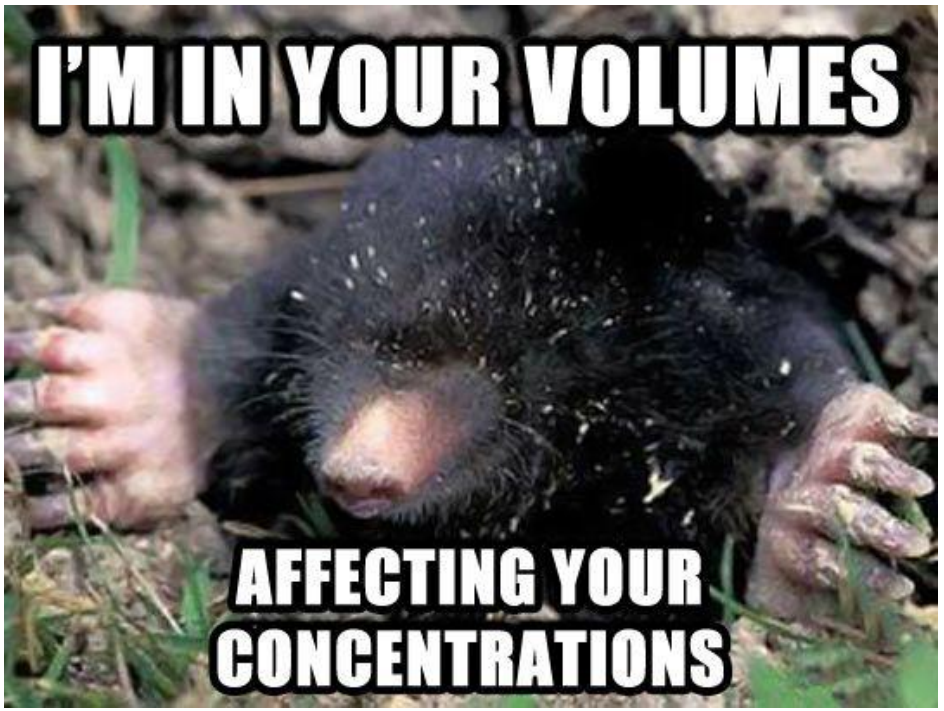
Warm-Up Problem 1

- If 45mL of water added to 250mL of a 0.75 M K_2SO_4 solution, what will be the molarity (concentration) of the diluted solution?

