- synthesis
- decomposition
- combustion
- single-replacement
- double-replacement
- neutralization

Single-replacement reactions

Single-replacement reactions include reactions of the general form: A + BC ⟶ AC + B

There are two types of single-replacement reactions:

1. Single-replacement reactions of metals — Using Activity Series of Metals
2. Single-replacement reactions of nonmetals ⟵ Involving the halogens

Today we will focus on single-replacement reactions involving the halogens.

Single-replacement reactions

- synthesis
- decomposition
- combustion
- single-replacement
- double-replacement
- neutralization

1. Learn to *predict* Single-replacement reaction
   If and when a reaction occurs, what are the products?

2. Learn to *write* Single-replacement reaction:
   (i) Balanced chemical reaction
   (ii) Net ionic reaction
   (iii) Identify which species is oxidized, and which species is reduced
   (iv) Identify spectator ions in the reaction

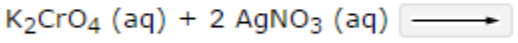
Unit 6

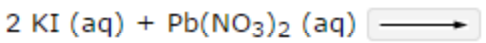
On completion of the unit you should be able to:

1. balance chemical equations.
2. interpret balanced equations in terms of moles, mass units and number of particles.
3. given the number of moles (or mass or number of particles) of one substance calculate the number of moles (or mass or number of particles) of another substance in the balanced equation.
4. define limiting and excess reactants.
5. identify the following types of reactions:
   - synthesis
   - decomposition
   - combustion
   - single-replacement
   - double-replacement
   - neutralization
6. define endothermic and exothermic reactions.
7. define acids and bases.

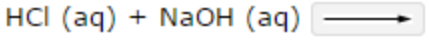
Today's focus.

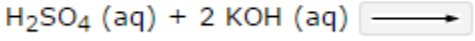
4. **Double-replacement reactions**
   - **PREDICT by using the table of solubility rules of ionic compounds in water**
   -  **Two double replacement reactions**
     - What happens when potassium chromate is mixed with silver nitrate?
     - What happens when potassium iodide is mixed with lead (II) iodide?





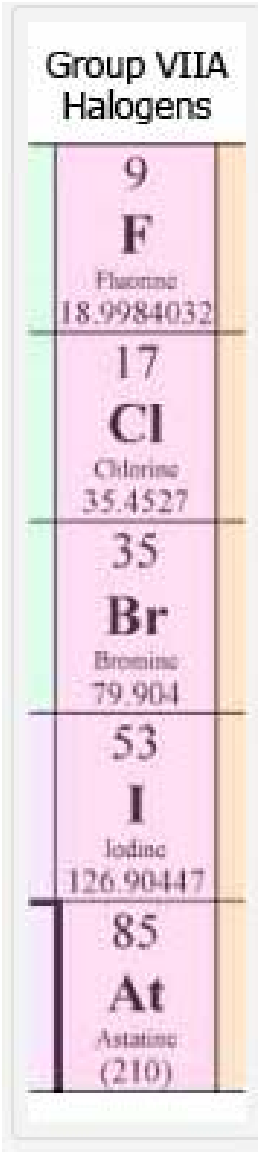
   - **Neutralization reactions** – a special class of double replacement reaction involving an acid and a base

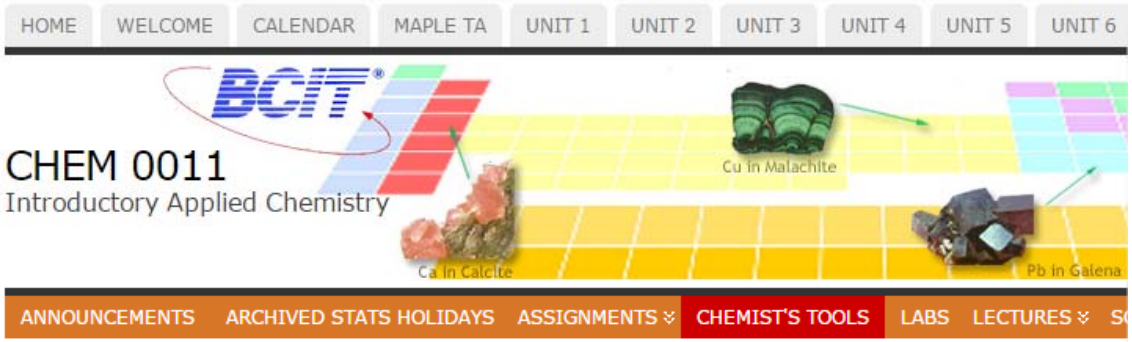




Single-replacement reactions involving the Halogens

$$A + BC \rightarrow AC + B$$





Chemist's Tools: Solubility Rules!!

