

Properties of Solutions

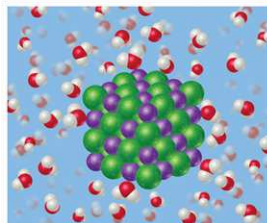
Solutions

- Solutions are homogeneous mixtures of two or more pure substances.
- In a solution, the solute is dispersed uniformly throughout the solvent.

State of Solution	State of Solvent	State of Solute	Example
Gas	Gas	Gas	Air
Liquid	Liquid	Gas	Oxygen in water
Liquid	Liquid	Liquid	Alcohol in water
Liquid	Liquid	Solid	Salt in water
Solid	Solid	Gas	H ₂ in Palladium
Solid	Solid	Liquid	Hg in Silver
Solid	Solid	Solid	Silver in Gold

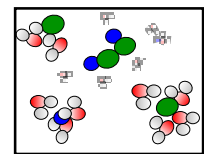
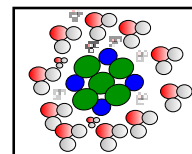
Solutions

The intermolecular forces between solute and solvent particles must be strong enough to compete with those between solute particles and those between solvent particles.



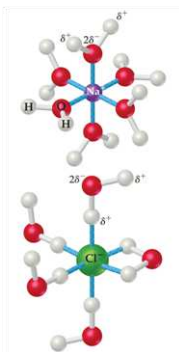
How Does a Solution Form?

As a solution forms, the solvent pulls solute particles apart and surrounds, or solvates, them.



The solute is added to the solvent. The negative ions are pulled away by the positive pole of the solvent molecule. The positive ions are pulled away by the negative pole of the solvent molecule.

How Does a Solution Form?



If an ionic salt is soluble in water, it is because the ion-dipole interactions are strong enough to overcome the lattice energy of the salt crystal.

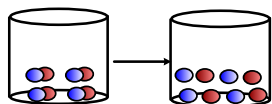
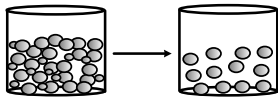
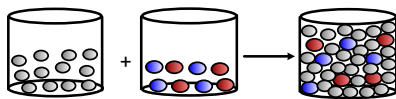
1 The process of solute particles being surrounded by solvent particles is known as _____.

- A salutation
- B agglomeration
- C solvation
- D agglutination
- E dehydration

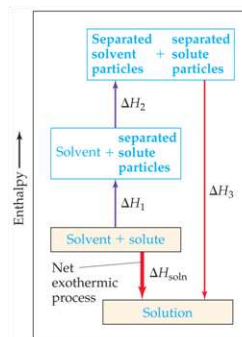
Energy Changes in Solution

Three processes affect the energetics of solution:

- separation of solute particles,
- separation of solvent particles,
- new interactions between solute and solvent.

D H₁ - Separation of solute moleculesD H₂ - Separation of solvent moleculesD H₃ - Formation of solute-solvent interactions

Energy Changes in Solution

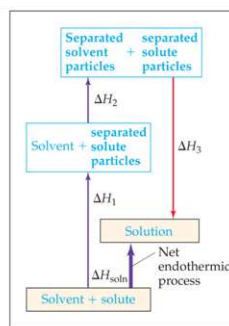


The enthalpy change of the overall process depends on ΔH for each of these steps.

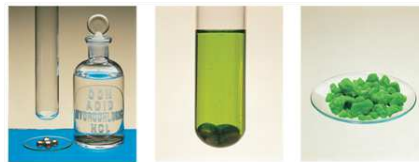
Energy Changes in Solution

Chemical reactions, as well as solution formation, will occur spontaneously as long as the change in Gibbs Free Energy is negative.

When an overall process is endothermic, the increase in enthalpy is offset by an increase in entropy.



Solution Formation

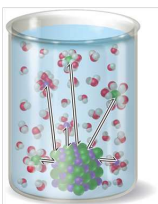


Just because a substance disappears when it comes in contact with a solvent, it doesn't mean the substance dissolved.

Dissolution is a physical change — you can get back the original solute by evaporating the solvent.

If you can't recover the original solute, then the substance didn't dissolve; it reacted.

