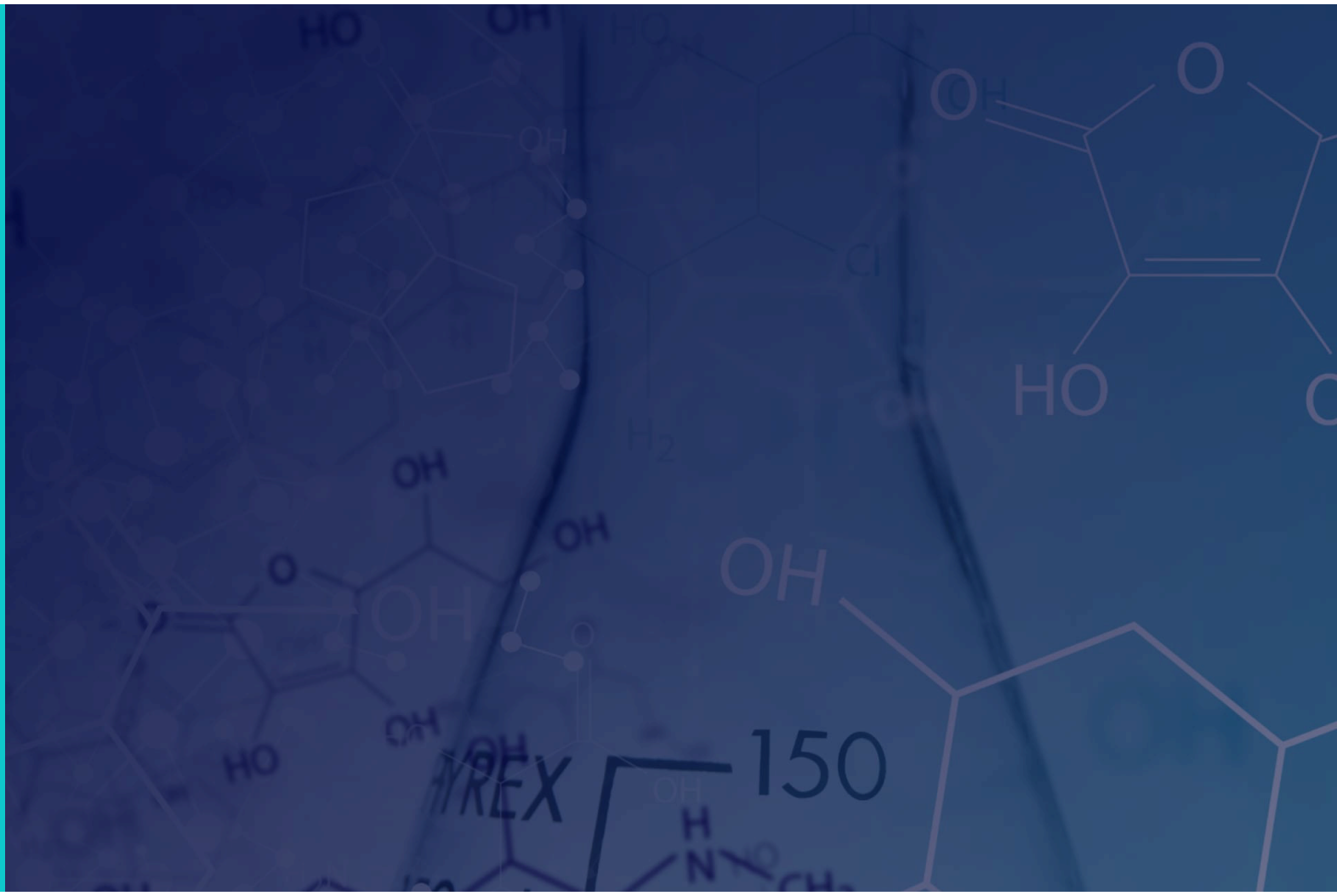

Ontario High School

Grade 11 Chemistry

Summer 2024, Chapter 7 Notes

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7. Solutions

7.1 Solutions

7.1.1

Solutions

- **Solutions** are **homogeneous mixtures** containing a **solvent** and a **solute**
  - The **solvent** is the component of a solution that is found in a greater quantity
  - The **solute** is the component found in a lesser amount
- Solutions can be gaseous, liquid or solid; the state of the solution is the same is as the state of the solvent
  - Solid solutions are also know as **alloys**
  - Liquid solutions with water as the solvent are known as **aqueous solutions**