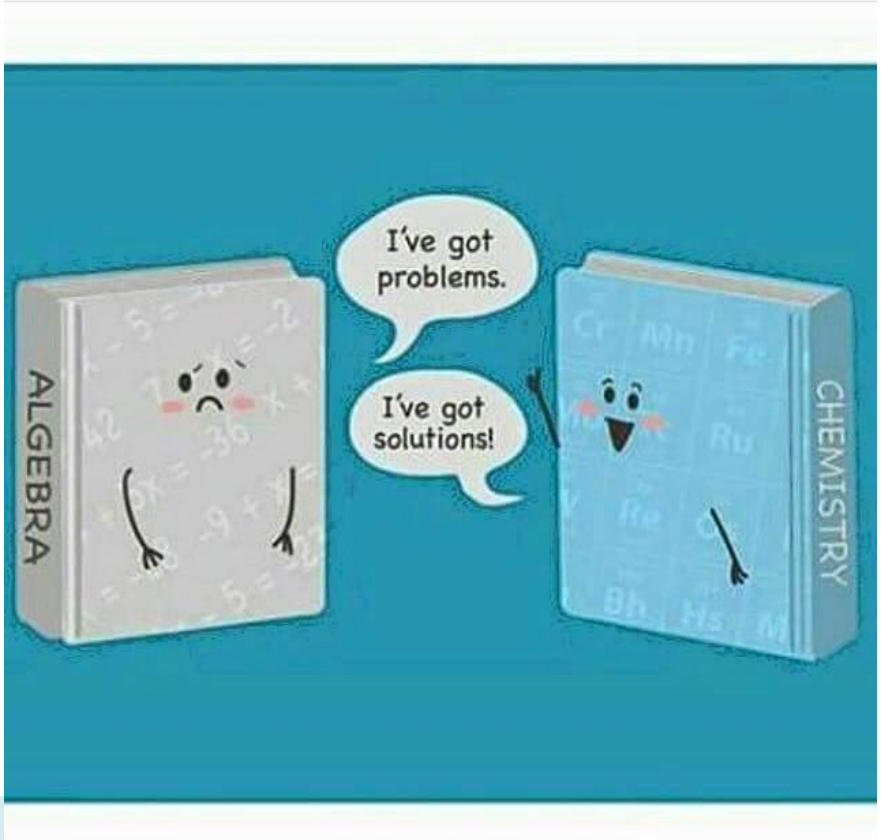
- ANS: 0.64mol/L



Warm-Up Problem 2

- Ms. Narang makes a 250mL solution of NaOH. The concentration is 1.23mol/L. What mass of NaOH is in the solution?

- ANS: 12.3g



Remember…

- C1V1 = C2V2 used for DILUTIONS (meaning liquid in liquid solutions)

