Sample Problems

Henry's Law $S_1 / P_1 = S_2 / P_2$
Solve for $S_2 = S_1 P_2 / P_1$

1. $S_2 = (S_1 \times P_2)/P_1 = (0.16 \text{ g/L} \times 288 \text{ kPa})/104 \text{ kPa} = 4.4 \times 10^{-1} \text{ g/L}$

Solve for $P_2 = S_2 P_1 / S_1$

2. $P_2 = (P_1 \times S_2)/S_1 = (1.0 \text{ atm} \times 9.5 \text{ g/L})/3.6 \text{ g/L} = 2.6 \text{ atm}$

Lesson Check Answers

3. agitation, temperature, particle size of the solute
4. A dynamic equilibrium exists between the solution and the undissolved solute, provided that the temperature remains constant. As new particles from the solid are solvated and enter into solution, an equal number of already-dissolved particles crystallize. *SC.912.P.12.13*
5. temperature (if the solute is a solid or liquid); temperature and pressure (if the solute is a gas)
6. grams of solute per 100 g of solvent
7. chemical composition of the solute and solvent
8. **a.** Add solvent.
   b. Increase the pressure.
9. 1.4 g/L

Sample Problems

Molarity = moles of solute / Liters of solution
M = mol/L

10. 36.0 g x 1 mol/180 g = 0.2 mol / 2.0 L = 0.1 M or or 1.0×10^{-1} M

11. *Change mL to L → 250 mL x 1/10^3 L = 0.250 L*
    0.70 mol / 0.250 mL = 2.8 M

12. *Change mL to L → 335 mL x 1/10^3 L = 0.335 L*
    M = mol/L → mol = M x L
    Mol = 0.425 M x 0.335 L = 0.142 mol or 1.42×10^{-1} mol

13. *Change mL to L → 250 mL x 1/10^3 L = 0.250 L*
M = mol/L → mol = M x L
Mol = 2.0 M x 0.250 L = 0.50 mol x molar mass of $CaCl_2$
molar mass of $CaCl_2$ = 111 g/mol x 0.50 mol = 55.5 g $CaCl_2$

14. $M_1V_1 = M_2V_2$
Solve for $V_1 = M_2V_2 / M_1$
V_1 = 250.0 mL x 0.760 M / 4.00 M = 47.5 mL
Place 47.5 mL of 4.00 M KI in a flask, and add water to make a total solution of 250.0 mL, meaning you add 202.5 mL of water.

15. $M_1V_1 = M_2V_2$
Solve for $V_1 = M_2V_2 / M_1$
V_1 = 250.0 mL x 0.20 M / 1.0 M = 50.0 mL
Place 50.0 mL of 1.0 M NaCl in a flask, and add water to make a total solution of 250.0 mL, meaning you add 200.0 mL of water.
Use a volumetric pipette to transfer 5.0×10^1 mL of the 1.0*M* solution to a 250-ml volumetric flask. Then add distilled water up to the mark.

16. percent volume = volume of solute / volume of solution x 100%
% Volume = 10 mL / 200 mL x 100 % = 5%

17. percent volume = volume of solute / volume of solution x 100%
Solve for volume of solute = volume of solution x % Volume / 100 %
Volume of solute = 400.0 mL x 3.0 % / 100% = 12 mL
- *Dividing the percentage by 100% leaves a decimal*

18. percent mass = mass of solute / mass of solution x 100%
Solve for mass of solute = mass of solution x percent mass / 100%
Mass of solute = 250 g x 0.10% / 100% = 0.25 g
- *Dividing the percentage by 100% leaves a decimal*

Lesson Check Answers

19. If the number of moles and the volume of a solution is known, its molarity is determined by dividing the moles of solute by the volume of the solution.

20. Diluting a solution reduces the number of moles of solute per unit volume, but the total number of moles of solute in solution does not change.

21. Express the concentration as the ratio of the volume of the solute to the volume of the solution (v/v) or as the ratio of the mass of the solute to the mass of the solution (m/m).

22. $6.27 \times 10^{-1} M$ $CuSO_4$

23. 7.50 mL

24. 1.00×10^{-2} mol KNO_3

25. 2.0% (v/v) diethyl ether

26. 7.5×10^{1} g K_2SO_4

27. **BIG**IDEA *M* = mol of solute/L of solution; %(v/v) = volume of solute/volume of solution. You would need to know the molar mass and density of the solute in order to convert moles of solute to volume of solute.

28. vapor-pressure lowering, boiling-point elevation, and freezing-point depression

29. Formation of solvation shells around solute particles reduces the number of water molecules with sufficient kinetic energy to escape the solution. Therefore, the vapor pressure is lower relative to pure solvent.

30. Because vapor pressure has been reduced, more kinetic energy is needed to reach the boiling point. For a solution to freeze, it must lose more kinetic energy than the pure solvent does.

31. concentrated sodium fluoride, because the magnitude of the boiling-point elevation is proportional to the number of solute particles dissolved in the solvent

32. **a.** MgI_2 solution
b. KI solution
c. KI solution

33. Volatile solutes quickly evaporate at higher temperatures and so would not be present to cause the elevation of the solvent's boiling point.