Saturated Solutions

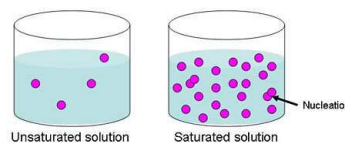


In a saturated solution, the solvent holds as much solute as is possible at that temperature.

Dissolved solute is in dynamic equilibrium with solid solute particles.

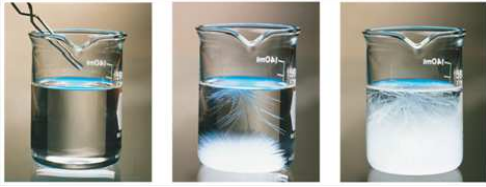
Unsaturated Solutions

An unsaturated solution contains **less than the maximum amount of solute** that can be dissolved in the solvent (at a given temperature).



Solid solute is **not** in dynamic equilibrium with dissolved solute.

Supersaturated Solutions



In supersaturated solutions, the solvent holds more solute than is normally possible at that temperature.

These solutions are unstable; crystallization can usually be stimulated by adding a "seed crystal" or scratching the side of the flask.

Rapid Crystallization (Supersaturated Solution Demo) - Video

2 A saturated solution _____.

- A contains as much solvent as it can hold
- B contains no double bonds
- C contains dissolved solute in equilibrium with undissolved solute
- D will rapidly precipitate if a seed crystal is added
- E cannot be attained

3 An unsaturated solution is one that _____.

- A has no double bonds
- B contains the maximum concentration of solute possible, and is in equilibrium with undissolved solute
- C has a concentration lower than the solubility
- D contains more dissolved solute than the solubility allows
- E contains no solute

4 A solution with a concentration higher than the solubility is _____.

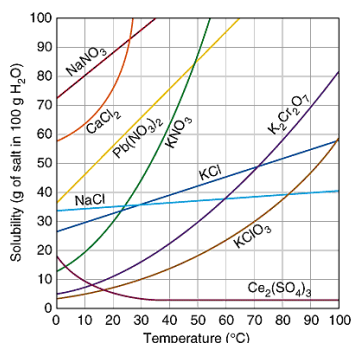
- A is not possible
- B is unsaturated
- C is supercritical
- D is saturated
- E is supersaturated

5 A supersaturated solution _____.

- A is one with more than one solute
- B is one that has been heated
- C is one with a higher concentration than the solubility
- D must be in contact with undissolved solid
- E exists only in theory and cannot actually be prepared

Factors Affecting Solubility

Temperature and Solubility



Generally, the solubility of solid solutes in liquid solvents increases with increasing temperature.

Factors Affecting Solubility

Chemists use the axiom "like dissolves like."

- Polar ionic substances and tend to dissolve in polar solvents.
- Nonpolar substances tend to dissolve in nonpolar solvents.

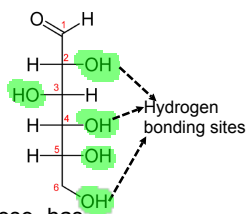
Alcohol	Solubility in water	Solubility in hexane
CH ₃ OH methanol	#	0.12
CH ₃ CH ₂ OH ethanol	#	#
CH ₃ CH ₂ CH ₂ OH propanol	#	#
CH ₃ CH ₂ CH ₂ CH ₂ OH butanol	0.11	#
CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ OH pentanol	0.030	#
CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ CH ₂ OH hexanol	0.0058	#

solubility expressed in mol/100g solvent
= completely miscible

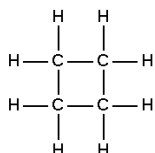
Factors Affecting Solubility

The more similar the intermolecular attractions, the more likely one substance is to be soluble in another.

Glucose (which has hydrogen bonding) is very soluble in water, while cyclobutane (which only has dispersion forces) is not.



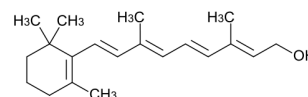
Glucose- has hydroxyl groups and is highly soluble in water



Cyclobutane- has no polar OH groups and is essentially insoluble in water

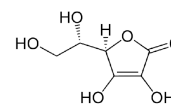
Factors Affecting Solubility

Vitamin A has a large non-polar portion consisting of C-C and C-H bonds. Because of this long hydrophobic "tail", Vitamin A is soluble in nonpolar compounds (like fats).



