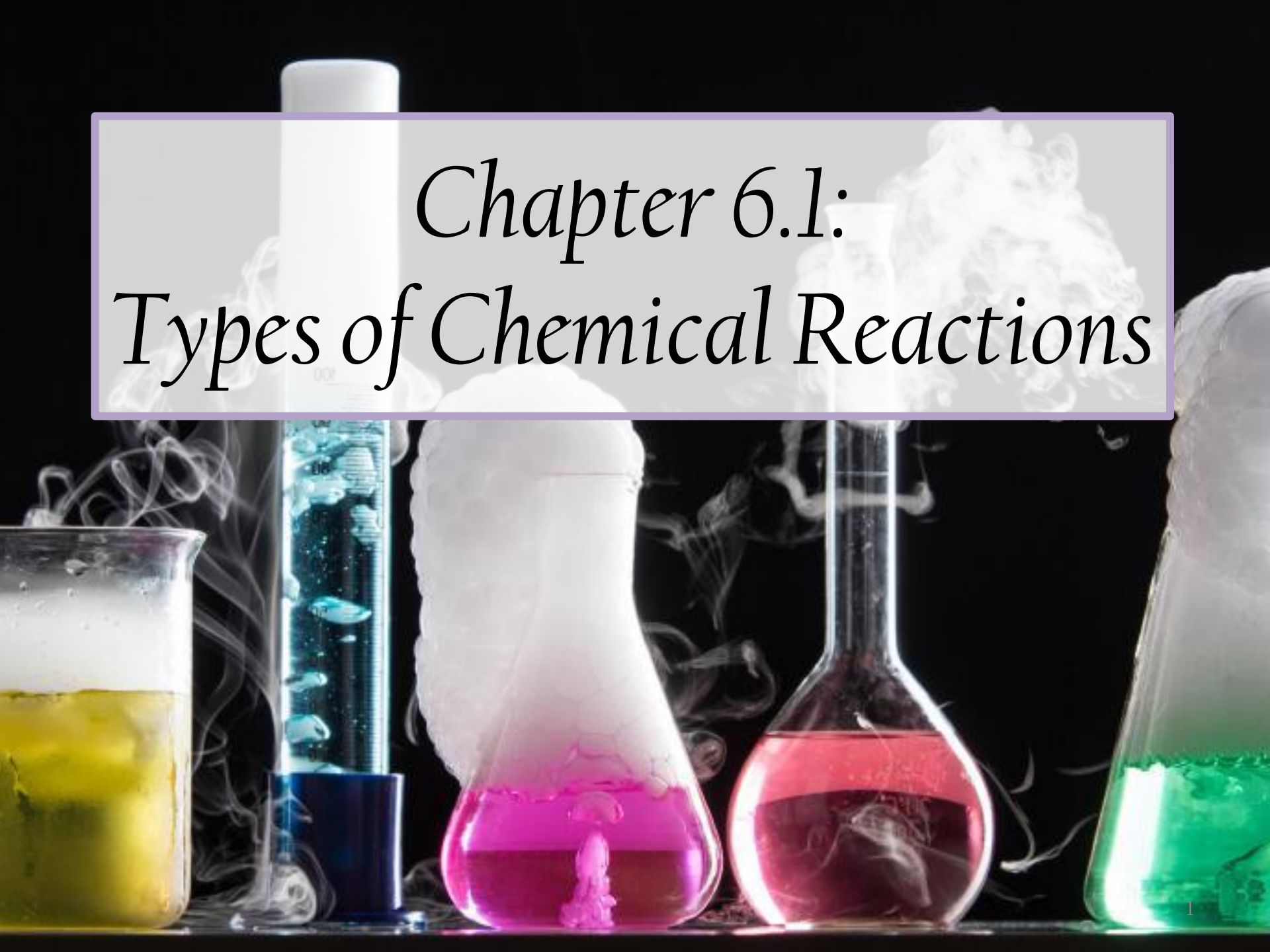


Chapter 6.1: Types of Chemical Reactions

Warm-up

Balance these equations.

1) ___ N_2 + 3 F_2 → 2 NF_3

2) 2 $KClO_3$ → 2 KCl + 3 O_2

3) ___ $C_{12}H_{22}O_{11}$ + 12 O_2 → 12 CO_2 + 11 H_2O

4) 3 $CuSO_4$ + 2 Fe → ___ $Fe_2(SO_4)_3$ + 3 Cu

5) ___ MgF_2 + ___ Li_2CO_3 → ___ $MgCO_3$ + 2 LiF

6) ___ H_3PO_4 + 3 NH_4OH → 3 H_2O + ___$(NH_4)_3PO_4$

Warm-up

Balance these equations.

Balancing chemical equations is useful, but only if we already know the reactants and products.

4) 3 $CuSO_4$ + 2 Fe → $Fe_2(SO_4)_3$ + 3 Cu

5) MgF_2 + Li_2CO_3 → $MgCO_3$ + 2 LiF

6) H_3PO_4 + 3 NH_4OH → 3 H_2O + $(NH_4)_3PO_4$

Warm-up

Predict the products.
Write your prediction down on a piece of paper.

$$CO_{2(s)} + Mg_{(s)} \rightarrow \_\_\_\_?$$

Dry ice: -78.5°C

Discuss: what do we have to consider when making predictions?

Warm-up

Discuss: what do we have to consider when making predictions?

Law of Conservation of Mass: atoms are never created or destroyed. Elements in reactants must be the same as elements in the products.

Which of these are possible?

$CO_{2(s)} + Mg_{(s)} \rightarrow$

Products	Possible?
$C + O_2 + Mg$	✓
$CO + MgO$	✓
$CH_3 + Mg$	✗
$CO_3 + Mg_2$	✗
$C_4 + MgO_2$	✗
$C + Mg + O_2 + MgO$	✓

Warm-up

Magnesium Burning in Carbon Dioxide

REACTION ONLY

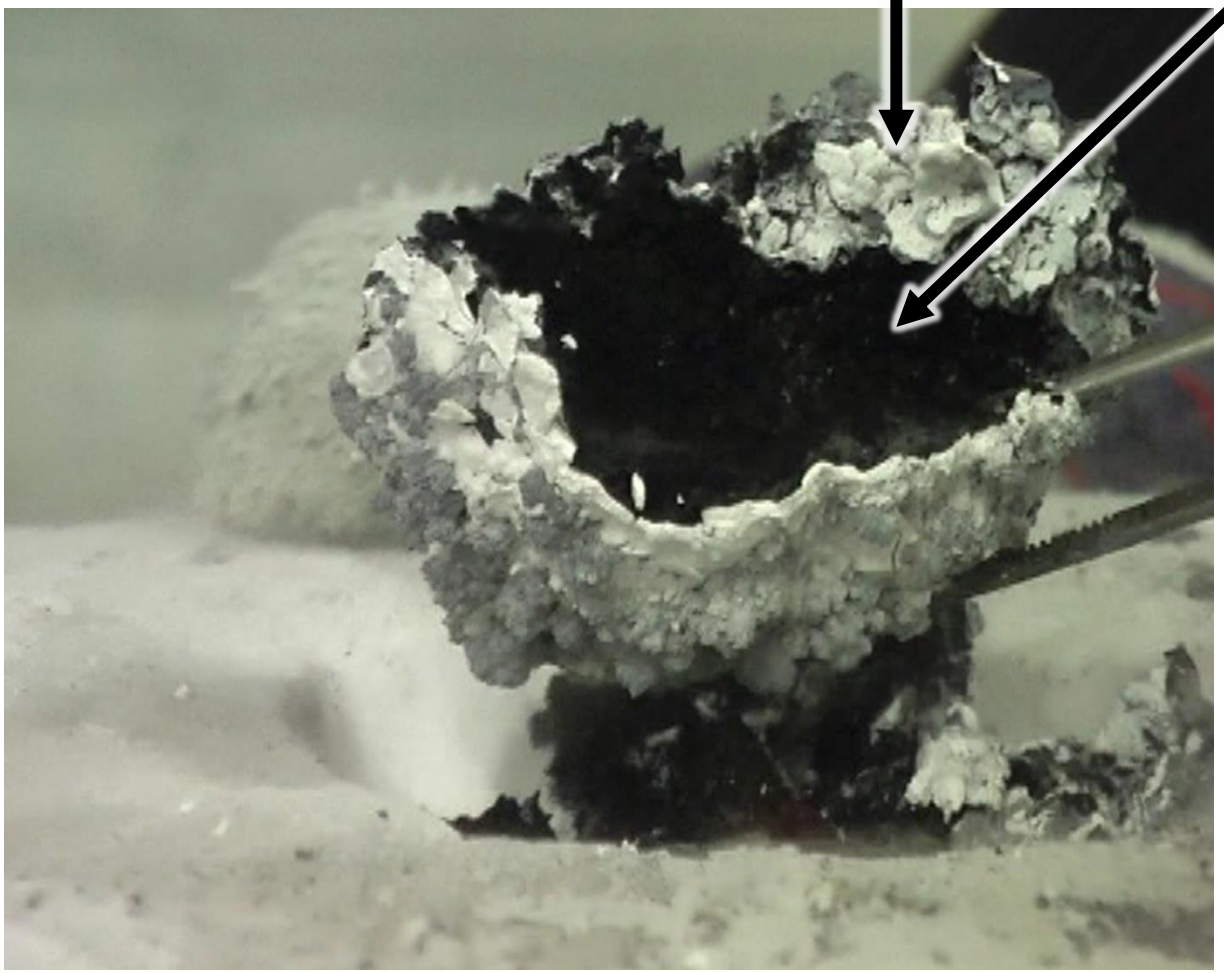
THE PERIODIC TABLE OF VIDEOS
By Brady Haran

The University of Nottingham

Full video: https://www.youtube.com/watch?v=NMZT2BAEtnc

Warm-up

$$CO_{2(s)} + Mg_{(s)} \rightarrow MgO_{(s)} + C_{(s)}$$



Introduction

To correctly predict products of a reaction, we will need to know:

- Law of Conservation of Mass: atoms are never created or destroyed; they are just rearranged in chemical reactions.
- Different types of reactions: synthesis, decomposition, single replacement, double replacement, neutralisation, combustion
- Balancing: How much reactant? How much product?

Synthesis:

combining multiple things into a single compound

$$C + O_2 \rightarrow CO_2\ Cl_2$$

Decomposition:

breaking a compound down into multiple parts

Synthesis:

combining multiple things into a single compound

$C + O_2 \rightarrow CO_2$

$Al + F_2 \rightarrow AlF_3$

$Mg + N_2 \rightarrow Mg_3N_2$

$K + O_2 \rightarrow K_2O$

Decomposition:

breaking a compound down into multiple parts

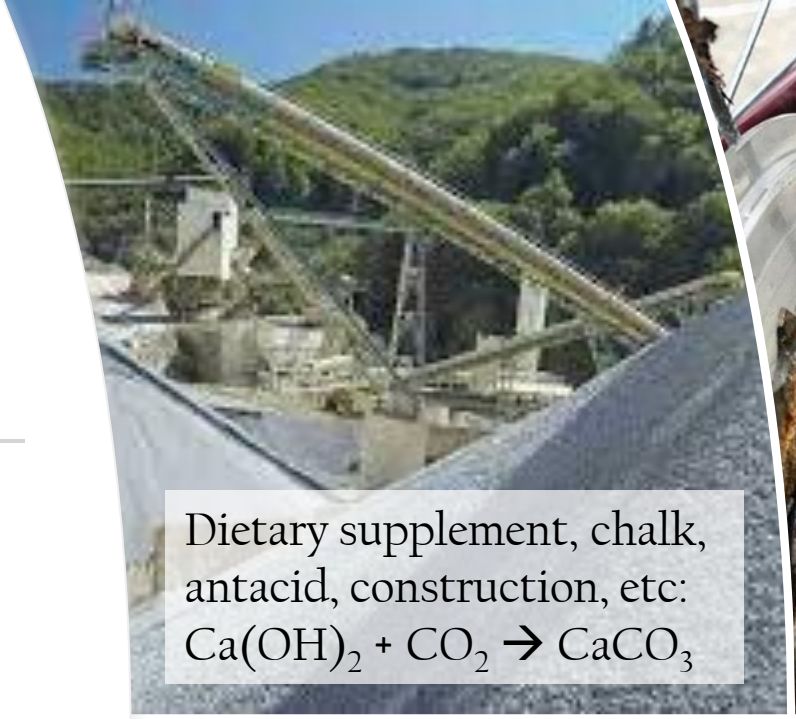
$K_2O \rightarrow K + O_2$

$H_2O \rightarrow H_2 + O_2$

$MgF_2 \rightarrow Mg + F_2$

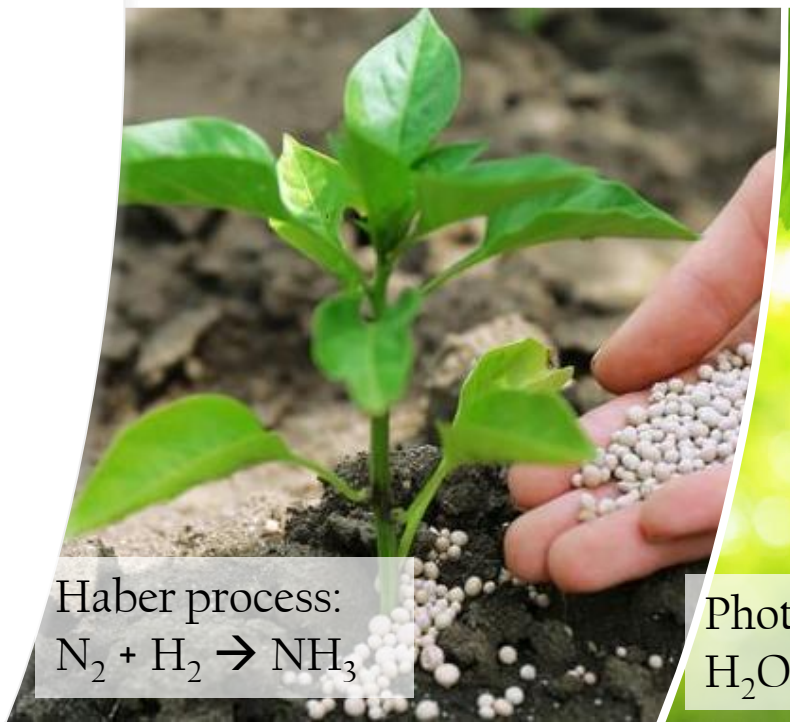
$AuCl_3 \rightarrow Au + Cl_2$

Synthesis: Real-Life Examples

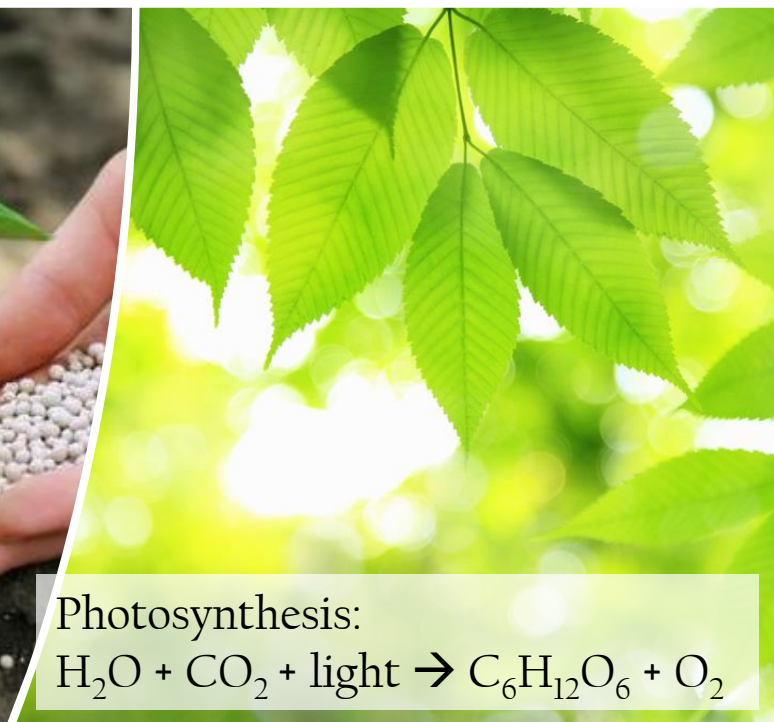


Dietary supplement, chalk, antacid, construction, etc:
$Ca(OH)_2 + CO_2 \rightarrow CaCO_3$

Rust: $Fe + O_2 \rightarrow Fe_2O_3$



Haber process:
$N_2 + H_2 \rightarrow NH_3$



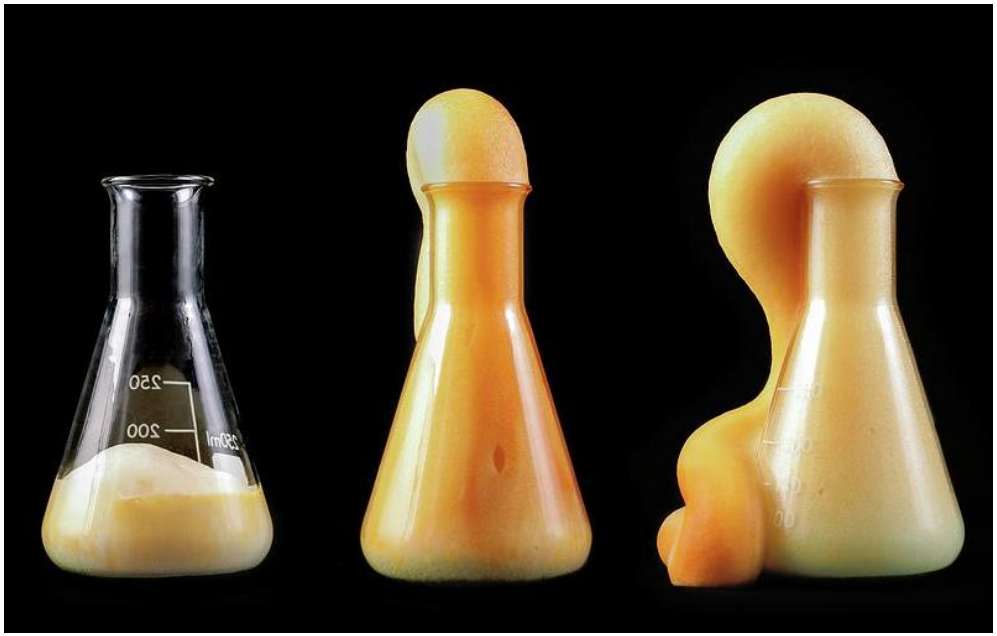
Photosynthesis:
$H_2O + CO_2 + light \rightarrow C_6H_{12}O_6 + O_2$

Decomposition: Real-Life Examples

"Elephant Toothpaste" (hydrogen peroxide decomposition)

$$H_2O_2 \rightarrow H_2O + O_2$$

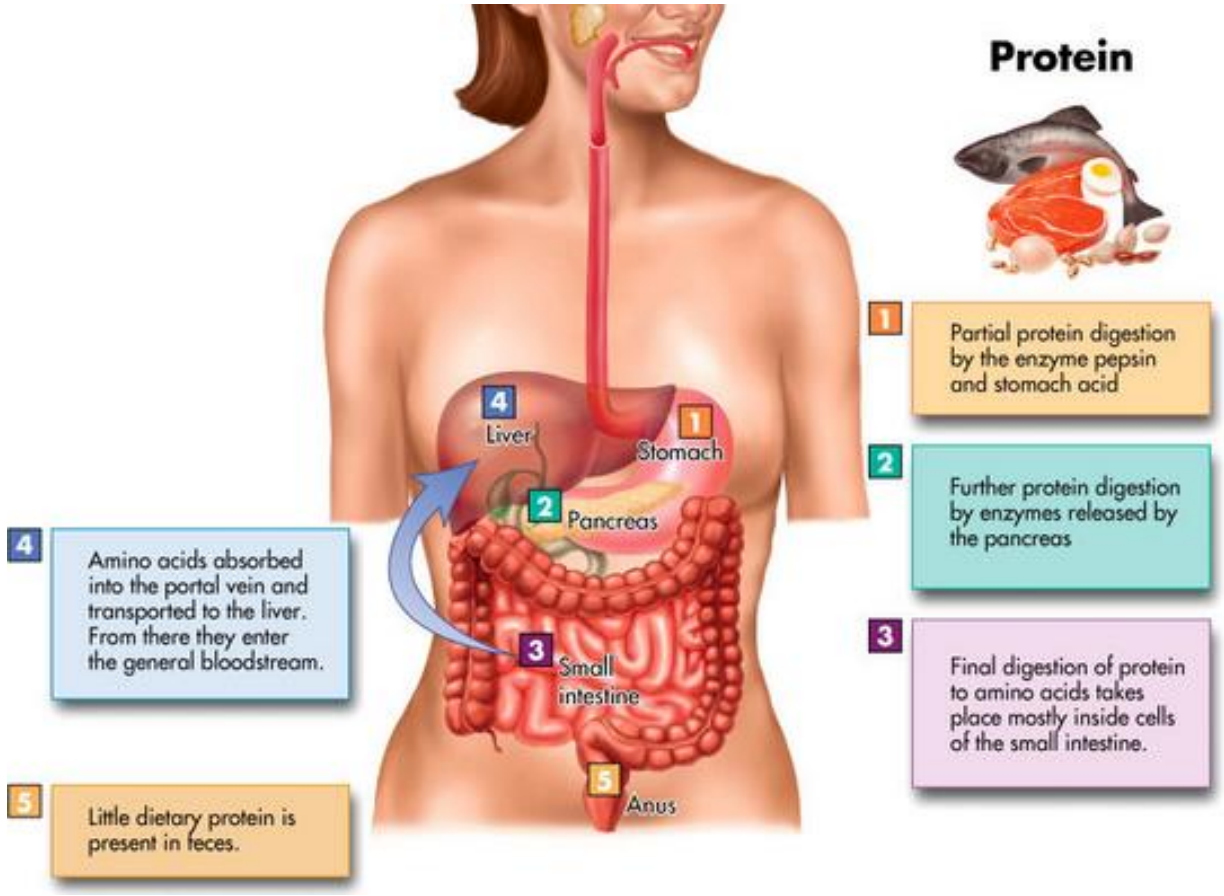
Watch https://www.youtube.com/watch?v=zbyqanuHQqU&ab_channel=VoyageDirectPrimaryCareVoyageDirectPrimaryCare from 0:30

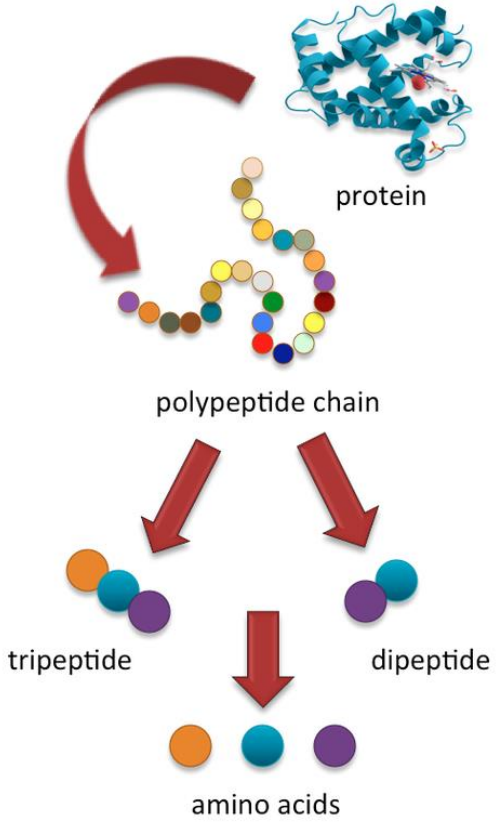


Decomposition: Real-Life Examples

During digestion, our foods are broken down into smaller parts that can be absorbed by the body.

protein → amino acids

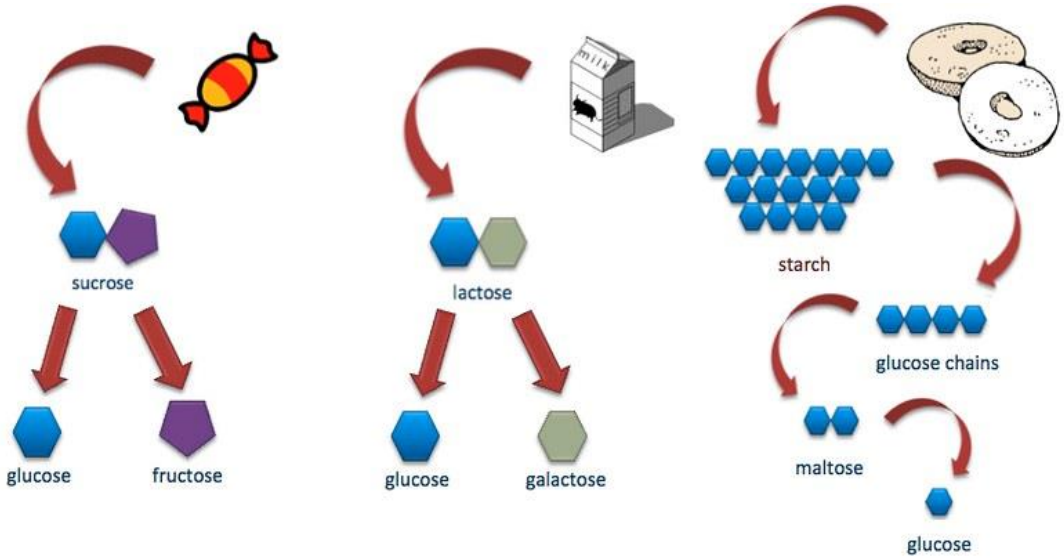




Decomposition: Real-Life Examples

During digestion, our foods are broken down into smaller parts that can be absorbed by the body.

complex carbohydrates → simple sugars



- **Mouth**
  - Salivary amylase breaks starch into sugar
- **Stomach**
  - pH is too low for amylase to work
- **Small Intestine**
  - Pancreatic juices neutralize stomach acids
  - Intestinal and pancreatic enzymes complete carbohydrate digestion

Synthesis: Predict the Products

Predicting the products of a synthesis reaction is easy! Just write the formula of the ionic compound formed between the two elements.

Example:

$2Na + Cl_2 \rightarrow 2NaCl$

$2Al + 3F_2 \rightarrow 2AlF_3$

Decomposition: Predict the Products

Predicting the products of a decomposition reaction is easy! Just write the formulas of the constituent elements.

Example:

$CuCl_2 \rightarrow Cu + Cl_2$

$2\,H_2O \rightarrow 2\,H_2 + O_2$

Summary Types of Reactions

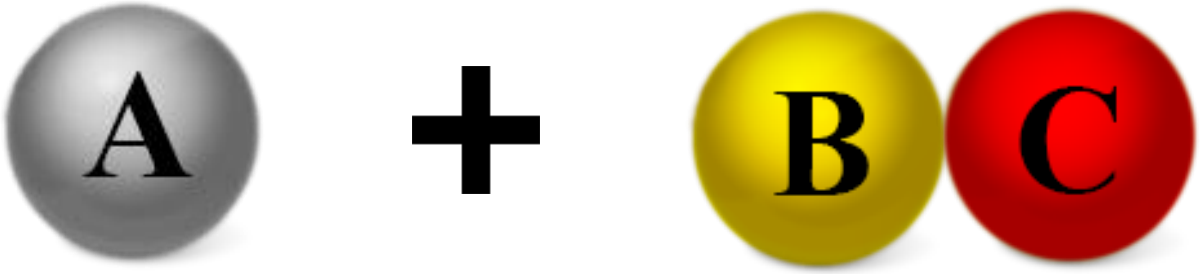
Reaction Type	Reactants	Products	Tips for Predicting Products
Synthesis	□ + □ →	□	Ionic compound between two elements. E+E→IC
Decomp-osition	□ →	□ + □	Two elements. Remember diatomic. IC→E+E or CC→E+E

Single/Double Replacement

Replacement reactions always involve at least one ionic compound.

Single Replacement

If A is a METAL:



What will the product(s) be?

a) A + BC

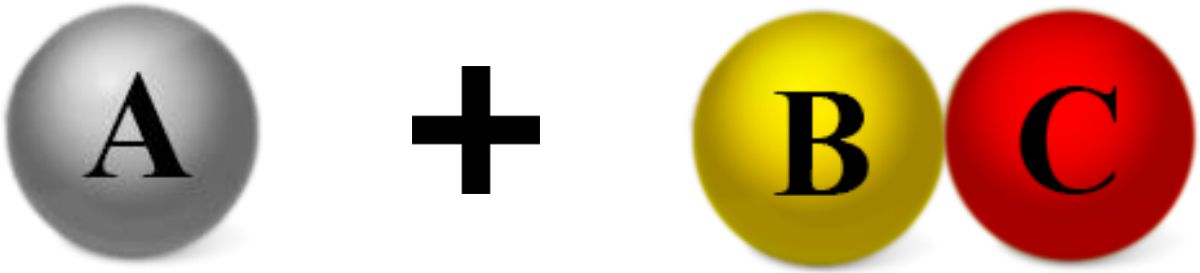
b) AB + C

c) AC + B

d) ABC

Single Replacement

If A is a NON-METAL:



What will the product(s) be?

a) B + AC

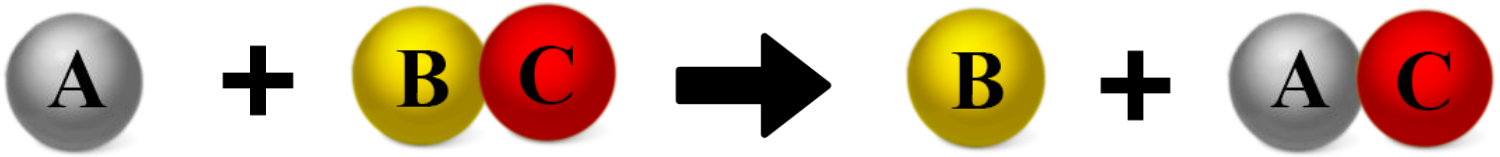
b) B + CA

c) C + AB

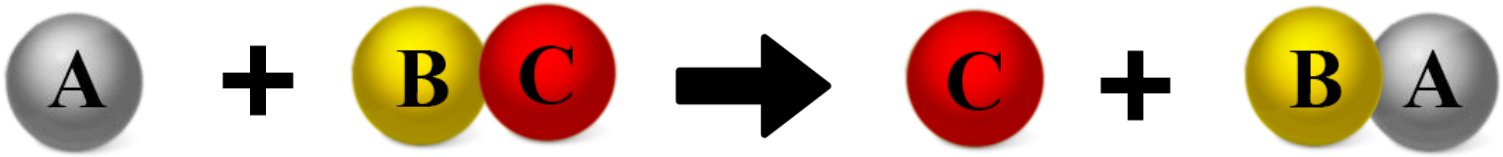
d) C + BA

Single Replacement

If A is a METAL:



If A is a NON-METAL:



Examples:

$CuSO_4 + Fe \rightarrow Fe_2(SO_4)_3 + Cu$

$LiCl + Br_2 \rightarrow LiBr + Cl_2$

$HCl + Al \rightarrow H_2 + AlCl_3$

Single Replacement: Predict the Products

To predict the products, write the formula of the new ionic compound that is formed, and the displaced element.

Examples:

$2\,Na + MgCl_2 \rightarrow 2\,NaCl + Mg$

$O_2 + 2MgF_2 \rightarrow 2F_2 + 2\,MgO$

$2\,NaBr + Cl_2 \rightarrow 2\,NaCl + Br_2$

Replacement Reactions: Real-Life Examples

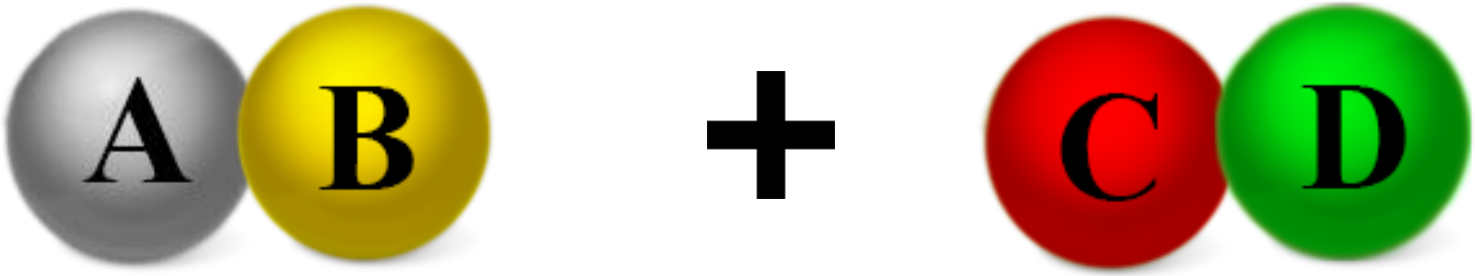
Concrete pillars contain iron rebar for structural strength. But iron reacts with salt water:

$$Fe + NaCl \rightarrow FeCl_2 + Na$$

To prevent this, attach zinc or magnesium to the iron as a 'sacrificial' element. The following reaction will occur instead and the iron is preserved!

$$Zn + NaCl \rightarrow ZnCl_2 + Na$$

Double Replacement



Examples:

$MgS + CaCl_2 \rightarrow MgCl_2 + CaS$

$RbNO_3 + BeF_2 \rightarrow Be(NO_3)_2 + RbF$

$NH_4HCO_3 + NaCl \rightarrow NaHCO_3 + NH_4Cl$

$H_3PO_4 + NH_4OH \rightarrow H_2O + (NH_4)_3PO_4$*

*This is actually a neutralization reaction, which is a type of double replacement. Stay tuned!

Replacement Reactions: Real-Life Examples

Baking soda (sodium bicarbonate) and vinegar (acetic acid) is an example of a double replacement!

$$NaHCO_3 + CH_3COOH \rightarrow H_2O + CO_2$$

Double Replacement: Predict the Products

To predict the products, write the formula of the two new ionic compounds that are formed. Use charge balancing rules.

Examples:

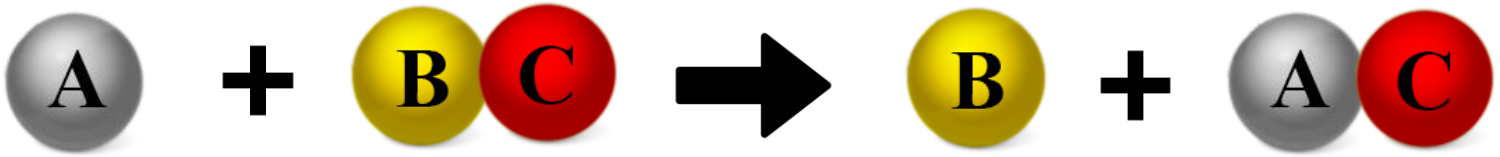
$BaCl_2 + Na_2SO_4 \rightarrow NaCl + BaSO_4$

$AgNO_3 + NaCl \rightarrow NaNO_3 + AgCl$

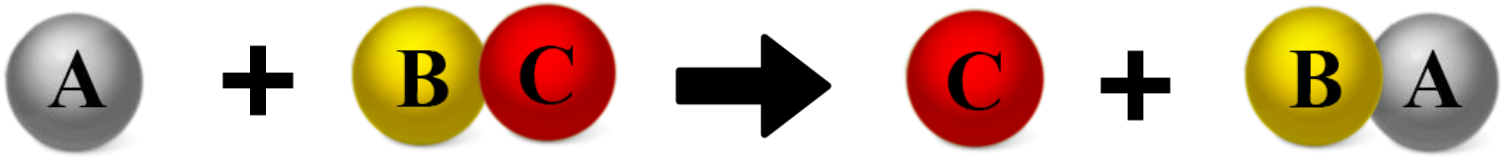
Single/Double Replacement

Single Replacement

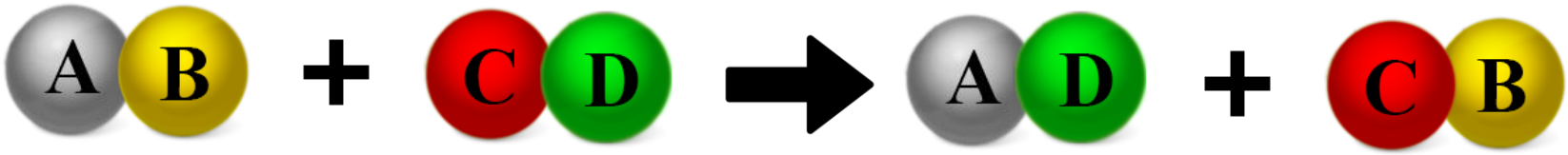
If A is a METAL:



If A is a NON-METAL:



Double Replacement



Summary Types of Reactions

Reaction Type	Reactants	Products	Tips for Predicting Products
Synthesis	□+□ →	□	Ionic compound between two elements. E+E→IC
Decomp-osition	□ →	□+□	Two elements. Remember diatomic. IC→E+E or CC→E+E
Single Replacement	□+□ → E + IC→	□+□ E + IC	Replace like with like. Ionic compound has cation and anion. Remember diatomic elements.
Double Replacement	□+□ → IC+IC→	□+□ IC + IC	Replace like with like. Ionic compound has cation and anion.

