1/13/16

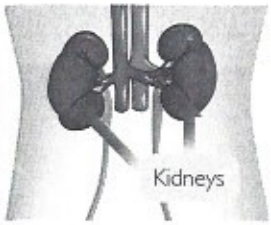
Reading Mark up

LESSON

23 Solid Evidence

Precipitation Reactions

Think About It



Sometimes reactions between dissolved substances result in the formation of a solid. In your kidneys, for example, dissolved substances can react to form solid calcium oxalate. If there is enough of this solid, a painful blockage called a kidney stone can form.

How does ppt cause a problem in kidneys?

Which substances precipitate from aqueous solutions?

To answer this question, you will explore

1. Precipitation of Ionic Solids
2. Solubility
3. ~~Toxicity of Precipitates~~

Exploring the Topic

What is a ppt? What do we call a rxn that results in a ppt? In our lab we had solutions of ions.

a ppt

1 Precipitation of Ionic Solids

(−) (+)

Sometimes certain anions and cations combine and come out of solution as a solid, or a **precipitate.** This kind of reaction is called a **precipitation reaction.**

The formation of kidney stones is an example of a precipitation reaction. If the concentrations of calcium ions, Ca^{2+}, and polyatomic oxalate ions, $C_2O_4^{2-}$, in urine become too great, calcium oxalate, CaC_2O_4, precipitates as kidney stones.

$$CaCl_2(aq) + Na_2C_2O_4(aq) \longrightarrow 2NaCl(aq) + CaC_2O_4(s)$$

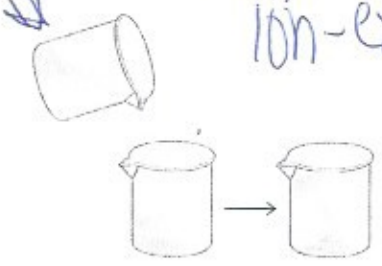
Dissolved calcium chloride	Dissolved sodium oxalate	Dissolved sodium chloride	Solid calcium oxalate

Kidney stone crystal

The equation for the formation of kidney stones shows that it is a double exchange reaction. Many other similar chemical combinations result in precipitation reactions.

Our lab handout says ion-exchange

Beakers



Example 1

Precipitation of Lead Iodide

An aqueous solution of lead nitrate, $Pb(NO_3)_2(aq)$, is mixed with an aqueous solution of potassium iodide, $KI(aq)$. The result is a bright yellow solid, lead iodide, $PbI_2(s)$, in a clear solution. Write a balanced chemical equation for this precipitation reaction.

We had Pb^{2+} and I^- in our lab!

What is an ion exchange reaction?

WEATHER CONNECTION

Precipitation can refer to either water coming out of the atmosphere as rain or snow, or compounds coming out of an aqueous solution as solids.

Solution

This is a double exchange reaction. The lead and potassium cations exchange anions with one another. Begin by writing an equation for what you know.

$$Pb(NO_3)_2(aq) + KI(aq) \longrightarrow PbI_2(s) + ?$$

lead nitrate | potassium iodide | lead iodide | clear solution

The potassium ions, K^+, and the nitrate ions, NO_3^-, combine in a 1:1 ratio to form KNO_3.

$$Pb(NO_3)_2(aq) + KI(aq) \longrightarrow PbI_2(s) + KNO_3(aq)$$

lead nitrate | potassium iodide | lead iodide | potassium nitrate

can't see this it is soluble

this yellow!!

Balance the equation.

$$Pb(NO_3)_2(aq) + 2KI(aq) \longrightarrow PbI_2(s) + 2KNO_3(aq)$$

lead nitrate | potassium iodide | lead iodide | potassium nitrate

❷ Solubility

Soluble means it will dissolve

Ionic substances vary significantly as to how much they will dissolve in water. Fo some ionic substances, large quantities dissolve in water. These substances have a high solubility. For other ionic substances, only very small quantities dissolve. These substances have a low solubility. Substances with a low solubility tend to form precipitates in aqueous solutions.

BIG IDEA Some ionic solids are more soluble than others. When a compound reaches the limits of its solubility, undissolved solid is visible.

*Because of the Law of Conservation of mass, we can predict the ? formula

You can use a solubility table such as the one shown here to determine the solubility of various ionic compounds. To use the table, combine a cation from the rows on the left with an anion from the columns on the right to determine i the compound formed is very soluble (S), insoluble, or not very soluble (N).