- n = C x V and m = n x M used for making solutions from a solid solute

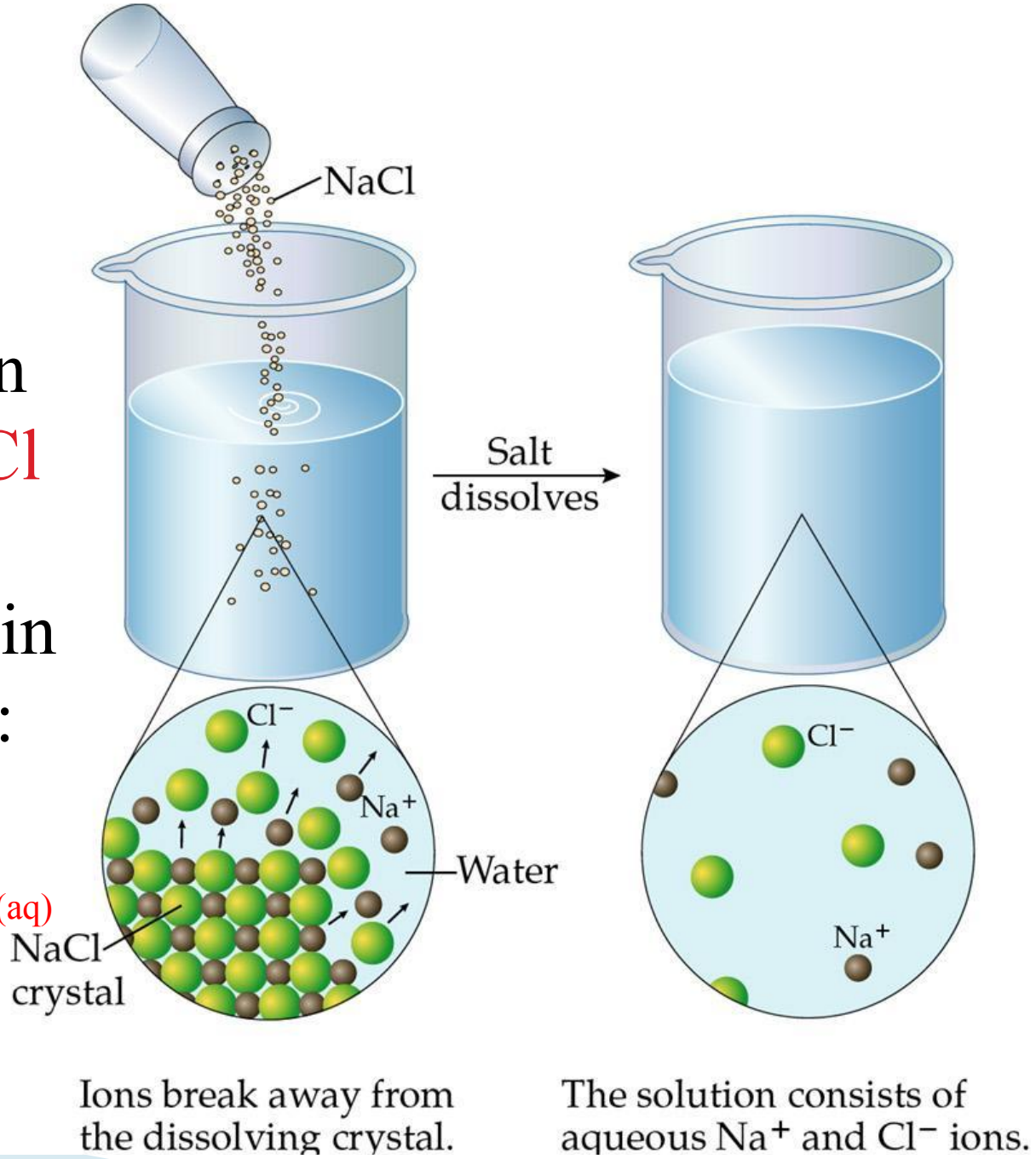
PRECIPITATION REACTIONS

Example #1:
No precipitate

NaCl in water

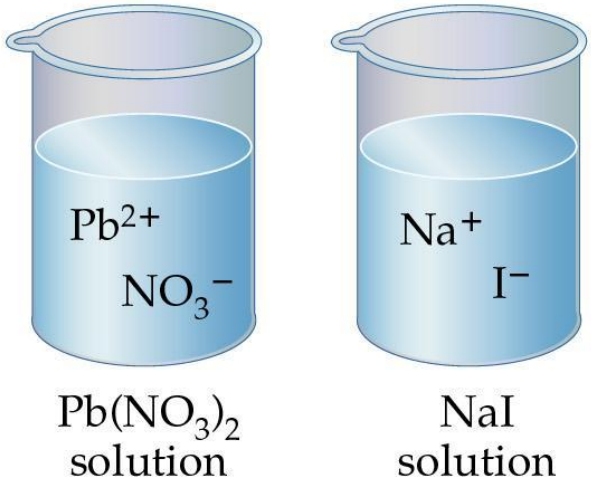
NaCl is *soluble* in water. Solid NaCl dissociates into Na^+ and Cl^- ions in aqueous solution:

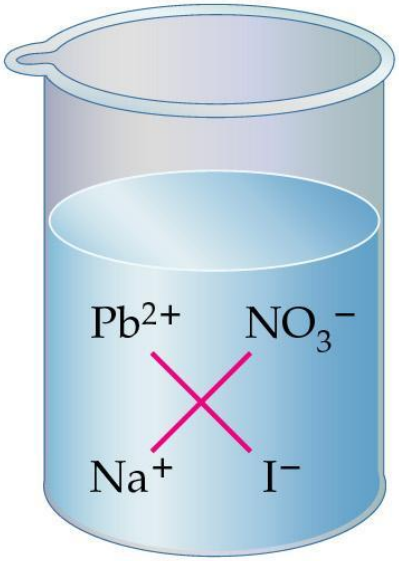
$$NaCl_{(s)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$$



