Chemistry 110 Unit 3

Chapter 12-Liquids, Solids, and Intermolecular Forces

I. Types of Intermolecular Forces: Dispersion, Dipole-Dipole, and Hydrogen Bonding- Sec 12.6

B. **Intra**molecular (particle) forces

The attractive forces within a molecule

C. **Inter**molecular (particle) forces

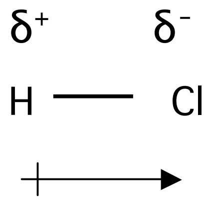
The attractive forces between molecules/paricles.

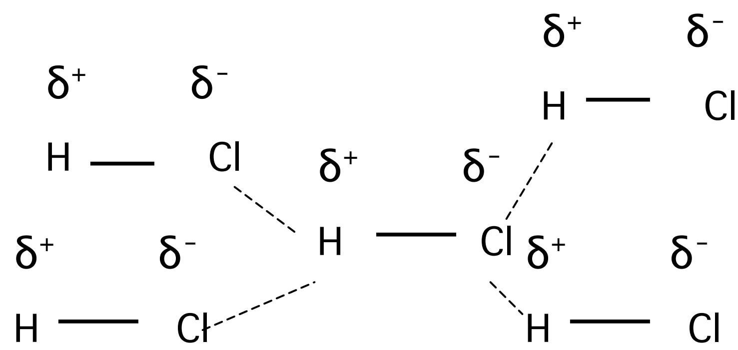
Types

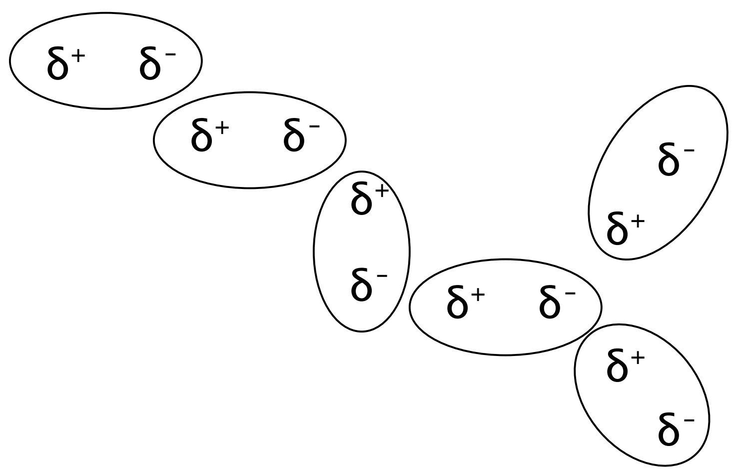
1. Dipole-Dipole interaction:

Dipole - dipole interactions are electrostatic attractions between polar molecules

POLAR MOLECULE







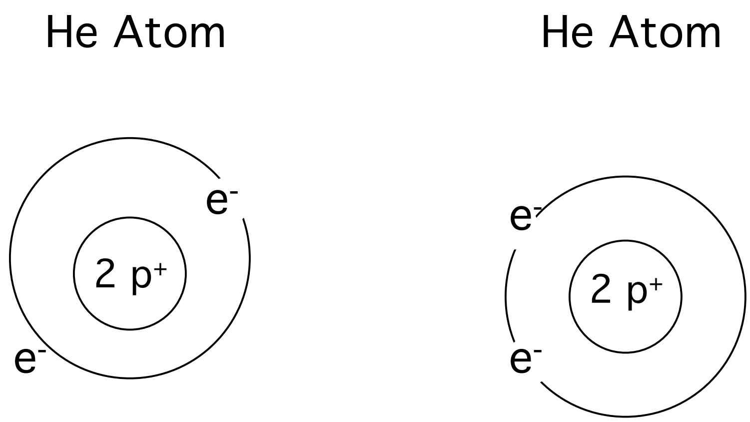
2. <u>Hydrogen bonds:</u>

A hydrogen bond is a relatively strong dipole-dipole attractive force between a hydrogen atom and a pair of nonbonding electrons on a F,O, or N atom

H – F
H – O
H – N

London forces are very weak electrostatic forces of attraction between molecules with "temporary" dipoles.

