Aqueous Reactions II

(Solutions/ Molarity)

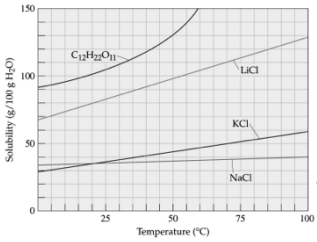
Concentration / Calculations

Dr. Ron Rusay

Solutions

- *Homogeneous solutions are comprised of solute(s), the substance(s) dissolved, [The lesser amount of the component(s) in the mixture], and*
- *solvent, the substance present in the largest amount.*
- *Solutions with less solute dissolved than is physically possible are referred to as "unsaturated". Those with a maximum amount of solute are "saturated".*
- *Occasionally there are extraordinary solutions that are "supersaturated" with more solute than normal*

Concentration and Temperature



Relative Solution Concentrations:
Saturated
Unsaturated
Supersaturated

Dilute
Concentrated

A solution of 35g of potassium chloride in 100g H_2O @ 25°C is Saturated & Concentrated; @ 75°C it is Unsaturated but Concentrated.

QUESTION

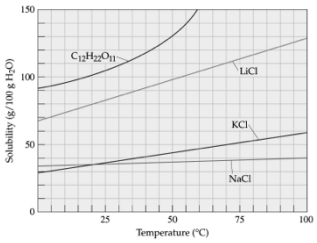
What describes a solution of 25.0g NaCl in 0.100L of H_2O @ 10°C?

A) Dilute

B) Concentrated

C) Saturated

D) Unsaturated



QUESTION

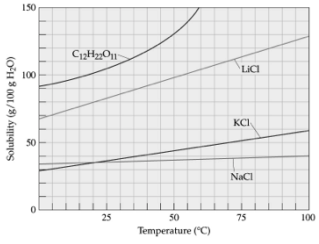
What describes a solution of 100.0g sucrose in 0.100L of H_2O @ 10°C?

A) Dilute

B) Concentrated

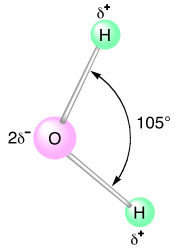
C) Saturated

D) Unsaturated



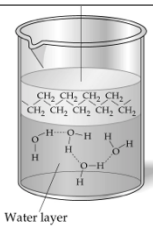
DHMO, dihydromonoxide : "The Universal" Solvent

http://www.dhmo.org



Water : "The Universal" Solvent

The oil (nonpolar) and water (polar) mixture don't mix and are **immiscible**. If liquids form a homogeneous mixture, they are **miscible**.



Gene ıd
nonp eg.
oil a

QUESTION

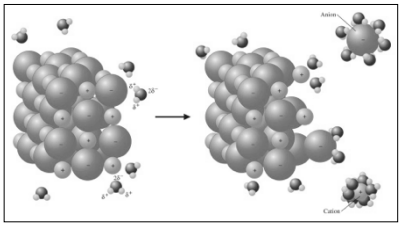
An unknown substance dissolves readily in water but not in benzene (a nonpolar solvent). Molecules of what type are present in the substance?

a) neither polar nor nonpolar
b) polar
c) either polar or nonpolar
d) nonpolar
e) none of these

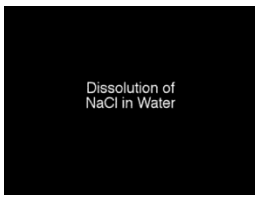
Aqueous Reactions & Solutions

- *Many reactions are done in a homogeneous liquid or gas phase which generally improves reaction rates.*
- *The prime medium for many inorganic reactions is water which serves as a solvent (the substance present in the larger amount), but does not react itself.*
- *The substance(s) dissolved in the solvent is (are) the solute(s). Together they comprise a solution. The reactants would be the solutes.*
- *Reaction solutions typically have less solute dissolved than is possible and are "unsaturated".*

Salt dissolving in a glass of water



Water dissolving an ionic solid



Solution Concentrations

- *A solution's concentration is the measure of the amount of solute dissolved.*
- *Concentration is expressed in several ways. One way is mass percent.*

Mass % = Mass solute / [Mass solute + Mass solvent] x100

- *What is the mass % of 65.0 g of glucose dissolved in 135 g of water?*

Mass % = 65.0 g / [65.0 + 135]g x 100
= 32.5 %

Solution Concentration

- Concentration is expressed more importantly as molarity **(M)**.

  Molarity (M) = Moles solute / Liter (Solution)

- An important relationship is **M x $V_{solution}$ = mol**
- This relationship can be used directly in mass calculations of chemical reactions.
- What is the molarity of a solution of 1.00 g KCl in 75.0 mL of solution?