The following table summarizes the solubility ionic compounds in water formed with these common anions a guide to predict products of chemical reactions for double-replacement reactions.

Anions Soluble Insoluble Nitrates, NO3- ALL

– Acetates, C2H3O2- ALL – Chlorides, Cl- ALL, except … AgCl, Hg2Cl2, PbCl2 Sulfates, SO42- ALL*, . . . →
Chemist's Tools: Solubility Rules!!

JANUARY 5TH, 2015 | CATEGORY: CHEMIST'S TOOLS | LEAVE A COMMENT | EDIT THIS POST

Chemist's Tools: Activity Series of Metals

The following table shows the activity series for some of the more common metals in order of deceasing r the most reactive metal at the top of the list. It should not be surprising to you to find the alkali metals at list and the more unreactive metals at . . . → Read More: **Chemist's Tools: Activity Series of Metals**

JANUARY 5TH, 2015 | CATEGORY: CHEMIST'S TOOLS | LEAVE A COMMENT | EDIT THIS POST

Chemist's Tools: Activity Series for the Halogens

General Activity Series For

Permanent Link to Chemist's Tools: Activity Series for the Halogens

F2 (Most active) Cl2 Br2 I2 (Least active)

JANUARY 5TH, 2015 | CATEGORY: CHEMIST'S TOOLS | LEAVE A COMMENT | EDIT THIS POST

Single-replacement reactions involving the Halogens

$$A + BC \rightarrow AC + B$$

The most reactive halogen is Fluorine, located at the top of the table.

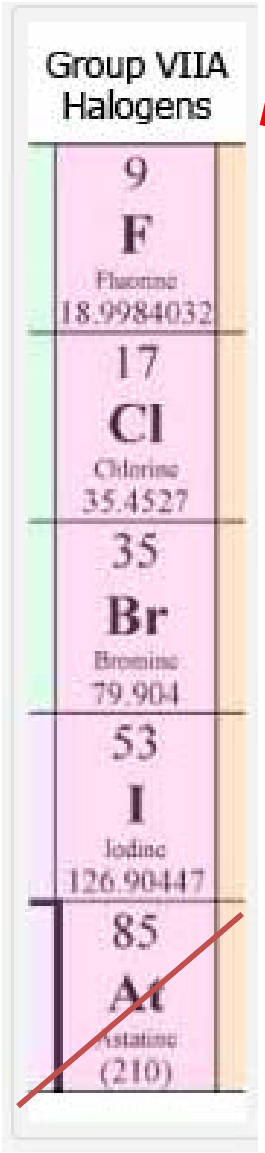
Unlike metals, the halogens form NEGATIVE ions.

Forms -1 charge ions.

Rule 1: If a more reactive halogen comes into contact with a compound containing a less reactive halogen,

a chemical reaction will take place.

When the reaction occurs, the less reactive halogen is **displaced** from the compound and **replaced** by the more reactive halogen. Hence, the name SINGLE-REPLACEMENT reaction.



This is a order of the elements as they appear on the Periodic Table.
Not to be memorized.

You are responsible to know how to use it.

The least reactive halogen is Iodine, located at the bottom of the table.

We will not be concerned with Astatine because it is radioactive.

Single-replacement reactions involving the Halogens

$$A + BC \rightarrow AC + B$$

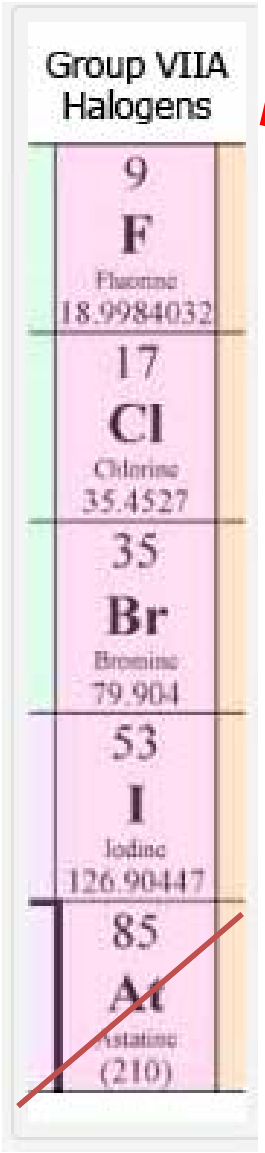
The most reactive halogen is Fluorine, located at the top of the table.