NON-POLAR MOLECULE



Chapter 13-Solutions

I. Solutions are homogeneous mixtures of two or more substances

II. Components of a solution:

III, Properties of a solution:

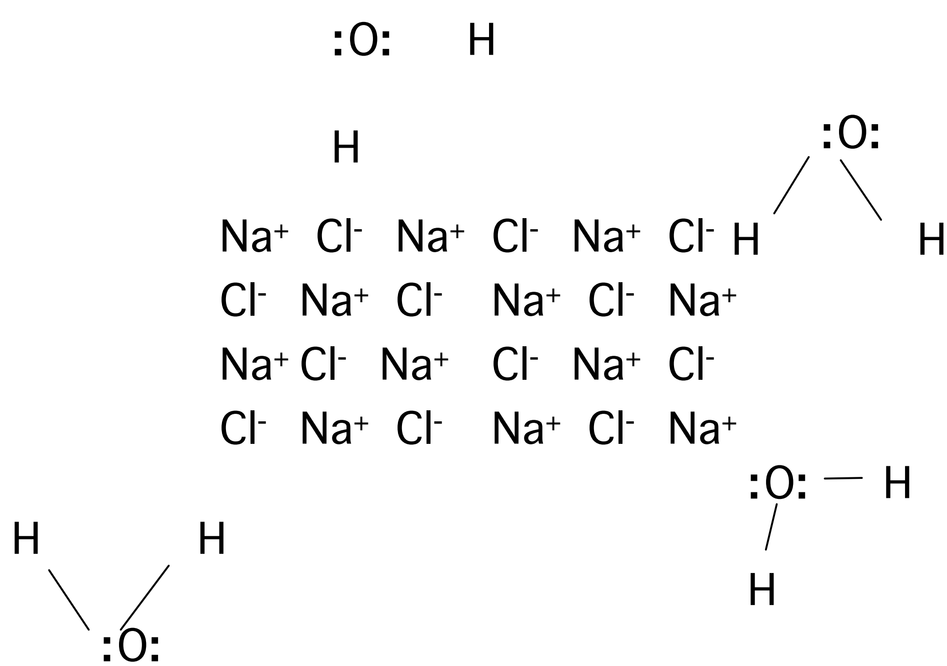
A. Solutions are homogeneous and variable in composition.

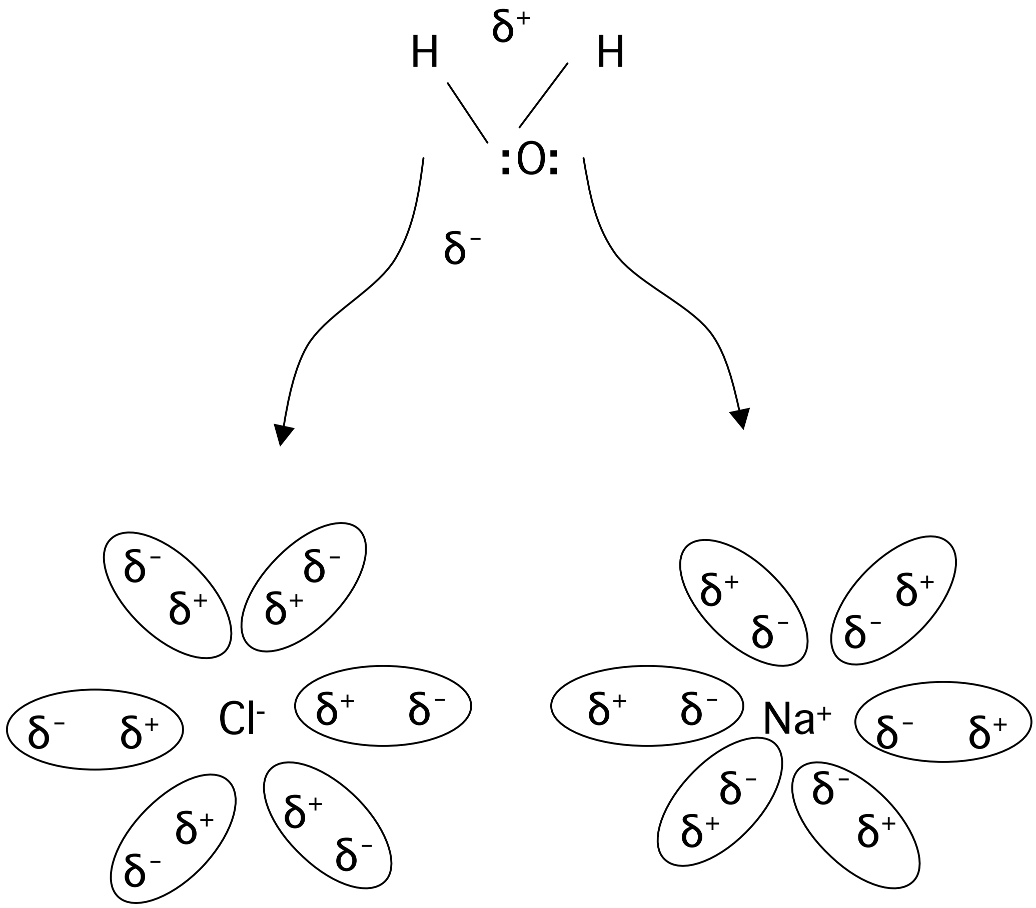
B. Solutions may be colored or colorless but are usually transparent.

