Predicting Product of Reactions

Video Workbook with Dr. B

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Be warned that this can be a challenging topic!

If you can identify the types of chemical reactions, the next step is to be able to predict the products when given only reactants.

To be successful:

- Watch the video Predicting Types of Reactions.
- Do the 20 practice problems and check your work! Watch the video solutions if you're stuck.
- Practice with the other types of reactions.

Note: Equations in this guide may not be balanced.

Predicting Chemical Reactions

Types of Chemical Reactions

Important!

- It isn't possible to predict the products for all reactions.
- You must know how to find and balance ionic charge!

Finding the Charge on Ions

Single Displacement

There are two primary types of Single Displacement Reactions.

Metal replacement reactions occur when a more reactive metal replaces a less reactive metal in a compound. Here A is the more reactive metal.

$$A + BX \rightarrow AX + B$$

Example: $Zn(s) + CuCl_2(aq) \rightarrow ZnCl_2(aq) + Cu(s)$ (video)

Practice 1: Predict the products of $Fe(s) + CuSO_4(aq) \rightarrow$

Practice 2: Predict the products of $Cu(s) + AgNO_3(aq) \rightarrow$

Answers

1: Fe will replace the Cu. The products of the reaction will be $FeSO_4(aq) + Cu(s)$. (video)

2. Cu will replace the Ag. The products of the reaction will be $Cu(NO_3)_2(aq) + Ag(s)$. You may have also predicted $CuNO_3$, although $Cu(NO_3)_2$ is more likely. (video)

Hydrogen replacement reactions occur when a metal reacts with an acid to produce hydrogen gas (H_2) and a salt (metal and non-metal).

$$M + HX \rightarrow MX + H_2$$

Example: $Zn(s) + HCl(aq) \rightarrow ZnCl_2 + H_2(g)$ (video)

Practice 1: Predict the products of $Mg(s) + HCl(aq) \rightarrow$

Practice 2: Predict the products of $Zn(s) + HNO_3(aq) \rightarrow$

Answers

1: Mg will replace the H. There products of the reaction will be $MgCl_2(aq) + H_2(g)$. (video)

1: Zn will replace the H. There products of the reaction will be $Zn(NO_3)_2(aq) + H_2(g)$.

It is possible to write equations that follow this pattern that don't actually occur.
The Activity Series can be used to determine if a Single Displacement reaction actually will take place.

Double Displacement

There are three primary types of Double Displacement reactions.

Precipitation Reactions result in the formation of a solid from two aqueous solutions**.**

AB + XY → AY + XB

$Pb(NO_3)_2\,(aq)$ + KI (aq) → $PbI_2\,(s)$ + $KNO_3\,(aq)$

(video)

Practice 1: Predict the products of $Ba(NO_3)_2 + Na_2SO_4$

Practice: Predict the products of $NaOH(aq) + CuSO_4\,(aq)$

Answers

1: Ba and Na will switch places. The products will be $BaSO_4\,(s)$ and $NaNO_3\,(aq)$. If you check on a solubility table, you can see $BaSO_4$ is insoluble and will be a solid. Therefore it is the precipitate in the rxn.

2. Na and Cu will switch places. The products will be $Na_2SO_4\,(aq)$ and $Cu(OH)_2\,(s)$. The $Cu(OH)_2$ is insoluble and is the precipitate. (video)

Acid-Base (Neutralization) Reactions involve an acid and a base reacting to form a salt and water.

Acid + Base → Salt + Water

Example: HCl + NaOH → NaCl + H_2O

(video)

Practice1: Predict the products of HBr (aq) + KOH (aq)

Practice 2: Predict the products of $HNO_3\,(aq)$ + $Ca(OH)_2\,(aq)$

Answers

1: HBr is an acid, KOH is a base. The products will be KBr and H_2O.

2. HNO_3 is an acid, $Ca(OH)_2$ is a base. The products will be $Ca(NO_3)_2$ (aq) an $H_2O\,(l)$. (video)

Acids often start with H.
Bases often end in OH (the OH is bonded to a metal).

Gas Producing Reactions

For the reaction: $CaCO_3\,(l)$ + HCl (aq) →

It seems like you should get $CaCl_2\,(aq)$ + $H_2CO_3\,(aq)$

But $H_2CO_3\,(aq)$ will decompose into $H_2O\,(l)$ and $CO_2\,(g)$.

So the final reaction is:

$CaCO_3\,(s)$ + HCl (aq) → $CaCl_2\,(aq)$ + $H_2O\,(l)$ + $CO_2\,(g)$

(video)

Practice for Gas Producing Reactions

1. Predict the products for $MgCO_3\,(s)$ to HCl (aq) →

Answers

1: The Mg and H switch places to give $MgCl_2$ + H_2CO_3. The H_2CO_3 then decomposes into H_2O and CO_2.

The final reaction is:

$MgCO_3\,(s) + HCl\,(aq) \rightarrow MgCl_2\,(aq) + H_2O\,(l) + CO_2\,(g)$

For Precipitation Reactions we can tell if the reaction takes place by determining if one of the products is insoluble (and will be a solid). We can use a solubility chart or the solubility rules to make that determination.

Combustion (organic) Reactions

When we have a hydrocarbon (C_xH_y) react with O_2 we always get CO_2 and H_2O.