Vitamin A

In contrast, Vitamin C is soluble in water due to its ability to form several hydrogen bonds.



Vitamin C

6 The phrase "like dissolves like" refers to the fact that _____.

- A gases can only dissolve other gases
- B polar solvents dissolve polar solutes; nonpolar solvents dissolve nonpolar solutes
- C solvents can only dissolve solutes of similar molar mass
- D condensed phases can only dissolve other condensed phases
- E polar solvents dissolve nonpolar solutes and vice versa

7 Which one of the following is most soluble in water?

- A CH₃OH
- B CH₃CH₂CH₂OH
- C CH₃CH₂OH
- D CH₃CH₂CH₂CH₂OH
- E CH₃CH₂CH₂CH₂CH₂OH

8 Which one of the following is most soluble in hexane (C_6H_{14})?

- A CH_3OH
 B $CH_3CH_2CH_2OH$
 C CH_3CH_2OH
 D $CH_3CH_2CH_2CH_2OH$
 E $CH_3CH_2CH_2CH_2CH_2OH$

9 Which of the following substances is more likely to dissolve in CH_3OH ?

- A CCl_4
 B Kr
 C N_2
 D CH_3CH_2OH
 E H_2

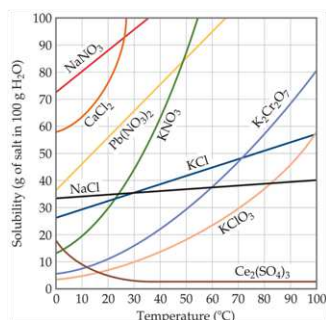
10 Which of the following substances is more likely to dissolve in water?

- A $HOCH_2CH_2OH$
 B $CHCl_3$
 C $CH_3(CH_2)_9 HC=O$
 D $CH_3(CH_2)_8CH_2OH$
 E CCl_4

11 Which one of the following substances is more likely to dissolve in CCl_4 ?

- A CBr_4
 B HBr
 C HCl
 D CH_3CH_2OH
 E NaCl

Temperature

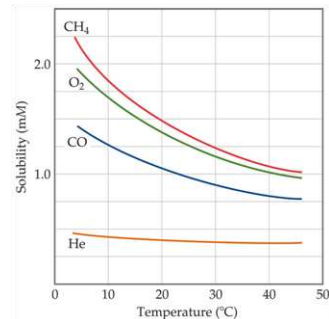


Generally, the solubility of solid solutes in liquid solvents increases with increasing temperature.

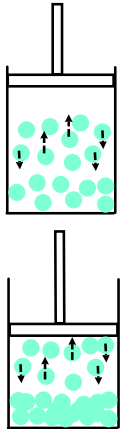
Temperature

The opposite is true of gases: as the solvent temperature increases, gases are usually LESS soluble.

- Carbonated soft drinks are more "bubbly" if stored in the refrigerator.
- Warm lakes have less O_2 dissolved in them than cool lakes.



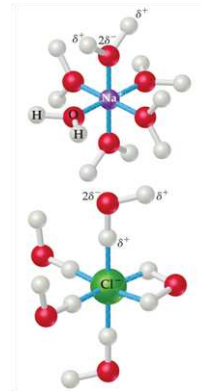
Gases in Solution



- The solubility of liquids and solids does not change appreciably with pressure.
- The solubility of a gas in a liquid is directly proportional to its pressure.

Gases in Solution

- In general, the solubility of gases in water increases with increasing mass.
- Larger molecules have stronger dispersion forces.



Henry's Law

$$S_g = kP_g \text{ where}$$

- S_g is the solubility of the gas,
- k is the Henry's Law constant for that gas in that solvent, and
- P_g is the partial pressure of the gas above the liquid.