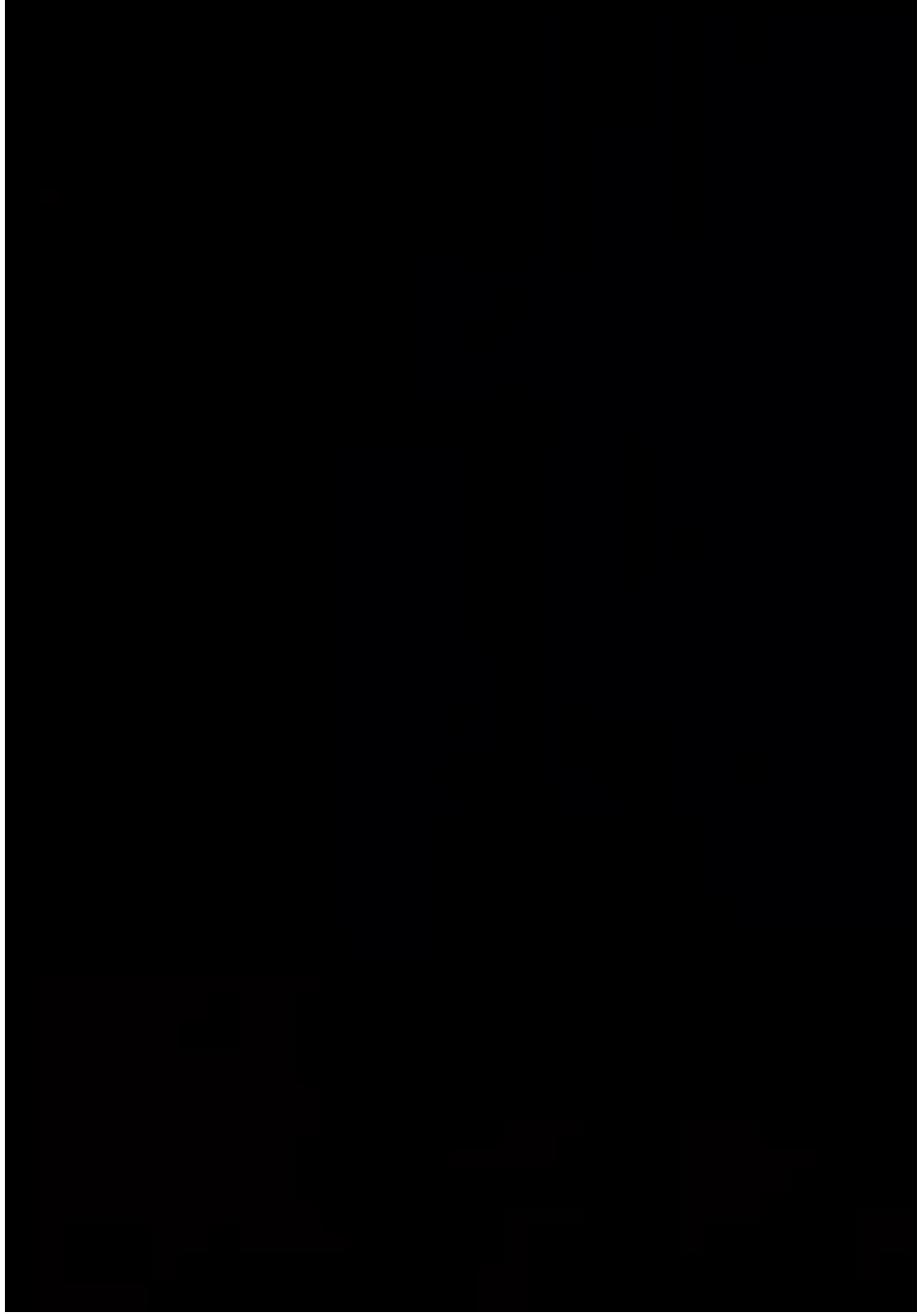
Mini Lab

Predict the products of the following. Classify the reactions as synthesis, decomposition, single replacement or double replacement.

1) lead (II) nitrate + potassium iodide →
2) aluminum + copper(II) chloride →

$$Pb(NO_3)_{2\,(aq)} + KI_{(aq)} \rightarrow PbI_{2(s)} + KNO_{3(aq)}$$

Precipitate:
an insoluble solid ionic compound that often forms in double replacement reactions

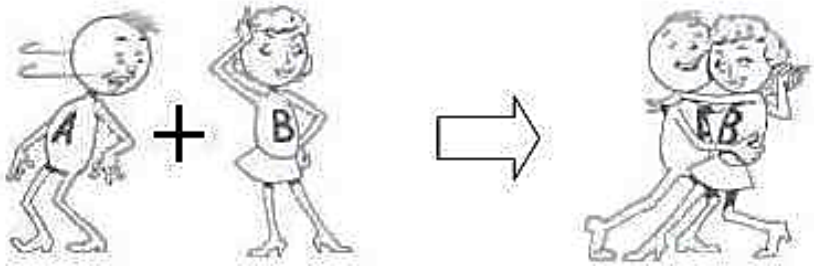


https://www.youtube.com/watch?v=2EQznGPZY5A

Dance Analogy (Warm-up)

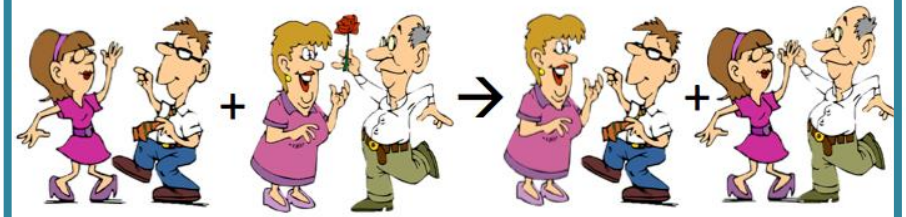
What reaction types are these?

1 Synthesis

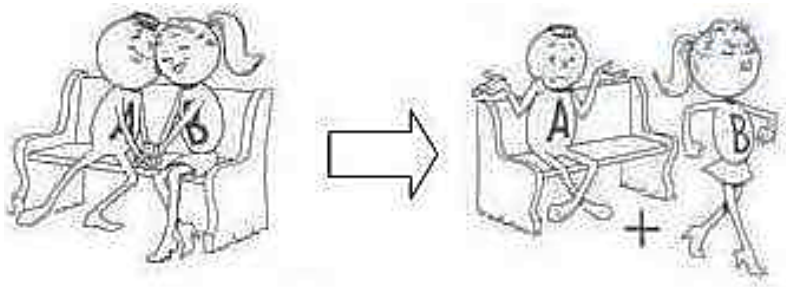


3 Single Replacement

2 Double Replacement



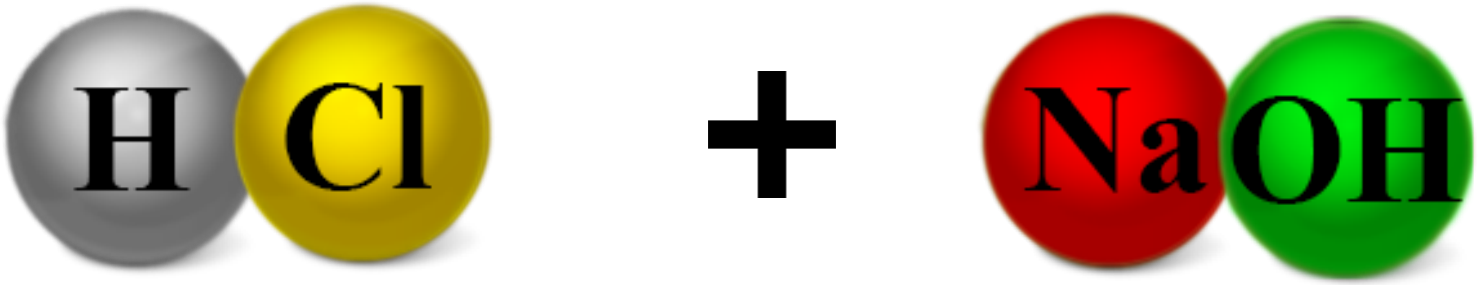
4 Decomposition



http://lorpub.gadoe.org/State%20of%20Georgia/GAVS%20Shared/Science/APChem_ChemicalReactions_Shared/APChem_ChemicalReactions_Shared2.html 31

Neutralisation

Neutralisation is a type of double replacement reaction. (Sometimes, salts are precipitates)!