Type of Solution	Solute	Solvent	Example
Gaseous Solutions	Gas	Gas	Air
	Liquid	Gas	Humid air
	Gas	Liquid	Soda
Liquid Solutions	Liquid	Liquid	Alcoholic beverages
	Solid	Liquid	Salty water
Solid Solution	Solid	Solid	Metal Alloys

7.1.2

Properties of Aqueous Solutions

- **Electrolytes** are compounds that dissolve in water, producing a solution that conducts electricity
  - **Strong electrolytes** dissolve to give solutions that **conduct electricity efficiently**
    These compounds **completely dissociate** or **ionize** in solution
    Example: ionic compounds, strong acids, and strong bases

$$NaC\ell(s) \rightarrow \ Na^{+}(aq) + C\ell^{-}(aq)$$

$$HC\ell\,(aq) \rightarrow H^{+}\,(aq) + C\ell^{-}\,(aq)$$

  - **Weak electrolytes** dissolve to give solutions that **don't conduct as much as strong electrolytes**
    These compounds **only produce few ions** when they dissolve in water
    Examples: Weak acids and weak bases

$$NH_3(aq) + H_2O(\ell) \rightleftharpoons NH_4^{+}(aq) + OH^{+}(aq)$$

- **Non-electrolytes** are solutions that **do not conduct electricity**
  These are molecular that **dissolve in water but don't produce any ions**
  Example: Molecular compounds like $C_6H_{12}O_6$

$$C_6H_{12}O_6\,(s) \rightarrow C_6H_{12}O_6\,(aq)$$

Example: Identifying Solutes and Solvents

Identify the solute and the solvent in the following solutions:

a. sweetened tea

b. vinegar

c. soft drinks

d. natural gas

7.1.4

Practice: Solutions Terms and Definitions

Match the following terms and definitions.

A. solid solution containing two or more metals

B. substance that dissolves in water to form a solution that conducts an electric current

C. substance that does the dissolving in a solution

D. solution with water as the solvent

E. substance that is dissolved in a solution

F. homogeneous mixture of two or more substances in a single physical state

- [ ] solution
- [ ] solute
- [ ] solvent
- [ ] alloy
- [ ] aqueous solution
- [ ] electrolyte

7.1.5

Practice: Identifying Solutes and Solvents

For each of the following solutions , identify:

- the original state of the solute (gas (G), liquid (L) or solid (S))
- the original state of the solvent (gas (G), liquid (L) or solid (S))
- the state of the solution itself (gas (G), liquid (L) or solid (S))

Solution	State of Solute	State of Solvent	State of Solution
Club Soda			
Hand Sanitizer			
Ocean Water			
Air			

7.1.6

Which of the following compounds is a weak electrolyte in water?

- HBr
- NaOH
- CH_3COOH
- HI
- HNO_3

7.2 Concentrations

7.2.1

Concentration

Amount concentration

- **Amount concentration** is a quantitative measure of the amount of solute present in a solution

$$\boxed{c = \frac{n_{\text{solute}}(\text{mol})}{V_{\text{solution}}(L)}}$$

Percent Concentrations

- When it comes to consumer products, often times concentration is expressed in terms of percentages

% Volume by Volume (% V/V)	% Weight by Volume (% w/V)	% Weight by Weight (% w/w)
$c = \frac{V_{\text{solute}}}{V_{\text{solution}}} \times 100\%$	$c = \frac{m_{\text{solute}}(g)}{V_{\text{solution}}(mL)} \times 100\%$	$c = \frac{m_{\text{solute}}}{m_{\text{solution}}} \times 100\%$

