

Ontario High School Grade 11 Chemistry

Summer 2024, Chapter 4 Notes

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Dana 4.4/5 ★

MSc

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4. Chemical Reactions

4.1 Expressing Chemical Reactions

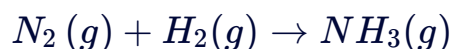
4.1.1

Balancing Chemical Reaction Equations

- A balanced chemical equation tells us the correct proportions of chemicals in a chemical reaction.

Steps to Balance Chemical Equations

Example: Nitrogen gas reacting with hydrogen gas to give us ammonia



1. Count the number of entities (atoms / ions / polyatomic ions) of each type on either side of the arrow. Look at subscripts to see exactly how much of an entity we have on each side.

[Solution available online](#)

2. Multiply the chemical formulas by an appropriate coefficient until all entities are balanced.

[Solution available online](#)

3. Check whether the numbers of each entity on both sides are balanced.

Watch the video tutorial for this lesson (04:10)

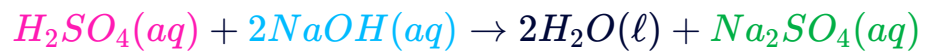
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Ways to Write Out Chemical Reactions

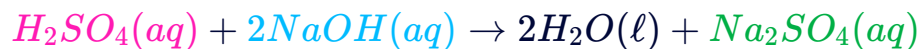
Formula Equation

- This is the way we are most familiar with



Total Ionic Equation

- To write the complete ionic equation, we need to look at the formula equation and identify which of the product and reactants can dissociate or ionize. Then write out the equation with all of the ions.



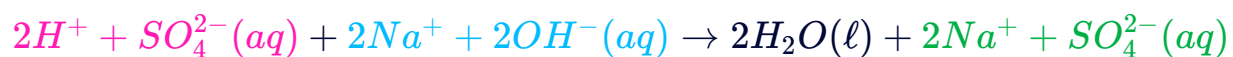
Compounds in the formula equation	Can this compound dissociate/ionize?	The dissociation/ionization reaction

- Next, since we figured out all the molecules that dissociate or ionize and balanced the equations, we need to put everything back into the formula equation:

[Solution available online](#)

Net Ionic Equation:

- For this equation, we take the total ionic equation and cross anything out that appears in equal quantities on both sides so that we are left with the net ionic equation.



Solution available online

- Spectator ions** are the ions that are not involved in the chemical reaction. These are the ions that appear as both reactants and products and remain unchanged. In this case, the spectator ions are _____ and _____.

Watch the video tutorial for this lesson (06:14)

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Example: Balancing Chemical Equations with Polyatomic Ions

Balance the following chemical equation:



Solution available online

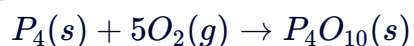
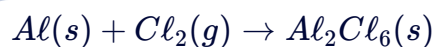
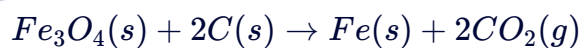
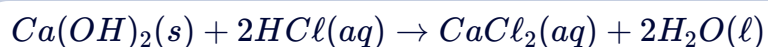
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Practice: Identifying Balanced Chemical Reactions

Which of the following are balanced chemical equations? Select all that apply.

☐☐☐☐

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4.1.5



MARK YOURSELF QUESTION

1. Grab a piece of paper and try this problem yourself.
2. When you're done, check the "I have answered this question" box below.
3. View the solution and report whether you got it right or wrong.

Practice: Balanced Equations

When given the unbalanced chemical equation: $Na + Cl_2 \rightarrow NaCl$

Student A balanced it as follows: $Na + Cl_2 \rightarrow NaCl_2$

Student B balanced it as follows: $2Na + Cl_2 \rightarrow 2NaCl$

Both are balanced, but which is correct and why?

☐ I have answered this question

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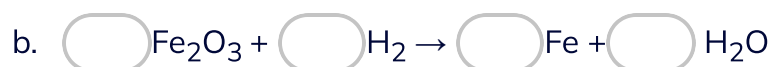
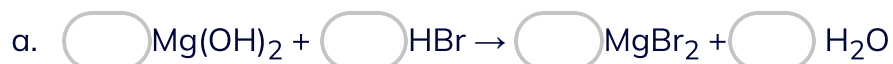
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Practice: Balancing Chemical Equations

Balance the following chemical equations. If the coefficient is 1, please include it as well.



