Molecular, Ionic & Net Ionic Equations

MOLECULAR EQUATIONS

In a **molecular equation**, all the reactants and products are written as if they were molecules. Precipitates and gases are indicated with the appropriate symbols (see the *General* section below).

Unstable compounds which appear as products are written in their more stable forms. Some common unstable compounds (molecules to the left of reaction arrow) are listed below. If the product to the left of an arrow is formed, it will decompose to the more stable molecules shown to the right of the reaction arrow.

$H_2CO_3 \rightarrow H_2O + CO_2\uparrow$ $H_2SO_3 \rightarrow H_2O + SO_2\uparrow$ $NH_4OH \rightarrow H_2O + NH_3\uparrow$

IONIC EQUATIONS

In an **ionic equation**, substances are shown as they occur in solution. A solubility table should be consulted to determine a substance's solubility. Soluble substances occur as ions in solution.

Strong electrolytes are shown as being dissociated in water.

Examples: $HC\ell$, HNO_3, H_2SO_4 (*dissociates as 2 H^+, not H_2^+!*), NaOH, KOH

Weak electrolytes, precipitates and gases are written in their molecular form.

Examples:

Weak electrolytes:	H_2O, $HC_2H_3O_2$, $H_2C_2O_4$, H_3PO_4
Precipitates:	*Consult a solubility table.*
Gases:	$CO_2\uparrow$, $SO_2\uparrow$, $NH_3\uparrow$

NET IONIC EQUATIONS

The **net ionic equation** only includes those substances and ions in the ionic equation that have undergone a chemical change. **Spectator ions**, which don't change over the reaction, don't appear in net ionic equations.

GENERAL

→ Equations must be balanced, both in atoms and in electrical charge.

→ Gases must be indicated using an up-arrow "↑" or with "$_{(g)}$".

→ Precipitates must be indicated using a down-arrow "↓" or with "$_{(s)}$".

→ Ions may be indicated with "$_{(aq)}$" for "aqueous".

→ If no reaction occurs, write "no reaction" as the right side of the equation.

→ Consult a table of ions to get the correct symbols and charges.

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Example 1: Write correct molecular, ionic and net ionic equations for the following:

1) $NaC\ell_{(aq)} + AgNO_{3\,(aq)} \rightarrow$ _____
2) $Na_2CO_3 + HC\ell \rightarrow$ _____

Solution: 1) **Molecular:** $NaC\ell_{(aq)} + AgNO_{3\,(aq)} \rightarrow AgC\ell_{(s)} + NaNO_{3\,(aq)}$
Ionic: $Na^+_{(aq)} + C\ell^-_{(aq)} + Ag^+_{(aq)} + NO_3^-{}_{(aq)} \rightarrow AgC\ell_{(s)} + Na^+_{(aq)} + NO_3^-{}_{(aq)}$
Since the sodium and nitrate ions are on both sides:
Net Ionic: $Ag^+_{(aq)} + C\ell^-_{(aq)} \rightarrow AgC\ell_{(s)}$

2) When balanced, the double displacement reaction is:
$Na_2CO_3 + 2\ HC\ell \rightarrow 2\ NaC\ell + H_2CO_3$
But H_2CO_3 is unstable, so:
Molecular: $Na_2CO_3 + 2\ HC\ell \rightarrow 2\ NaC\ell + H_2O + CO_2\uparrow$
Ionic: $2\ Na^+ + CO_3^- + 2\ H^+ + 2\ C\ell^- \rightarrow 2\ Na^+ + 2\ C\ell^- + H_2O + CO_2\uparrow$
Since the sodium and chlorine ions are spectators:
Net Ionic: $2\ H^+ + CO_3^- \rightarrow H_2O + CO_2\uparrow$

