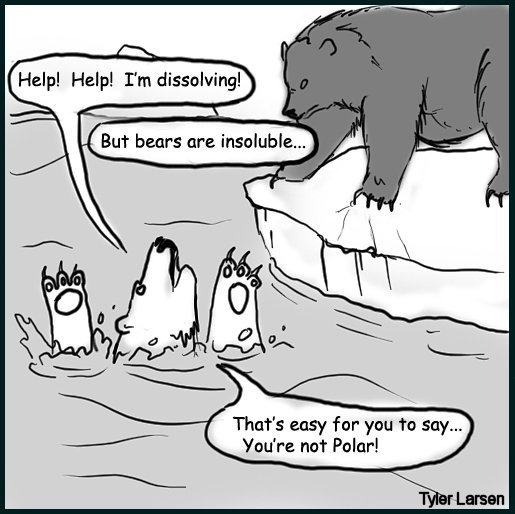
*Chapter 12 – Solutions*



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| Homework | Quiz |
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*Important Vocab for unit 12*

Solution

Solute

Solvent

Molarity

Molality

Mole fraction

Percent by mass

Colligative Properties

Unsaturated Solution

Saturated Solution

Supersaturated Solution

Intermolecular Forces

Dispersion Force

Dipole-Dipole

Hydrogen Bond

Dilution

ConcentrationNotes: Components of Solutions, Concentration

Solution**:** Homogeneous mixture of two or more substances not chemically combined.

Solute**:** Substance being dissolved

Solvent**:** Substance that dissolves the solute (assume the solvent is H2O unless specifically told otherwise)

Solution Properties:

* Particles are very small (cannot be filtered out)
* Particles are evenly distributed or intermingle uniformly
* Particles will not separate no matter how long the solution is allowed to stand under constant conditions

Many chemical compounds are stored, measured and used as solutions. Medicines are commonly prepared by dissolving them in water so they can enter the bloodstream faster. Household cleaners such as bleach, ammonia, and vinegar contain compounds dissolved in water.

The measurement that describes a solution in a quantitative way is called concentration. In this unit, we will deal with three methods of expressing concentration: molarity, molality, and in the next set of notes, % by mass. We will also deal with the dilution of concentrated solutions.

**Concentration:** Ratio of solute to solvent

1) Concentrated solutions contain a large amount of solute per solvent

2) Dilute solutions contain a relatively small amount of solute per solvent

3) Concentrated solutions can be made dilute by adding more solvent.

I. **Molarity (M):** The number of moles of solute per liter of solution

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Example #1: What is the molarity if 25.0 g of sodium nitrate, NaNO3, is dissolved 400.0 mL of solution?

Example #2: What volume (in mL) of 1.15 M potassium sulfate solution can be prepared using 75.0 g of K2SO4?

Example #3: What mass (in grams) of magnesium chloride is in 825 mL of a 1.50 M MgCl2 solution.

II. **Molality (m):** The number of moles of solute per kilogram of solvent

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Example #4: Calculate the molality when 35.0 g of ethyl alcohol, C2H5OH is dissolved in 1.25 kg of water.

Example #5: What mass (in grams) of sucrose, C12H22O11, is present in a solution that contains 750.0 g of water and is 2.0 m?

Example #6: What mass of water (in grams) is present in a 1.75 m solution made with 65.0 g of urea (NH2CONH2)

**III. Dilution**: Lowering the concentration of a solution by adding more solvent. The number of moles of solute remain the same; only the amount of solvent is changed.

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therefore

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M1 = original molarity M2 = new (diluted) molarity

V1 = original volume V2 = new volume

*Note: Volume can be measured in any units as long as you are consistent. Also,*

***V1 + Vwater = V2***

Example #7: What is the new molarity if 250.0 mL of 0.500 M NaOH is diluted to 1.5 L?

Example #8: What volume (in mL) **of water** must be added to 12.5 mL of concentrated HCl (12.0 M) to make a 0.250 M solution?

Example #9: What volume (in mL) of concentrated H2SO4 (18.0 M) is needed to make 2.5 L of a 0.25 M solution?

Notes: Percent by Mass and Mole Fraction

**% Mass**  – The number of grams of solute per grams of solution.

**% by Mass = grams (solute) x 100 % or %m = (m/m)100**

**grams (solution)**

Example #1: What is the percent of solute of a solution made by mixing 25.0 g. of sodium chloride with 85.0 g. of water?

Example #2: How would you make 125 g. of a solution that was 2.50% potassium nitrate?

Example #3: How much water would you have to add to 35.0 g. of glucose, C6H12O6, to make a 5.00 % solution?

**Mole Fraction ( χ ) =** Mole of substance / Total number of moles present in mixture

Example #1: Calculate the mole fraction of water in a sucrose solution that contains 25 moles of water and 15 moles of sucrose.

Example #2: Calculate the mole fraction of water in a salt solution that contains 250. grams of water and 15.0 grams of NaCl.

Example #3: Calculate the mole fraction of nitrogen gas in a mixture of gas that contains 1.2 atm oxygen, 3.4 atm carbon dioxide and 5.4 atm nitrogen.

*Notes: Solution Stoichiometry*

(Create your own set of notes over solution stoichiometry on this page)

How many milliliters of 0.100 M Ca(OH)2 would be needed to neutralize 35.5 mL of a 0.150 M HCl?

*Notes: Colligative Properites*

Colligative properties are properties that are determined by the **number** of particles in a solution rather than the type of particles present.

Properties affected: (Know these and WHY they happen!!!!!!!)

A) Boiling point of a solvent is increased when solute is added.

B) Freezing point of a solvent is decreased when solute is added.

C) Vapor pressure of a solvent is decreased when solute is added.

D) Osmotic pressure of a solvent is increased when solute is added.

A) BOILING POINT ELEVATION B) FREEZING POINT DEPRESSION

BP of solvent in increased when solute is added FP of solvent is decreased when solute is added

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ΔTb = i kb m |  |  |  |  |  | ΔTf = i kf m |

Where: i = number of particles in soln per formula unit of solute

m = molality of solution

ΔTb = change in BP ΔTf = change in FP

kb = BP constant of solvent (see chart) kf = FP constant of solvent (see chart)

How to determine i:

For covalent compounds and weak acids and bases (nonelectrolytes), i = 1.

For ionic compounds and strong acids and bases, i = total number of ions.

|  |
| --- |
| **Boiling Point Elevation and Freezing Point Depression Constants** |
| **See back of packet for constants.** |

Example #1: What is the boiling point of a solution that consists of 171 g of sucrose, C12H22O11, in 2.0 kg of water?

Example #2: What is the freezing point of a solution that contains 34.2 g of sucrose, C12H22O11, in 250.0 g of water:

Example #3: 3.7 g of hexanoyl chloride (C6H11OCl) are dissolved in 50.0 g of benzene. What is the freezing point of this solution?

Example #4: Calculate the freezing point of a 0.50 m solution of calcium nitrate, Ca(NO3)2, in water.

*Notes: Using colligative properties to determine Molar Mass*

Freezing or boiling point data may be used to estimate the molar mass of an unknown solute. A solvent is selected who’s freezing or boiling point and molal freezing or boiling point constants are known. A measured mass of solute is dissolved in a measured mass of solvent. The freezing or boiling point of the solution is determined. The calculation method is as follows:

1. Use ΔTb = Kbm or ΔTf = Kfm to calculate the molality of the solution.

2. Calculate the moles of solute from molality above and the mass of the solvent

3. Divide grams of solute by moles of solute to get molar mass.

**EX1**: Pure benzene freezes at 5.50°C. 10.9 grams of an unknown solute are dissolved in 75.8 grams of benzene. The solution freezes at 1.44°C. Estimate the molar mass of the solute. Kf = 5.12 ° C/m for benzene.

**EX2:** A solution was made by dissolving 3.75g of a non-electrolyte solute in 104.0 g of acetone. The solution boiled at 56.58oC. The boiling point of pure acetone is 55.95oC and Kb for acetone is 1.71oC/m. Calculate the molar mass of the solute.