Sample Problems

34. Molality = moles of solute / kg of solvent
m = mol/kg
Solve for mol = m x kg = 0.400 m x 0.750 kg = 0.3 mol
0.3 mol x molar mass NaF (42 g/mol) = 12.6 g NaF
Remember that 750 g x 1 kg/10^3 g = 0.750 kg

35. Find mol NaCl = Na (23 g/mol) + Cl (35.5 g/mol) = 58.5 g/mol
10.0 g x 1 mol/58.5 g = 0.17 mol
Molality = moles of solute / kg of solvent
m = 0.17 mol / 0.600 kg = 0.285 m
Remember that 600 g x 1 kg/10^3 g = 0.600 kg

36. 300 g (C_2H_6O) / 46 g/ml = 6.52 mol
500 g (H_2O) / 18 g/ml = 27.8 mol
6.52 mol + 27.8 mol = 34.3 mol total
6.52/34.3 = 0.19 mole fraction (C_2H_6O)
27.8/34.3 = 0.81 mole fraction (H_2O)
Mole fractions also add up to 1

37. 50 g (CCl_4) / 154 g/ml = 0.325 mol
50 g ($CHCl_3$) / 119.5 g/ml = 0.418 mol
0.325 mol + 0.418 mol = 0.743 mol total
0.325/0.743 = 0.437 mole fraction (CCl_4)
0.418/0.743 = 0.563 mole fraction ($CHCl_3$)

38. *Find moles of $C_6H_{12}O_6$*
10.0 g x 1 mol/180 g = 0.0556 mol
Find m = mol/kg
m = 0.0556 mol / 0.0500 kg = 1.11 m
$\Delta T_f = k_f$ x m
ΔT_f = 1.86 C/m x 1.11 m = 2.06 C
Remember that 50.0 g x 1 kg/10^3 g = 0.0500 kg

39. *Find moles of C_3H_6O*
200 g x 1 mol/58 g = 3.4 mol
Find m = mol/kg
m = 3.4 mol / 0.4 kg = 8.6 m
$\Delta T_f = k_f$ x m
ΔT_f = 5.12 C/m x 8.6 m = 44 C
Remember that 400 g x 1 kg/10^3 g = 0.4 kg

40. *Find m = mol/kg* *Remember that 1400 g x 1 kg/10^3 g = 1.4 kg*
m = 1.25 mol / 1.4 kg = 0.89 m
$\Delta T_b = k_b$ x m x I → *$CaCl_2 \rightarrow Ca^{+2} + 2Cl^-$ [dissociates into 3 mol ions]*
ΔT_b = 0.512 C/m x 0.89 m = 0.457 C x 3 mol ions = 1.37 C
T_b = 100 C + 1.37 C = 101.37 C

41. $\Delta T_b = k_b \times m \times I$ → *NaCl → Na^+ + Cl^- [dissociates into 2 mol ions]*
Solve for m = ΔT_b / 0.512 C/m x i
m = 2.00 C / 0.512 C/m x 2 = 1.95 m
m = mol/kg … solve for mol = m x kg = 1.95 mol x 1.000 kg = 1.95 mol
1.95 mol x molar mass NaCl (58.5 g/mol) = 114 g NaCl

42. Molality and mole fractions are two convenient ways of expressing the ratio of solute particles to solvent particles.

43. The magnitudes of the freezing-point depression (ΔT_f) and the boiling-point elevation (ΔT_b) of a solution are directly proportional to the molal concentration (*m*) when the solute is molecular, not ionic.

44. 20.6 g NaBr

45. X_{CH_3COOH} = 0.200; X_{H_2O} = 0.800

46. 4.95°C

47. Given the list of dissolved elements and their concentrations in ppm, students should infer that the freezing point of ocean water is less than 0°C at 1 atm and that the rate of evaporation of ocean water is slower because of lowered vapor pressure.

44. Molality = moles of solute / kg of solvent
m = mol/kg
Solve for mol = m x kg = 0.500 m x 0.400 kg = 0.2 mol
0.2 mol x molar mass NaBr (102.9 g/mol) = 20.6 g NaBr
Remember that 400 g x 1 kg/10^3 g = 0.400 kg

45. 2.50 mol ($C_2H_4O_2$)
10.00 mol (H_2O)
2.50 mol + 10.00 mol = 12.50 mol total
2.50/12.50 = 0.20 mole fraction (C_2H_6O)
10.00/12.50 = 0.80 mole fraction (H_2O)
Mole fractions also add up to 1

46. *Find moles of CCl_4*
12.0 g x 1 mol/154 g = 0.0779 mol
Find m = mol/kg
m = 0.0779 mol / 0.750 kg = 0.104 m
Remember that 750 g x 1 kg/10^3 g = 0.750 kg
$\Delta T_f = k_f \times m$
ΔT_f = 5.12 C/m x 0.104 m = 0.532 C
T_f = 5.48 C – 0.532 C = 4.95 C