C. The solute can be molecular or ionic and is dissolved in the solvent.

IV. Solution Formation

Rule of thumb: Like dissolves like





<u>Dissolved</u> <u>Ions</u>

E. Solubility and the nature of the solvent and solute

"Like" dissolves "like"

1. Polar or ionic substances are more soluble in polar solvents

2. Nonpolar substances are more soluble in nonpolar solvents

*Note:

Solubility Rules → memorize

Na_2S	FeS
$LiOH$	K_2CrO_4
$PbCO_3$	$Mn(OH)_3$
$AgCl$	$PbSO_4$

SOLUBILITY RULES FOR IONIC COMPOUNDS

Ion contained in the Compound	Solubility	Exceptions
Group IA	soluble	
NH_4^+	soluble	
$C_2H_3O_2^-$	soluble	
NO_3^-	soluble	
Cl^-, Br^-, and I^-	soluble	Ag^+, Pb^{2+}, Hg_2^{2+}
SO_4^{2-}	soluble	Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}
CO_3^{2-}, PO_4^{3-}, CrO_4^{2-}	insoluble	group IA and NH_4^+
S^{2-}	insoluble	group IA, IIA, and NH_4^+
OH^-	insoluble	group IA, Ca^{2+}, Ba^{2+}, Sr^{2+}

STRONG BASES	
LiOH	CsOH
KOH	$Sr(OH)_2$
RbOH	$Ba(OH)_2$
NaOH	$Ca(OH)_2$

STRONG ACIDS	
HNO_3	HCl
$HClO_4$	HBr
H_2SO_4	HI

V. Solubility:

The amount of solute that dissolves in a given amount of solvent at a given T° and Pressure

A. In: $\frac{\text{g solute}}{\text{100 g solvent}}$

B. Past solubility g Additional solute will not dissolve

ex.

C. Concentration of solutions

1) Dilute solutions contain a relatively small amount of solute.

2) Concentrated solutions contain a relatively large amount of solute.

D. Solubility terms for **solids** as the solute

1) Unsaturated solutions: A solution that contains less solute than it's solubility limit

2) Saturated solutions: A solution that contains the maximum amount of solute.

3) Supersaturated Solution - A solution that has been prepared to hold more solute than its solubility limit

4) Saturated, Unsaturated, or supersaturated?

E. Solubility terms for **liquids** as the solute

1) Miscible - 2 liquids that form a solution in all proportions

2) Immiscible - 2 liquids that do not form a solution

3) Partially miscible - 2 liquids that forms a solution in limited proportions

F. Factors that Effect Dissolving Rate

1) Particle size

Smaller crystals will have a larger surface to volume ratio. Therefore, smaller crystals will dissolve faster due to the increased solute-solvent contact.

2) Temperature

Solids

At higher temperatures solvent molecules possses more kinetic energy (more movement). At higher temperatures solvent molecules will hit the crystal surfaces with more force and frequency.

3) Stirring/Agitation

Stirring/Agitation increases the solute - solvent contact.

G. Factors that Effect Solubility (How much will dissolve in a given amount of solvent)

1) Temperature

In general, the solubility of solids increases with increasing temperature

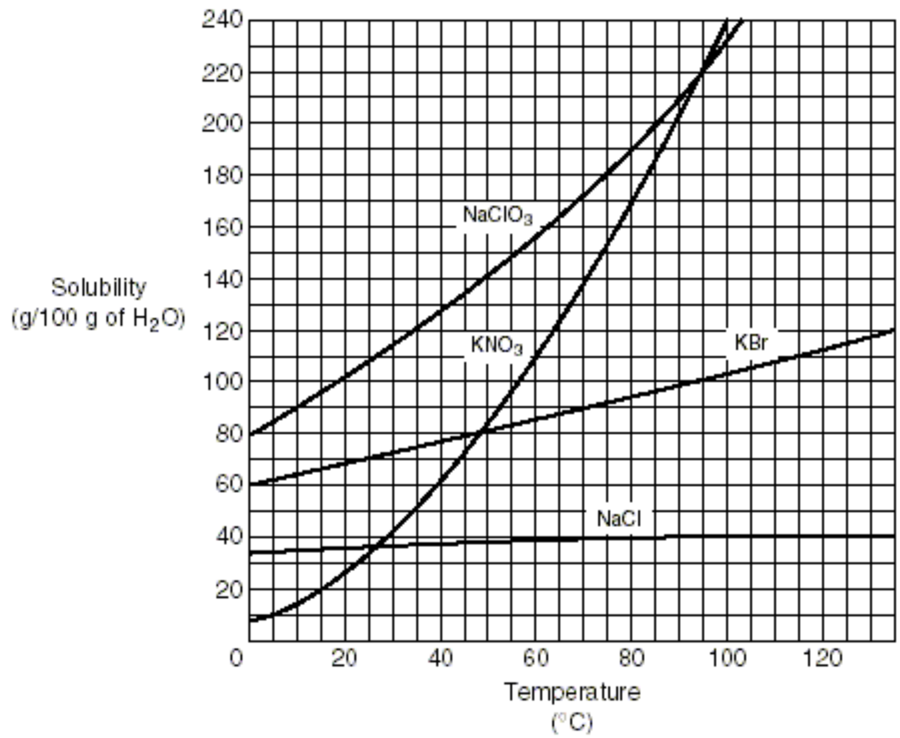
The solubility of gases decreases with increasing temperature

2) Pressure (gases)

The solubility of gases increases with increasing pressure.

3) Nature of the Solute/Solvent

H. <u>Solubility curves</u>



1. Solubility at various temperatures

2. Problems:

a. 2 L of a compound KBr solution contains 90 g KBr per 200 g water at 30°C. What type of solution is this?

b. At 55° C 20 grams of KNO_3 is dissolved in 100 g of water. How many more grams can be dissolved in this solution?

V. Concentrations

A. Percent solute

1. % by weight

2. % by volume

3. Wt-Vol %

Problems:

1) What is the % concentration (m/m) of a solution made by dissolving 125 grams of sucrose in 450.0 grams of water?

2) What volume of solvent is needed to prepare 5.0 L a 45.5 % NaCl solution?

3) How many mls of solute are needed to make 2.35 L of a 25.6 % (v/v) ethanol solution?

B. Molarity—The ratio of moles of solute to liters of total solution.

Units for molarity:

Problem:

1) What is the molar concentration of a solution that has 10.3 g of sodium bromide in 251 mL of solution?

2) What is the mass of solute dissolved in 2.5 L of a .25 M aqueous solution of cupric sulfate? (Molar mass of Cupric sulfate: 159.61 g/mol)

4) What is the volume, in L, of a 1.25 molar solution of cupric sulfate that contains 235.5 grams of solute?

C. Molality- The ratio of moles of solute to kg solvent

Units for molality:

Problems:

1) What is the molality of a solution that has 10.3 g sodium bromide that has been dissolved in 300. mL of water?

2) How many grams of water must be added to 311 g KBr to make a 15.4 m KBr solution?
REM: 1 gram H_2O = 1 ml H_2O

3)How many N atoms are in 100.0 ml of a 0.100 M $Fe(NO_3)_2$ solution?