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4.2 Chemical Reactions

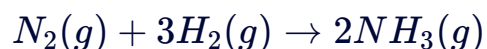
4.2.1

Formation and Decomposition Reactions

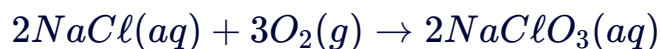
- A **formation or synthesis reaction** is a reaction in which two or more reactants come together to form one larger compound. The general formula for a synthesis reaction is:



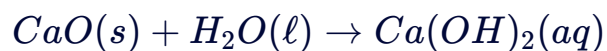
Example 1: Two elements combining to form a compound



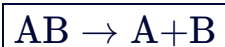
Example 2: An element reacting with a compound to form a new, larger compound



Example 3: Two compounds combining to form an even more complex compound



- A **decomposition reaction** is one in which a complex compound breaks down into simpler compounds. The general formula for a decomposition reaction is:



Example 1: Binary compounds decomposing into their elements



Example 2: A compound decomposing into a simpler compound and an element



Example 3: A compound decomposing into simpler compounds



Watch the video tutorial for this lesson (03:04)

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Replacement Reactions

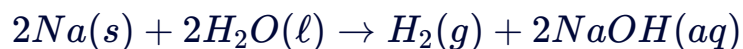
- In order for a displacement reaction to occur, we need to look at the activity series of metals
- A more reactive element will displace a less reactive element in a displacement reaction

Au	Ag	Hg	Cu	H	Pb	Sn	Ni	Fe	Zn	Al	Mg	Na	Ca	Ba	K	Li
----	----	----	----	---	----	----	----	----	----	----	----	----	----	----	---	----

-
- In **single replacement reactions**, an element replaces a similar element in another reactant. The general formula for a single replacement reaction is:



Example 1: Hydrogen can be replaced by more reactive metals



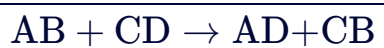
Example 2: Metals can replace other metals



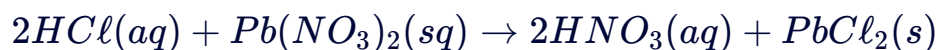
Example 3: Halogens will replace other halogens. Activity increases from the bottom to the top in the group.



- In **double replacement reactions**, the positive or negative ions of two ionic compounds switch places to form new compounds. The general formula for a double replacement reaction is:



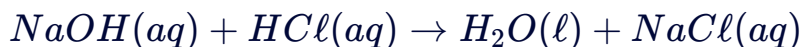
Example 1: A double replacement reaction can be used to precipitate a compound



Example 2: A double replacement reaction can be used to release a gas



Example 3: Neutralization reactions between an acid and a base are double replacement reactions



Watch the video tutorial for this lesson (04:34)

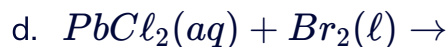
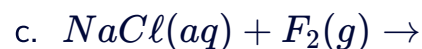
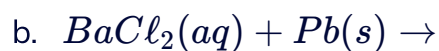
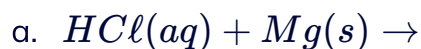
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4.2.3 Example: Using the Activity Series

Example: Using the Activity Series

Using the activity series, predict the products for each reaction. If there is no reaction, write NR (no reaction). If a reaction occurs, complete the equation and balance it.



Solution available online

b.

c.

d.

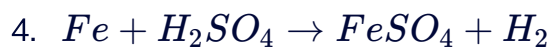
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4.2.4

Classify the following reactions as synthesis (S), decomposition (D), single-replacement (SR) or double-replacement (DR)



1. S or D or SR or DR

2. S or D or SR or DR

3. S or D or SR or DR

4. S or D or SR or DR

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4.2.5

When a solution sodium bicarbonate is heated, water vapour, carbon dioxide gas and a precipitate are formed. What type of reaction is this?

synthesis

☐

single replacement

☐

decomposition

☐

double replacement

☐

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Practice: Using the Activity Series

Based on the activity series of metals, which of the following reactions will not occur? Select all that apply.