Dilute Solutions

- When working with very dilute solutions, we can express their concentrations using **parts-per notation**
- We can make the assumption that very dilute aqueous solutions have a density equal to the density of water or 1g/mL, then we can use the mass percent equation to get the part-per concentration

Parts per Million (ppm)	Parts per Billion (ppb)	Parts per Trillion (ppt)
$c_{ppm} = \frac{m_{\text{solute}}}{m_{\text{solution}}} \times 10^{6}$	$c_{ppb} = \frac{m_{\text{solute}}}{m_{\text{solution}}} \times 10^{9}$	$c_{ppt} = \frac{m_{\text{solute}}}{m_{\text{solution}}} \times 10^{12}$

Example: Calculation of Concentration

Calculate the amount concentration of a solution of 24g NaOH in 150mL of water.

7.2.3 **Example: Solution Stoichiometry**

Example: Solution Stoichiometry

What volume of 0.125mol/L NaOH(aq) is required to react completely with 15.0mL of 0.100mol/L $Al_2(SO_4)_3(aq)$?

$$6NaOH(aq) + Al_2(SO_4)_3(aq) \rightarrow 2Al(OH)_3(s) + 3Na_2SO_4(aq)$$

2.

3.

7.2.4 Example: Mixed Stoichiometry

Example: Mixed Stoichiometry

Lithium metal was added to a 25mL of a 1.3mol/L solution of Ag_2SO_4. Once the reaction has gone to completion, what mass of silver metal is produced?

$$Ag_2SO_4(aq) + 2Li(s) \rightarrow Li_2SO_4(aq) + 2Ag(s)$$

2.

3.

7.2.5

Practice: Amount Concentration

To make a 2.00mol/L solution, how many moles of solute will be needed if 4.0 liters of solution are required? Give your answer to one decimal place; do not include units.

Answer

7.2.6

Practice: Percent Volume by Volume

How many mL of hydrogen peroxide are needed to make a 8.5% solution by volume of hydrogen peroxide if you want to make 450mL of solution?

Answer

7.2.7

Practice: Dilute Concentrations

Symptoms of mercury poisoning become apparent after a person has accumulated 20mg of mercury. If a person ingested 30mg of mercury, what concentration of mercury in parts per million, are in his body? Assume the person has a mass of 65kg.

- 2.17ppm
- 0.46ppm
- 0.31ppm
- 3.25ppm

7.2.8

Practice: Balancing Chemical Reactions and Stoichiometry

When solutions of lead (II) nitrate and sodium iodide are mixed, a bright yellow precipitate of lead (II) iodide appears.

Part 1

MARK YOURSELF QUESTION

1. Grab a piece of paper and try this problem yourself.
2. When you're done, check the "I have answered this question" box below.
3. View the solution and report whether you got it right or wrong.

Write the complete balanced equation for this double-replacement reaction.

Practice: Balancing Chemical Reactions and Stoichiometry

When solutions of lead (II) nitrate and sodium iodide are mixed, a bright yellow precipitate of lead (II) iodide appears.

Part 2

What volume, in mL, of 0.400 mol/L NaI(aq) is necessary to precipitate all the aqueous lead(II) ions in 50.0 mL of 0.200 mol/L $Pb(NO_3)_2(aq)$? Give your answer to one decimal place; do not include units in your answer.

Answer

Practice: Balancing Chemical Reactions and Stoichiometry

When solutions of lead (II) nitrate and sodium iodide are mixed, a bright yellow precipitate of lead (II) iodide appears.

Part 3

What mass of precipitate, in grams, is formed in this reaction? Give your answer to one decimal place; do not include units in your answer.