VI. Dilutions

Dilution Problems:

1. 25 ml of a 8.0 M HCl solution is diluted to 1 liter. What is the final molarity?

2. What volume of 6.00 M H_2SO_4 is needed to prepare 0.500 L of a 0.300 M H_2SO_4 solution?

Deeper PROBLEMS

1. A solution is made by mixing 175 ml of 0.100 M K_3PO_4 with 27.0 ml of 0.200 M KCl. Assuming that the volumes are additive, what are the molar concentrations of the following ions in the new solution?

   a. potassium ion

   b. chloride ion

   c. phosphate ion

2. Calculate the molarity of an 8.92 m ethyl alcohol (molar mass of C_2H_6O = 46.08) solution whose density is .927 g/ml

Chapter 14 - ACIDS AND BASES

I. ACIDS AND BASES

A. Acidic Characteristics

1. Tart/Sour taste
2. Produces color changes with indicators
3. Will react with and neutralize a base to form water
4. Will react with certain metals with H_2 as a product

B. Basic Characteristics → Ionic Compounds that contains **OH-**

1. Bitter taste
2. Slippery feeling
3. Produces color changes with indicatiors
4. Will neutralize an acid to form water
5. Will form a precipitate (ppt) with certain cations

C. Definitions of Acids and Bases

Arrhenius Acid → A substance that INCREASES the concentration of **H^+** in water

Arrhenius base → A substance that INCREASES the concentration of **OH^-** in water

Bronsted Acid-A proton (H^+) donor

Bronsted Base-A proton (H^+) acceptor

D. Acid-Base reaction

$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

E. Salts- A salt is produced in an acid-base reaction.

$HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O$

Acid + Base $\rightarrow$ Salt + H_2O

How to recognize:

A salt is an ionic compound that does not contain OH^- and is not a metal oxide

$HCl(aq)$	$NaBr$	$Zn(C_2H_3O_2)_2$	KOH
$Sn(OH)_2$	$HClO(aq)$	$HC_6H_6O_2(aq)$	$AgHSO_4$

F. Strong and Weak Acids and Bases section 14.7

Strong Acids

Weak Acids

Strong Bases

Weak Bases

STRONG BASES

LiOH	NaOH
KOH	RbOH
CsOH	$Sr(OH)_2$
$Ba(OH)_2$	$Ca(OH)_2$

STRONG ACIDS

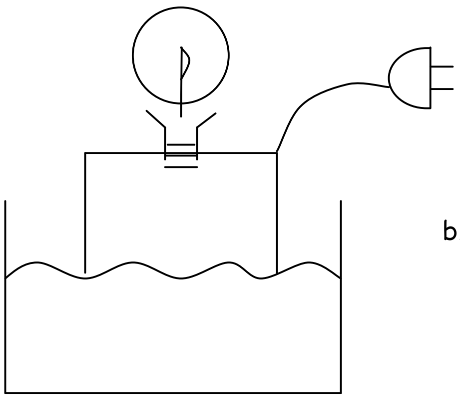
HNO_3	H_2SO_4
$HClO_4$	HCl
HBr	HI

II. Electrolytes

A. Experimental background:

B. Strong, Weak, and Nonelectrolytes

1. Strong Electrolytes: a.



b.

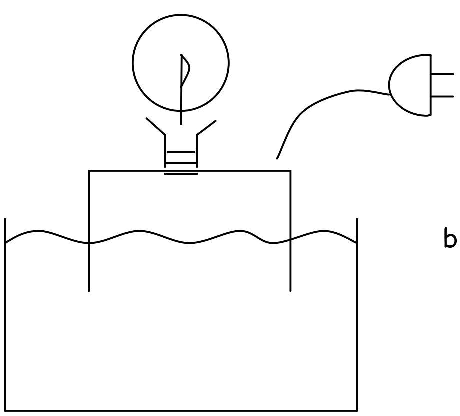
c. Substances which are strong electrolytes:

(1) Soluble ionic compounds

(2) Strong Acids

(3) Strong Bases

2. Weak Electrolytes: a.



b.

c. Substances which are weak electrolytes:

