

Student Packet: 9.1: Precipitation Reactions: Student Handout

I. Solubility Rules

You've got to know the solubility rules!

Soluble

- All nitrates (NO_3^-) are soluble
- All chlorides (Cl^-) are soluble except AgCl , HgCl_2 , and PbCl_2
- All bromides (Br^-) are soluble except AgBr , HgBr_2 , and PbBr_2
- All iodides (I^-) are soluble except AgI , HgI_2 , and PbI_2
- All group IA salts are soluble
- Most acetates ($\text{C}_2\text{H}_3\text{O}_2^-$) and ammonium (NH_4^+) salts are soluble
- All sulfates (SO_4^{2-}) are soluble except BaSO_4 , PbSO_4 , and SrSO_4

Insoluble

- All carbonates (CO_3^{2-}) are insoluble except those of group IA elements and $(\text{NH}_4)_2\text{CO}_3$
- All sulfites (SO_3^{2-}) are insoluble except those of group IA elements and $(\text{NH}_4)_2\text{SO}_3$
- All phosphates are insoluble except those of group IA elements and $(\text{NH}_4)_3\text{PO}_4$
- All sulfides (S^{2-}) are insoluble except those of group IA and IIA elements and $(\text{NH}_4)_2\text{S}$
- All hydroxides are insoluble except those of group IA elements and $\text{Ba}(\text{OH})_2$ and NH_4OH
- Most chromates are insoluble except those of group IA elements and some group IIA elements

II. Net Ionic Equation

The **molecular equation** shows molecules. It shows no dissociation.

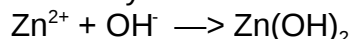
The **complete ionic equation** shows dissociated ions including spectator ions.

The **net ionic equation** shows dissociated ions who participate in the reaction.

Remember to always eliminate spectator ions (ions that don't take part in the reaction).

Precipitation reactions are just basically breaking the molecules into ions, switching anions and cations and seeing if an insoluble molecule forms.

Ex.) Solutions of zinc nitrate and sodium hydroxide are mixed. Write the net ionic equation



All nitrates are soluble so zinc nitrate goes into solution as (Zn^{2+} and NO_3^-) and all group IA's are soluble so the sodium hydroxide goes into solution as (Na^+ and OH^-). The pcpt. $\text{Zn}(\text{OH})_2$ falls out of solution and (Na^+ and NO_3^-) are spectators.

Notice that the equation isn't balanced. On the AP[®] exam, you do not have to balance the equations. Just get the correct products and eliminate spectator ions.

III. Precipitating Agents

Ammonia: NH_3 makes OH^- ions in H_2O . Hydroxides are insoluble.

Hydrogen Sulfide: H_2S makes S^{2-} ions in H_2O . Sulfides are insoluble.

Sulfur Dioxide: SO_2 in basic solution forms sulfites. Sulfites are insoluble.

Student Packet: 9.1: Precipitation Reactions: AssessMe questions

- 1) The addition of ammonia to solution may result in the formation of a precipitate because:
- A) ammonium salts are insoluble.
 - B) ammonia complexes are insoluble.
 - C) hydroxides are often insoluble.
 - D) metal hydrides are insoluble.
 - E) I'm clueless
- 2) Which salt is the least soluble in water?
- A) Hg_2CrO_4 ($K_{\text{sp}} = 2.0 \times 10^{-9}$)
 - B) BaF_2 ($K_{\text{sp}} = 1.7 \times 10^{-6}$)
 - C) CaF_2 ($K_{\text{sp}} = 4.0 \times 10^{-11}$)
 - D) AgOH ($K_{\text{sp}} = 1.5 \times 10^{-8}$)
 - E) I'm clueless
- 3) Which of the following series is ranked in order of increasing electronegativity?
- A) O, S, Se, Te
 - B) Cl, S, P, Si
 - C) In, Sn, N, O
 - D) C, Si, P, Se
 - E) I'm clueless
- 4) Which series is ranked in order of increasing electronegativity?
- A) N, P, As, Sb
 - B) F, O, N, C
 - C) I, Br, Cl, F
 - D) Ga, Si, P, Se
 - E) I'm clueless
- 5) A pH indicator is
- A) neither an acid nor a base, but a species which changes color upon protonation/deprotonation.
 - B) an acid or base which changes color upon protonation/deprotonation.
 - C) an acid which has a very different pK_a from the acid being tested.
 - D) none of the above.
 - E) I'm clueless
- 6) What is the pH of a 2×10^{-8} molar solution of hydrochloric acid (HCl)?
- A) -5.7
 - B) 6
 - C) 6.9
 - D) 5.7
 - E) I'm clueless

Student Packet: 9.1: Precipitation Reactions: ShowMe questions

Write the net ionic equation for each of the reactions.