Unlike metals, the halogens form NEGATIVE ions.

Forms -1 charge ions.

Rule 2: If a less reactive halogen comes into contact with a compound containing a more reactive halogen,

no chemical reaction will take place.



This is a order of the elements as they appear on the Periodic Table. Not to be memorized.

You are responsible to know how to use it.

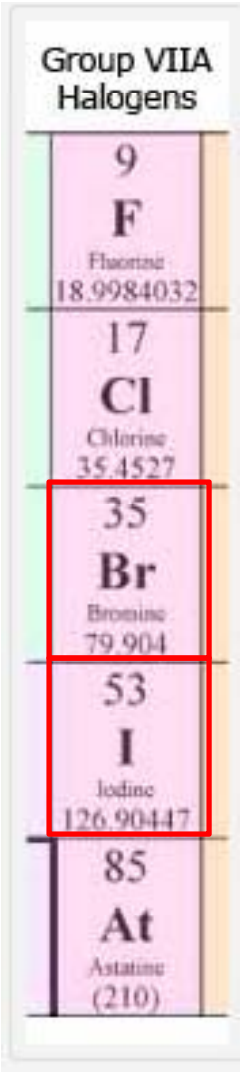
The least reactive halogen is Iodine, located at the bottom of the table.

We will not be concerned with Astatine because it is radioactive.

Single-replacement reactions involving the Halogens

$A + BC \rightarrow AC + B$

Q: What happens when bromine in water and an aqueous solution of sodium iodide are mixed together? If there is a reaction, write the balanced chemical reaction, net ionic reaction, identify the species oxidized, reduced, and the spectator ions.

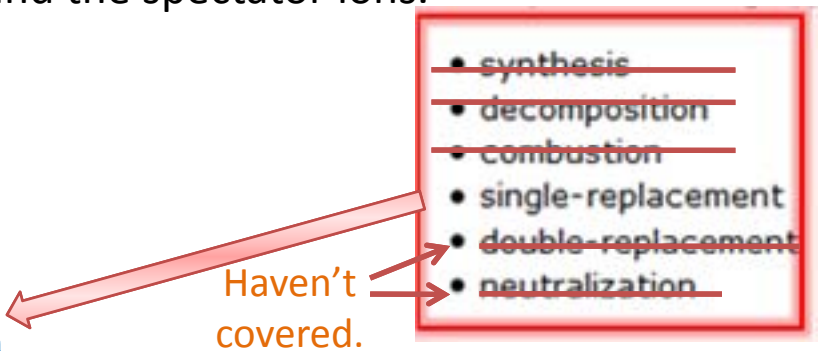


Step 1: Identify the reacting species.

$Br_2\,(aq) + \;\; NaI\,(aq) \rightarrow$

Step 2: What type of reactions is this?

Single-replacement reaction



Step 3: SR Involving metals or the Halogens?

Since there is only one metal, Na, in the reacting species, this reaction cannot be SR involving metals. (Clue: There is no 2nd metal to compare with.)

Therefore, this must be **SR involving the Halogens**.

(Clue: There are two non-metals to compare, Bromine and Iodine.)

Step 4: Which is more reactive, Bromine or Iodine?

Bromine, Rule 1 applies, a reaction occurs.

Step 5: Write the balanced chemical reaction.

$Br_2\,(aq) + 2\,NaI\,(aq) \rightarrow I_2\,(aq) + 2\,NaBr\,(aq)$

Step 6: Identify the spectator ions, the species oxidized and reduced?