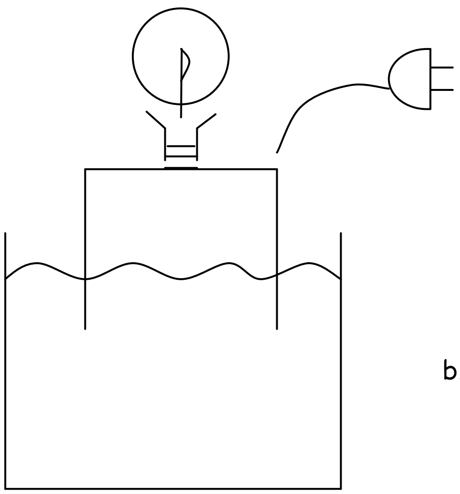
(1) Weak Acids

(2) Weak Soluble Bases

*(3) Slightly soluble ionic compounds

*Do not need to know at this time

3. Nonelectrolytes:



a.

b.

c. Substances which are nonelectrolytes:

(1) Insoluble ionic compounds

(2) Soluble substances that only exists as molecules in water

I. The pH and pOH Scales: Ways to Express Aciodity and Basicity

A. Autoionization of water

Experiments have shown that a very small percentage of water will undergo the following ionization to produce ions:

$$H_2O + H_2O \rightarrow H_3O^+ + OH^-$$

Experimentally, it was determined that the product between the molar concentraions of the hydronium ion and hydroxide ion is a constant:

$$[H_3O^+] \times [OH^-] = 10^{-14}$$ ← ion product for water (constant)

or $[H^+] \times [OH^-] = 10^{-14}$ as an abbreviation

Therefore, in pure water, $[H_3O^+] = [OH^-] = 10^{-7}$

Problems:

1. What is the hydrogen (hydronium) ion concentration when $[OH^-] = 2 \times 10^{-3}$M?

2. What is the hydroxide ion concentration in a 0.50 M HCl solution?

B. The pH scale

Hydrogen ion concentrations, $[H^+]$ and hydroxide ion concentrations, $[OH^-]$ are usually very small numbers.....$[H^+] = 2 \times 10^{-1}$M and $[H^+] = 1 \times 10^{-11}$M for example. The pH scale was developed to handle these very small numbers over a wide range.
(2×10^{-1} is 20 **trillion** times larger than 1×10^{-11}!)

$$pH = -\log [H_3O^+]$$

and $pOH = -\log [OH^-]$

Problems:

1. What is the pH when $[H^+] = 10^{-3}$M?

2. What is the what is the pH of a 0.002 M HCl solution?

\

3. What is the pH of a 1.00×10^{-2} M NaOH solution?

Acidic, Basic, and Neutral solutions:

$[H_3O^+]$	$[OH^-]$	pH	acidic/basic/neutral
10^{0}	10^{-14}	0	
10^{-1}	10^{-13}	1	
10^{-2}	10^{-12}	2	
10^{-3}	10^{-11}	3	
10^{-4}	10^{-10}	4	
10^{-5}	10^{-9}	5	
10^{-6}	10^{-8}	6	
10^{-7}	10^{-7}	7	
10^{-8}	10^{-6}	8	
10^{-9}	10^{-5}	9	
10^{-10}	10^{-4}	10	
10^{-11}	10^{-3}	11	
10^{-12}	10^{-2}	12	
10^{-13}	10^{-1}	13	
10^{-14}	10^{-0}	14	

Problem: Basic, acidic or neutral solutions?

1. 2×10^{-10} M $[H^+]$
2. $[H^+] = 2 \times 10^{-10}$
3. $[OH^-] = 6 \times 10^{-5}$
4. pH = 12

Chapter 7-CHEMICAL REACTIONS

PART 1 CHEMICAL REACTIONS

A chemical reaction occurs when there is a change in chemical composition.

I. Evidence of a reaction- One of the following would be observed:

a. A precipitate is formed or dissolved

b. A change of color

c. Effervescence occurs (gas formation)

d. Energy in the form of heat, light, or electricity is released

III. Balancing Chemical Equations

A. Conservation of Mass → Matter cannot be created or destroyed.

B. Balancing

Object: Each side of the equation must have the same number of atoms of each element.