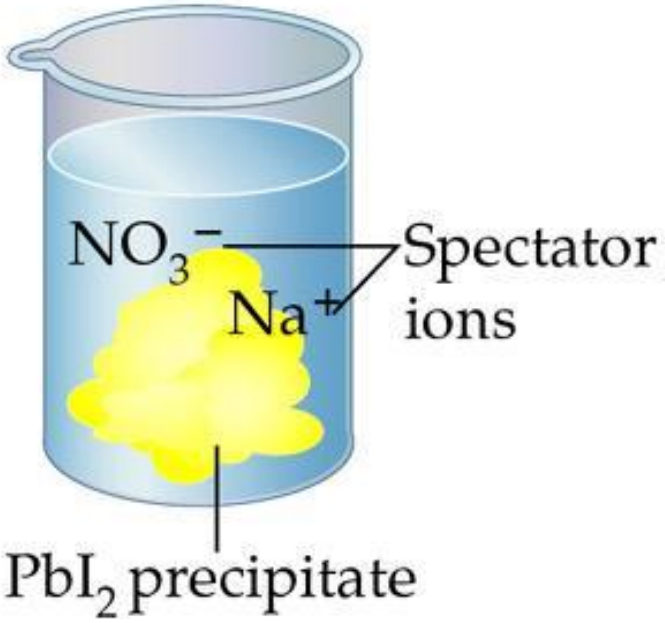
Example #2:
Precipitate forms

$$Pb(NO_3)_{2\,(aq)} + 2NaI_{(aq)}$$





Possible new combinations of cations and anions



$$Pb(NO_3)_2\ (aq) + 2NaI\ (aq) \rightarrow PbI_2\ (s) + 2NaNO_3\ (aq)$$

Solubility Rules

Applies to	Statement	Exceptions
Li^+, Na^+, K^+, NH_4^+	Group IA and ammonium compounds are soluble.	—
$C_2H_3O_2^-$, NO_3^-	Acetates and nitrates are soluble.	—
Cl^-, Br^-, I^-	Most chlorides, bromides, and iodides are soluble.	AgCl, Hg_2Cl_2, $PbCl_2$, AgBr, $HgBr_2$, Hg_2Br_2, $PbBr_2$, AgI, HgI_2, Hg_2I_2, PbI_2
SO_4^{2-}	Most sulfates are soluble.	$CaSO_4$, $SrSO_4$, $BaSO_4$, Ag_2SO_4, Hg_2SO_4, $PbSO_4$
CO_3^{2-}	Most carbonates are insoluble.	Group IA carbonates, $(NH_4)_2CO_3$
PO_4^{3-}	Most phosphates are insoluble.	Group IA phosphates, $(NH_4)_3PO_4$
S^{2-}	Most sulfides are insoluble.	Group IA sulfides, $(NH_4)_2S$
OH^-	Most hydroxides are insoluble.	Group IA hydroxides, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$

Ion	Solubility	Exceptions
NO_3^-	soluble	none
ClO_4^-	soluble	none
Cl^-	soluble	except Ag^+, Hg_2^{2+}, *Pb^{2+}
I^-	soluble	except Ag^+, Hg_2^{2+}, Pb^{2+}
SO_4^{2-}	soluble	except Ca^{2+}, Ba^{2+}, Sr^{2+}, Hg^{2+}, Pb^{2+}, Ag^+
CO_3^{2-}	insoluble	except Group IA and NH_4^+
PO_4^{3-}	insoluble	except Group IA and NH_4^+
-OH	insoluble	except Group IA, *Ca^{2+}, Ba^{2+}, Sr^{2+}
S^{2-}	insoluble	except Group IA, IIA and NH_4^+
Na^+	soluble	none
NH_4^+	soluble	none
K^+	soluble	none

*slightly soluble

CHEMICAL EQUATIONS

There are three basic types of chemical equations:

Chemical, Ionic, & Net ionic.

- Chemical EQUATIONS are written as if all substances were molecular, even though some substances may exist as ions.

$$HCl\ (aq) + NaOH\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$$

CHEMICAL EQUATIONS

- IONIC EQUATIONS have the substances which exist as ions (i.e. dissociate in water) written in ionic form.

Note: H_2O does not break into ions

$$H^+_{(aq)} + Cl^-_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)} + H_2O_{(l)}$$

- Precipitation, Acid/base, and Redox reactions can all be written depicting the appropriate substances as ions.

CHEMICAL EQUATIONS

- NET IONIC EQUATIONS are ionic equations with the Spectator ions removed.

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

- SPECTATOR IONS do not participate in a reaction (that is they do not react to form a new substance). Common Spectator ions are Group I, many Group II, and NO_3^- (nitrate) and $C_2H_3O_2^-$ (acetate) ions.

