CHAPTER 10: Solutions

Part 1: Types of solutions and concentration

Types and Examples of Solutions			
Types of Solution	**Example**	**Solvent**	**Solute**
Gas	air	Nitrogen (gas)	Oxygen (gas)
Liquid	Carbonated water	Water (liquid)	Carbon dioxide (gas)
	Ocean water	Water (liquid)	Oxygen gas (gas)
	antifreeze	Water (liquid)	Ethylene glycol(liquid)
	Vinegar	Water (liquid)	Acetic acid (liquid)
	Ocean water	Water (liquid)	Sodium chloride (solid)
Solid	Dental amalgam	Silver (solid)	Mercury (liquid)
	Steel	Iron (solid)	Carbon (solid)

Solutions are homogeneous mixtures that contain two or more substances called the solute and solvent.
Most solutions are liquids, but gaseous and solid solutions exist.
A substance that dissolves in a solvent is **soluble.**
•Two liquids that are soluble in each other in any proportion are **miscible**.
•A substance that does not dissolve in a solvent is **insoluble.**
•Two liquids that can be mixed but separate shortly after are **immiscible.**
The concentration of a solution is a measure of how much solute is dissolved in a specific amount of solvent or solution.
Concentration can be described as concentrated or dilute.

•Dilution equation: $M_1V_1 = M_2V_2$

Concentration Ratios	
Concentration Description	**Ratio**
Percent by mass	$\frac{\text{mass of solute}}{\text{mass of solution}} \times 100\%$
Percent by volume	$\frac{\text{volume of solute}}{\text{volume of solution}} \times 100\%$
Molarity	$\frac{\text{Moles of solute}}{\text{Liters of solvent}}$
Molality	$\frac{\text{Moles of solute}}{\text{Kg of solvent}}$
Mole fraction	$\frac{\text{Moles of solute}}{\text{Moles of solute + Moles of solvent}}$

Q1 **A measure of how much solute is dissolved in a specific amount of solvent or solution...**
CH 10
A Solution Volume **B** Solution Mass
C Solution Concentration **D** Solution Solubility
The concentration of a solution is a measure of how much solute is dissolved in a specific amount of solvent or solution. →C

Q2 **The ratio between solute and solvent or the solution as a whole...**
CH 10
A Density **B** Concentration
C Volume **D** Mass
The concentration is the ratio between solute and solvent or the solution. →B

Q3 **The percent by mass of a solution containing 10 g of dissolved solute in 40g of water...**
CH 10
A 10% **B** 9% **C** 5% **D** 20%
$\frac{10g}{10+40} \times 100\%$
$= 20\%$
→D

Q4 **Miscible substances are:**
CH 10
A Two liquids that are not soluble in each other
B Solids that do not dissolve in liquids
C Two liquids that are soluble in each other
D Solids that do not dissolve in liquids
Two liquids that are soluble in each other in any proportion are miscible. →C

Q5 **Immiscible substances are:**
CH 10
A Two liquids that are not soluble in each other
B Solids that do not dissolve in liquids
C Two liquids that are soluble in each other
D Solids that do not dissolve in liquids
Two liquids that can be mixed but separate shortly after are immiscible. →A

Q6 **The percent by volume of a solution containing 500ml of HNO_3 in 2L of H_2O...**
CH 10
A 10% **B** 9% **C** 5% **D** 20%
$\frac{500\ ml}{(500+2000)\ ml} \times 100\%$
$= 20\%$
→D

Q7 **The number of moles of solute divided by liters of the solution is called ____.**

CH 10
A Molarity
B Molality
C Percent by volume
D Percent by mass

The number of moles of solute divided by liters of the solution is called Molarity →A

Q8 **Molarity is...**

CH 10
A Moles of solute/liters of solution
B Moles of solute + liters of solution
C Moles of solute x liters of solution
D Moles of solute - liters of solution

The number of moles of solute divided by liters of the solution is called Molarity →A

Q9 **Moles per liter is the unit of...**

CH 10
A Molality **B** Molarity
C Molar ratio Volume **D** Percent by mass

The number of moles of solute divided by liters of the solution is called Molarity →B