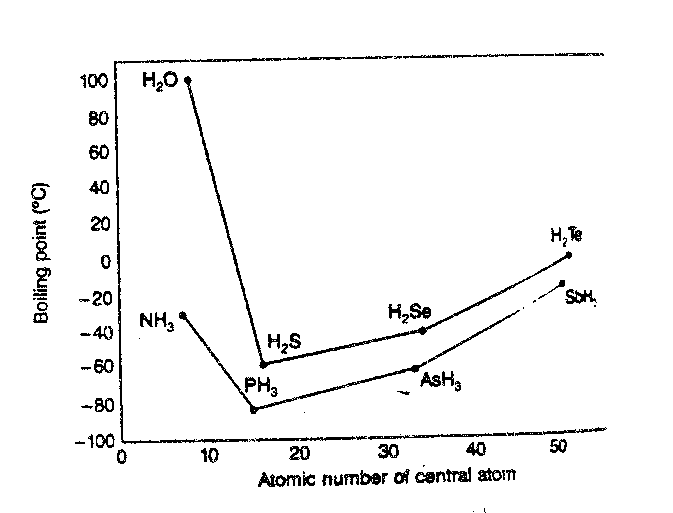
**EX3**: 3.50 g of a sodium halide salt was added to 100.0 g of water. It was found that the solution froze at -0.868oC. What is the formula of the salt?

*Notes: Review of IMFs*

**Intermolecular Forces (van der Waals forces)**

There are three basic intermolecular forces that hold liquids together. The molecules must overcome these forces to become a gas.

|  |  |
| --- | --- |
| **Dipole-dipole forces:**  Occurs between polar molecules. |  |
|  |  |
| **London Dispersion Forces:**  Occurs between all molecules. Primary interaction between non-polar molecules. |  |
|  |  |
| **Hydrogen bonding forces:**  Occurs between molecules that have a hydrogen atom bonded to an O, N, or F atom. |  |



Use the concept of hydrogen bonding to explain the trends observed in the graph above.

*Notes: Solubility*

Saturated – the solution contains exactly the amount of solute that can be dissolved in a given amount of solvent at that temperature

Unsaturated – the solution contains less than the maximum amount of solute that can be dissolved in a given amount of solvent at that temperature

Supersaturated – the solution contains more than the maximum amount of solute that can be dissolved in a given amount of solvent at that temperature.

Use the figure below to answer the following questions:

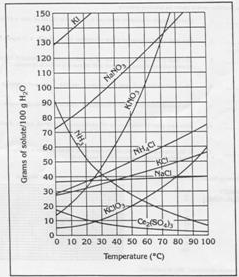
1.              At which temperature do NaNO3 and KNO3 have the same solubility?

2.              100 g of water saturated with KClO3 is cooled from 50°C to 30°C. How much solid crystallizes?

3.              How much NH4Cl is needed to saturate 50 g of water at 35°C?

4.           Assuming that all of the following can form supersaturated solutions, indicate whether the following solutions are saturated, unsaturated, or supersaturated.

* 1. 40 g of KCl in 100 g of H2O at 80°C
  2. 120 g of KNO3 in 100 g of H2O at 60°C
  3. 80 g of NaNO3 in 100 g of H2O at 10°C



*Problem Set #1: Molarity, Molality, Dilution*

1. Find the molarity of a solution made by dissolving 44.2 g of ammonium sulfate, (NH4)2SO4, in 600.0 mL of solution.
2. What mass (in grams) of calcium nitrate, Ca(NO3)2, is present in 400.0 mL of a 0.150 M solution?
3. What volume (in mL) of a 3.00 M solution would contain 6.50 g of lithium silicate, Li2SiO3.
4. Find the mass(in grams) of potassium permanganate, KMnO4, present in 2.50 L of a 2.00 M solution.
5. A 1.25 M solution was made using 65.0 g of aluminum chloride, AlCl3. What volume (in mL) of solution was made?
6. A student dissolved 17.2 g of potassium phosphate, K3PO4, in 250.0 mL of solution. What was the molarity?
7. How many grams of potassium iodide, KI, must be dissolved in 500.0 g of water to produce a 0.600 m solution?
8. A solution is prepared by dissolving 2.50 g of sodium chromate, Na2CrO4, in 23.2 g of water. Calculate the molality of the solution.
9. What mass of water (in grams) must be added to 25.0 g of oxalic acid, H2C2O4, to prepare a 2.50 m solution?
10. How many grams of glucose, C6H12O6, are there in a 0.77 m glucose solution made with 450.0 g of water?
11. A solution contains 75.0 g of methyl alcohol, CH3OH, dissolved in 600.0 g of water. What is the molality?
12. What mass (in grams) of water must be used to make a 3.0 m solution of sucrose, C12H22O11, if 15.0 g of sucrose is used?
13. What volume (in mL) of concentrated nitric acid (HNO3, 15.8 M) would be needed to make 100.0 mL of a 3.00 M solution?
14. If 60.0 mL **of water were added** to 80.0 mL of a 0.500 M sodium carbonate, Na2CO3, solution, what would the final molarity be? (Hint – what is the total new volume?)
15. What volume (in mL) of water would have to be added to 150.0 mL of 0.450 M potassium chloride, KCl, to give a solution with a concentration of 0.100 M?