M_{KCl} = [1.00g $_{KCl}$ / 75.0mL][1mol$_{KCl}$ / 74.55 g $_{KCl}$][1000mL / L]
= 0.18 mol$_{KCl}$ / L

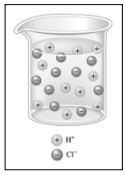
QUESTION

20.0-g of HF [MM = 20.0 g/mol] was dissolved in water to give 2.0 x 10^2 mL of HF(aq), a weak acid solution. The concentration of the solution is:

a) 1.0 M
b) 3.0 M
c) 0.10 M
d) 5.0 M
e) 10.0 M

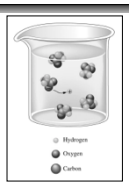
Solution Concentrations:

Solute vs. Ion Concentrations



HCl
1.0M 100% Ionized

[H+] = [Cl-] = 1.0M



Acetic Acid ($HC_2H_3O_2$) < 100% Ionized

[H+] = [$C_2H_3O_2$-] < 1.0M

Seven Solutions Post Lab Questions
http://chemconnections.org/general/chem120/solutions-mixes.108.html

QUESTION

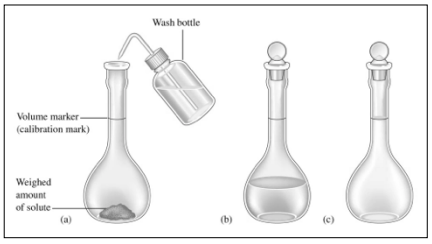
Solutions: molarity & volume → mass

How many grams of NaCl are contained in 350. mL of a 0.250 M solution of sodium chloride?

A) 41.7 g
B) 5.11 g
C) 14.6 g
D) 87.5 g
E) None of these

Preparation of Solutions

Preparing a Standard Solution



QUESTION

A 51.24-g sample of $Ba(OH)_2$ [MM= 171.3 g/mol] is dissolved in enough water to make 1.20 liters of solution. What is the molarity of the solution?

a) 0.300 M

b) 3.33 M

c) 0.278 M

d) 2.49 x 10^{-1} mol/L

e) 42.7 g/mL

Solution Concentration

- *The following formula can be used in dilution calculations:*

  $M_1V_1 = M_2V_2$

- *A concentrated stock solution is much easier to prepare and then dilute rather than preparing a dilute solution directly. Concentrated sulfuric acid is 18.0M. What volume would be needed to prepare 250.mL of a 1.50M solution?*
- $V_1 = M_2V_2 / M_1$
- $V_1 = 1.50\ M \times 250.\ mL / 18.0\ M$
- $V_1 = 20.8\ mL$

QUESTION

What volume of 18.0 M sulfuric acid must be used to prepare 15.5 L of 0.195 M H_2SO_4?

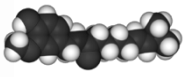
A) 168 mL
B) 0.336 L
C) 92.3 mL
D) 226 mL
E) None of these

Solution Dilution

Solution Applications

Scoville Units / Capsaicin

Will all molecules with the same molecular formula taste hot?

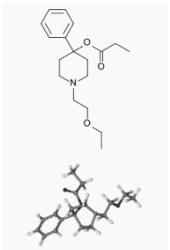


Capsaicin: $C_{18}H_{27}NO_3$

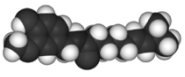
http://en.wikipedia.org/wiki/Scoville_scale

Molecular Applications

Capsaicin / Prosidol



Will all molecules with the same molecular formula taste hot?



Capsaicin: $C_{18}H_{27}NO_3$

Prosidol: $C_{18}H_{27}NO_3$ (opiate analgesic)

QUESTION

What happens to the number of moles of $C_{12}H_{22}O_{11}$ (sucrose) when 100.0 mL of a 0.20 M solution is diluted to a final concentration of 0.10 M?

A) The number of moles of $C_{12}H_{22}O_{11}$ decreases.

B) The number of moles of $C_{12}H_{22}O_{11}$ increases.

C) The number of moles of $C_{12}H_{22}O_{11}$ does not change.

D) There is insufficient information to answer the question.

(Chem 120 Prep)

Solution Applications

A solution of barium chloride was prepared by dissolving 26.0287 g in water to make 500.00 mL of solution. What is the concentration of the barium chloride solution? M_{BaCl2} = ?

M_{BaCl2} =

= [26.0287g $_{BaCl2}$ / 500.00mL][1mol $_{BaCl2}$ / 208.23g $_{BaCl2}$] [1000mL / L]

= 0.25000 mol / L

Solution Applications

10.00 mL of this solution was diluted to make exactly 250.00 mL of solution which was then used to react with a solution of potassium sulfate. What is the concentration of the diluted solution. M_2 = ?

$M_{BaCl2} = M_1$

$M_2 = M_1V_1 / V_2$

$M_2 = 0.25000\ M \times 10.00\ mL / 250.00\ mL$

$M_2 = 0.010000\ M$

QUESTION

A 51.24-g sample of $Ba(OH)_2$ is dissolved in enough water to make 1.20 liters of solution. How many mL of this solution must be diluted with water in order to make 1.00 liter of 0.100 molar $Ba(OH)_2$?

a) 400. mL

b) 333 mL

c) 278 mL

d) 1.20 x 10^3 mL

e) 285 mL

Answer

A 51.24-g sample of $Ba(OH)_2$ is dissolved in enough water to make 1.20 liters of solution. How many mL of this solution must be diluted with water in order to make 1.00 liter of 0.100 molar $Ba(OH)_2$?

a) 400. mL, $V_1 = M_2V_2 / M_2$

b) 333 mL

c) 278 mL

d) 1.20 x 10^3 mL

e) 285 mL

Solution Applications

20.00 mL of a $M_2 = 0.010000\ M$ *barium chloride solution required 15.50 mL of the potassium sulfate solution to react completely.* M_{K2SO4} = ?

$BaCl_2(aq) + K_2SO_4(aq) \rightarrow\ ?\ +\ ?$

$BaCl_2(aq) + K_2SO_4\ (aq) \rightarrow 2\ KCl(aq) + BaSO_4\ (s)$

$?M_{K2SO4} = [M_{BaCl2} \times V_{BaCl2} / V_{K2SO4}]\ [?\ mol_{K2SO4} / ?\ mol_{BaCl2}]$

$$?M_{K2SO4} = \frac{0.010000\ mol_{BaCl2} \times 0.02000\ L_{BaCl2} \times 1\ mol_{K2SO4}}{L_{BaCl2} \times 0.01550\ L_{K2SO4} \times 1\ mol_{BaCl2}}$$

$?M_{K2SO4}$ = 0.01290 mol_{K2SO4} / L_{K2SO4} = 0.01290 M_{K2SO4}

Solution Applications

How many grams of potassium chloride are produced?

$BaCl_2(aq) + K_2SO_4(aq) \rightarrow \quad ? \quad + \quad ?$

1 $BaCl_2(aq) + K_2SO_4(aq) \rightarrow 2\,KCl(aq) + BaSO_4(s)$

$?g_{KCl} = 0.010000\ mol_{BaCl2} / L_{BaCl2} \times 0.02000\ L_{BaCl2} \times \frac{2\ mol_{KCl}}{1\ mol_{BaCl2}} \times \frac{74.55\ g_{KCl}}{mol_{KCl}}$

$= 0.02982\ g_{KCl}$

Solution Applications

If **20.00** mL of a **0.10** M solution of barium chloride was reacted with **15.00** mL of a **0.20** M solution of potassium sulfate, what would be the theoretical yield of barium sulfate?

$BaCl_2(aq) + K_2SO_4(aq) \rightarrow 2\,KCl(aq) + BaSO_4(s)$

Which is the Limiting Reagent?

$Mol_{BaCl2} = M_{BaCl2} \times V_{BaCl2}$

$= \frac{0.10\ mol_{BaCl2} / L_{BaCl2} \times 0.02000\ L_{BaCl2}}{1\ mol_{BaCl2}}$

$= 2.0 \times 10^{-3}$

$Mol_{K2SO4} = M_{K2SO4} \times V_{K2SO4}$

$= \frac{0.20\ mol_{K2SO4} / L_{K2SO4} \times 0.01500\ L_{K2SO4}}{1\ mol_{K2SO4}}$

$= 3.0 \times 10^{-3}$

$2.0 \times 10^{-3} < 3.0 \times 10^{-3}$

2.0×10^{-3} mol *is limiting*

Solution Applications

If **20.00** mL of a **0.10** M solution of barium chloride was reacted with **15.00** mL of a **0.20** M solution of potassium sulfate, what would be the theoretical yield of barium sulfate?

$BaCl_2(aq) + K_2SO_4(aq) \rightarrow 2\,KCl(aq) + BaSO_4(s)$

Must use the limiting reagent:

$= \frac{0.10\ mol_{BaCl2} \times 0.02000\ L_{BaCl2} \times \frac{1\ mol_{BaSO4}}{1\ mol_{BaCl2}} \times \frac{233.39\ g_{BaSO4}}{mol_{BaSO4}}}{L_{BaCl2}}$

$= 0.47\ g$

QUESTION

What mass of NaOH is required to react exactly with 25.0 mL of 1.2 M H_2SO_4?

A) 1.2 g
B) 1.8 g
C) 2.4 g
D) 3.5 g
E) None of these

ANSWER

C) 2.4 g

-

Remember that the reaction is $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$, so there are two moles of NaOH used per one mole of H_2SO_4.