Net Ionic Equations

Balanced Chemical Equation:

$$Pb(NO_3)_{2(aq)} + 2NaI_{(aq)} \rightarrow PbI_{2(s)} + 2NaNO_{3(aq)}$$

"Complete Ionic" Equation:

$$Pb^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2Na^+_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)} + 2Na^+_{(aq)} + 2NO_3^-{}_{(aq)}$$

Cancel the "spectator ions" that appear on both sides of the arrow

$$Pb^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2Na^+_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)} + 2Na^+_{(aq)} + 2NO_3^-{}_{(aq)}$$

"Net Ionic" Equation:

$$Pb^{2+}_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)}$$

Sample Problem

Balanced Molecular Equation:

$Ba(NO_3)_{2(aq)} + NiSO_{4(aq)} \longrightarrow Ni(NO_3)_{2\ (aq)} + BaSO_{4(s)}$

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Balanced Molecular Equation:

$$Ba(NO_3)_{2(aq)} + NiSO_{4(aq)} \longrightarrow Ni(NO_3)_{2\ (aq)} + BaSO_{4(s)}$$

Complete Ionic Equation:

$$Ba^{2+}_{(aq)} + 2NO_3^{1-}{}_{(aq)} + Ni^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \longrightarrow Ni^{2+}_{(aq)} + 2NO_3^{1-}{}_{(aq)} + BaSO_{4\ (s)}$$

Sample Problem

Balanced Molecular Equation:

$$Ba(NO_3)_{2(aq)} + NiSO_{4(aq)} \rightarrow Ni(NO_3)_{2\,(aq)} + BaSO_{4(s)}$$

Complete Ionic Equation:

$$Ba^{2+}_{(aq)} + \cancel{2NO_3^-}_{(aq)} + \cancel{Ni^{2+}}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow \cancel{Ni^{2+}}_{(aq)} + \cancel{2NO_3^-}_{(aq)} + BaSO_{4\,(s)}$$

Sample Problem

Balanced Molecular Equation:

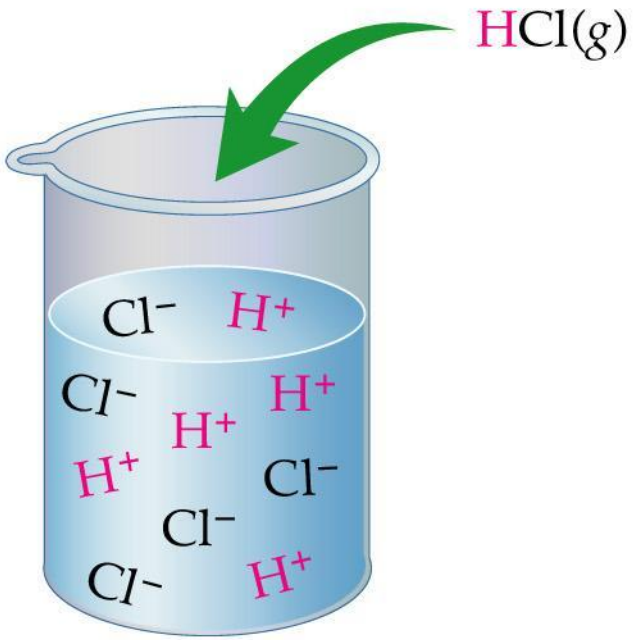
$$Ba(NO_3)_{2(aq)} + NiSO_{4(aq)} \rightarrow Ni(NO_3)_{2\,(aq)} + BaSO_{4(s)}$$

Complete Ionic Equation:

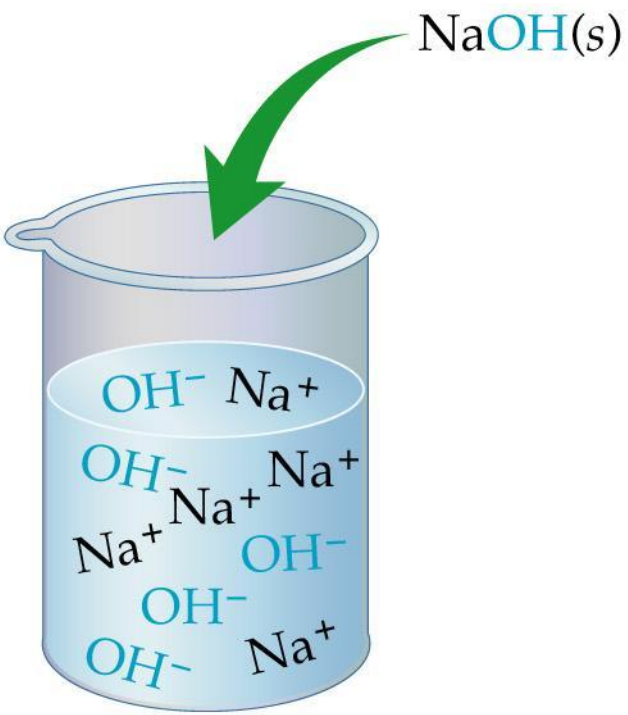
$$Ba^{2+}_{(aq)} + \cancel{2NO_3^-}_{(aq)} + \cancel{Ni^{2+}}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow \cancel{Ni^{2+}}_{(aq)} + \cancel{2NO_3^-}_{(aq)} + BaSO_{4\,(s)}$$