Q10 **A solution has a 1000ml volume and the number of moles of the solute is 2 mol, what is the molarity of this solution?**

CH 10
A 0.1 M **B** 0.2 M
C 2 M **D** 20 M

The number of moles of solute divided by liters of the solution is called Molarity →C

Q11 **The number of solute moles _____ when diluting solutions.**

CH 10
A Decreases **B** Increases
C Doubles **D** Doesn't change

The number of solute moles Doesn't change when diluting solutions. →D

Q12 **What is the volume required of a 0. 4M KI solution to form a 0.2M solution with a volume of 0.4 L?**

CH 10
A 100 ml **B** 200 ml
C 300 ml **D** 400 ml

$M_1V_1=M_2V_2$
$0.4M \times V_1 = 0.2M \times 0.4L$
$V_1 = 0.2L = 200ml$ →B

Q13 **The number of moles of solute dissolved in 1 Kg of solvent...**

CH 10
A Molarity **B** Molality
C Mole fraction **D** Percent by mass

Molality is a measure of the number of moles of solute in a solution corresponding to 1 kg or 1000 g of solvent. →B

Q14 **Calculate the molality of a solution containing 20 moles dissolved in 2 kg of water.**

CH 10
A 10 mol/kg **B** 15 mol/kg
C 20 mol/kg **D** 25 mol/kg

$\frac{20\ mol}{2\ Kg} = 10\ mol/kg$ →A

Part 2: Solvation

The Solvation Process

- Solvation is the process of surrounding solute particles with solvent particles to form a solution.
- Solvation in water is called hydration.
- The attraction between dipoles of a water molecule and the ions of a crystal is greater than the attraction among ions of a crystal.
- During solvation, the solute must separate into particles and move apart, which requires energy.
- The overall energy change that occurs during solution formation is called the heat of the solution.

Solubility

- Solubility depends on the nature of the solute and solvent.
- Unsaturated solutions are solutions that contain less dissolved solute for a given temperature and pressure than a saturated solution.
- Saturated solutions contain the maximum amount of dissolved solute for a given amount of solute at a specific temperature and pressure.
- Solubility is affected by increasing the temperature of the solvent because of the kinetic energy of the particles increases.
- A supersaturated solution contains more dissolved solute than a saturated solution at the same temperature.
- To form a supersaturated solution, a saturated solution is formed at a high temperature and then slowly cooled.
- Supersaturated solutions are unstable.
- Gases are less soluble in liquid solvents at high temperatures.
- The solubility of gases increases as their external pressure is increased.

Henry's law states that at a given temperature, the solubility (S) of a gas in a liquid is directly proportional to the pressure (P)

$$\frac{S_1}{P_1} = \frac{S_2}{P_2}$$

Q15 **Solutes in a solution can be:**

CH 10
A Liquids only
B Liquids and solids only
C Gases and solids only
D Gases, liquids, or solids

Solutes in a solution can be Gases, liquids, or solids →D

Q16 **For a given amount, which type of solution contains the LEAST amount of solute?**

CH 10
A Solvated **B** Saturated
C Supersaturated **D** Unsaturated

Unsaturated solutions are solutions that contain less dissolved solute for a given temperature and pressure than a saturated solution. →D

Q17 **Which is NOT a type of solution?**

CH 10
A Polyunsaturated **B** Saturated
C Supersaturated **D** Unsaturated

Solution could be saturated, unsaturated, or supersaturated →A

Q18 **Which of the following solutions contains the largest amount of solute?**

CH 10
A Buffer solution **B** Saturated
C Supersaturated **D** Unsaturated

A supersaturated solution contains more dissolved solute than a saturated solution at the same temperature. →C

Q19 **The amount of solute in a supersaturated solution is greater than that of a ___ solution.**

CH 10
A Buffer solution **B** Saturated
C Standard **D** Normal

A supersaturated solution contains more dissolved solute than a saturated solution at the same temperature. →B

Q20 **At a given temperature, the solubility of a gas is directly proportional to what?**