HenrysLawMovie.MOV

12 Increasing the temperature _____ the solubility of solids and _____ the solubility of gases in a liquid.

- A decreases, increases
- B doesn't effect, increases
- C increases, decreases
- D increases, increases
- E solids and liquids

13 Increasing the pressure on a liquid _____ the solubility of solids and _____ the solubility of gases in a liquid.

- A decreases, increases
- B doesn't effect, increases
- C increases, decreases
- D increases, increases
- E solids and liquids

14 Pressure has an appreciable effect on the solubility of _____ in liquids.

- A gases
 B solids
 C liquids
 D salts
 E solids and liquids

Calculating Concentrations of Solutions

Expressing Concentrations of Solutions

Mass Percentage of Solute

$$\text{Mass \% of solute A} = \frac{\text{Mass of A in solution}}{\text{Total mass of solution}} \times 100\%$$

15 The concentration of urea in a solution prepared by dissolving 16 g of urea in 39 g of H₂O is _____% by mass.

- A 29
 B 41
 C 0.29
 D 0.41
 E 0.48

16 A solution contains 11% by mass of sodium chloride. This means that _____.

- A there are 11 g of sodium chloride in 1.0 mL of this solution
 B 100 g of the solution contains 11 g of sodium chloride
 C 100 mL of the solution contains 11 g of sodium chloride
 D the density of the solution is 11 g/mL
 E the molality of the solution is 11

Expressing Concentrations of Solutions

Mole Fraction (X)

Assume a solute A is dissolved in a solvent B

$$X_A = \frac{\text{moles of A}}{\text{total moles (A + B) in solution}}$$

In some applications, one needs the mole fraction of *solvent*, not solute — make sure you find the quantity you need!

17 The mole fraction of He in a gaseous solution prepared from 4.0 g of He, 6.5 g of Ar, and 10.0 g of Ne is _____.

- A 0.60
 B 1.5
 C 0.20
 D 0.11
 E 0.86

Expressing Concentrations of Solutions

Molarity (M)

- Two solutions can contain the same compounds but be quite different because the proportions of those compounds are different.
- Molarity is one way to measure the concentration of a solution.
- Since volume is temperature-dependent, molarity can change with temperature.

$$\text{Molarity (M)} = \frac{\text{moles of the solute}}{\text{volume of solution in liters}}$$

20 What is the concentration (M) of CH₃OH in a solution prepared by dissolving 11.7 g of CH₃OH in sufficient water to give exactly 230 mL of solution?

- A 11.9
 B 1.59×10^{-3}
 C 0.0841
 D 1.59
 E 11.9×10^{-3}

18 The mole fraction of urea (MW = 60.0 g/mol) in a solution prepared by dissolving 16 g of urea in 39 g of H₂O is _____.

- A 0.58
 B 0.37
 C 0.13
 D 0.11
 E 9.1

19 When 0.500 mol of HC₂H₃O₂ is combined with enough water to make a 300.0 mL solution, the concentration of HC₂H₃O₂ is _____ M.

- A 3.33
 B 1.67
 C 0.835
 D 0.00167
 E 0.150

Expressing Concentrations of Solutions

Molality (m)

$$m = \frac{\text{mol of solute}}{\text{kg of solvent}}$$

Since both moles and mass do not change with temperature, molality (unlike molarity) is *not* temperature-dependent.

21 The concentration of a benzene solution prepared by mixing 12.0 g C_6H_6 with 38.0 g CCl_4 is _____ molal.

- A 4.04
 B 0.240
 C 0.622
 D 0.316
 E 0.508

22 The concentration of HCl in a solution that is prepared by dissolving 5.5 g of HCl in 200g of C_2H_6O is _____ molal.

- A 27.5
 B 7.5×10^{-4}
 C 3.3×10^{-2}
 D 0.75
 E 1.3

23 Which one of the following concentration units varies with temperature?

- A molarity
 B mass percent
 C mole fraction
 D molality
 E all of the above

24 Which one of the following is a correct expression for molarity?

- A mol solute/L solvent
 B mol solute/mL solvent
 C mmol solute/mL solution
 D mol solute/kg solvent
 E $\mu\text{mol solute/L solution}$

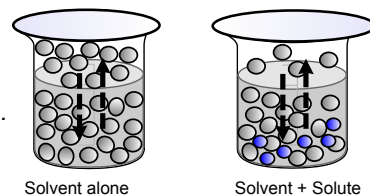
Colligative Properties

- Changes in colligative properties depend only on the number of solute particles present, not on the identity of the solute particles.
- Among colligative properties are
 - Vapor pressure lowering
 - Boiling point elevation
 - Melting point depression
 - Osmotic pressure

Vapor Pressure Lowering

Because of solute-solvent intermolecular attraction, higher concentrations of nonvolatile solutes make it harder for solvent to escape to the vapor phase.