Solubility Trends

		Anions						
		NO_3^-	Cl^-	OH^-	SO_4^{2-}	CO_3^{2-}	$C_2O_4^{2-}$	PO_4^{3-}
Cations	Most alkali metals, such as Li^+, Na^+, K^+, NH_4^+	S	S	S	S	S	S	S
	Most alkaline earth metals, such as Mg^{2+}, Ca^{2+}, Sr^{2+} Ba2+	S	S	N	S	N	N	N
	Some Period 4 transition metals, such as Fe^{3+}, Co^{3+}, Ni^{2+}, Cu^{2+}, Zn^{2+}	S	S	N	S	N	N	N
	Other transition metals, such as Ag^+, Pb^{2+}, Hg^{2+}	S	N	N	N	N	N	N

We saw a solid with Barium. Barium in row 6—is its location why it formed an insoluble solid??

How do my lab results compare?

EARTH SCIENCE CONNECTION

Stalactites and stalagmites are caused by precipitation of solids from water that drips from cave walls. The word *stalagmite* comes from the Greek word for "drip." These beautiful cave structures are often formed from calcium carbonate.

Recall that in Unit 1: Alchemy, you characterized ionic solids as soluble in water. This is true for many ionic solids. But as you can see from the solubility table, some ionic solids are not very soluble.

Example 2

Predicting Solid Products

Suppose that you combine aqueous calcium nitrate, $Ca(NO_3)_2$, with aqueous sodium phosphate, Na_3PO_4, and there is a double exchange reaction. Do you expect a precipitate to form?

Solution

First, write a balanced chemical equation for this reaction. You know that the two aqueous cations exchange anions:

$$3Ca(NO_3)_2(aq) + 2Na_3PO_4(aq) \longrightarrow Ca_3(PO_4)_2(?) + 6NaNO_3(?)$$

Next, use the solubility table to determine if there is a precipitate. According to the table, $NaNO_3$ is soluble in water, so it remains dissolved. $Ca_3(PO_4)_2$ is insoluble, so it forms a precipitate.

$$3Ca(NO_3)_2(aq) + 2Na_3PO_4(aq) \longrightarrow Ca_3(PO_4)_2(s) + 6NaNO_3(aq)$$

Reactions in aqueous solutions usually involve ions in solution. To describe what is happening, you can write a **complete ionic equation,** which shows all of the dissolved ions involved in the reaction. Examine the complete ionic equation for the reaction in Example 2.

$$3Ca^{2+}(aq) + 6NO_3^-(aq) + 6Na^+ + 2PO_4^{3-}(aq) \longrightarrow Ca_3(PO_4)_2(s) + 6Na^+ + 6NO_3^-$$

CAREER CONNECTION

Doctors use a type of treatment called *chelation therapy* to treat patients who have had long-term exposure to metals like arsenic, mercury, or lead, usually in the workplace. In chelation therapy a compound is introduced into the bloodstream of the patient. This compound bonds with heavy metals, forming water-soluble products that are then passed out of the body.

An ion that appears on both sides of a complete ionic equation and does not directly participate in the reaction is called a **spectator ion.** For example, Na^+ and NO_3^- are spectator ions in this reaction. To write a more efficient equation for this reaction, you can cancel the spectator ions on each side of the equation:

$$3Ca^{2+}(aq) + \cancel{6NO_3^-}(aq) + \cancel{6Na^+} + 2PO_4^{3-}(aq) \longrightarrow Ca_3(PO_4)_2(s) + \cancel{6Na^+} + \cancel{6NO_3^-}$$

The result is a **net ionic equation** that describes the reaction in terms of only the ions that are involved in the reaction:

$$3Ca^{2+}(aq) + 2PO_4^{3-}(aq) \longrightarrow Ca_3(PO_4)_2(s)$$

❸ Toxicity of Precipitates

There are positive and negative aspects to the solubility of toxic substances. On the one hand, if a substance is not very soluble, it might not react with anything, and it might pass through the body relatively unnoticed. For example, some metals that can be ingested go through our bodies without causing harm. (Imagine a child swallowing a nickel.) However, many metal compounds are soluble, and once our bodies absorb them, they can do long-term damage.