Hint: Work Systematically

BALANCING EQUATIONS

HOW TO:

1. Correct formulas for reactants and products must be written, for example,

$NaCl_2$ → WRONG!!

2. Physical states must be included.

Keys: 1. Know the physical states of the elements

(g) (l) (s) (aq)

2. Know solubility rules

3. Balancing equations

a) Count and compare the number of atoms of each element on both sides of the equation.

b) Balance each element individually by placing whole numbers in front of the chemical formula

c) Check all elements after each individual element is balanced to see, whether or not in balancing one element, others have become imbalanced.

d) Hydrogen, nitrogen, oxygen plus the halogens are diatomic and **must** be written as such.

H_2, O_2, N_2, Cl_2, Br_2, I_2, F_2

1. . Aqueous solutions of barium hydroxide and potassium sulfate are mixed to produce barium sulfate and potassium hydroxide

2. Nitrogen gas is added to hydrogen to produce ammonia

3. Sulfuric acid is mixed with aqueous sodium hydroxide to produce water and sodium sulfate

B. SOLUBILITY RULES FOR IONIC COMPOUNDS

Ion contained in the Compound	Solubility	Exceptions
Group IA	soluble	
NH_4^+	soluble	
$C_2H_3O_2^-$	soluble	
NO_3^-	soluble	
Cl^-, Br^-, and I^-	soluble	Ag^+, Pb^{2+}, Hg_2^{2+}
SO_4^{2-}	soluble	Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}
CO_3^{2-}, PO_4^{3-}, CrO_4^{2-}	insoluble	group IA and NH_4^+
S^{2-}	insoluble	group IA, IIA, and NH_4^+
OH^-	insoluble	group IA, Ca^{2+}, Ba^{2+}, Sr^{2+}

STRONG BASES	
LiOH	CsOH
KOH	$Sr(OH)_2$
RbOH	$Ba(OH)_2$
NaOH	$Ca(OH)_2$

SOLUTION INVENTORIES (PREDOMINANT SPECIES)

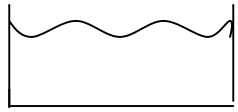
The most abundant particle(s) in aqueous solutions

Key:
1. Know solubility rules
2. Know strong and weak acids and bases
3. Know intermolecular attractions

ACIDS	**BASES**	**IONIC COMPOUNDS**	**MOLECULAR COMPOUNDS**

PARTICLE — **Solution Inventory/ Most abundant particle(s)**

KCl →



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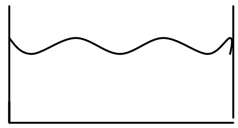
$Ba(C_2H_3O_2)_2$ →



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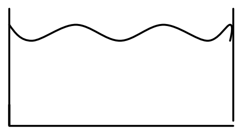
HCl →



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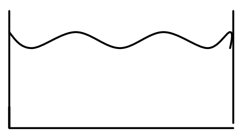
Ag_2CO_3 →



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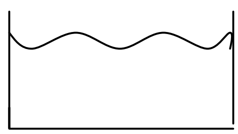
HClO →



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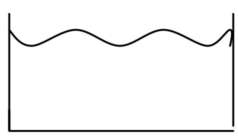
Ammonia →



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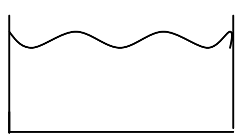
$Fe(OH)_3$ →



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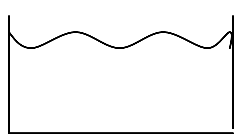
H_2 →



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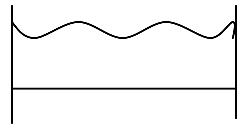
$C_6H_{12}O_6$ (polar) $\longrightarrow$  ____________________

Name	Formula	Soluble in H_2O	Ions or Molecules in Solution	Solution Inventory	

EXAM III-practice

SHOW ALL YOUR WORK. YOUR ANSWERS MUST HAVE THE CORRECT NUMBER OF SIGNIFICANT FIGURES AND UNITS. CORRECT SPELLING MUST BE USED.

1. A Student mixed a solution that contained 16.2 g Calcium Chloride in 131g of water
   a. What is the molality of the solution?

   b. What is the weight-weight percent of the solution?

   c. What is the weight-volume percent of the solution (if the volume of the solution=133 mls)?

