Key

SOLUBILITY OF IONIC SALTS

It is difficult to predict the solubility of ionic compounds. The Solubility Guidelines (Table F) can be used to determine whether a compound is soluble or insoluble. Write the appropriate IUPAC name and determine if the salt is soluble or insoluble.

Salt	IUPAC Name	Soluble or Insoluble
1) $CaCO_3$	calcium carbonate	insoluble
2) Na_2CrO_4	sodium chromate	soluble
3) $Mg(OH)_2$	magnesium hydroxide	insoluble
4) AgCl	silver chloride	insoluble
5) CaS	calcium sulfide	insoluble
6) NH_4ClO_3	ammonium chlorate	soluble
7) $PbBr_2$	lead (II) bromide	insoluble
8) $Zn(HCO_3)_2$	zinc hydrogen carbonate	soluble
9) $KC_2H_3O_2$	potassium acetate	soluble
10) NaOH	sodium hydroxide	soluble

When the aqueous solutions of ionic salts are combined a visible double replacement reaction occurs if one of the products is a precipitate (insoluble). Using your knowledge of double replacement reactions, predict the products of the reactions and then balance the equation using the smallest whole number coefficients. Finally, using table F determine if either of the products is insoluble. Circle any insoluble products.

1) $\underline{2}\ Rb^{+1}NO_3^{-1}(aq) + \_\_\_\ Pb^{+2}(ClO_3)_2^{-1}(aq) \rightarrow \underline{2}\ RbClO_3(aq) + \_\_\_\ Pb(NO_3)_2(aq)$

2) $\underline{2}\ Na^{+1}HCO_3^{-1}(aq) + \_\_\_\ Cu^{+2}Cl_2^{-1}(aq) \rightarrow \underline{2}\ NaCl(aq) + \_\_\_\ Cu(HCO_3)_2(aq)$

3) $\_\_\_\ Li_2^{+1}CO_3^{-2}(aq) + \_\_\_\ Mg^{+2}SO_4^{-2}(aq) \rightarrow \_\_\_\ Li_2SO_4(aq) + \_\_\_\ MgCO_3(s)$

4) $\underline{2}\ NH_4^{+1}Cl^{-1}(aq) + \_\_\_\ Pb^{-2}(NO_3)_2^{+1}(aq) \rightarrow \underline{2}\ NH_4NO_3(aq) + \_\_\_\ PbCl_2(s)$

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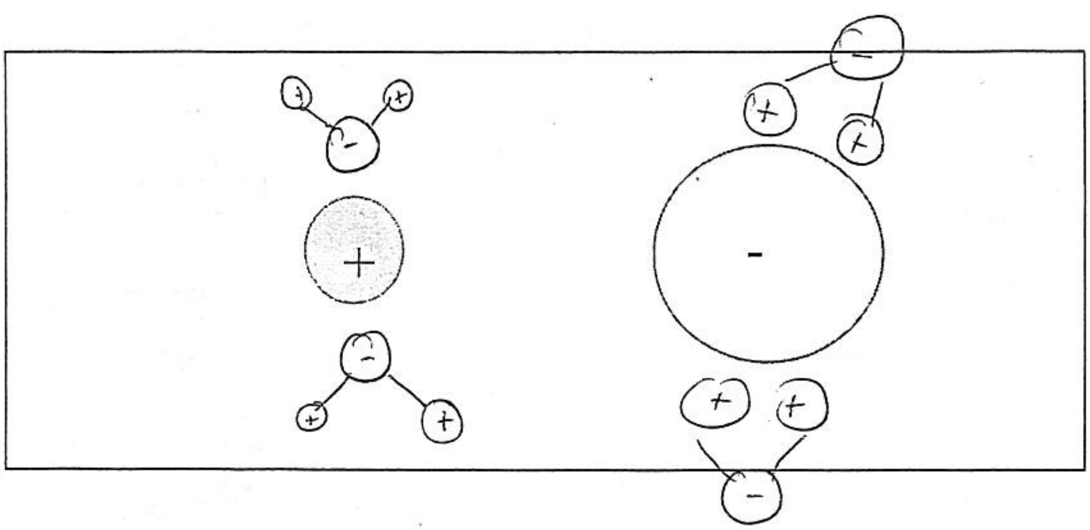
SOLUTION FORMATION

Directions: Please fill out the following table. For each solute listed, determine where the nature of the compound is nonpolar covalent, polar covalent or ionic. Then determine if the solute will be soluble or insoluble in each solvent.

REMINDER: “Like dissolves like”

		Solvent			
		Water polar	**Octane (nonpolar)**	**Hexane (nonpolar)**	**Ethanol (Polar)**
Solute	**NaCl** **Nature:** ionic	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble
	HCl **Nature:** polar	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble
	CO_2 **Nature:** nonpolar	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble
	O_2 **Nature:** nonpolar	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble	Soluble Insoluble

When ionic solids dissolve to form aqueous solutions, the water molecules hydrate (surround) the ions. In the space below, illustrate the molecule-ion attractions that occur during the solvation of the ions of an ionic salt by adding water molecules (in the correct orientation).



Key

Rate of Dissolving vs. Solubility

Rate of dissolving = a measure of how fast something dissolves

Factors Affecting Rate of Dissolving:

- particle size
- stirring
- amount of solute already dissolved
- temp.

Solubility = how much solute can dissolve at a given temp.

Factors Affecting Solubility

Factor	Solid Solute	Gaseous Solute
temperature	↑ temp, ↑ solubility	↑ temp, ↓ solubility
Pressure	no effect	↑ pressure, ↑ solubility

Practice Questions:

1. A decrease in pressure has the gretatest effect on a solution that contains
   a. A gas in a liquid
   b. A liquid in a liquid
   c. A solid in a solid
   d. A solid in a liquid

2. As the temperature increases, the solubility ~~of a~~ gas in water
   a. Incresaes
   b. Decreases
   c. Remains the same

3. Which compound becomes less ~~solute~~ soluble in water as the temperature of the solution increased?
   a. HCl
   b. KCl
   c. NaCl
   d. NH_4Cl

   * Look on Table G!

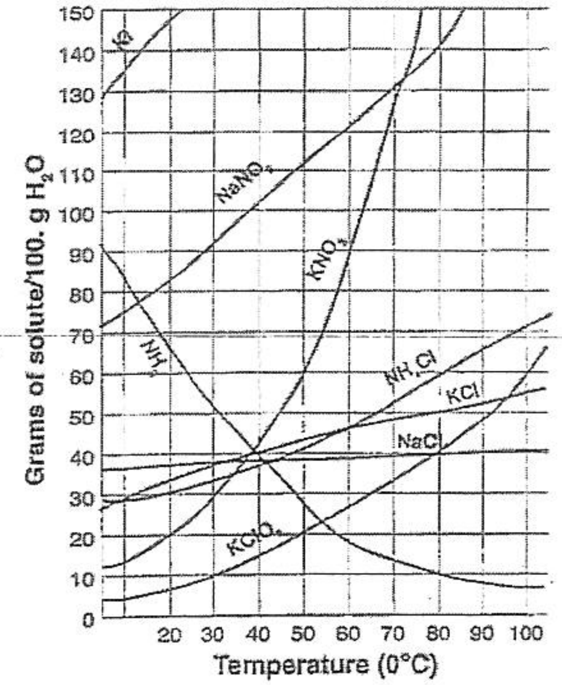
4. Which of the following will affect both the rate of dissolving and the solubility of $NaNO_3$ (s) in water?
   a. Stirring the beaker
   b. Increasing the pressure
   c. Increasing the temperature
   d. Crushing the solid

5. Which of the following will increase the solubility of a gas but not the solubility of a solid?
   a. Stirring the contents
   b. Increasing the temperature
   c. Increasing the pressure
   d. None of the above

Key

Solubility Curves Practice

Use the solubility curve on this sheet to answer the following questions.