*Problem Set #2: Percent by Mass*

1. How many grams of potassium iodide, KI, must be added to 500.0 g. of water to produce a 6.00 % solution?
2. A solution is prepared by dissolving 2.50 g. of sodium chromate, Na2CrO4, in 50.0 g. of water. Calculate the percent of the solute in this solution.
3. What mass of water (in grams) must be added to 25.0 g. of oxalic acid, H2C2O4, to prepare a 15.0 % solution?
4. How many grams of glucose, C6H12O6, are there in a 20.0 % glucose solution made with 450.0 g. of water?
5. A solution contains 75.0 g. of methyl alcohol, CH3OH, dissolved in 600.0 g. of water. What is the percent of methyl alcohol?
6. What mass (in grams) of water must be used to make a 3.25 % solution of sucrose, C12H22O11, if 15.0 g. of sucrose is used?

*Problem Set #3: Mix concentration problems*

1. Calculate the percent by mass of 3.55 g NaCl dissolved in 88 g water.

2. What mass of water must be added to 255.0 g of NaCl to make a 15.00% by mass aqueous solution?

3. How many milliliters of 2.55 M NaOH is needed to make 125 mL of 0.75 M NaOH?

4. What is the molarity of the resulting solution when 500.0 mL H2O is added to 20.0 mL of 6.00 M HNO3?

5. Calculate the molality if 3.76 g NaOH is dissolved in 850. mL of water.

6. A solution of 26.2 grams of ammonium chloride in water has a mass of 35 grams. Calculate the percentage ammonium chloride.

7. What is the percentage concentration of a solution prepared by dissolving 5.48 grams of silver nitrate in 25.0 grams of water?

8. How many grams of sodium carbonate are needed to prepare 800. grams of a 18.1% solution?

9. How many grams of potassium nitrate and water must be used to prepare 175 g of a 22.5% solution

10. Calculate the volume of water in which to dissolve 75.0 grams of calcium chloride if the concentration is to be 15.0%

11. What is the mole fraction of oxalic acid, H2C2O4, in a solution prepared by dissolving 1.89 grams in 15.0 mL of water?

12. Calculate the mole fraction of each component in a mixture of 70.5 g of C2H5OH, 41.0 g of CH3OH and 36.7 grams of water.

13. If 56.0 grams of sodium bromide are dissolved in 1.50 liters of water, what is the molality of the solution?

14. Calculate the molality of a solution made by dissolving 58.1 grams of isopropyl alcohol, C3H7OH, in 302 grams of water.

15. How many grams of solute should be used in preparing 0.200 m C12H22O11 in 2.50 x 102 grams of water?

16. What mass of solute having a molar mass of 109 g/mol should be dissolved in 185 grams of water to make a 0.411 m solution?

17. Calculate the mass of sodium fluoride to dissolve in 1.00 liter of water in the preparation of 0.230 m sodium fluoride.

18. How many grams of sodium carbonate are needed to prepare 800. grams of a 18.1% solution?

19. 65.8 grams of potassium carbonate are used to prepare 0.268 m K2CO3. How many grams of water are needed?

20. How many milliliter of water should be used to dissolve 61.8 grams of HC2H3O2 in preparing a 0.300 molal solution?

*Problem Set #4: Solution Stoichiometry*

Show all work.

1. A 15.0 mL sample of a solution of H2SO4 with an unknown molarity is titrated with 32.4 mL of 0.145M NaOH. Based on the titration, what is the molarity of the sulfuric acid?

Balanced Rxn: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. A Ca(OH)2 solution of unknown concentration is used to titrate 15.0 mL of a 0.125M H3PO4 solution. If 12.4 mL of Ca(OH)2 are used to reach the endpoint, what is the concentration of the calcium hydroxide solution?

Balanced Rxn: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. A student finds that 31.5 mL of a 0.175M solution of LiOH was required to titrate 15.0 mL of a phosphoric acid solution to the endpoint. What is the molarity of H3PO4?