Net Ionic Equation:

$$Ba^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow BaSO_{4\,(s)}$$



HCl is an acid because it dissociates in water to produce $H^+(aq)$ ions.

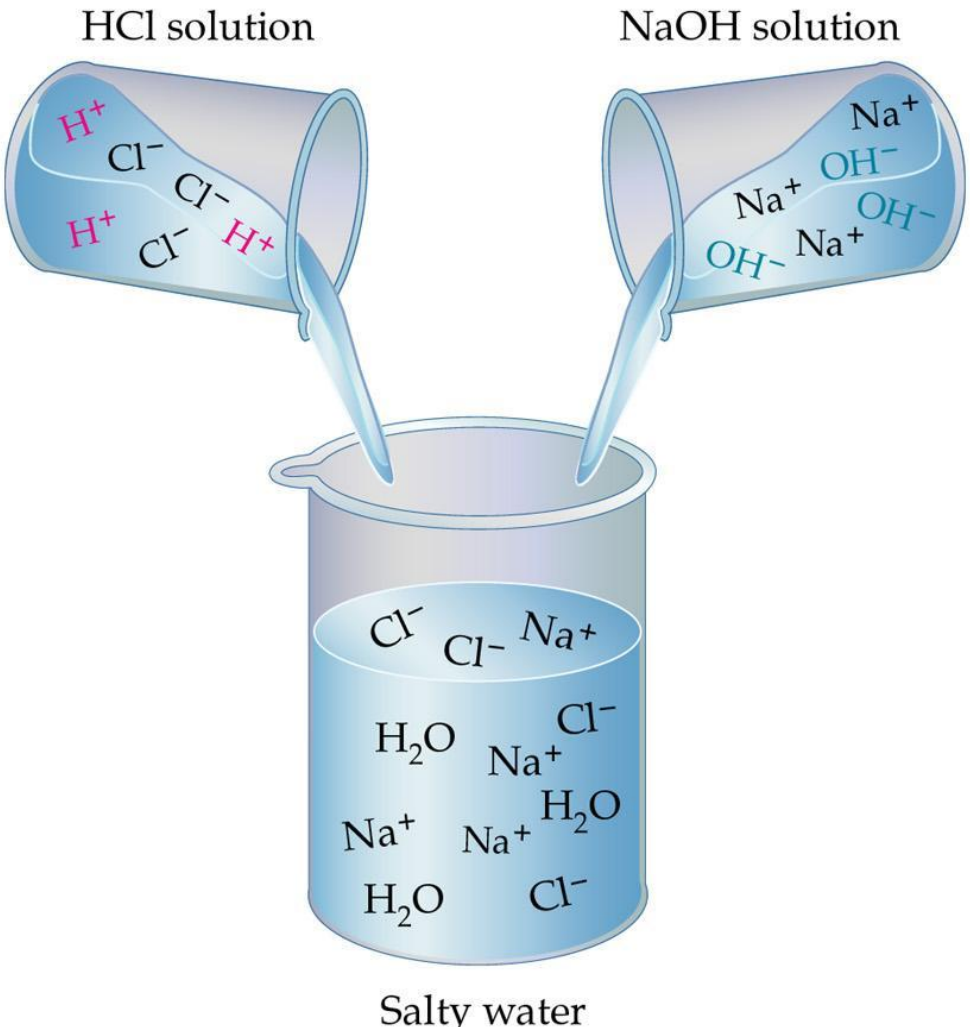


NaOH is a base because it produces $OH^-(aq)$ ions when added to water.