Therefore, the vapor pressure of a solution is lower than that of the pure solvent.



Raoult's Law

When a nonvolatile solute is dissolved in a solvent, The vapor pressure above the solution is proportional to mole-fraction of the of the solvent and its vapor pressure.

$$P_A = X_A P_A^\circ$$

where...

- X_A is the mole fraction of the solvent, A
- P_A° is the normal vapor pressure of pure A at that temperature.

NOTE: This is one of those times when you want to make sure you have the vapor pressure of the *solvent*.

Colligative Properties and Ionization

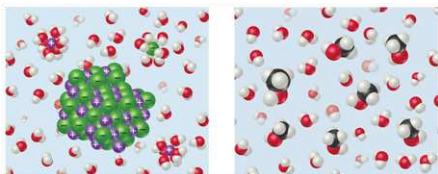
We said earlier that colligative properties depend only on the number of solute particles present, not on the *identity* of the solute particles.

However, it's important to note that it's the number of particles in solution, not the number of particles before they are dissolved.

If a solute ionizes, you can get more particles in solution than you started with...depending on the substance.

Colligative Properties of Electrolytes

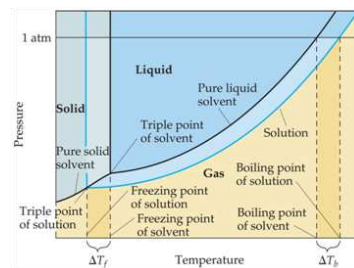
However, a 1M solution of NaCl does not show twice the change in freezing point that a 1M solution of methanol does.



Boiling Point Elevation and Freezing Point Depression

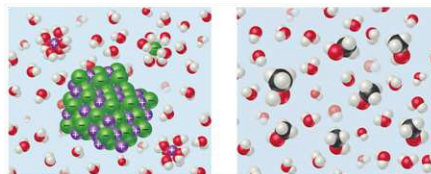
Nonvolatile solute-solvent interactions also cause solutions to have higher boiling points and lower freezing points than the pure solvent.

The boiling point elevation and freezing point depression depend on the number (but not the kind) of solute particles in the solution.

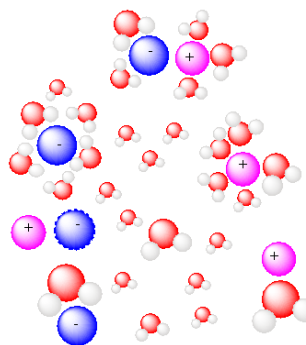


Colligative Properties of Electrolytes

Since these properties depend on the number of particles dissolved, solutions of electrolytes (which dissociate in solution) should show greater changes than those of nonelectrolytes.



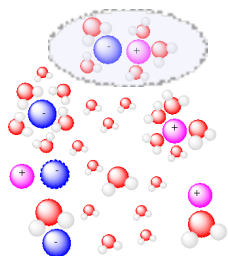
van't Hoff Factor, i



The van't Hoff factor is a theoretical number of particles created by one mole of a dissolved substance.

The van't Hoff factor for all non-electrolytes is 1.

van't Hoff Factor



- One mole of NaCl in water does not really give rise to two moles of ions because some Na^+ and Cl^- reassociate for a short time.
- So, the true concentration of particles is somewhat less than two times the concentration of NaCl.

Nevertheless, we say that NaCl has a van't Hoff factor of 2.

Note that reassociation is more likely at higher concentration. Thus, the number of particles present is concentration-dependent.

van't Hoff Factor, i

The value of i is found to be limited to the number of particles, (ions) the solute will dissociate into.

Each NaCl formula unit will produce 2 particles or ions.

So the van't Hoff factor for NaCl is $i=2$

Each CaCl_2 formula unit will produce 3 particles or ions.