Balanced Rxn: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. A student neutralizes 20.0 L of potassium hydroxide with 11.6 mL of 0.500M HCl. What is the molarity of potassium hydroxide?

Balanced Rxn: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. An antacid tablet that contains 0.400 g magnesium hydroxide, Mg(OH)2, is titrated with 22.0 mL of HCl. What is the molarity of HCl?

Balanced Rxn: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. How many milliliters of 0.100M NaOH are required to neutralize 25.0 mL of 0.150M HCl?

Balanced Rxn: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. What volume of 0.100M HNO3 is needed to neutralize 56.0 mL of 6.00M KOH?

Balanced Rxn: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*Problem Set #5 Colligative Properties*

1. Calculate the freezing point and boiling point of 12.0 g of glucose (C6H12O6) in 50.0 g of H2O
2. Calculate the freezing point and boiling point of 1.26 m of naphthalene (C10H8) in benzene.
3. Calculate the freezing point and boiling point of 0.586 m water in ethanol.
4. Calculate the freezing point and boiling point of a solution that contains 55.4 g NaCl and 42.3 g KBr dissolved in 750.3 mL H2O.
5. What would be the maximum freezing point depression of a 0.20 molal solution of potassium phosphate in water if the solute was 100% ionized?
6. Find the boiling point of a solution of 15.4 g of glycerol (mm = 92.1 g/mol) in 64.3 grams of ethanol.
7. What is the boiling point of a solution that contains 15.0 g of sucrose, C12H22O11, in 150.0 g of water?
8. What is the freezing point of a solution that contains 10.0 g of sucrose, C12H22O11, in 85.0 g of water?
9. What is the freezing point of a solution that contains 12.5 g of glucose, C6H12O6 in 325 g of ethyl alcohol, C2H5OH?
10. What is the boiling point of a solution that contains 4.50 g of p-cresyl acetate (C9H10O2) dissolved in 50.0 g of benzene (C6H6)?
11. Calculate freezing point when 25.0 g of glucose, C6H12O6, is dissolved in 675 g of acetic acid, HC2H3O2.
12. 15.0 g of an organic compound with a formula mass of 156 g/mole was dissolved in 585 g of chloroform (CClH3). What is the boiling point of this solution?
13. Find the freezing point of a solution made by dissolving 0.512 g of an organic compound with a formula mass of 192 g/mole in 7.03 g of napthalene, (C10H8).
14. Calculate the boiling point if 75.0 g of sodium phosphate, Na3PO4, is dissolved in 250.0 g of water.
15. Calculate the boiling point if 65.0 g of aluminum chloride, AlCl3, is dissolved in 500.0 g of water.
16. Calculate the freezing point if 45.0 g of ammonium carbonate, (NH4)2CO3, is dissolved in 125.0 g of water.

*Problem Set #6: More Colligative Property Stuff*

Refer to your table on boiling and freezing point data.

1. If 5.64 grams of an unknown nonelectrolyte are dissolved in 65.8 grams of carbon tetrachloride, the boiling point increases to 79.1°C. Calculate the molar mass of the solute.

2. A student finds that the freezing point of a solution of 2.78 grams of an unknown nonelectrolyte in 88.1 grams of naphthalene is 76.4°C. Estimate the molar mass of the solute.

3. When 30.0 g of a nonvolatile solute having the empirical formula CH2O is dissolved in 800 g of water, the solution freezes at -1.16°C. What is the molecular formula of the solute?

4. A certain nonvolatile nonelectrolyte contains 40.0% carbon, 6.7% hydrogen, and 53.3% oxygen. An aqueous solution containing 5% by mass of the solute boils at 100.15°C. Determine the molecular formula of the compound.

5. Of the following 0.10 m aqueous solutions, which one will exhibit the largest boiling point elevation? Assume all are soluble.

(a) KCl (b) C6H12O6 (c) K2SO4 (d) Al2(SO4)3 (e) NaCl

6. Arrange the following 010 m aqueous solutions in order of increasing freezing points (that is, lowest first). Assume all are soluble.

(a) C2H5OH (b) Ba3(PO4)2 (c) Na2SO4 (d) KCl (e) Li3PO4

7. An aqueous solution of sodium chloride freezes at -0.343°C. What will be the boiling point of this solution?

8. The freezing point of 1.34 m aqueous solution is -4.5°C. The solute is known to be an electrolyte. Calculate the van’t Hoff factor, i, for this solution.