What is the Net Ionic Equation for the reaction: $HCl_{(aq)} + NaOH_{(aq)}$?

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow H_2O_{(l)} + NaCl_{(aq)}$$

$$H^+_{(aq)} + {}^-OH_{(aq)} \longrightarrow H_2O_{(l)}$$



PRACTICE PROBLEMS

Balance the following molecular equations then write both the ionic & net ionic equations:

1. __$Na_2CO_3(aq)$ + __$HNO_3(aq)$ → __$H_2CO_3(aq)$ + __$NaNO_3$ (aq)

Note: carbonic acid decomposes into carbon dioxide and water.

2. __$KBr(aq)$ + __$I_2(g)$ → __ $KI(aq)$ + __$Br_2(l)$

3. __$AlCl_3(aq)$ + __$K_3PO_4(aq)$ → __$AlPO_4(s)$ + __$KCl(aq)$

Answers to PRACTICE PROBLEMS

. $Na_2CO_3(aq) + 2\ HNO_3(aq) \rightarrow H_2CO_3(aq) + 2\ NaNO_3\ (aq)$

lote: carbonic acid decomposes into carbon dioxide and water.

onic: $2Na^+_{(aq)} + CO_3^{2-}{}_{(aq)} + 2H^+_{(aq)} + 2NO_3^-{}_{(aq)} \rightarrow H_2O\ (l) + CO_2(g) + 2Na^+_{(aq)} + 2NO_3^-{}_{(aq)}$

Net ionic: $CO_3^{2-}{}_{(aq)} + 2H^+_{(aq)} \rightarrow H_2O\ (l) + CO_2(g)$

. $2KBr(aq) + I_2(g) \rightarrow 2\ KI(aq) + Br_2(l)$

Ionic: $2K^+_{(aq)} + 2Br^-_{(aq)} + I_2(g) \rightarrow 2K^+_{(aq)} + 2I^-_{(aq)} + Br_2(l)$

Net ionic: $2Br^-_{(aq)} + I_2(g) \rightarrow 2I^-_{(aq)} + Br_2(l)$

. $AlCl_3(aq) + \_\_K_3PO_4(aq) \rightarrow \_\_AlPO_4(s) + 3\ KCl(aq)$

Ionic: $Al^{3+}{}_{(aq)} + 3Cl^-_{(aq)} + 3K^+_{(aq)} + PO_4^{3-}{}_{(aq)} \rightarrow AlPO_4(s) + 3K^+_{(aq)} + 3Cl^-_{(aq)}$

Net ionic: $Al^{3+}{}_{(aq)} + PO_4^{3-}{}_{(aq)} \rightarrow AlPO_4(s)$

All ions are aqueous states!!

MORE PRACTICE

Balance the following chemical equations then write both the ionic & net ionic equations:

1. __$Na_2SO_4(aq)$ + __$AlCl_3(aq)$ → __$Al_2(SO_4)_3(aq)$ + __$NaCl(aq)$

2. __$NaBr(aq)$ + __$Cl_2(g)$ → __ $NaCl(aq)$ + __$Br_2(l)$

3. __$SbCl_3(aq)$ + __$Na_2S(aq)$ → __$Sb_2S_3(s)$ + __$NaCl(aq)$

4. __$Mg(OH)_2(aq)$ + __ $H_2SO_4(aq)$→ __ $H_2O(l)$ + __$MgSO_4(aq)$

Net Ionic Equations Revisited:

1) Write the (balanced!) molecular equation first
   - Reaction products: swap cations and anions
   - Predict solubility (using Solubility rules)

2) Write the complete ionic equation next
   - (s) compounds don't ionize
   - (aq) compounds do ionize

   ion subscripts in the molecular equation become coefficients in the complete ionic equation!

3) Write the net ionic equation next
   - cancel spectator ions

The net ionic equation is a "simplified" form of the complete ionic equation