17 atm−1 at 25oC. If 1.10 atm of NOBr, 0.100 atm of NO, and 0.0100 atm of Br2 are mixed at 25oC, what reaction will occur? Explain.
   1. When 5.00 atm of NOBr is allowed to equilibrate at 50oC, the equilibrium pressure of NOBr is measured to be 4.30 atm. What is the value of Kp at 50oC? Compare with the value of Kp at 25oC and explain.
3. Assume that you place a fresh water plant into a salt solution and examine it under a microscope. What happens to the plant cells? What if you placed a salt-water plant in pure water? Explain. Draw pictures to illustrate your explanation.
4. Pure iodine (100.0 g) is dissolved in 300.0 g of CCl4 at 65oC. Given that the vapor pressure of CCl4 at this temperature is 504 mm Hg, what is the vapor pressure of the CCl4/I2 solution at 65oC? (Assume that I2 does not contribute to the vapor pressure.)