9. A 0.36 m iron chloride solution has a boiling point of 100.737°C. Is the solution ferrous or ferric chloride?

10. An aqueous solution with a freezing point of -787°C is known to have been made by dissolving 15.0 g of the solute in 750. g of water. Is the solute sodium carbonate or sodium sulfate?

*Problem Set #7: IMF review and solubility*

1. What type of intermolecular force would be most prevalent in each of the following?

a. CS2

b. H2CO

c. HF

Use the figure on page 10 to answer the following questions.

2. Which substance on the graph shows the smallest increase in solubility over the range 80°C to 100°C?

3. Which of the substances on the graph have approximately the same solubility over the range 20°C to 25°C?

4. 321 g of KNO3 are used to saturate water at 60°C. What is the mass of water that is used?

5. What is the smallest mass of water necessary to dissolve 40 g of NH3 completely at 4°C?

6. Which of the substances on the graph has a solubility that is relatively unaffected by changes in temperature?

7. Which substances on the graph have solubilities that decrease with increases in temperature?

8. 30 g of KI are dissolved in 300 g of water at 10°C. How much additional KI is necessary to saturate the solution?

9. 500 g of water is saturated with KCl at 10°C. If the temperature is raised to 60°C, how much additional KCl is needed to resaturate the solution?

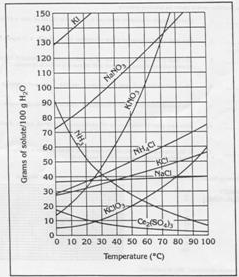
10. Which substance shows the largest increase in solubility in the range 30°C - 70°C?

11. 100 g of water is saturated with KClO3 at 70°C. To what temperature must the solution be cooled in order for 10 g of solid to crystallize?

*Problem Set #8: Solubility*

***I. SOLUBILITY. Define the following.***

1. Saturated
2. Unsaturated
3. Supersaturated
4. ***Use the solubility curve below to answer the questions following it:***
5. How many grams of potassium nitrate can be dissolved in 100 mL of water at 60 degrees Celsius?
6. how many grams of potassium nitrate will saturate 100 mL of water at 10 degrees Celsius?
7. How many grams of potassium nitrate will precipitate (fall out of solution) if 100 mL of a saturated solution of potassium nitrate at 60 degrees Celsius is cooled to 10 degrees Celsius?
8. 100 mL of water at 50 degrees Celsius can hold \_\_\_\_\_ grams of ammonium chloride.
9. 100 mL of water at 80 degrees Celsius can hold \_\_\_\_\_ grams of potassium chlorate.
10. How many grams of sodium nitrate will precipitate out of a 100-mL solution of sodium nitrate if the solution is cooled from 80 degrees Celsius to 50 degrees Celsius?
11. If 50 grams of potassium chloride are dissolved in 100 mL of water at 55 degrees Celsius, will the solution be saturated, supersaturated, or unsaturated?



*Review Solutions*

\_\_\_\_\_\_\_ 1. The solute is

A. the substance that is dissolved B. the substance that dissolves another substance

C. the solubility of the substance D. the whole solution

\_\_\_\_\_\_\_ 2. The solvent is

A. the substance that is dissolved B. the substance that dissolves another substance

C. the solubility of the substance D. the whole solution

\_\_\_\_\_\_\_ 3. A solution which contains a small amount of solute in a large amount of solvent is said to be

A. concentrated B. dilute C. boiling D. imaginary

\_\_\_\_\_\_\_ 4. A concentrated solution has a(n)

A. equal amount of solute and solvent B. no solvent present

C. a high solute to solvent ratio D. a low solute to solvent ratio

\_\_\_\_\_\_\_ 5. A dilute solution has a(n)

A. equal amount of solute and solvent B. no solvent present

C. a high solute to solvent ratio D. a low solute to solvent ratio

\_\_\_\_\_\_\_ 6. When the conc. is expressed as moles of solute per liter of solution, we refer to the conc. as

A. Formal B. Normal C. Molal D. Molar

\_\_\_\_\_\_\_ 7. When the conc. is expressed as moles of solute per kilogram of solvent, we refer to the conc. as

A. Formal B. Normal C. Molal D. Molar

\_\_\_\_\_\_\_ 8. Which of the following would have the greatest effect on the boiling point of water, if dissolved to form solutions of equal molality?