☐☐☐☐

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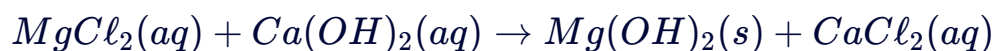


4.3 Chemical Analysis

4.3.1

Precipitation Reactions

- Two soluble ionic compounds react to form an insoluble product, that is a precipitate (solid)



- In this reaction, two water soluble salts (magnesium chloride and calcium hydroxide) react to form another soluble salt (calcium chloride) and a precipitate (magnesium hydroxide).
- How do we know magnesium hydroxide is insoluble? Check out the solubility chart below to predict the solubility of ionic compounds.

Solubility Rules

CATIONS	ALL group 1 alkali metals and ammonium (NH_4^+) compounds are soluble
HALIDES (Cl^- , I^- , Br^-)	MOST halides are soluble EXCEPT halides of silver (Ag^+), mercury (Hg^{2+}) and lead (Pb^{2+})
SOLUBLE ANIONS	ALL nitrates (NO_3^-) and acetates (CH_3COO^-) are soluble
SULFATES (SO_4^{2-})	MOST sulfates are soluble EXCEPT those of barium (Ba^{2+}), strontium (Sr^{2+}), calcium (Ca^{2+}) and lead (Pb^{2+})
INSOLUBLE ANIONS	MOST phosphates (PO_4^{3-}), carbonates (CO_3^{2-}) and sulfides (S^{2-}) are insoluble EXCEPT group 1 alkali metals and ammonium (NH_4^+) compounds
HYDROXIDES (OH^-)	MOST hydroxides are insoluble EXCEPT group 1 alkali metals, calcium (Ca^{2+}), barium (Ba^{2+}), strontium (Sr^{2+}) and ammonium (NH_4^+) compounds

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Hydrocarbon Combustion Reactions

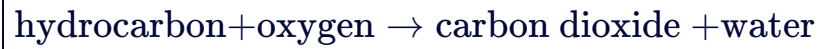
- A **combustion reactions** is a reaction between a hydrocarbon (C_xH_y) with oxygen to produce carbon dioxide (CO_2) and water (H_2O).



- Combustion reactions are commonly used in elemental analysis to determine the empirical formula of a compound.

Complete vs Incomplete Combustion:

- **Complete combustion** occurs when **an excess of oxygen** reacts with a hydrocarbon **to produce carbon dioxide and water**.



- **Incomplete combustion** occurs when there is **insufficient oxygen** present and the oxygen reacts with the hydrocarbon to form water and either carbon monoxide or carbon, or both



Steps to Balance a combustion reaction:

1. Balance the carbons
2. Balance the hydrogens
3. Balance the oxygens using ONLY the coefficient of elemental oxygen (O_2)
4. If the equation has any fractions (often times the coefficient in front of O_2 is a fraction), multiply the ENTIRE equation by 2

Example: Balance the following reaction



[Solution available online](#)

Watch the video tutorial for this lesson (03:07)

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Example: Determining the Solubility of Salts

Decide whether these following ionic salts are soluble or not in water.

1) NaCl

Solution available online

2) AgCl

Solution available online

3) BaSO₄

Solution available online

4) KNO₃

Solution available online

Watch the video tutorial for this lesson (01:46)

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4.3.4

Which of the following compounds is soluble in water at 25 °C?

$\text{Fe}(\text{OH})_2$

☐

HgS

☐

$(\text{NH}_4)_2\text{SO}_4$

☐

CaCO_3

☐

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Practice: Solubility Rules and Precipitation

Which of the following correctly describes what happens when aqueous solutions of ammonium carbonate, $(\text{NH}_4)_2\text{CO}_3$, and potassium bromide, KBr , are mixed?

No precipitate forms

☐

A precipitate of $\text{NH}_4\text{Br(s)}$ forms

☐

A precipitate of $\text{K}_2\text{CO}_3\text{(s)}$ forms

☐

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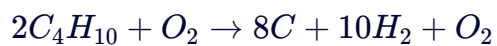
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4.3.6