- 1) Hydrogen sulfide gas is bubbled through a solution of iron (II) nitrate.

Solutions of sodium phosphate and calcium chloride are mixed.

Ammonia gas is bubbled through a solution of stratum nitrate.

- 2) Sulfur dioxide is bubbled into a saturated solution of calcium hydroxide.

Saturated barium hydroxide is mixed with copper (II) sulfate.

Dilute sulfuric acid is added to a solution of barium iodide.

- 3) Solutions of silver nitrate and potassium chromate are mixed.

Solutions of iron (II) sulfate and sodium phosphate are mixed.

Solutions of silver nitrate and lithium chloride are mixed.

- 4) Ammonia is added to a solution of ion (III) chloride.

Hydrogen sulfide is added to a solution of lead (II) nitrate.

Solutions of lithium sulfite and cadmium chloride are mixed.

Student Packet: 9.1: Precipitation Reactions: TestMe questions

1) Aqueous solutions of copper (II) chloride and potassium hydroxide are mixed. What is the net ionic equation?

- A) $\text{Cu}^{2+}_{(\text{aq})} + \text{K}^{+}_{(\text{aq})} \longrightarrow \text{K}_{(\text{s})} + \text{Cu}^{3+}_{(\text{aq})}$
- B) $\text{CuCl}_2 + \text{KOH} \longrightarrow \text{Cu}(\text{OH})_2 + \text{KCl}$
- C) $\text{Cu}^{2+}_{(\text{aq})} + \text{OH}^{-}_{(\text{aq})} \longrightarrow \text{Cu}(\text{OH})_{2(\text{s})}$
- D) $\text{K}^{+}_{(\text{aq})} + \text{Cl}^{-}_{(\text{aq})} \longrightarrow \text{KCl}_{(\text{s})}$
- E) None of the above

2) Which of the following reactions yield a precipitate? (All solutions are aqueous)

- I. Solutions of potassium sulfide and lithium carbonate are mixed.
- II. Solutions of barium nitrate and calcium sulfate are mixed.
- III. Solutions of ammonium hydroxide and copper (II) chloride are mixed.
- IV. Solutions of magnesium acetate and sodium iodide are mixed.
- V. Solutions of lithium phosphate and ammonium hydroxide are mixed.

- A) II, III, IV B) II, IV, V C) I, II, III D) II, III E) None of the above.

3) Hydrogen sulfide is added to a saturated solution of cadmium hydroxide. What is the net ionic equation?

- A) No reaction occurs, cadmium hydroxide is a solid.
- B) $\text{Cd}^{2+}_{(\text{aq})} + \text{H}_2\text{S}_{(\text{aq})} \longrightarrow \text{CdS}_{(\text{s})} + \text{H}^{+}$
- C) $\text{H}_2\text{S}_{(\text{aq})} + \text{OH}^{-} \longrightarrow \text{H}_2\text{O}_{(\text{l})} + \text{S}_{(\text{s})}$
- D) $\text{Cd}^{2+} + \text{H}_2\text{S}_{(\text{aq})} \longrightarrow \text{H}_{2(\text{g})} + \text{CdS}_{(\text{s})}$
- E) None of the above

4) Ammonia gas is bubbled through an aqueous solution of aluminum nitrate. What is the net ionic equation?

- A) There is no reaction, aluminum nitrate is a solid.
- B) $\text{NH}_3_{(\text{g})} + \text{H}^{+}_{(\text{aq})} + \text{NO}_3^{-}_{(\text{aq})} \longrightarrow \text{NH}_4\text{NO}_{3(\text{s})}$
- C) $\text{Al}^{3+}_{(\text{aq})} + \text{NH}_3_{(\text{g})} + \text{H}_2\text{O}_{(\text{l})} \longrightarrow \text{Al}(\text{OH})_{3(\text{s})} + \text{NH}_4^{+}_{(\text{aq})}$
- D) $\text{Al}^{3+}_{(\text{aq})} + \text{NH}_3_{(\text{g})} + \text{H}_2\text{O}_{(\text{l})} \longrightarrow \text{Al}_2\text{O}_{3(\text{s})} + \text{NH}_4^{+}$
- E) None of the above.

5) Which of the following reactions yield a precipitate? (All solutions are aqueous)

- I. Solutions of lithium phosphate and barium chloride are mixed.
- II. Solutions of sodium sulfite and cesium hydroxide are mixed.
- III. Solutions of calcium sulfate and lead (II) nitrate are mixed.
- IV. Solutions of silver nitrate and sodium chloride are mixed.
- V. Solutions of ammonium carbonate and barium sulfide are mixed.

- A) I, II, III, IV, V B) I, II, IV, V C) I, III, IV D) I, III, IV, V E) None of the above