A. K2CO3 B. MgSO4 C. C6H12O6 D. Li3PO4

\_\_\_\_\_\_\_\_ 9. The type of properties that are dependent upon the number of particles dissolved in a given mass of solute are

A. chemical B. reactionary C. inert D. colligative

\_\_\_\_\_\_\_10. The freezing point of a solution is \_\_\_\_\_ that of a pure solvent.

A. higher than B. lower than C. equal to D. not related to

\_\_\_\_\_\_\_11. The boiling point of a solution is \_\_\_\_\_ than that of a pure solvent.

A. higher than B. lower than C. equal to D. not related to

\_\_\_\_\_\_\_12. The vapor pressure of a solution is \_\_\_\_\_ than that of a pure solvent.

A. higher than B. lower than C. equal to D. not related to

\_\_\_\_\_\_\_13. When a solution is diluted by the addition of the solvent, which of the following is true?

1. molarity, volume of solution, and moles of solute all change.
2. molarity is increased and volume is decreased.
3. molarity and volume both increase.
4. molarity, volume of solution, and volume of solvent all change.

***Problems: Show all work as directed INCLUDING UNITS!!!!!!!!***

1. What is the freezing point of a solution made by dissolving 50.0 g of an organic solute (formula mass = 160. g/mole) in 225 g of camphor?
2. What is the molarity of a solution made by dissolving 65.0 g of zinc nitrate, Zn(NO3)2, in enough water to make 350.0 mL of solution?
3. What mass (in grams) of lithium carbonate, Li2CO3, must be used to make a 1.25 m solution with 75.0 g of water.
4. Find the new molarity when 75.0 mL of 2.5 M sliver nitrate, AgNO3, is diluted to 400.0 mL.
5. How many grams of aluminum chloride, AlCl3, must be used to make 1.75 L of a 0.450 M solution.
6. What is the boiling point of a solution made by dissolving 55.0 g of strontium chlorate, Sr(ClO3)2, in 500.0 g of water?
7. What volume of water would be added to 20.0 mL of a 1.50 M amonium sulfide, (NH4)2S, solution to make a 0.80 M solution.
8. What mass (in grams) of water must be used to make a 1.25 m solution of carbonic acid, H2CO3? (Use 35.0 g. H2CO3)

Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Date:\_\_\_\_\_\_\_\_\_\_\_\_\_Period:\_\_\_

1. **Review for Solutions Exam**

* The best way to study for this exam is to do all of the problems.
* Show all of your work for these problems on separate paper.
* The questions on this review will help you understand the types of questions on the exam; however, **this does not cover all of the material on the exam**. You are responsible for completing and reviewing all material associated with this unit.

1. Butylated hydroxytoluene (BHT) is used as an antioxidant in processed foods. (It prevents fats and oils from becoming rancid.) A solution of 2.500 g BHT in 100.0 g of benzene has a freezing point of 4.880 °C. The freezing point of pure benzene is 5.48 °C. (Kf benzene= 5.12 °C *m-1* )
   1. Identify the solvent and solute.
   2. What is the molar mass of BHT?
2. How many milliliters of 0.100 M HCl would be required to completely react with 5.00 grams of calcium hydroxide?

Ca(OH)2 + 2HCl 🡪 CaCl2 + 2H2O

1. What is the molar mass of glucose if 22.5 g gives a freezing point of **-**0.930 °C when dissolved in 250. g of water? (Kf water = 1.86 °C *m-1* )
2. If 23.0 g of ethanol are dissolved in 1.000 x 103 g of water, the freezing point is **‑**0.930°C. What is the molar mass of ethanol? (Kf water = 1.86 °C *m-1* )
3. A compound containing only boron, nitrogen, and hydrogen was found to be 40.3% B, 52.2% N, and 7.5% H by mass.

When 3.301 g of this compound is dissolved in 50.00 g of benzene, C6H6, the solution produced freezes at 1.30 °C. The freezing point of pure benzene is 5.48 °C. (Kf for benzene is 5.12 °C *m* -1)

* 1. What is the empirical formula of this compound?
  2. Determine the number of moles of compound that was dissolved in the solvent.
  3. What is the molar mass of this unknown compound?
  4. What is the molecular formula of this compound?
  5. Determine the mole fraction of the solute.