CH 10
A Volume **B** Mass
C Molarity **D** Pressure

Henry's law states that at a given temperature, the solubility (S) of a gas in a liquid is directly proportional to the pressure (P) →D

Q21 **The solubility of gas in liquid increases by...**

CH10
A Increasing agitation
B Increasing volume
C decreasing pressure
D Decreasing the temperature

Decreasing the temperature increase solubility of gases →D

Q22 **How do we make carbon dioxide dissolve in liquid?**

CH 10
A Continuous agitation
B decreasing the pressure
C Increasing the temperature
D Decreasing the temperature

Decreasing the temperature increase solubility of gases →D

Q23 **When the pressure is 40 Pa, the solubility of the gas is 20 g/L. what is the pressure if the solubility is 10 g/L**

CH 10
A 20 Pa **B** 800 Pa
C 200 Pa **D** 400 Pa

$P_2 = (P1 \times S_2) \div S_1$
$P_2 = (40\ Pa \times 10 g/L) \div 20\ g/L$
$= 20\ Pa$ →A

Part 3: Colligative Properties of Solutions

• Colligative properties are physical properties of solutions that are affected by the number of particles but not by the identity of dissolved solute particles.
–Colligative means depending on the collection
–Colligative properties include vapor pressure lowering, boiling point elevation, freezing point depression, and osmotic pressure.
• Ionic compounds are electrolytes because they dissociate in water to form a solution that conducts electricity.
–Electrolytes that produce many ions are strong electrolytes.
–Electrolytes that produce only a few ions are weak electrolytes.
• Many molecular compounds do not ionize when dissolved and do not conduct electricity, these are called nonelectrolytes.
–There are some exceptions, so those molecular compounds that do ionize are electrolytes.
• Adding a nonvolatile solute (one that has little tendency to become a gas) to a solvent lowers the solvent's vapor pressure, increase the boiling point, decrease the freezing point.

Boiling Point elevation

$\Delta T_b = K_b m$

ΔT_b represents the boiling point elevation
K_b represents the molal boiling elevation constant
m represent molality

The temperature difference is equal to the molal boiling point elevation constant multiplied by the solution's molality.

Boiling Point elevation

$\Delta T_f = K_f m$

ΔT_f represents temperature
K_b represents the freezing point depression constant
m represent molality

The temperature difference is equal to the freezing point depression constant multiplied by the solution's molality.

Q24 **Nonvolatile solutes……...the vapor pressure of a solution.**

CH 10
A Increase **B** Decrease
C Do not change **D** Unpredictably change

Nonvolatile solutes decrease the vapor pressure of a solution. →B

Q25 **Vapor pressure_____ when the number of solute particles in a solvent_____.**

CH 10
A Increases, increases **B** Increases, decrease
C Decreases, increases **D** Decreases, decreases

Vapor pressure decreases when the number of solute particles in a solvent increases →C

Q26 **Which of the following is not a colligative property of solutions?**

CH 10
A Boiling point elevation
B Osmotic pressure
C Density
D Freezing point depression

Colligative properties include vapor pressure lowering, boiling point elevation, freezing point depression, and osmotic pressure. →C

Q27 **The vapor pressure effect on 1 mol NaCl is lower than the vapor pressure effect on...**

CH 10
A 1 mol KCl **B** 1 mol MgO
C 1 mol HBr **D** 1 mol $AlCl_3$

$AlCl_3 \longrightarrow Al + 3Cl^-$ (4 ions in the solution) →D

Q28 **The vapor pressure of a liquid decreases when dissolving a non-volatile solid that will result in...**

CH 10

A An increase of its boiling point
B Its boiling point stays stable
C An increase of its freezing point
D Its freezing point stays stable

Adding a nonvolatile solute (one that has little tendency to become a gas) to a solvent lowers the solvent's vapor pressure, increase the boiling point, decrease the freezing point. →A

Q29 **The temperature difference between a solution's boiling point and a pure solvent's boiling point is called the...**

CH 10

A Boiling point depression
B Boiling point of the pure solvent
C Boiling point elevation
D Boiling point of the solute

The temperature difference between a solution's boiling point and a pure solvent's boiling point is called the Boiling point elevation →C

