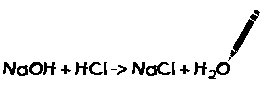
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| **Objectives:** | | |
| * Name salts based on the acid from which they are formed. * Use the solubility rules to determine the solubility of any salt. * Calculate the solubility product constant for a reversible salt-forming reaction. * Describe the Common Ion Effect. |  |  |

**Salts:**

**crystalline compounds composed of the negative ion  
of an acid and the positive ion of a base.**

**Neutralization: the reaction of a base and an acid to produce a salt and water.**



   
While the reaction shown here usually comes to mind when salt production is mentioned, there are many reactions that produce salts. It is even possible to have salts that do not produce neutral solutions.

**Salts can also be formed by the reaction of an acidic or basic anhydride with a corresponding base, acid, or anhydride.**

* **acidic anhydride + base salt**   
     
  SO3 + 2NaOH Na2SO4 + H2O



* **basic anhydride + acid salt**   
     
  Na2O + H2SO4 Na2SO4 + H2O



* **basic anhydride + acidic anhydride salt**   
     
  Na2O + SO3 Na2SO4



Certain acids and bases react to produce only a partial neutralization. These reactions produce either acidic salts or basic salts.

* This reaction produces an acidic salt:

**H2SO4 (aq) + NaOH (aq) NaHSO4 (aq) + H2O (l)**



   
Sodium hydrogen sulfate is an acidic salt because it still contains an ionizable hydrogen atom.

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| |  | | --- | | **Naming salts: the name of a salt is related to the name of the acid that forms it.**   * **Binary acids produce salts ending with ide.** * **Ternary acids ending in ic produce salts ending with ate.** * **Ternary acids ending in ous produce salts ending with ite.** * **Any prefixes in the ternary acid remain in the salt name.** * **In naming acidic and basic salts, each ion in the salt is named separately.**    + Hydrogen is named immediately before the names of any negative ions.     - A prefix is used to indicate more than one hydrogen.   + Hydroxide is named immediately after the names of any positive ions.     - The hydroxide is commonly placed in parenthesis. | |

**Examples of Salts:**

CaCl2 - calcium chloride  
K2SO4 - potassium sulfate  
NaHC2O4 - sodium hydrogen oxalate  
NaHS - sodium hydrogen sulfide  
NaH2PO4 - sodium dihydrogen phosphate  
Sn(OH)NO3 - tin (II) hydroxide nitrate

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| |  | | --- | | **Practice Problems:**   * 1. Write a balanced equation for the neutralization reaction that produces each of the salt examples above.   2. Name the following salts.      1. KHC4H4O6      2. NaH2PO4      3. NaHS      4. Al(OH)SiO3 | |

**One way of grouping and identifying salts is by their solubility in water.**

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|  | **A salt dissolved in water makes a solution.** |

For about 95% of all compounds, solubility in water increases with increasing temperature. Many compounds can have their solubility in water increased or decreased by the presence of another solute.

**Solubilities can be broken into four general classes:**

* **soluble** - all of the material dissolves and does so fairly quickly.
* **slightly soluble** - some of the material visibly dissolves over a period of time.
* **sparingly soluble** - the materials has a very low solubility, such as 0.5 g per liter.
* **insoluble** - none of the material dissolves.

**Follow these general rules to predict the solubility of salts.**

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| |  | | --- | | **Solubility Rules:**   1. **Salts of group 1 and ammonia are soluble.** 2. **Acetates and nitrates are soluble.** 3. **Binary compounds of group 17, except F, are soluble with metals, except Ag, Hg+, and Pb.** 4. **All sulfates are soluble, except those of Ba, Sr, Pb, Ca, Ag, and Hg+ .** 5. **Except for those in rule 1, carbonates, hydroxides, oxides, sulfides, and phosphates are insoluble.** | |

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| |  |  |  | | --- | --- | --- | | **Practice Problems:**  Use the rules above to determine the solubility of the following salts. Give the number of the rule you used to determine the answer.   |  |  | | --- | --- | | 1. AgNO3 2. Ag2SO4 3. HgCl2 4. BaSO4 5. CaCl2 6. NH4OH 7. PbCl4 8. Mg(C2H3O2)2 | 9. HgCl 10. CaF2 11. CuO 12. AgI 13. Al(OH)3 14. Fe2(CO3)3 15. CrPO4 16. K2S | | |