Answer

7.3 Solubility

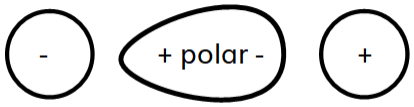
7.3.1

Solubility

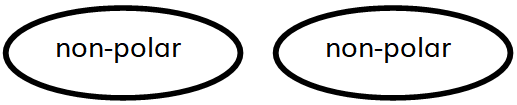
- **Solubility** is defined as the amount of solute that can be dissolved in an amount of solvent at a given temperature.
- Whether a solute will dissolve in a solvent, depends on the intermolecular forces between:
  - Solute particles
  - Solvent particles
  - Solute and solvent particles

- A solute **will dissolve** in a solvent if the **solute-solvent forces of attraction are greater than the solute-solute and solvent-solvent forces of attraction.**
  - Polar substances will dissolve in polar substances
    Example: water and methanol (CH_3OH)

  - Ionic substances will dissolve in polar substances
    Example: water and salt (NaCl)



  - Non-polar substances will dissolve in other non-polar substances
    Example: hexane and benzene

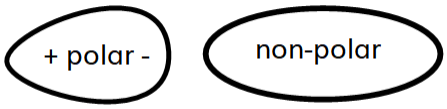


WIZE TIP

Remember, "like dissolves like"!

- **Polar (or ionic) substances dissolve other polar substances**
- **Non-polar substances dissolve other non-polar substances**

- A solute **will not dissolve** in a solvent if the **solute-solvent forces of attraction are weaker than individual solute and solvent force of attractions.**
    - Non-polar substances don't dissolve in polar substance, since they cannot break the strong forces of attraction inside the polar substance



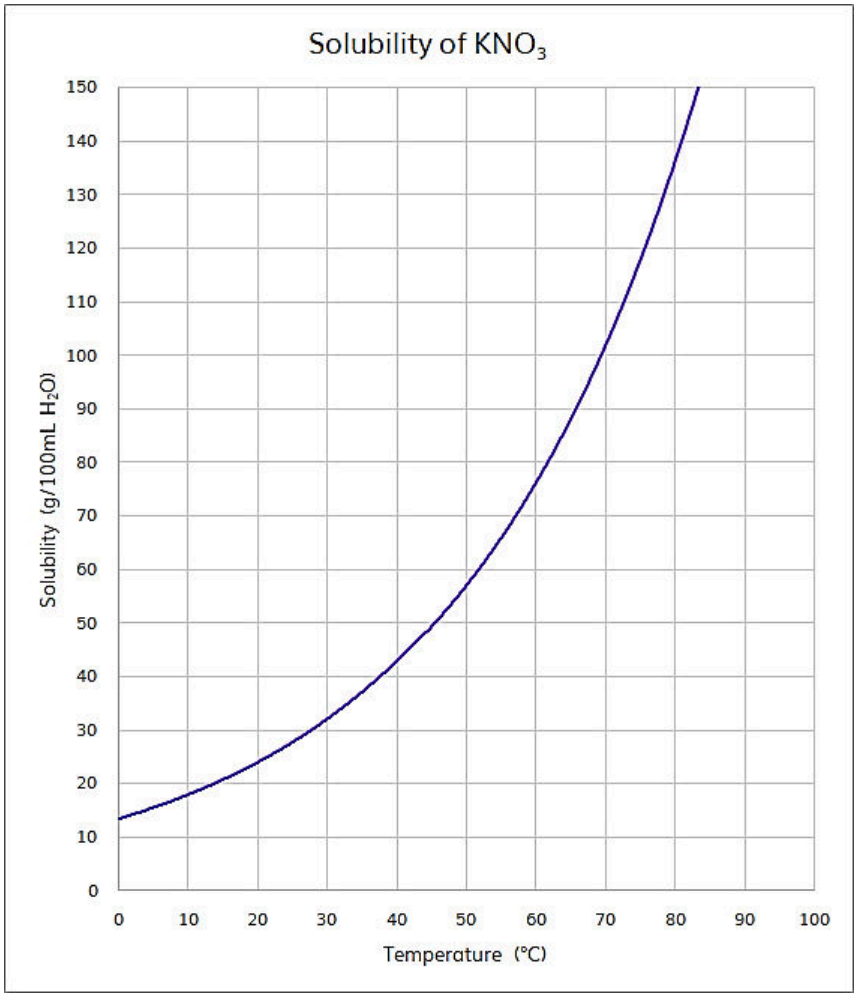
Types of Solutions

- An **unsaturated solution** is a solution in which more solute can be dissolved in the solvent at a given temperature and pressure
- A **saturated solution** contains the maximum amount of solute that can be dissolved in a solvent at a given temperature and pressure
- A **super saturated solution** contains more than the maximum amount of solute that can be dissolved in a solvent at a given temperature and pressure