2. Calculate the molarity of a solution containing 0.016 kg of potassium bromide in 4.00×10^6 μls of solution.

3. What volume of 0.44 M of silver nitrate solution must be used in an experiment requiring 1.2 g of the compound

4. How many grams of sodium dichromate are there in a 1.55 m sodium dichromate solution When 75 g of H_2O is present.

5. Give the correct chemical formula and classify the following as a strong electrolyte, weak electrolyte, or nonelectrolyte.

Calcium iodide

____

hydrobromic acid

____

C_2H_5OH (aq)

____

NH_3(aq)

____

ammonium hydrogen sulfite

____

Bromous acid

____

acetic acid

____

Aurous sulfate

____

C_2H_4O(aq)

____

cupric chloride

____

hydrocyanic acid

____

Nickel (II) hydroxide

____

Mercuric carbonate

____

6. Write the solution inventory (the predominant species) for the following compounds:

Silver sulfate	Magnesium carbonate
_______________________	_______________________
mercuric carbonate	Ammonium sulfide
_______________________	_______________________
Silver bromide	CH_3OH (A polar compound)
_______________________	_______________________
Plumbic acetate	sodium iodate
_______________________	_______________________
Barium sulfate	Cobalt (III) sulfide
_______________________	_______________________
nickel (II) nitrate	aurous iodide
_______________________	_______________________
barium phosphate	potassium hydroxide
_______________________	_______________________
calcium hydroxide	nitrous acid
_______________________	_______________________

7. List and briefly discuss two factors that effect solubility

8. List and briefly discuss two factors that effect the rate of dissolving

9. Indicate if the following would be soluble, insoluble, miscible, or immiscible in water.

C_6H_6 (l) [nonpolar]	________________	KBr	________________
ethanol[polar molecule]	________________	$PbSO_4$	________________
Nickel (II) sulfide	________________	$CaBr_2$	________________
CCl_4(l) [nonpolar]	________________		

10. How many mls of a 0.100 M HCl solution can be made by diluting 20.0 mls of a 1.50 M HCl solution

11. Given the solubility curve for compound W answer the following questions:

A. What is the solubility of W at 35 ^{o}C

B. For the following tell whether the solution is (a) saturated, (b) unsaturated or (c) supersaturated:

1. 20 g of W dissolved in 1 x 10^5 mg of H_2O at 20 ^{o}C ________________

2. 27 g of W dissolved in 50 g of H_2O at 301 K ________________

3. 40 g of W dissolved in 225 g of H_2O at 60 ^{O} C ________________

C. 1. How many g of W can dissolve in a solution of W already containing $\frac{40.0 \text{ g W}}{150.0 \text{ g } H_2O}$ at 70°C

2. 5.00 kg of W was added to 10.0 L of water at 55 °C. How many g of W will remain undissolved?

12. Some commercial drain cleaners contain two components: sodium hydroxide and aluminum powder. When the mixture is poured down a clogged drain, the following reaction occurs:

$$2NaOH\,(aq) + 2Al(s) + 6H_2O(l) \rightarrow 2NaAl(OH)_4(aq) + 3H_2(g)$$

How many mLs of 5.0 M NaOH are needed to react to form 6.7 liters of H_2 gas at 755 torr and 25^oC?

13. Classify the intermolecular forces between molecules of each of the following liquids.

a. CO
b. O_2
c. CH_3OH
d. HF
e. CO_2
f. CH_2O

14. How many grams of liquid carbon tetrachloride [CCl_4] can be converted to vapor at its normal boiling point by the addition of 485 kJ of energy. The molar heat of vaporization for CCl_4 is 33.5 kJ/mol.

15. Calculate the quantity of heat in kJ needed to raise the temperature of 125 g of liquid water from 25.0 ^oC to steam at 125 ^oC.

16. How many kilojoules are required to change 5.0 moles of ice at -30.0 ^{o}C to liquid water at 89.0 ^{o}C?

17. List three factors that affect reaction rates and give the reasons why they affect the rate

18. Draw a potential energy diagram for a reaction. Label all the components as well as both axis of the graph.