Net Ionic Equations

Unit: Chemical Reactions

NGSS Standards/MA Curriculum Frameworks (2016): HS-PS1-2

Mastery Objective(s): (Students will be able to…)

- Write chemical equations as net ionic equations.

Success Criteria:

- Soluble ionic compounds are dissociated.
- Insoluble ionic compounds remain together as solids.
- Spectator ions are identified and omitted from the final net ionic equation.

Tier 2 Vocabulary: net, spectator

Language Objectives:

- Review dissociation. Explain how to dissociate a compound and write its ions separately in an equation.

Notes:

net ionic equation: a chemical equation that shows only ions or pure substances that are changed by the reaction.

spectator ion: an ion that remains in solution and does not participate in a chemical reaction.

If you mixed aqueous solutions of calcium chloride ($CaCl_{2\,(aq)}$) and sodium nitrate ($NaNO_{3\,(aq)}$), you might be tempted to predict that the following (unbalanced) chemical reaction would occur:

$$CaCl_{2\,(aq)} + NaNO_{3\,(aq)} \rightarrow Ca(NO_3)_{2\,(aq)} + NaCl_{\,(aq)}$$

However, recall that aqueous ions dissociate when they dissolve in water:

Symbol	**What Actually Happens in H_2O**
$CaCl_{2\ (aq)}$	$Ca^{2+}{}_{(aq)} + Cl^{-}{}_{(aq)}$
$NaNO_{3\ (aq)}$	$Na^{+}{}_{(aq)} + NO_3^{-}{}_{(aq)}$
$Ca(NO_3)_{2\ (aq)}$	$Ca^{2+}{}_{(aq)} + NO_3^{-}{}_{(aq)}$
$NaCl_{\ (aq)}$	$Na^{+}{}_{(aq)} + Cl^{-}{}_{(aq)}$

This means that what we really have in the beaker is:

$$Ca^{2+}{}_{(aq)} + Cl^{-}{}_{(aq)} + Na^{+}{}_{(aq)} + NO_3^{-}{}_{(aq)} \rightarrow Ca^{2+}{}_{(aq)} + NO_3^{-}{}_{(aq)} + Na^{+}{}_{(aq)} + Cl^{-}{}_{(aq)}$$

The above is called a detailed ionic equation.

Use this space for summary and/or additional notes:

Big Ideas | Details | **Unit:** Chemical Reactions

In the detailed ionic equation:

$$Ca^{2+}(aq) + Cl^{-}(aq) + Na^{+}(aq) + NO_3^{-}(aq) \rightarrow Ca^{2+}(aq) + NO_3^{-}(aq) + Na^{+}(aq) + Cl^{-}(aq)$$

Notice that the right side and the left side contain exactly the same ions. In other words, *nothing has changed*. If no substances are changed—no chemical bonds are formed or broken—then *no chemical reaction has occurred!*

Now consider the reaction of aqueous silver nitrate with aqueous sodium carbonate:

$$AgNO_3(aq) + Na_2CO_3(aq) \rightarrow Ag_2CO_3(s) + NaNO_3(aq)$$

Notice that one of the products, silver carbonate, forms a solid (precipitate).

The detailed ionic equation would look like this:

$$Ag^{+}(aq) + NO_3^{-}(aq) + Na^{+}(aq) + CO_3^{2-}(aq) \rightarrow Ag_2CO_3(s) + Na^{+}(aq) + NO_3^{-}(aq)$$

The spectator ions (ions that remain unchanged by the reaction) are Na^{+} and NO_3^{-}. If we cross those out:

$$Ag^{+}(aq) + \cancel{NO_3^{-}}(aq) + \cancel{Na^{+}}(aq) + CO_3^{2-}(aq) \rightarrow Ag_2CO_3(s) + \cancel{Na^{+}}(aq) + \cancel{NO_3^{-}}(aq)$$

we are left with the *unbalanced net ionic equation* for this reaction:

$$Ag^{+}(aq) + CO_3^{2-}(aq) \rightarrow Ag_2CO_3(s)$$

Of course, we still need to balance the equation! The *balanced net ionic equation* would therefore be:

$$2\,Ag^{+}(aq) + CO_3^{2-}(aq) \rightarrow Ag_2CO_3(s)$$

Notice that the net ionic reaction is much simpler than the full chemical equation, because the net ionic equation leaves out everything that does not matter in the equation, allowing you to focus only on the details that are important.

If you take AP® Chemistry, you will be expected to write all chemical equations in net ionic form.

Use this space for summary and/or additional notes:

Homework Problems

For each of the following potential double replacement reactions:

a. Predict the products. (Remember to balance the charges!)
b. Use your solubility rules to write the phase after each product.
If the product is soluble, write (aq) after it. If an ionic compound is not soluble, then it precipitates; write (ppt) after it. If a product is a gas (such as CO_2), then write (g) after it. If a product is a pure liquid (such as H_2O), then write (ℓ) after it.
c. Rewrite the equation with the aqueous compounds dissociated (split up).
d. Cancel (cross out) any ions that are the same (unchanged) on both sides.
e. Write and balance the net ionic equation as your final answer. If it turns out that you have crossed out everything, write "N.R." ("No Reaction") instead.

1. $Na_2CO_3\ (aq) + CaCl_2\ (aq) \rightarrow$

2. $(NH_4)_3PO_4\ (aq) + NaOH\ (aq) \rightarrow$

3. $Ba(C_2H_3O_2)_2\ (aq) + K_3PO_4\ (aq) \rightarrow$

4. $Ca(MnO_4)_2\ (aq) + KOH\ (aq) \rightarrow$

Use this space for summary and/or additional notes:

5. $AlCl_3$ (aq) + H_3PO_4 (aq) →

6. $CaSO_4$ (aq) + $KMnO_4$ (aq) →

7. NaN_3 (aq) + $Ca(NO_3)_2$ (aq) →

8. $Sr(NO_3)_2$ (aq) + $K_2Cr_2O_7$ (aq) →

9. $NaClO_3$ (aq) + $MgSO_4$ (aq) →

10. Na_3BO_3 (aq) + $ZnSO_4$ (aq) →

Use this space for summary and/or additional notes: