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LESSON NOTES

Year/Level: 11 C/D **Subject:** Chemistry

Strand	3 Reactions
Sub Strand	3.1 chemical equations and calculations
Content Learning Outcome	To be able to write net ionic equation

Ionic Equation

The ionic equation is used to describe the chemical reaction while also clearly indicating which of the reactants and/or products exist primarily as ions in aqueous solution.

Steps of writing a net ionic equation:

1. Start with a balanced molecular equation.
2. Break all soluble strong electrolytes (compounds with (aq) beside them) into their ions.
   - Indicate the correct formula and charge of each ion.
   - Indicate the correct number of each ion.
   - Write (aq) after each ion.
3. Bring down all compounds with (s), (l) or (g) unchanged.

Example: $2Na_3PO_{4(aq)} + 3CaCl_{2(aq)} \rightarrow 6NaCl_{(aq)} + Ca_3(PO_4)_{2(s)}$

For the reaction given above, the complete ionic equation is:

$6\ Na^+_{(aq)} + 2PO_4^{3-}{}_{(aq)} + 3Ca^{2+}_{(aq)} + 6Cl^-_{(aq)} \rightarrow 6Na^+_{(aq)} + 6Cl^-_{(aq)} + Ca_3(PO_4)_{2\ (s)}$

The following shows how each ion is achieved; Consider each reactant or product separately:

- 1 mole of Na_3PO_4 contains 3 moles of Na^+ and 1 mole of PO_4^{3-}. Since the balanced equation shows that two moles of Na_3PO_4 are involved in the reaction, a total of 6 moles (2 x 3) of Na^+ and 2 moles (2 x 1) of PO_4^{3-} are formed. Take note that the subscript "4" in the formula for the phosphate ion is not used when determining the number of phosphate ions present. The subscript is part of the formula for the phosphate ion itself.

  $2\ Na_3PO_{4\ (aq)} \rightarrow 6\ Na^+_{(aq)} + 2\ PO_4^{3-}{}_{(aq)}$

- 1 mole of $CaCl_2$ contains 1 mole of Ca^{2+} and 2 moles of Cl^-. Remember, the subscript "2" indicates the number of chloride ions. You will never have a diatomic chlorine ION (i.e. Cl_2^- or Cl_2^{2-}) in aqueous solution. Since the balanced equation shows that 3 moles of $CaCl_2$ are involved in the reaction a total of 3 moles (3 x 1) of Ca^{2+} and 6 moles (3 x 2) of Cl^- are formed.

  $3\ CaCl_{2(aq)} \rightarrow 3\ Ca^{2+}_{(aq)} + 6\ Cl^-_{(aq)}$

- 1 mole of NaCl contains 1 mole of Na^+ and 1 mole of Cl^-. Since the balanced equation shows that 6 moles of NaCl are produced by the reaction, 6 moles (6 x 1) of Na^+ and 6 moles (6 x 1) of Cl^- will be formed.

  $6\ NaCl_{(aq)} \rightarrow 6\ Na^+_{(aq)} + 6\ Cl^-_{(aq)}$

- Since calcium phosphate is an insoluble solid (indicated by the (s) beside its formula), it will not form ions in water. It is brought down unchanged into the complete ionic equation.

Obtaining Net Ionic Equation

In the previous example, the complete ionic equation for the reaction between sodium phosphate and calcium chloride was:

$$6Na^{+}_{(aq)} + 2PO_4^{3-}{}_{(aq)} + 3Ca^{2+}{}_{(aq)} + 6Cl^{-}_{(aq)} \rightarrow 6Na^{+}_{(aq)} + 6Cl^{-}_{(aq)} + Ca_3(PO_4)_{2(s)}$$

Some ions are present on the reactant and product sides of the equation, these ions are exactly the same on both sides of the equation.

For example, $6Na^{+}$ (aq) and $6Cl^{-}$ (aq) are present on both sides of the equation. That means that the sodium ions and the chloride ions were present in the reaction mixture but did not participate in the reaction. The sodium and chloride ions in this reaction are referred to as spectator ions.

Spectator ions are ions that are present in the reaction mixture but do not participate in it.. You can recognize spectator ions by looking for ions that are present on both sides of the equation.

They will always have the same formula, charge and physical state. They will also be present in exactly the same number on both sides of the equation.
To get a net ionic equation:
1. Write the balanced molecular equation.
2. Write the balanced complete ionic equation.
3. Cross out the spectator ions that are present.
4. Write the "leftovers" as the net ionic equation.

For the above reaction, the net ionic equation is found by crossing out the spectator ions from the complete ionic equation:

$$\cancel{6Na^{+}_{(aq)}} + 2PO_4^{3-}{}_{(aq)} + 3Ca^{2+}{}_{(aq)} + \cancel{6Cl^{-}_{(aq)}} \rightarrow \cancel{6Na^{+}_{(aq)}} + \cancel{6Cl^{-}_{(aq)}} + Ca_3(PO_4)_{2(s)}$$

Net ionic equation: $2PO_4^{3-}{}_{(aq)} + 3Ca^{2+}{}_{(aq)} \rightarrow Ca_3(PO_4)_{2(s)}$

Activity
Write balanced net ionic equations for the following:

i. $Mg_{(s)} + 2HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$

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ii. $2NaOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$

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