Q30 **A solution has a 0.5 m concentration of and K_b= 0.5˚C/m, its boiling point elevation is...**

CH 10

A 0˚C **B** 0.25˚C
C 0.5˚C **D** 0.75˚C

$\Delta T_b = K_b \times m$
$\Delta T_b = 0.5^\circ C/m \times 0.5\ m$
$= 0.25^\circ C$ →B

Q31 **The difference in temperature between the freezing point of the solution and the freezing point of its pure solvent is called...**

CH 10

A Boiling point depression
B Boiling point of the pure solvent
C Freezing point depression
D Boiling point of the solute

The temperature difference between a solution's freezing point and a pure solvent's freezing point is called the freezing point depression. →C

Q32 **An aqueous solution has a concentration of 0.25 m, and the freezing point depression constant is 2˚C/m. what is the freezing point depression?**

CH 10

A 0.1˚C **B** 0.25˚C
C 0.5˚C **D** 1˚C

$\Delta T_f = K_f \times m$
$\Delta T_f = 2^\circ C/m \times 0.25\ m$
$= 0.5^\circ C$ →C

Q33 **Osmotic pressure is caused by the movement of water molecules...**

CH 10

A From the Standard solution
B Concentrated solution
C Freezing point depression
D From the Buffer solution

Osmotic pressure is caused by the movement of water molecules into the concentrated solution. →B

Chapter 10: Do It Answer key	
1	2
B	B

Q34 **The diffusion of a solvent from a higher concentration to a lower concentration is called...**

CH 10

A Molar concentration **B** Dilution
C Osmosis **D** Solubility

The diffusion of a solvent from a higher concentration to a lower concentration is called osmosis. →C

Q35 **Which one of the following solutions has the highest boiling point?**

CH 10

A NaCl **B** $CaCl_2$
C $AlCl_3$ **D** HF

$AlCl_3 \longrightarrow Al + 3Cl^-$
(4 ions in the solution) →C

Q36 **Which one of the following solutions has the lowest freezing point?**

CH 10

A NaCl **B** $BaCl_2$
C MgO **D** HCl

$BaCl_2 \longrightarrow Ba + 2Cl^-$
(3 ions in the solution) →B

Q37 **NaCl solution has a 0.5 m concentration of and K_b= 0.5˚C/m, its boiling point elevation is...**

CH 10

A 0˚C **B** 0.25˚C
C 0.5˚C **D** 0.75˚C

$NaCl \longrightarrow Na^+ + Cl^-$ (2 ions)
$\Delta T_b = K_b \times m \times$ number of ions
$\Delta T_b = 0.5^\circ C/m \times 0.5\ m \times 2$
$= 0.5^\circ C$ →C

Q38 **LiBr solution has a 1 m concentration of and K_b= 0.5˚C/m, its boiling point elevation is...**

CH 10

A 0˚C **B** 0.25˚C
C 0.5˚C **D** 1˚C

$LiBr \longrightarrow Li^+ + Br^-$ (2 ions)
$\Delta T_b = K_b \times m \times$ number of ions
$\Delta T_b = 0.5^\circ C/m \times 1\ m \times 2$
$= 1^\circ C$ →D

Q39 **$AlCl_3$ solution has a 0.25 m concentration of and K_b= 2˚C/m, its boiling point elevation is...**

CH 10

A 0˚C **B** 2˚C
C 0.5˚C **D** 1˚C

$AlCl_3 \longrightarrow Al^{+3} + 3Cl^-$ (4 ions)
$\Delta T_b = K_b \times m \times$ number of ions
$\Delta T_b = 2^\circ C/m \times 0.25\ m \times 4$
$= 2^\circ C$ →D

1 **What is the boiling point of an aqueous solution 2m of KBr? (K_b= 0.5˚C/m)**

Do It?

A 101˚C **B** 102˚C
C 103˚C **D** 100˚C

2 **What is the freezing point of an aqueous solution 0.5m of LiBr? (K_f= 2˚C/m)**

Do It?

A -1˚C **B** -2˚C
C -3˚C **D** -4˚C