1. Which salt is least soluble in water at 20°C?

   $\boxed{KClO_3}$

2. How many grams of potassium chloride can be dissolved in 200g of water at 80°C? KCl

   $\frac{50\text{ g}}{100\text{ mL } H_2O} \times 2 = \boxed{100\text{g}}$

3. At 40°C, how much potassium nitrate can be dissolved in 300 g of water? → KNO_3

   ×3

   $42 \times 3 = \boxed{126\text{g}}$

4. Which salt shows the least change in solubility from 0°C-100°C?

   $\boxed{NaCl}$

5. At 30°C, 90g of sodium nitrate is dissolved in 100g of water. Is this solution saturated, unsaturated, or supersaturated? → $NaNO_3$

   can hold ~92 g, so unsaturated

6. A saturated solution of potassium chlorate is formed from one hundred grams of water. If the saturated solution is cooled from 80°C to 50°C, how many grams of precipitate are formed? $KClO_3$

   $40\text{g} - 20\text{g} = \boxed{20\text{g}}$

7. a.What solute shows a decrease in solubility as temperature increases?

   $\boxed{NH_3}$

   b. Classify this compound as a solid, liquid, or gas, and explain your reasoning.

   gas – For a gas, as temp ↑, solubility ↓ b/c gas particles bubble out of solution.

8. Which compound is most soluble at 10°C?

   $\boxed{KI}$

9. Which compound is least soluble at 50°C?

   $\boxed{KClO_3}$

10. Which salt is least soluble at 90°C?

    salt = ionic

    $\boxed{NaCl}$ ✱ Not NH_3, b/c NH_3 is molecular. "Salt" means ionic.

Concentrations of Solutions problems HC - Key

1. Each of the solutions has the same amound of solute (1 mol of NaOH), but a different amount of solvent (1 M is in 1 L of solution & 1 m is in 1 kg of solvent).

2. Both percent by mass & mole fraction are $\frac{\text{part}}{\text{whole}}$, but...
   - $\% \text{ by mass} = \frac{\text{mass solute}}{\text{mass solution}} \times 100\%$
   - $\text{mole fraction} = \frac{\text{moles solute}}{\text{moles solution}} \times 100\%$

3. $$\frac{20.0\text{g } NaHCO_3}{(600 + 20\text{g}) \text{ solution}} \times 100\% = \boxed{3.22\% \ NaHCO_3}$$

4. $$3.62 = \frac{x}{1500.0} \times 100 \qquad \boxed{x = 54.3\text{g } NaOCl}$$

5. $$\frac{4.5 \times 10^{-3}\text{ g } F^-}{450 \text{ g solution}} \times 1{,}000{,}000 = \boxed{10.\text{ ppm } F^-}$$

6. $$6.9 = \frac{x}{750\text{g}} \times 1{,}000{,}000$$
   $$\boxed{x = 5.2 \times 10^{-3}\text{ g } Cl^-}$$

7. $$\frac{0.25 \text{ mol}}{0.375\text{ L}} = \boxed{0.67 \text{ M } MgBr_2}$$

8. $$.45\text{ L} \times \frac{.58 \text{ mol}}{1 \text{ L}} = \boxed{0.26 \text{ mol } Na_2CO_3}$$

(9) $1.5\text{ L} \times \dfrac{.25\text{ mol}}{1\text{ L}} \times \underbrace{\dfrac{74.1\text{ g}}{1\text{ mol}}}_{\text{molar mass of } Ca(OH)_2} = \boxed{28\text{ g } Ca(OH)_2}$

(10) $6.00\,\cancel{\text{g}}\text{ NaCl} \times \dfrac{1\text{ mol NaCl}}{58.5\,\cancel{\text{g}}} = 0.102564\text{ mol NaCl}$

$$\frac{0.102564\text{ mol}}{0.9965\text{ kg}} = \boxed{0.103\text{ m}}$$

(11) $.400\,\cancel{\text{kg}} \times \underbrace{\dfrac{1\,\cancel{\text{mol}}}{1\,\cancel{\text{kg}}}}_{1.00\text{ m}} \times \underbrace{\dfrac{171.3\text{ g}}{1\,\cancel{\text{mol}}}}_{\text{molar mass of } Ba(OH)_2} = \boxed{68.5\text{ g } Ba(OH)_2}$

(12) $\dfrac{2.9\text{ mol}}{(2.9 + 3.5 + 7.2)} = \dfrac{2.9}{13.6} = \boxed{0.213}$

(13) $125\,\cancel{\text{g}}\text{ NaCl} \times \underbrace{\dfrac{1\text{ mol}}{58.5\,\cancel{\text{g}}}}_{\text{molar mass of NaCl}} = \dfrac{2.13675\text{ mol NaCl}}{(\underset{\text{mol NaCl}}{2.13675} + \underset{\text{mol } H_2O}{37.5}\text{ mol total})} = \boxed{0.0539}$

(14) (1st,) find g NaOH using % solution equation

$$22.8 = \frac{x}{500} \times 100\%$$

$x = 114\text{ g NaOH}$

(2nd:) g NaOH → mol NaOH

$$114\,\cancel{\text{g}}\text{ NaOH} \times \frac{1\text{ mol}}{40\,\cancel{\text{g}}} = 2.85\text{ mol NaOH}$$

(3rd) mass H_2O = 500 g solution − 114 g NaOH = $386\,\cancel{\text{g}}\ H_2O \times \dfrac{1\text{ mol}}{18.0\,\cancel{\text{g}}} = \underline{\underline{21.4\text{m}}}$

(4th) mole fraction $= \dfrac{\text{mol NaOH}}{\text{total moles}} = \dfrac{2.85\text{ mol NaOH}}{(2.85 + 21.4\text{ mol})} = \boxed{0.118}$

Practice Questions:

1. Which solution has the highest boiling point?
   (1) 0.5 M NaCl – 2 particles × 0.5 M = like 1 M
   (2) 0.5 M $CaCl_2$ – 3 particles × 0.5 M = like 1.5 M
   (3) 1.0 M $(NH_4)_3PO_4$ – 4 particles × 1.0 M = like 4.0 M
   (4) 2.0 M CH_3OH – 1 particle × 2.0 = like 2.0 mol

2. Compared to pure water, an aqueous solution of calcium chloride has a
   (1) higher boiling point and higher freezing point
   (2) higher boiling point and lower freezing point
   (3) lower boiling point and higher freezing point
   (4) lower boiling point and lower freezing point

3. Which solution has the highest boiling point?
   (1) 1.0 M KNO_3
   (2) 2.0 M $\underbrace{KNO_3}_{\text{2 particles}}$
   (3) 1.0 M $Ca(NO_3)_2$
   (4) 2.0 M $\underbrace{Ca(NO_3)_2}_{\text{3 particles}}$ – higher conc.

4. Which solution has the *lowest* freezing point? – highest concentration
   (1) 10. g of KI dissolved in 100. g of water 10%
   (2) 30. g of KI dissolved in 100. g of water 30%
   (3) 20. g of KI dissolved in 200. g of water 10%
   (4) 40. g of KI dissolved in 200. g of water 20%

5. As water is added to a 0.10 M NaCl aqueous solution, the conductivity of the resulting solution
   dissociates/breaks into ions
   making more dilute
   (1) decreases because the concentration of ions decreases
   (2) decreases, but the concentration of ions remains the same
   (3) increases because the concentration of ions decreases
   (4) increases, but the concentration of ions remains the same

6. Which aqueous solution of KI freezes at the lowest temperature? highest concentration
   (1) 1 mol of KI in 500. g of water
   (2) ~~2 mol of KI in 500. g of water~~
   (3) 1 mol of KI in 1000. g of water
   (4) 2 mol of KI in 1000. g of water

7. Compared to a 2.0 M aqueous solution of NaCl at 1 atmosphere, a 3.0 M aqueous solution of NaCl at 1 atmosphere has a
   more conc.
   (1) lower boiling point and a higher freezing point
   (2) lower boiling point and a lower freezing point
   (3) higher boiling point and a higher freezing point
   (4) higher boiling point and a lower freezing point

8. Based on Reference Table F, which of these saturated solutions has the lowest concentration of dissolved ions?
   (1) NaCl(aq) 2 ions
   (2) $MgCl_2$(aq) 3 ions
   (3) $NiCl_2$(aq) 3 ions
   (4) AgCl(aq) insoluble