7.3.2

Solubility Curves

- We can tell what type of solution we have from a solubility curve by looking at the concentration of the solution and the temperature at which the solution is at.
    - To the left of the curve - **supersaturated solution**
      Example: a 50g KNO_3/100mL H_2O of at 20°C
    - On the curve - **saturated solution**
      Example: a 50g KNO_3/100mL H_2O of at 45°C
    - To the right of the curve - **unsaturated solution**
      Example: a 50g KNO_3/100mL H_2O of at 80°C

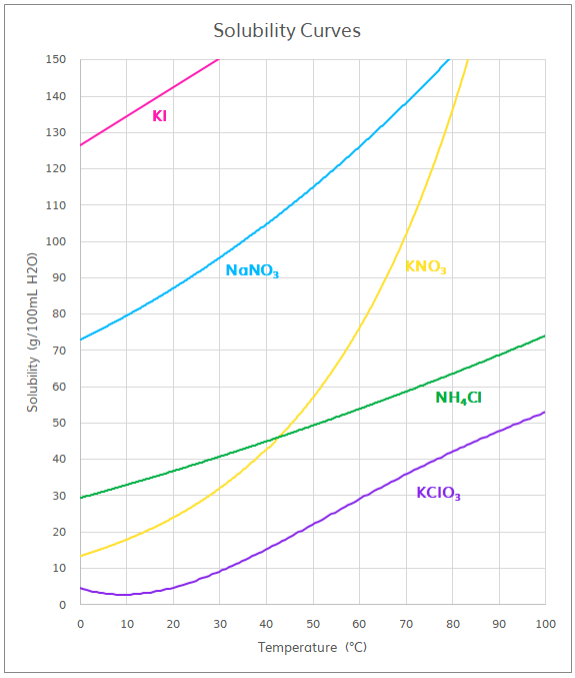

Solubility of KNO_3
Solubility (g/100mL H_2O)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Temperature (°C)

7.3.3

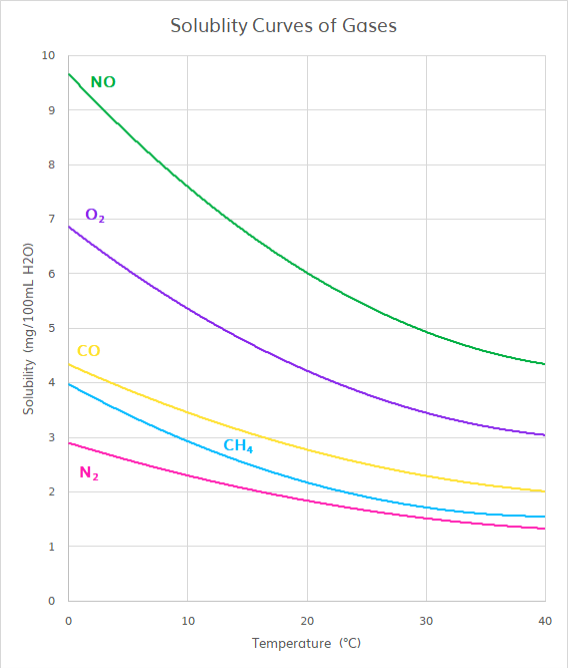
Factors Affecting Solubility

Temperature

- For **solids** in an aqueous solution, **an increase in temperature** will typically result in an **increase in solubility**



- For **liquids**, there is no defined trend
- For **gases** in an aqueous solution, an **increase in temperature** will typically result in a **decrease in solubility**