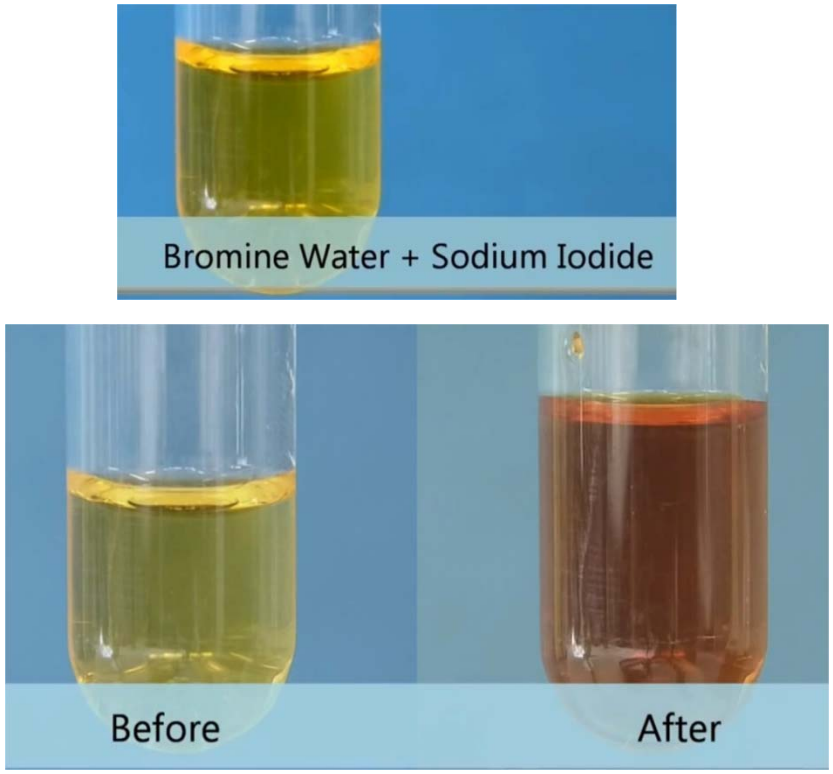
Na^+ (aq) **I^- (aq)** **Br_2 (aq)**

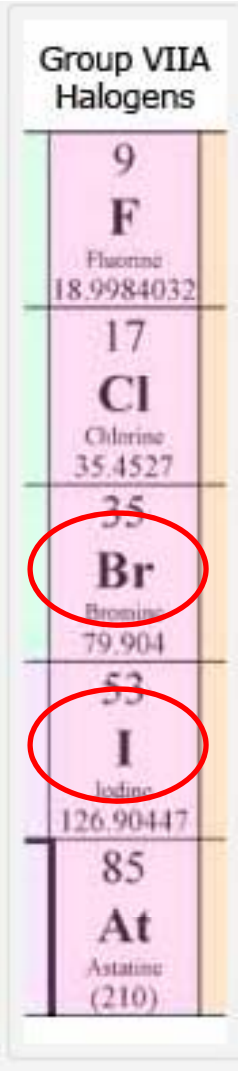
Step 7: Write the net ionic reaction?

$Br_2\,(aq) + \;2\,I^-\,(aq) \rightarrow I_2\,(aq) + 2\,Br^-\,(aq)$

Single-replacement reactions involving the Halogens

https://www.youtube.com/watch?v=tNvERqFmDXo



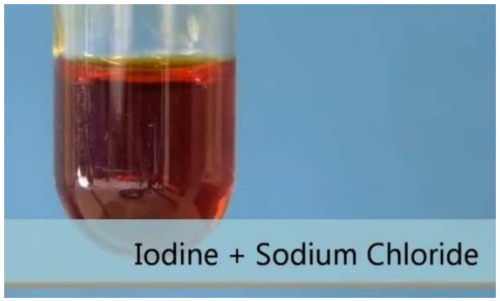


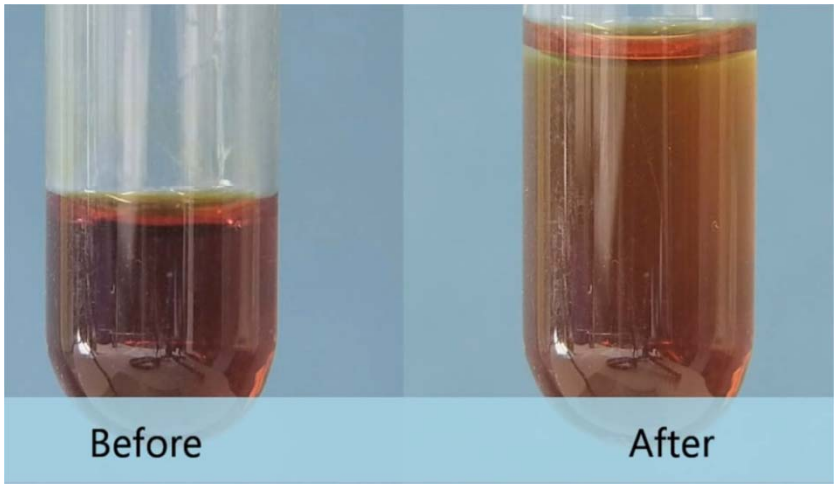
Balanced chemical reaction: $Br_2\,(aq) + 2\,NaI\,(aq) \rightarrow I_2\,(aq) + 2\,NaBr\,(aq)$

