1

Molality, Weight Percent, and Mole Fraction

Syllabus Learning Outcomes : 1, 3, 7

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- Solution: homogeneous mixture of 2 or more substances in a single phase.
- One substance is the solvent.
- The others are solutes.

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- Saturated solutions contain the maximum quantity of solute that dissolves at a temperature.
- Unsaturated solutions contain less.
- Supersaturated Solutions contain more than is possible and are unstable.

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Calculating Enthalpy of Solution

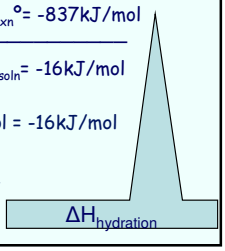
$KF(s) \rightarrow K^+(g) + F^-(g)$ $\Delta H_{rxn}^\circ = 821 kJ/mol = -\Delta H_{lattice}$

$K^+(g) + F^-(g) \rightarrow K^+(aq) + F^-(aq)$ $\Delta H_{rxn}^\circ = -837 kJ/mol$

$KF(s) \rightarrow K^+(aq) + F^-(aq) + heat$ $\Delta H^\circ_{soln} = -16 kJ/mol$

$\Delta H^\circ_{solution} = 821 kJ/mol + -837 kJ/mol = -16 kJ/mol$

Forming this solution is exothermic.



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- Unlike KF, NaOAc and NH_4Cl have endothermic heats of solution, so heat releases with crystalization.

$Na^+(aq) + CH_3CO_2^-(aq) \rightarrow NaCH_3CO_2(s) + heat$

Forming this solution is endothermic.

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Henry's Law gives gas solubility

$S_g = k_H \cdot P_{gas}$

Gas solubility (S_g, mol/L)

Henry's law constant (k_H, M/atm)

Pressure of gas (P_{gas}, atm)

k_H for O_2 in H2O = 1.66×10^{-6} M/mmHg

$P_{gas} \downarrow, S_g \downarrow$

Watch units! If K_H is mmHg, use P in mmHg

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Colligative properties depend on the number of particles in solution, not the type

- Concentration units for colligative properties must tell the number of solute particles per solvent particle
- Molality, mole fraction, and weight percent do this.
- Molarity doesn't (need the density of solution to get from L to mass of solution).

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Mole fraction, X, molality, m, and weight % for a mixture of A (solute) and, B (solvent)

X_A = mol A / (mol A + mol B)

X has no units (dimensionless)

m = (mol A / kg B)

Weight % = grams A / 100 g solution
= g A / (g A + g B) * 100%
= g A / (g solution) * 100%

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Calculate m, X, and wt%

Dissolve 92.1g (1.00 mol) of propylene glycol ($C_3H_8O_3$) in 500.g (27.8 mol) of H_2O.

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Calculate mole fraction, X

Dissolve 92.1g (1.00 mol) of $C_3H_8O_3$ in 500.g (27.8 mol) H_2O

$$X_{glycol} = \frac{1.00\text{mol } C_3H_8O_3}{1.00\text{mol } C_3H_8O_3 + 27.8\text{mol } H_2O}$$

$$X_{glycol} = 0.0347$$

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Calculate m and wt%

Dissolve 92.1g (1.00 mol) of $C_3H_8O_3$ in 500.g (27.8 mol) H_2O

$$m(C_3H_8O_3) = \frac{1.00\text{mol } C_3H_8O_3}{0.500\text{kg } H_2O} = 2.00 \text{ molal}$$

$$wt\%(C_3H_8O_3) = \frac{92.1\text{ g}}{92.1\text{g} + 500.\text{g}} \times 100\% = 15.6\%$$

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Convert Concentration Units

Dissolve 92.1g (1.00 mol) of $C_3H_8O_3$ in 500.g (27.8 mol) H_2O

X_{glycol} = 0.0347
= 2.00 molal $C_3H_8O_3$
=15.6% $C_3H_8O_3$

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To convert these units, start with the definitions, make an assumption, calculate g and mol

- Convert a 2.00m aqueous $C_3H_8O_3$ solution to wt% and X.

1) Assume 1kg of H_2O
2) 1kg H_2O x (2.00mol $C_3H_8O_3$/kg H_2O)=2.00 mol $C_3H_8O_3$.
3) (1kg) 1000g H_2O is 55.5mol H_2O, and
   2.00mol$C_3H_8O_3$ is 184.2g $C_3H_8O_3$
4) wt%= 184.2g $C_3H_8O_3$/(184.2g $C_3H_8O_3$+1000g H_2O)·100%
5) X= 2.00mol $C_3H_8O_3$/(2.00mol $C_3H_8O_3$+ 55.5mol H_2O)

Answers are slide 12

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To convert these units, start with the definitions, make an assumption, calculate g and mol

- Convert a 15.6% aqueous $C_3H_8O_3$ solution to m and X.

1) Assume 100g of solution
2) 100g sol'n x (15.6g $C_3H_8O_3$/100g sol'n)= 15.6g $C_3H_8O_3$.
3) 15.6g $C_3H_8O_3$ is 0.169 mol $C_3H_8O_3$, and
   100g-15.6g= 84.4g H_2O is 4.68mol H_2O
4) m= 0.169mol $C_3H_8O_3$/0.0844kg H_2O
5) X= 2.00mol $C_3H_8O_3$/(2.00mol $C_3H_8O_3$+ 55.5mol H_2O)

Answers are on slide 12

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To convert these units, start with the definitions, make an assumption, calculate g and mol

- Convert an aqueous solution with a mole fraction of 0.0347 $C_3H_8O_3$ solution to m and wt%.

1) Assume 1 mol $C_3H_8O_3$
2) 1 mol $C_3H_8O_3$/(1 mol $C_3H_8O_3$+x)=0.0347. x=27.8mol H_2O
3) 1mol $C_3H_8O_3$ is 92.1g $C_3H_8O_3$, and
   27.8mol H_2O is 501g H_2O
4) m= 1mol $C_3H_8O_3$/0.501kg H_2O
5) wt%= 92.1g $C_3H_8O_3$/(92.1g $C_3H_8O_3$+ 501g H_2O)

Answers are on slide 12