So, for CaCl_2 , $i=3$

Each $\text{Al}_2(\text{SO}_4)_3$ formula unit will produce ___ particles or ions. So, for $\text{Al}_2(\text{SO}_4)_3$, $i=$ ___

Recall that $i=1$ for all non-electrolytes such as glucose and sucrose.

Boiling Point Elevation

The change in boiling point is proportional to the molality of the solution:

$$\Delta T_b = i \times K_b \times m$$

where K_b is the molal boiling point elevation constant, a property of the solvent.

Solvent	Normal boiling point 0°C	K_b	Normal freezing point 0°C	K_f
H_2O	100	0.51	0.0	1.86
C_6H_6	80.1	2.53	5.5	5.12
$\text{C}_2\text{H}_5\text{OH}$	78.4	1.22	-114.6	1.99
CCl_4	76.8	5.02	-22.3	29.8
CHCl_3	61.2	3.63	-63.5	4.68

ΔT_b is added to the normal boiling point of the solvent.

Freezing Point Depression

- The change in freezing point can be found similarly:

$$\Delta T_f = i \times K_f \times m$$

- Here K_f is the molal freezing point depression constant of the solvent.

Solvent	Normal boiling point 0°C	K_b	Normal freezing point 0°C	K_f
H_2O	100	0.51	0.0	1.86
C_6H_6	80.1	2.53	5.5	5.12
$\text{C}_2\text{H}_5\text{OH}$	78.4	1.22	-114.6	1.99
CCl_4	76.8	5.02	-22.3	29.8
CHCl_3	61.2	3.63	-63.5	4.68

ΔT_f is subtracted from the normal boiling point of the solvent.

Boiling Point Elevation and Freezing Point Depression

Note that in both equations, ΔT does not depend on what the solute is, but only on how many particles are dissolved, according to the van't Hoff factor.

$$\Delta T_b = i K_b m$$

$$\Delta T_f = i K_f m$$

25 Which of the following will have the highest boiling point?

- A pure H_2O
- B 0.10 M aqueous glucose
- C 0.20 M aqueous glucose
- D 0.20 M CaCl_2
- E 0.20 M NaCl

$$\Delta T_b = i (K_b) m$$

$$\Delta T_f = i (K_f) m$$

26 Which of the following will have the lowest melting point?

- A 0.10 m aqueous sucrose ($C_{12}H_{22}O_{11}$)
 B 0.20 M $Pb(NO_3)_2$
 C 0.20 M KOH
 D 0.20 M NaCl
 E 0.20 M KCl

$$DT_b = i (K_b)m$$

$$DT_f = i (K_f)m$$

27 Which of the following will have the lowest vapor pressure?

- A pure H_2O
 B 0.20 M $Pb(NO_3)_2$
 C 0.20 M $AlCl_3$
 D 0.20 M RbCl
 E 0.20 M MgF_2

$$DT_b = i (K_b)m$$

$$DT_f = i (K_f)m$$

28 Which of the following aqueous solutions will have the lowest vapor pressure?

- A 0.25 M glucose, $C_6H_{12}O_6$
 B 0.50 M glucose
 C 0.50 M sucrose, $C_{12}H_{22}O_{11}$
 D 1.0 M sucrose
 E All of these aqueous solutions have equal vapor pressure.

$$DT_b = i (K_b)m$$

$$DT_f = i (K_f)m$$

29 Which of the following aqueous solutions will have the highest vapor pressure?

- A 0.75 M glucose, $C_6H_{12}O_6$
 B 0.50 M glucose
 C 0.25 M sucrose, $C_{12}H_{22}O_{11}$
 D 0.50 M sucrose
 E All of these aqueous solutions have equal vapor pressure.