Examples of **Combustion Reactions**

$CH_4 + O_2 \rightarrow CO_2 + H_2O$ (video)
$C_2H_6 + O_2 \rightarrow CO_2 + H_2O$
$C_2H_5OH + O_2 \rightarrow CO_2 + H_2O$ (video)
$C_{11}H_{22}O_{11} + O_2 \rightarrow CO_2 + H_2O$
$C + O_2 \rightarrow CO_2$ (this is considered combustion)

Note that combustion reactions are exothermic so we could write *+ energy* or *+ heat* in the products.

Combustion Reactions Practice

Practice: Predict the products of the following:

$C_6H_{14} + O_2 \rightarrow$
$C + O_2 \rightarrow$
$C_2H_2 + O_2 \rightarrow$
$C_5H_{11}OH + O_2 \rightarrow$
$C_3H_6 + O_2 \rightarrow$

Answer: Each will give CO_2 and H_2O as products with the exception of $C + O_2 \rightarrow CO_2$.

Combination/Synthesis Reactions

These can be difficult. Sometimes you can rely on memory or common sense. Other times ionic charge can be helpful.

For Combination/Synthesis reactions two or more reactants combine to form one product

$A + B \rightarrow AB$
$Na + Cl_2 \rightarrow NaCl$ (video)

When dealing with ionic compounds (like NaCl) you need to balance the ionic charge.

For covalent compounds (two or more non-metals bonding) it isn't as straightforward.

$S + O_2 \rightarrow SO_2$ or it could be $S + O_2 \rightarrow SO_3$

Practice

Predict the products of the following:

1. $Mg + I_2 \rightarrow$
2. $Al + O_2 \rightarrow$
3. $H_2 + O_2 \rightarrow$

Answers

1. The products are MgI_2. (video)
2. The products are Al_2O_3. (video)
3. The products are likely H_2O. (video)

Decomposition Reactions

Probably the most difficult.

Decomposition Reactions

While simple to recognize as decomposition reactions, many are challenging to predict. For example:

$$CaCO_3 \rightarrow CaO + CO_2$$

$$NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$

Often you can predict the products if you should also know the common diatomic gases (H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2).

Examples: $NH_3 \rightarrow N_2 + H_2$

Note that most decomposition reactions require heat to occur. This means they will be endothermic rxns.

Decomposition Rxns Practice

Predict the products of the following:

1. $KCl \rightarrow$
2. $Fe_2O_3 \rightarrow$
3. $H_2O \rightarrow$

Answers

1. The products are $K + Cl_2$. (video)
2. The products are $Fe + O_2$.
3. The products are likely $H_2 + O_2$.

Practice Five Main Reaction Types

1. $Zn + AgNO_3 \rightarrow$
2. $C_2H_4 + O_2 \rightarrow$
3. $SO_3 + H_2O \rightarrow$
4. $CaCl_2 + Na_3PO_4 \rightarrow$
5. $NaBr + Cl_2 \rightarrow$
6. $Pb(OH)_2 + HCl \rightarrow$
7. $Mg + H_2SO_4 \rightarrow$
8. $Na + O_2 \rightarrow$
9. $Al + Fe_2O_3 \rightarrow$
10. $Cu(NO_3)_2 \rightarrow$
11. $C_6H_{12}O_6 + O_2 \rightarrow$
12. $Pb(NO_3)_2 + KI \rightarrow$
13. $Ca + N_2 \rightarrow$
14. $Cu + AgNO_3 \rightarrow$
15. $C_6H_{12}O_6 + O_2 \rightarrow$
16. $CaCl_2 + Na_2CO_3$
17. $CaCO_3 \rightarrow$
18. $C_2H_2 + O_2 \rightarrow$
19. $Fe + CuSO_4 \rightarrow$
20. $Na_2CO_3 + HCl \rightarrow$

Answers

1. $Zn + AgNO_3 \rightarrow Ag + Zn(NO_3)_2$
2. $C_2H_4 + O_2 \rightarrow CO_2 + H_2O$
3. $SO_3 + H_2O \rightarrow H_2SO_4$
4. $CaCl_2 + Na_3PO_4 \rightarrow Ca_3(PO_4)_2\ (s) + NaCl$
5. $NaBr + Cl_2 \rightarrow NaCl + Br_2$
6. $Pb(OH)_2 + HCl \rightarrow PbCl_2\ (s) + H_2O$
7. $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$
8. $Na + O_2 \rightarrow Na_2O$
9. $Al + Fe_2O_3 \rightarrow Al_2O_3 + Fe$
10. $Cu(NO_3)_2 \rightarrow CuO + NO_2 + O_2$
11. $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$ (video)
12. $Pb(NO_3)_2 + KI \rightarrow KNO_3 + PbI_2\ (s)$ (video)
13. $Ca + N_2 \rightarrow Ca_3N_2$
14. $Cu + AgNO_3 \rightarrow Cu(NO_3)_2 + Ag$ (video)
15. $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$ (video)
16. $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3\ (s) + NaCl$
17. $CaCO_3 \rightarrow CaO + CO_2$
18. $C_2H_2 + O_2 \rightarrow CO_2 + H_2O$
19. $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$ (video)
20. $Na_2CO_3 + HCl \rightarrow NaCl + H_2O + CO_2$

If your time is extremely limited, watch these videos:

Types of Chemical Reactions: https://youtu.be/ddY2RQ3ziLo
Predicting the Products of Chemical Reactions: https://youtu.be/TeXWuTMLe9M
Finding Ionic Charge: https://youtu.be/N4N1Njh7nCo
Criss-Cross Method for Formula Writing: https://youtu.be/77LVxv05XKE
Using the Solubility Table and Chart: https://youtu.be/snxoegzVnWw
Using the Activity Series: https://youtu.be/IS3_BAfQT54

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