EXERCISES

A. Write correct molecular, ionic and net ionic equations for the following:

1) $NaBr + AgNO_3 \rightarrow$
2) $ZnSO_4 + BaC\ell_2 \rightarrow$
3) $CuC\ell_2 + Pb(NO_3)_2 \rightarrow$
4) $NaC\ell + KNO_3 \rightarrow$
5) $NaC_2H_3O_2 + HC\ell \rightarrow$
6) $Na_2SO_4 + BaC\ell_2 \rightarrow$
7) $Ca(NO_3)_2 + (NH_4)_2CO_3 \rightarrow$
8) $(NH_4)_2SO_4 + LiNO_3 \rightarrow$
9) $Na_2CO_3 + HBr \rightarrow$
10) $NaOH + HC\ell \rightarrow$

SOLUTIONS

A. (1) M: $NaBr + AgNO_3 \rightarrow NaNO_3 + AgBr\downarrow$; I: $Na^+ + Br^- + Ag^+ + NO_3^- \rightarrow Na^+ + NO_3^- + AgBr\downarrow$; NI: $Ag^+ + Br^- \rightarrow AgBr\downarrow$

(2) M: $ZnSO_4 + BaC\ell_2 \rightarrow ZnC\ell_2 + BaSO_4\downarrow$; I: $Zn^{2+} + SO_4^{2-} + Ba^{2+} + 2\ C\ell^- \rightarrow Zn^{2+} + 2\ C\ell^- + BaSO_4\downarrow$; NI: $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4\downarrow$

(3) M: $CuC\ell_2 + Pb(NO_3)_2 \rightarrow Cu(NO_3)_2 + PbC\ell_2\downarrow$; I: $Cu^{2+} + 2\ C\ell^- + Pb^{2+} + 2\ NO_3^- \rightarrow Cu^{2+} + 2\ NO_3^- + PbC\ell_2\downarrow$; NI: $Pb^{2+} + 2\ C\ell^- \rightarrow PbC\ell_2\downarrow$

(4) M: $NaC\ell + KNO_3 \rightarrow$ *no reaction*

(5) M: $NaC_2H_3O_2 + HC\ell \rightarrow NaC\ell + HC_2H_3O_2$; I: $Na^+ + C_2H_3O_2^- + H^+ + C\ell^- \rightarrow Na^+ + C\ell^- + HC_2H_3O_2$; NI: $H^+ + C_2H_3O_2^- \rightarrow HC_2H_3O_2$

(6) M: $Na_2SO_4 + BaC\ell_2 \rightarrow 2\ NaC\ell + BaSO_4\downarrow$; I: $2\ Na^+ + SO_4^{2-} + Ba^{2+} + 2\ C\ell^- \rightarrow 2\ Na^+ + 2\ C\ell^- + BaSO_4\downarrow$; NI: $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4\downarrow$

(7) M: $Ca(NO_3)_2 + (NH_4)_2CO_3 \rightarrow CaCO_3\downarrow + 2\ NH_4NO_3$; I: $Ca^{2+} + 2\ NO_3^- + 2\ NH_4^+ + CO_3^{2-} \rightarrow CaCO_3\downarrow + 2\ NH_4^+ + 2\ NO_3^-$; NI: $Ca^{2+} + CO_3^{2-} \rightarrow CaCO_3\downarrow$

(8) M: $(NH_4)_2SO_4 + LiNO_3 \rightarrow$ *no reaction*

(9) M: $Na_2CO_3 + 2\ HBr \rightarrow 2\ NaBr + H_2O + CO_2\uparrow$; I: $2\ Na^+ + CO_3^{2-} + 2\ H^+ + 2\ Br^- \rightarrow 2\ Na^+ + 2\ Br^- + H_2O + CO_2\uparrow$; NI: $2\ H^+ + CO_3^{2-} \rightarrow H_2O + CO_2\uparrow$

(10) M: $NaOH + HC\ell \rightarrow NaC\ell + H_2O$; I: $Na^+ + OH^- + H^+ + C\ell^- \rightarrow Na^+ + C\ell^- + H_2O$; NI: $H^+ + OH^- \rightarrow H_2O$