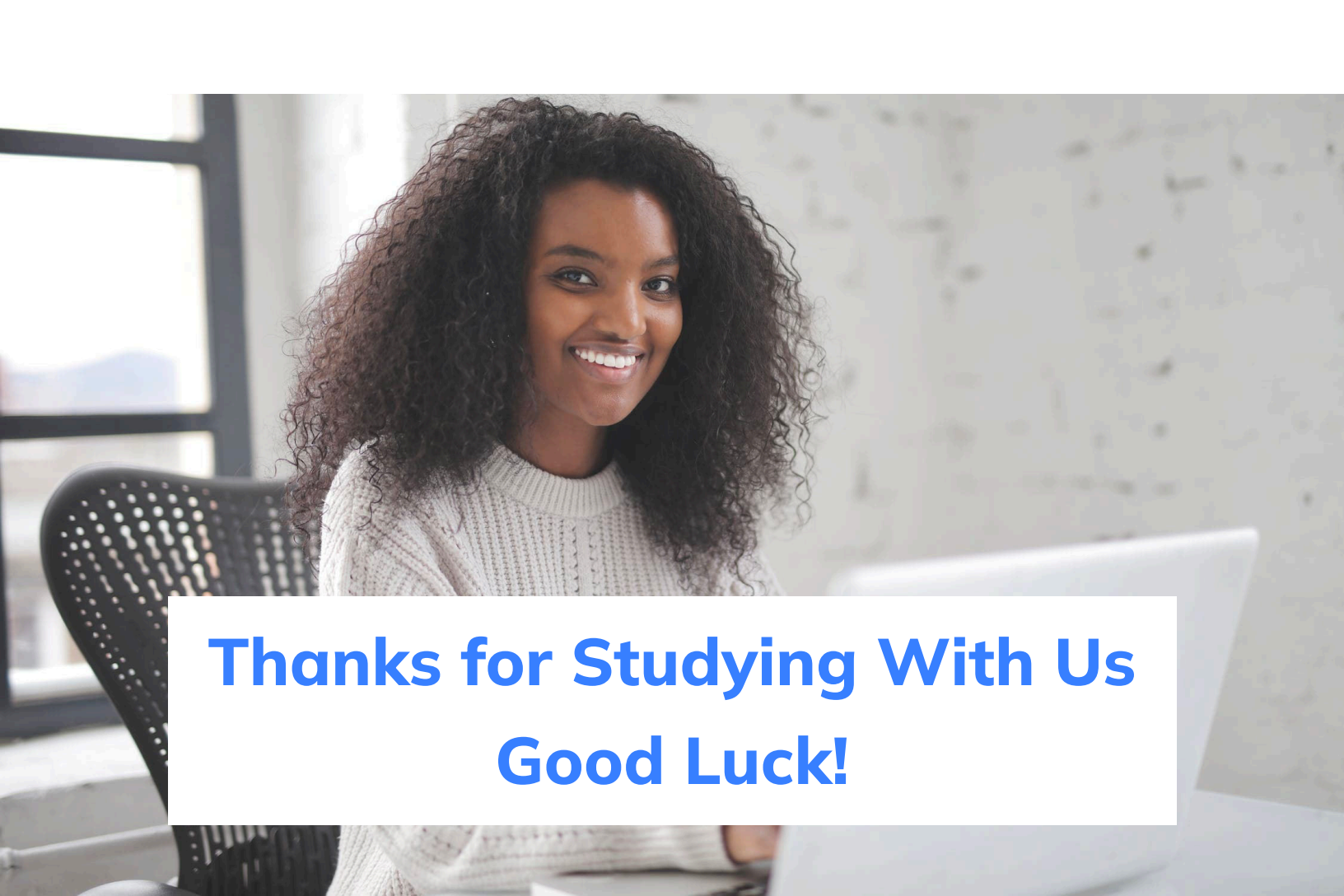
Select the correct balanced equation for the complete combustion reaction expected to occur between C_4H_{10} and O_2 .

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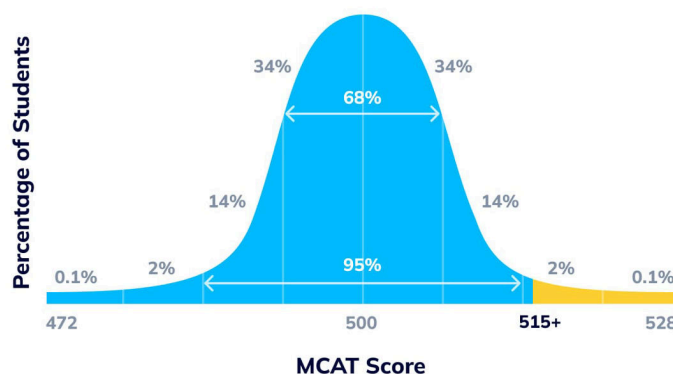
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