$$DT_b = i (K_b)m$$

$$DT_f = i (K_f)m$$

30 Which of the following will have the highest vapor pressure?

- A pure water
 B 1.0 m sucrose (aq)
 C 1.0-m NaCl (aq)
 D 1.0-m HCl (aq)
 E 1.0-m $CaCl_2$ (aq)

$$DT_b = i (K_b)m$$

$$DT_f = i (K_f)m$$

31 Which of the following will have the lowest vapor pressure?

- A pure water
 B 1.0 m sucrose (aq)
 C 1.0-m $CaCl_2$ (aq)
 D 1.0-m HCl (aq)
 E 1.0-m KCl (aq)

$$DT_b = i (K_b)m$$

$$DT_f = i (K_f)m$$

32 Which of the following will have the highest boiling point?

- A pure water
 B 1.0 m sucrose (aq)
 C 1.0-m NaCl (aq)
 D 1.0-m HCl (aq)
 E 1.0-m CaCl₂ (aq)

$$DT_b = i (K_b)m$$

$$DT_f = i (K_f)m$$

33 Which of the following will have the lowest boiling point?

- A pure water
 B 1.0 m sucrose (aq)
 C 1.0-m NaCl (aq)
 D 1.0-m HCl (aq)
 E 1.0-m CaCl₂ (aq)

$$DT_b = i (K_b)m$$

$$DT_f = i (K_f)m$$

34 Which of the following will have the highest freezing point?

- A pure water
 B 0.20-m glucose (aq)
 C 0.20-m KBr (aq)
 D 0.20-m HCl (aq)
 E 0.20-m AlCl₃ (aq)

$$DT_b = i (K_b)m$$

$$DT_f = i (K_f)m$$

35 Which of the following will have the lowest freezing point?

- A pure water
 B 0.15-m Mg(NO₃)₂ (aq)
 C 0.15-m glucose(aq)
 D 0.15-m NaF (aq)
 E 0.15-m HBr (aq)

$$DT_b = i (K_b)m$$

$$DT_f = i (K_f)m$$

36 Which of the following aqueous solutions will have the highest boiling point?

- A 0.10 m NaCl
 B 0.15 m NaCl
 C 0.20 m NaCl
 D 0.25 m NaCl
 E pure water

$$DT_b = i (K_b)m$$

$$DT_f = i (K_f)m$$

37 What is the boiling point for a 2m aqueous solution of glucose?

- A 1
 B 2
 C 101
 D 102
 E 103

$$DT_b = i (K_b)m$$

$$DT_f = i (K_f)m$$

38 What is the boiling point for a $2m$ aqueous solution of NaF?

- A 2
 B 101
 C 102
 D 103
 E 105

$$DT_b = i (K_b)m$$

$$DT_f = i (K_f)m$$

Colligative Properties

Sorry, this element requires Flash, which is not currently supported in PDFs.

Please refer to the original Notebook file.



Credit to Tom Greenbowe

Molar Mass Determination

$$M = \frac{1000 K_f w}{W DT} \qquad M = \frac{1000 K_b w}{W DT}$$

M = molar mass of the solute
 K_f or K_b = molal depression or boiling point elevation constant
 w = mass of the solute in grams
 W = mass of the solvent in grams
 DT = change in Freezing pt or Boiling pt

39 A solution is prepared by dissolving 2.53 grams of p-dichlorobenzene (molecular weight 147.0) in 25.86 grams of naphthalene (molecular weight 128.2). Calculate the molality of the p-dichlorobenzene solution.

40 The freezing point of pure naphthalene is determined to be 80.2°C . The solution prepared in p-dichlorobenzene is found to have an initial freezing point of 75.7°C . Calculate the molal freezing-point depression constant of naphthalene.

41 A solution of 2.42 grams of the unknown hydrocarbon dissolved in 26.7 grams of naphthalene is found to freeze initially at 76.2°C . Calculate the apparent molecular weight of the unknown hydrocarbon on the basis of the freezing-point depression experiment above.

- 42 A solution of 1.570 grams of the compound in 16.08 grams of camphor is observed to freeze at a temperature 15.2 Celsius degrees below the normal freezing point of pure camphor. Determine the molar mass and apparent molecular formula of the compound. (The molal freezing-point depression constant, K_f , for camphor is 40.0 $\text{kg}\cdot\text{K}\cdot\text{mol}^{-1}$.)

Osmosis

Some substances form semipermeable membranes, allowing some smaller particles to pass through, but blocking other larger particles.

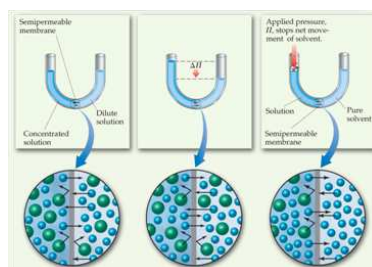
In biological systems, most semipermeable membranes allow water to pass through, but solutes are not free to do so.

Osmosis and Osmotic Pressure.MOV

- 43 Colligative properties of solutions include all of the following except _____.

- A depression of vapor pressure upon addition of a solute to a solvent
- B elevation of the boiling point of a solution upon addition of a solute to a solvent
- C depression of the freezing point of a solution upon addition of a solute to a solvent
- D an increase in the osmotic pressure of a solution upon the addition of more solute
- E the increase of reaction rates with increase in temperature

Osmosis



In osmosis, there is net movement of solvent from the area of higher solvent concentration (*lower solute concentration*) to the area of lower solvent concentration (*higher solute concentration*).

Osmotic Pressure

The pressure required to stop osmosis, known as osmotic pressure, P is

$$PV = nRT$$

$$P = \frac{nRT}{V} = MRT$$

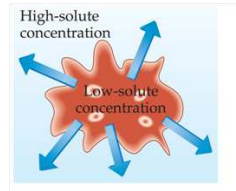
where M is the molarity of the solution.

If the osmotic pressure is the same on both sides of a membrane (i.e., the concentrations are the same), the solutions are isotonic.

Osmosis in Blood Cells

If the solute concentration outside the cell is greater than that inside the cell, the solution is hypertonic.

Water will flow out of the cell, and crenation results.



44 Osmosis is best defined as the movement of

- A Molecules from an area of high concentration to an area of lower concentration
- B Molecules from an area of low concentration to an area of higher concentration
- C Water molecules across a membrane from an area of low water to an area of higher concentration
- D Water molecules across a membrane from an area of high concentration to low area of concentration
- E Water molecules inside a container

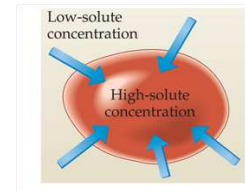
46 A 5% urea solution is hypotonic to a 10% urea solution.

- True
- False

Osmosis in Cells

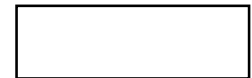
If the solute concentration outside the cell is less than that inside the cell, the solution is hypotonic.

Water will flow into the cell, and hemolysis results.



45 Which of the following will pass through a cell membrane most easily?

- A small polar molecules
- B small nonpolar molecules
- C large polar molecules
- D large nonpolar molecules
- E large neutral molecules



Colloids

Suspensions of particles larger than individual ions or molecules, but too small to be settled out by gravity are called colloids.

Phase of Colloid	Dispersing (solutelike) Substance	Dispersed (solventlike) Substance	Colloid Type	Example
Gas	Gas	Gas	—	None (all are solutions)
Gas	Gas	Liquid	Aerosol	Fog
Gas	Gas	Solid	Aerosol	Smoke
Liquid	Liquid	Gas	Foam	Whipped cream
Liquid	Liquid	Liquid	Emulsion	Milk
Liquid	Liquid	Solid	Sol	Paint
Solid	Solid	Gas	Solid foam	Marshmallow
Solid	Solid	Liquid	Solid emulsion	Butter
Solid	Solid	Solid	Solid sol	Ruby glass

Tyndall Effect

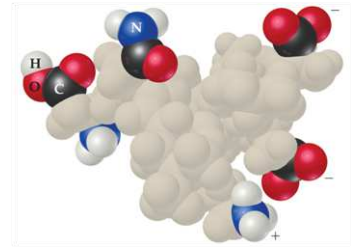


- Colloidal suspensions can scatter rays of light.
- This phenomenon is known as the Tyndall effect.



Colloids in Biological Systems

Some molecules have a polar, hydrophilic (water-loving) end and a non-polar, hydrophobic (water-hating) end.



Colloids in Biological Systems



Sodium stearate is one example of such a molecule.

Colloids in Biological Systems

These molecules can aid in the emulsification of fats and oils in aqueous solutions.