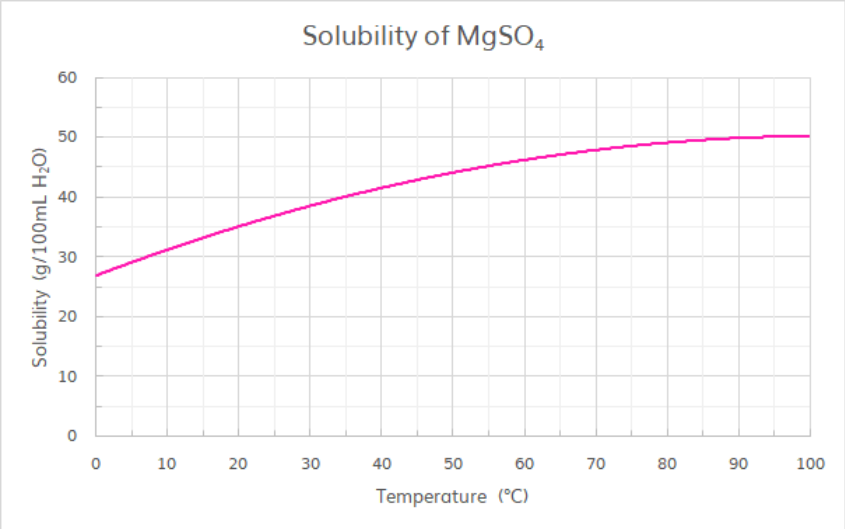
Pressure

- For **solids and liquid**s, a change in pressure will have a negligible effect on solubility
- For **gases**, **an increase in pressure** will typically result in **an increase in solubility**

7.3.4

Example: Solubility Curves

Suppose a solution contains 20g of $MgSO_4$ dissolved in 100mL of water at 50°C. Is the solution saturated, unsaturated, or supersaturated? Explain your answer.



7.3.5

Practice: Solubility

What would HCl readily dissolve in?

- H_2O
- C_6H_6 (benzene)
- Both
- None

7.3.6

Practice: Factors affecting Solubility

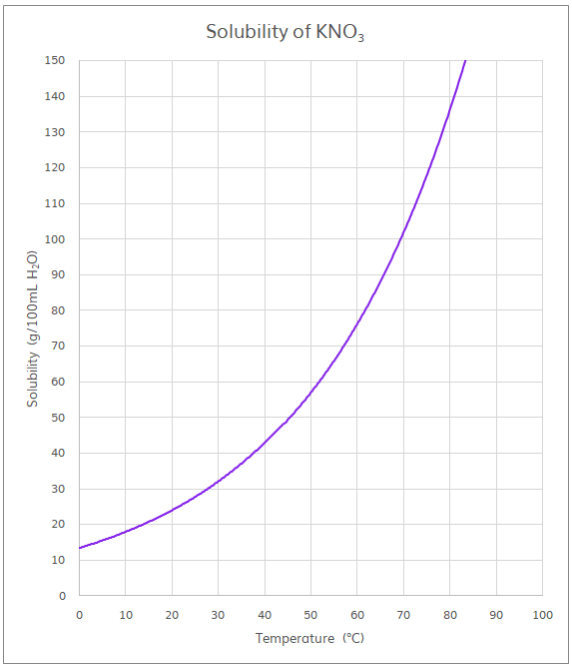
Most solutes dissolve faster in a water when the temperature is increased. Which of the following solutes is an exception to this rule?

- $NaCl$
- KNO_3
- CO_2
- NH_4Cl

7.3.7

Practice: Solubility Curves

Use the solubility curve below to answer the following questions:



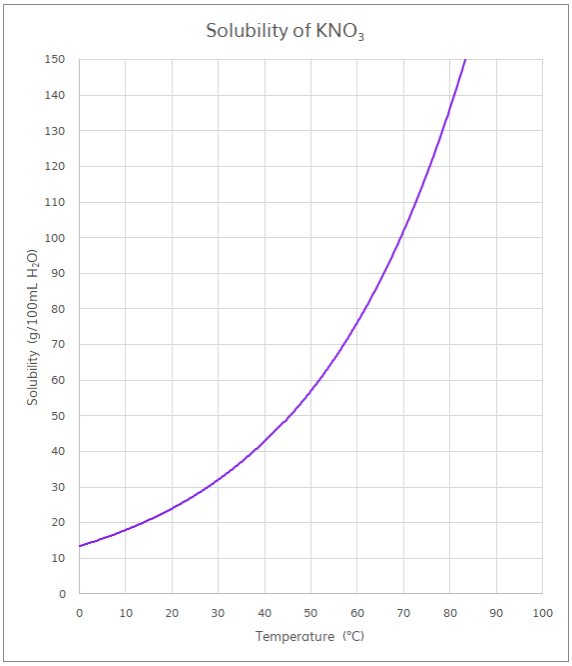
Part 1

What happens to a solution of KNO_3 that is saturated at 50°C when it is cooled quickly to 10°C?

- the solution is not changed
- the solution becomes saturated
- the average kinetic energy rises
- extra solute falls out of solution

Practice: Solubility Curves

Use the solubility curve below to answer the following questions:



Part 2

How would you describe a solution of KNO_3 at 80°C is there are about 45g of KNO_3 dissolved in 100mL of water?

- it is supersaturated
- it is dilute
- it is unsaturated
- it is saturated

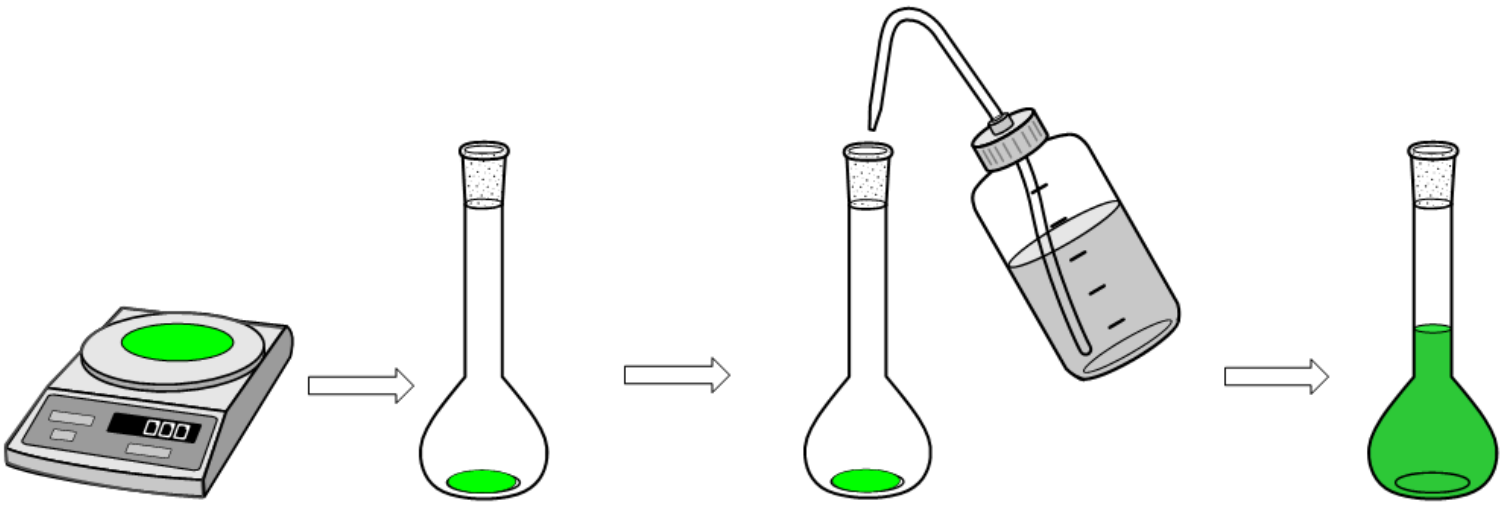
7.4 Making Solutions

7.4.1

Making Solutions

Making Standard Solutions

- A **standard** or **stock solution** is a solution that we know the concentration of accurately. Stock or standard solution can be **diluted.**
- To make a standard or stock solution, you have to dissolve the desired number of moles of solute in enough solvent to give the desired final volume of solution.