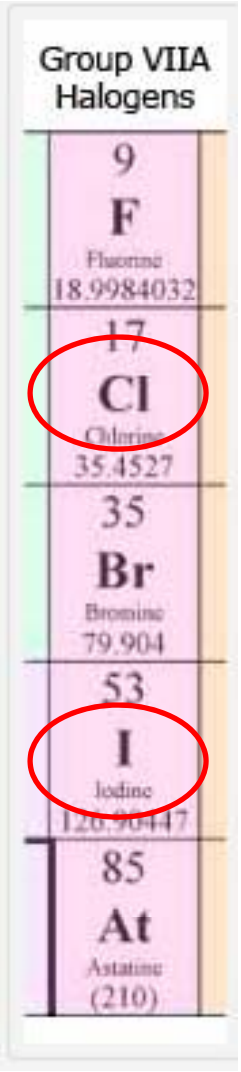
Net ionic reaction: $Br_2\,(aq) + 2\,I^-\,(aq) \rightarrow I_2\,(aq) + 2\,Br^-\,(aq)$

Single-replacement reactions involving the Halogens

https://www.youtube.com/watch?v=Zd9fsYxpYuM







Balanced chemical reaction: $I_2\ (aq) + NaCl\ (aq) \rightarrow$ No reaction, because iodine is less active than chlorine.

Single-replacement reactions involving the Halogens

Scanned Lecture Notes

Road Maps:

- Mole – Mass – Volume – Particles conversion
- From Percent Composition to Empirical Formula to Chemical Formula

Worksheets:

- Lab Report Write up Instructions
- Test #1 covers Unit 2 to 5. Here are the worksheets to prepare for Test #1:
  - Unit 2 – Density Questions Worksheet
  - Unit 3 – Naming Worksheet – Name to Chemical Formula and Chemical Formula to Name
  - Unit 5 – Mole Concept Worksheet
  - Unit 5 – Salt & Sugar Worksheet
  - Unit 5 – Percent Composition, Empirical Formula, Chemical Formula Worksheet
  - Unit 5 – Solution Worksheet – Maple TA Type Questions
  - Unit 5 – Solution Dilution Worksheet
- Unit 6 – From Combustion Analysis of C, H, O containing compounds to Empirical Formula to Che
  Maple TA type problem in Assignment 7
- Unit 6 – Single Replacement Reactions Worksheet (Watch animation here)
- Unit 6 – Single Replacement Reactions Worksheet – 2nd worksheet
- Unit 6 – Double Replacement Reactions Worksheet
- Unit 7 – Calculations involving Chemical Reactions Worksheet
- Unit 8 – Periodic Trends Worksheet

Try the second worksheet!

Double-replacement reactions

- synthesis
- decomposition
- combustion
- single-replacement
- double-replacement
- neutralization

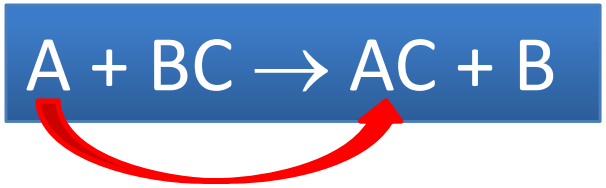
1. Learn to *predict* Double-replacement reaction
   If and when a reaction occurs, what are the products?

2. Learn to *write* Double-replacement reaction:
   (i) Balanced chemical reaction
   (ii) Net ionic reaction
   (iii) Identify spectator ions in the reaction

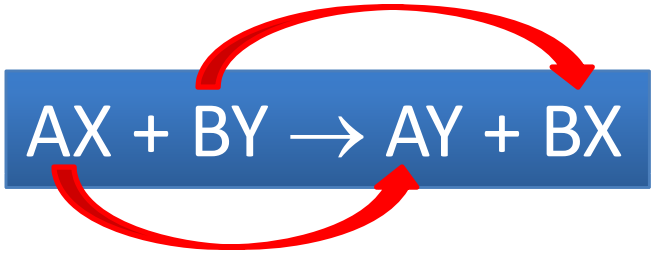
Double-replacement reactions

Recall:

Single-replacement reaction

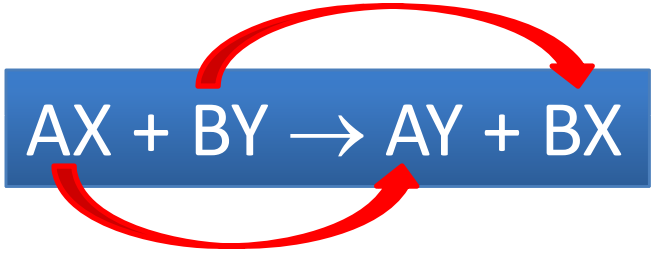


Double-replacement reaction



Double-replacement reactions

Double-replacement reaction



Driving force for a double-replacement to occur is the formation of a compound as a product of the reaction.

The compound can be in (s), (l), or (g) states.

(i) Formation of a solid or a precipitate.

Check the Solubility Rules table

(ii) Formation of a liquid, H_2O (l), water.

(iii) Formation of a gas, H_2S (g), dihydrogen sulfide gas.

Double-replacement reactions

$$AX + BY \rightarrow AY + BX$$

Double-replacement reactions

$$AX + BY \rightarrow AY + BX$$

	Soluble	Not soluble
Nitrates, NO_3^-	ALL	-
Acetates, $C_2H_3O_2^-$	ALL	-
Chlorides, Cl^-	ALL, except	AgCl, Hg_2Cl_2, $PbCl_2$.
Sulfates, SO_4^{2-}	ALL, except	$BaSO_4$, $SrSO_4$, $PbSO_4$
salts of groupIA	ALL	
salts of ammonium, NH_4^+	ALL	
acids	ALL	
oxides, O^{2-}	group IA, group IIA (Ca, Sr, Ba)	ALL
hydroxides, OH^-	group IA, Ca, Sr, Ba of group IIA	ALL
sulfides, S^{2-}	group IA, group IIA, $(NH_4)_2S$	ALL
phosphates, PO_4^{3-}	group IA, $(NH_4)_3PO_4$	ALL
carbonates, CO_3^{2-}	group IA, $(NH_4)_2CO_3$	ALL

This is a REFERENCE table. Not to be memorized.

You are responsible to know how to use it.

Double-replacement reactions

$$AX + BY \rightarrow AY + BX$$

	Soluble	Not soluble
Nitrates, NO_3^-	ALL	-
Acetates, $C_2H_3O_2^-$	ALL	-
Chlorides, Cl^-	ALL, except	$AgCl$, Hg_2Cl_2, $PbCl_2$
Sulfates, SO_4^{2-}	ALL, except	$BaSO_4$, $SrSO_4$, $PbSO_4$
salts of groupIA	ALL	
salts of ammonium, NH_4^+	ALL	
acids	ALL	
oxides, O^{2-}	group IA, group IIA (Ca, Sr, Ba)	ALL
hydroxides, OH^-	group IA, Ca, Sr, Ba of group IIA	ALL
sulfides, S^{2-}	group IA, group IIA, $(NH_4)_2S$	ALL
phosphates, PO_4^{3-}	group IA, $(NH_4)_3PO_4$	ALL
carbonates, CO_3^{2-}	group IA, $(NH_4)_2CO_3$	ALL

Soluble column

-Means compounds produced with these anions will dissolve in water.

-Physical state is (aq)

Not soluble column

-Means compounds Produced with these anions will NOT dissolve in water. (i.e. precipitate forms)

-Physical state is (s)

Double-replacement reactions

$AX + BY \rightarrow AY + BX$

Let's test if the following reactions will occur. If a reaction occurs, write: (i) the balanced chemical reaction
(ii) the net ionic reaction
(iii) identify the spectator ion(s)

Reactants: ❯ / ❮	K_2CO_3 (aq)	NaCl (aq)	Na_3PO_4 (aq)
$Mg(NO_3)_2$ (aq)	1		
$Ca(NO_3)_2$ (aq)			
$Sr(NO_3)_2$ (aq)		2	
$Ba(NO_3)_2$ (aq)			

Double-replacement reactions

$AX + BY \rightarrow AY + BX$

Let's consider if the following reactions will occur:

1 $K_2CO_3\,(aq) + Mg(NO_3)_2\,(aq) \rightarrow ?$

Step 1: What are the potential products formed?