**Solubility Product Constant,** **Ksp**

* Given this equilibrium equation: AgBr (cr) Ag+(aq) + Br -(aq)



* The equilibrium constant expression for the equation is:
  + Keq = [products] / [reactants]
  + Keq = [Ag+] [Br -] / [AgBr]
  + *Remember that the brackets*, [ ], *indicate "concentration"*.
* Since AgBr is a solid substance, its concentration is constant. The equilibrium constant expression can therefore be manipulated to read: Keq[AgBr] = [Ag+] [Br -]
* Keq[AgBr] is the new constant, the solubility product constant, **Ksp**

|  |
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| If solid silver bromide is placed in water and allowed to stand, it dissolves until an equilibrium exists between the undissolved solid and the ions in solution.   * At room temperature, the Ksp of silver bromide is 5.01 X 10-13 * Using the equilibrium constant expression, [Ag+] [Br -] = 5.01 X 10-13 * The concentration of both ions are the same, [Ag+]2 = 5.01 X 10-13 * The square root of 5.01X10-13 gives: [Ag+] = 7.08 X 10-7M, which is also the [Br -] |

**Common Ion Effect: The addition of a substance containing an ion already at equilibrium in a saturated solution will shift the equilibrium toward the undissolved substance.** Another way to say this is that the addition of a common ion decreases the solubility of a substance in solution.

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| |  | | --- | | **Practice Problems:**   1. Write the solubility product constant expression for these equations:    1. PbI2 (cr) Pb+2 (aq) + 2I -1 (aq)  * 1. Cu3(PO4)2 (cr) 3Cu+2 (aq) + 2PO4 -3 (aq)  1. A saturated solution of PbI2 has a lead ion concentration of 1.21X10 -3M. What is the Ksp for PbI2 ? | |

Neutralization Reaction Answers:

problem 1

* 2HCl + Ca(OH)2 CaCl2 + 2H2O



* H2SO4 + 2KOH K2SO4 + 2H2O



* H2C2O4 + NaOH NaHC2O4 + H2O



* H2S + NaOH --> NaHS + H2O
* H3PO4 + NaOH NaH2PO4 + H2O



* HNO3 + Sn(OH)2 Sn(OH)NO3 + H2O



problem 2

* 1. potassium hydrogen tartrate
  2. sodium dihydrogen phosphate
  3. sodium hydrogen sulfide
  4. aluminum hydroxide silicate

  Salt solubility answers:

|  |  |
| --- | --- |
| 1. soluble 2. insoluble 3. soluble 4. insoluble 5. soluble 6. soluble 7. insoluble 8. soluble | 9. insoluble 10. insoluble 11. insoluble 12. insoluble 13. insoluble 14. insoluble 15. insoluble 16. soluble |

Be sure to give the number or numbers of the rules that apply.

  Ksp answers:

1.

* 1. Ksp = [Pb+2] [I -1]2
  2. Ksp = [Cu+2]3 [PO4 -3]2

2. Ksp = 7.09X10 -9

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| Salt Problems | Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

1. Write a balanced equation for the neutralization reaction that produces the salt Mg3(PO4)2

1. Is the salt in question number one acidic, basic, or neutral? Give the reason for your answer.

1. Write the solubility product constant expression for: Cu(IO3)2 (cr) Cu+2 (aq) + 2IO3-1 (aq)



1. Is the salt in question number three soluble? Which solubility rule or rules apply?

1. Write the name for this salt: CaHPO4

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| Chemistry Reading Assignment . . . . . . | Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

Use complete sentences to answer these questions.

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| 1. | What is a salt? |
| 2. | What is a neutralization reaction? |
| 3. | Salts commonly have one of three 3-letter endings based, on the acid forming the salt. What are these three possible endings and the acid indicated by each? |
| 4. | Compare the terms "slightly soluble" and "sparingly soluble". |
| 5. | Describe the "common ion effect". |
| 6. | What group of nitrogen-containing salts is always soluble? |
| 7. | How can you identify an acidic salt by looking at its chemical formula? |
| 8. | For the vast majority of salts, what happens to their solubility in water when the temperature of the water is increased? |
| 9. | Which group of metals on the periodic table always produces soluble salts? |