1. A compound contains 42.9% C, 2.4% H, 16.6% N, and 38.1% O by mass. The addition of 3.16 g of this compound to 58.43 g of cyclohexane gives a solution with a freezing point of 0.0 °C. The normal freezing point of cyclohexane is 6.5 °C and its freezing point depression constant is 20.2 °C/*m*.
   1. Determine the number of moles of compound that was dissolved in the solvent.
   2. Determine molecular weight (i.e. molar mass) of compound.
   3. Determine empirical formula of the compound.
   4. Determine the molecular formula of the compound.
2. A solution is 2.0% hydrogen peroxide, H2O2, by mass.
   1. How many grams of H2O2 are in 170.0 grams of the H2O2 solution?
   2. What is the molality of the H2O2 solution?
   3. Calculate the mole fraction of H2O2.
3. How many milliliters of 1.5M HCl would be required to completely react with 20.0 mL of 2.0M calcium hydroxide?

Ca(OH)2 + 2HCl 🡪 CaCl2 + 2H2O

1. How many milliliters of 2.75 M calcium hydroxide would be required to completely react with 15.5 mL of 0.5M hydrochloric acid?

Ca(OH)2 + 2HCl 🡪 CaCl2 + 2H2O

1. How many milliliters of 0.500 M Ca(OH)2 would be required to completely react with 30.4 grams of hydrochloric acid?

Ca(OH)2 + 2HCl 🡪 CaCl2 + 2H2O

1. What volume (in mL) of 1.25 M potassium sulfate solution can be prepared using 89.0 g of K2SO4?
2. How many milliliters of water should be added to 40.0 mL of a 2.0-molar solution to make the solution 1.50-molar?
3. Nicotinamide is a water-soluble vitamin important in metabolism. A deficiency in this vitamin results in the debilitating condition known as pellagra. Nicotinamide is 59.0% C, 5.0% H, 22.9% N, 13.1% O, by mass. Addition of 3.88 g of nicotinamide to 36.12 g nitrobenzene, C6H5NO2 , lowers the freezing point from 5.7 to -1.4 °C. (Kf for nitrobenzene is 8.1 °C *m-1* )
   1. What is the molecular formula of this compound?
   2. Write a sentence that describes each step you used to solve this problem. Imagine you had to explain to someone step-by-step instructions for solving this type of problem.
4. The absorptivity of a particular chemical is 1.5/M·cm. What is the concentration of a solution made from this chemical if a 2.0 cm sample has an absorbance of 1.20?
5. The molar absorptivity constant of a particular chemical is 1.5/M·cm. What is the concentration of a solution made from this chemical that has an absorbance of 0.72 with a cell path length of 0.011 meters?

**Molal Freezing and Boiling Point Constants**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Compound | Normal Freeezing  Point (°C) | Kf  (°C/m) | Normal Boiling  Point (°C) | Kb  (°C/m) |
| Acetic acid, HC2H3O2 | 16.6 | 3.90 | 118.1 | 3.07 |
| Acetone, CH2O | -95.0 | 174 | 56.2 | 1.71 |
| Benzene, C6H6 | 5.5 | 5.12 | 80.1 | 2.53 |
| Camphor, C10H16O | 179.5 | 37.7 | 207.4 | 5.61 |
| Carbon disulfide, CS2 | -110.8 | --- | 46.5 | 2.34 |
| Carbon tetrachloride, CCl4 | -23.0 | 29.8 | 76.8 | 4.48 |
| Chloroform, CHCl3 | -63.5 | 4.68 | 61.2 | 3.62 |
| Cyclohexane, C6H12 | 6.5 | 20 | 80.7 | 2.79 |
| 1,2-dibromoethane, C2Br2H4 | 10.0 | 12.5 | 131.7 | 6.61 |
| Diethyl ether, (C2H5)2O | -116.3 | 1.79 | 34.6 | 2.02 |
| Ethanol, C2H5OH | -114.6 | 1.99 | 78.4 | 1.16 |
| Naphthalene, C10H8 | 80.2 | 6.94 | 218.0 | 5.80 |
| Nitrobenzene, C6H5NO2 | 5.7 | 8.1 | 210.6 | 5.24 |
| Phenol, C6H5OH | 40.6 | 7.4 | 181.9 | 3.56 |
| Water, H2O | 0.0 | 1.86 | 100.0 | 0.52 |