Potential products would be: KNO_3 and $MgCO_3$.

Make sure the formulae are chemically correct.

Step 2: Determine the physical states of the products.

Check to see whether the products would be:

(i) A solid (i.e. precipitate), (ii) A liquid, water (iii) A gas, H_2S (g)

Using the Solubility Rules table:

	Soluble	Not soluble
Nitrates, NO_3^-	ALL	-
carbonates, CO_3^{2-}	group IA, $(NH_4)_2CO_3$	ALL

$KNO_3(aq)$ $MgCO_3(s)$

Formation of a solid is the driving force for this reaction to occur!

Double-replacement reactions

$AX + BY \rightarrow AY + BX$

Let's consider if the following reactions will occur:

1 $K_2CO_3\ (aq) + Mg(NO_3)_2\ (aq) \rightarrow ?$

Make sure the reaction is balanced.

Step 3: Write the balanced chemical reaction.

$K_2CO_3\ (aq) + Mg(NO_3)_2\ (aq) \rightarrow 2\,KNO_3\ (aq) + MgCO_3\ (s)$

Step 4: Write the net ionic reaction.

$2K^+\ (aq) + CO_3^{2-}\ (aq) + Mg^{2+}\ (aq) + 2NO_3^-\ (aq) \rightarrow$

$2K^+\ (aq) + 2NO_3^-\ (aq) + MgCO_3\ (s)$

$CO_3^{2-}\ (aq) + Mg^{2+}\ (aq) \rightarrow MgCO_3\ (s)$

Step 5: Identify the spectator ions.

$K^+\ (aq)$ and $NO_3^-\ (aq)$

Double-replacement reactions

$AX + BY \rightarrow AY + BX$

Let's test if the following reactions will occur. If a reaction occurs, write: (i) the balanced chemical reaction
(ii) the net ionic reaction
(iii) identify the spectator ion(s)

Reactants: ❯ / ❯	K_2CO_3 (aq)	NaCl (aq)	Na_3PO_4 (aq)
$Mg(NO_3)_2$ (aq)	1 ✔		
$Ca(NO_3)_2$ (aq)			
$Sr(NO_3)_2$ (aq)		2	
$Ba(NO_3)_2$ (aq)			

Double-replacement reactions

$AX + BY \rightarrow AY + BX$

Let's consider if the following reactions will occur:

2 $Sr(NO_3)_2(aq) + NaCl\ (aq) \rightarrow ?$

Step 1: What are the potential products formed?

Potential products would be: $SrCl_2$ and $NaNO_3$.

Make sure the formulae are chemically correct.

Step 2: Determine the physical states of the products.

Check to see whether the products would be:

(i) A solid (i.e. precipitate), (ii) A liquid, water (iii) A gas, H_2S (g)

	Soluble	Not soluble
Nitrates, NO_3^-	ALL	-
Chlorides, Cl^-	ALL, except	$AgCl$, Hg_2Cl_2, $PbCl_2$

$SrCl_2(aq)$ $NaNO_3(aq)$

Potential products all stay in solution. No reaction will occur!

Double-replacement reactions

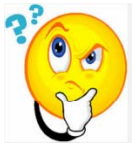
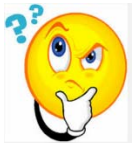
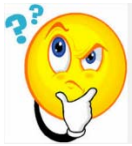
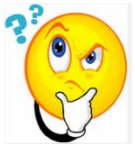
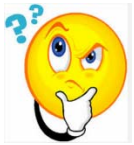
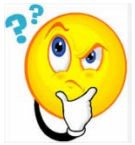
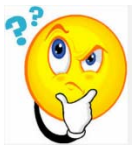
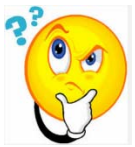
$AX + BY \rightarrow AY + BX$

Finish the rest of this matrix. If a reaction occurs, write:

(i) the balanced chemical reaction

(ii) the net ionic reaction

(iii) identify the spectator ion(s)

Reactants:	K_2CO_3 (aq)	NaCl (aq)	Na_3PO_4 (aq)
$Mg(NO_3)_2$ (aq)	1 ✔		
$Ca(NO_3)_2$ (aq)			
$Sr(NO_3)_2$ (aq)		2 ✔	
$Ba(NO_3)_2$ (aq)			

Try some practice problems in Maple TA.

Use Dimensional Analysis in ALL your calculations!!