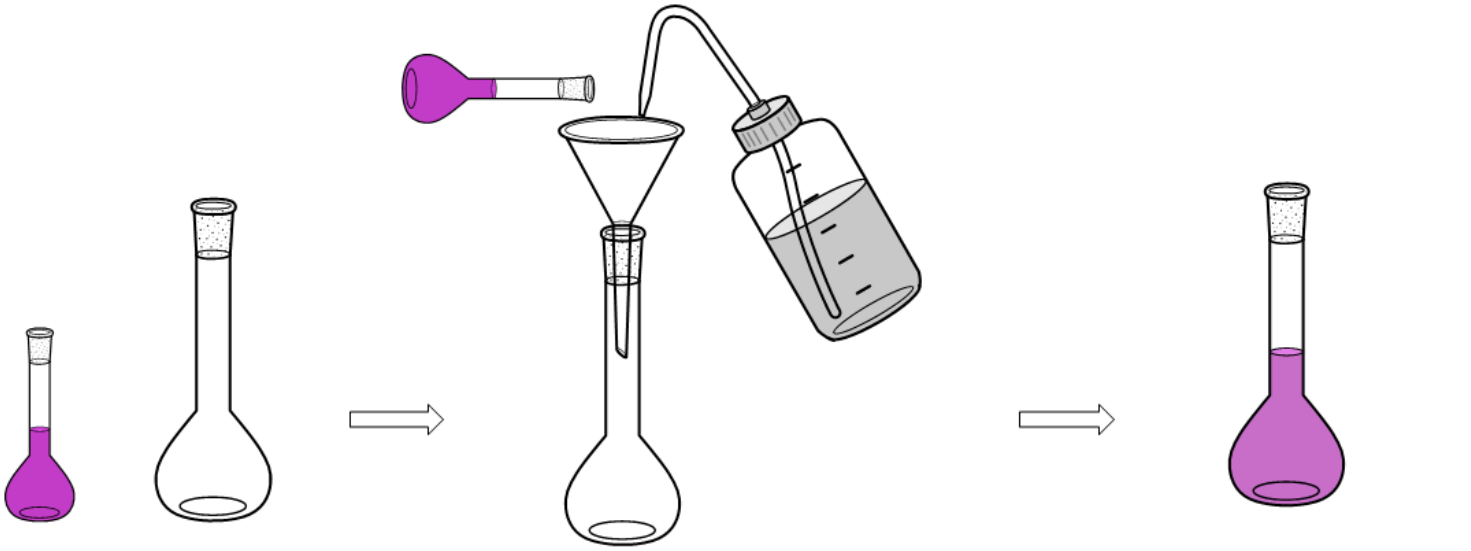
Weigh out the solid that is your solute.

Transfer the solid to a volumetric flask.

Fill the volumetric flask to the mark with distilled or deionized water.

Diluting Standard Solutions

- We can reduce the concentration of a standard solution by adding more solvent to the solution



Standard solution is in the small flask

Solution is transferred to a larger volumetric flask which is then filled with water to the mark

New solution has less solute per unit volume, so color is faded

- We can calculate the concentration of the diluted solution using the following equation:

$$\boxed{c_1 V_1 = c_2 V_2}$$

7.4.2 Example: Dilution Calculations

Example: Dilutions

Calculate the concentration of a diluted HCl solution prepared by taking 5.00mL of 1.50mol/L HCl and diluting it to 100.0mL in a volumetric flask.

7.4.3

Practice: Dilutions

During a dilution, the number of moles of solute:

- decreases
- increases
- does not change
- may increase or decrease, depending on the dilution

7.4.4

Practice: Dilutions

What volume of 4.0mol/L HCl solution is needed to make 0.50L of 3.0mol/L HCl solution?

- 6.0mL
- 375mL
- 24mL
- 0.375mL
- 66.7mL

7.4.5

Practice: Making Solutions

Match the following changes to the effect they will have on the final concentration of the solution.

A. doubling the original volume by adding water

B. doubling the original volume by adding more of an identical solution

C. doubling the number of moles by dissolving more solute

the concentration will halve

no effect on the final concentration

the concentration will double