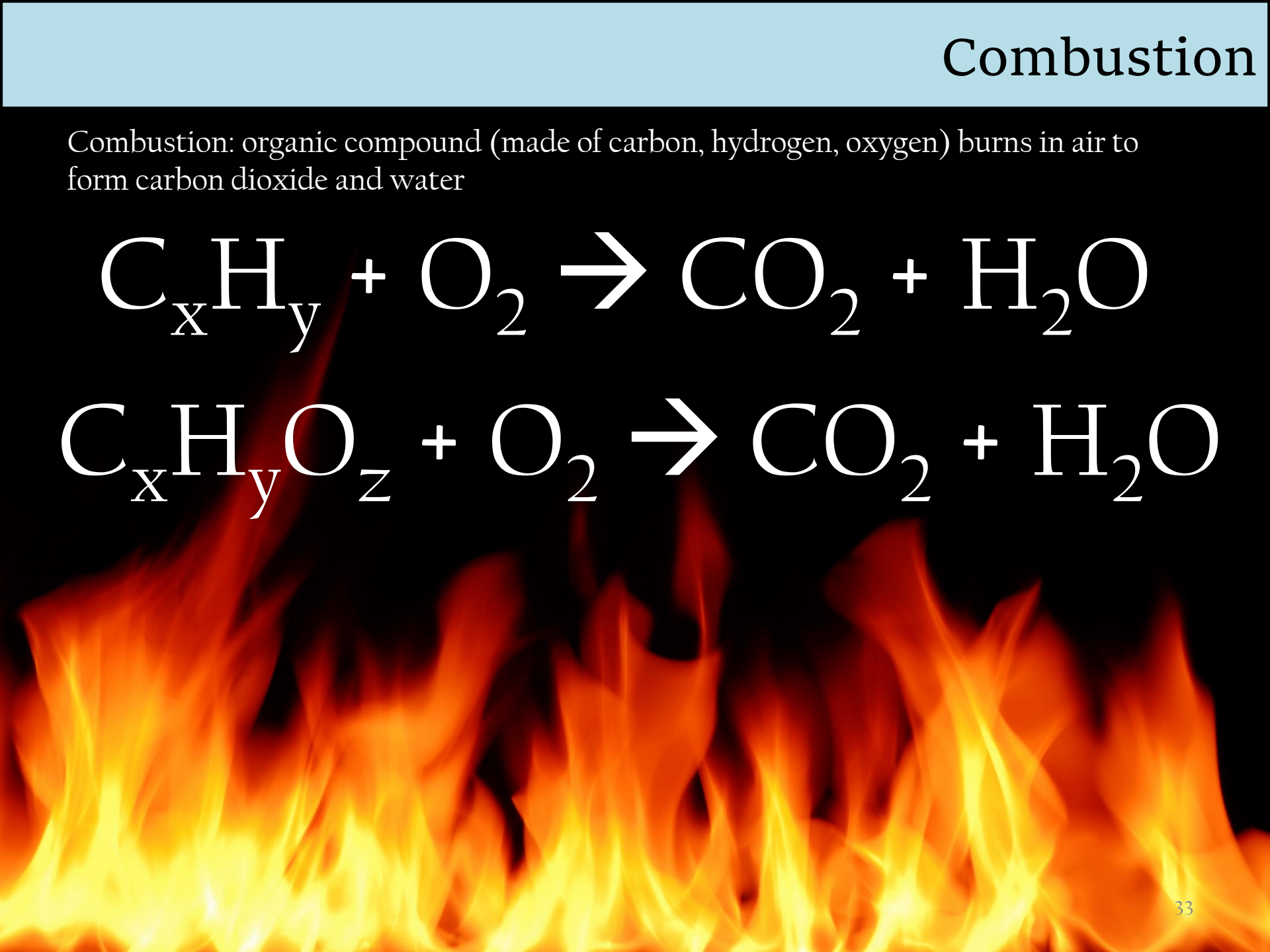


Combustion

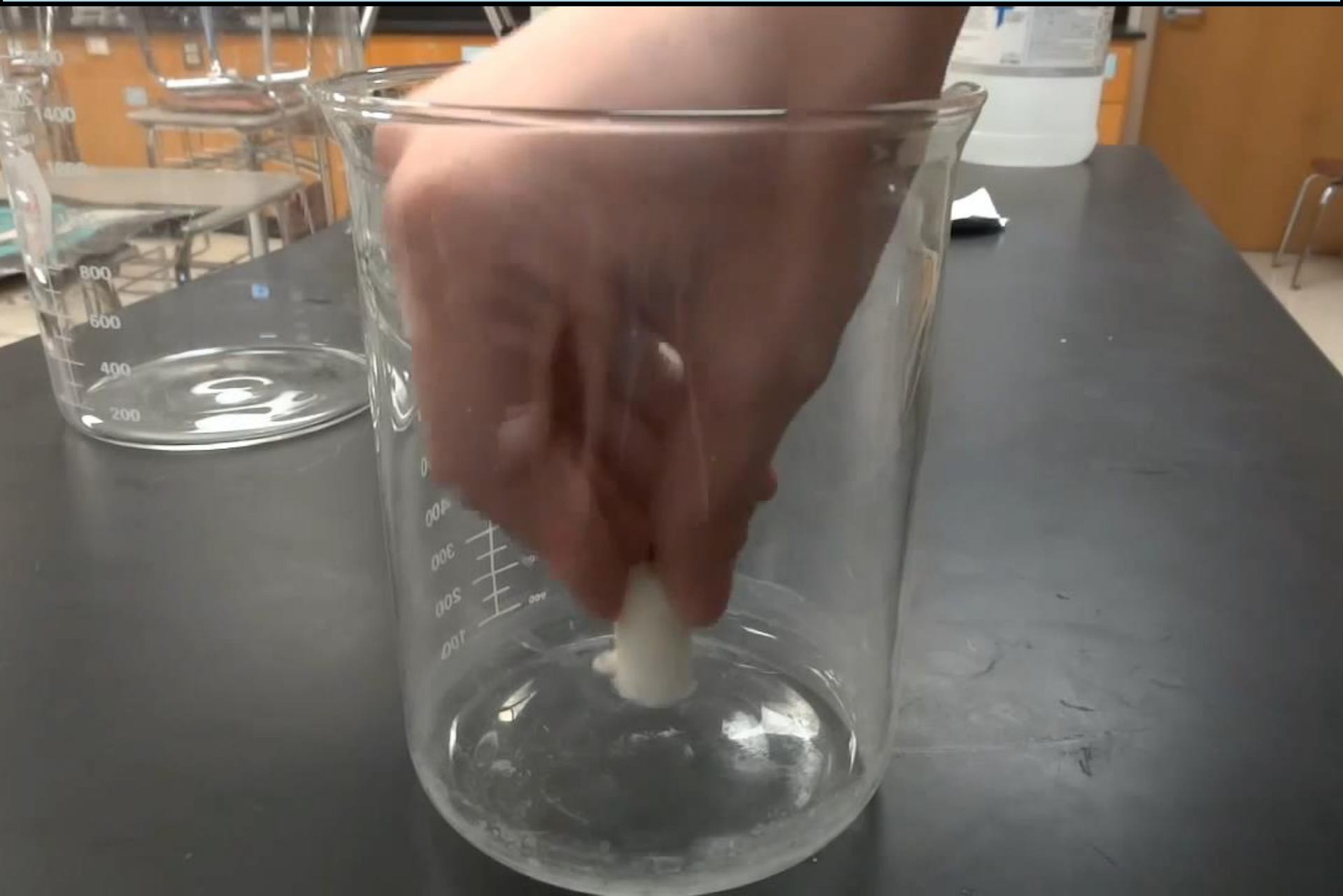
Combustion: organic compound (made of carbon, hydrogen, oxygen) burns in air to form carbon dioxide and water

$$C_xH_y + O_2 \rightarrow CO_2 + H_2O$$

$$C_xH_yO_z + O_2 \rightarrow CO_2 + H_2O$$



Combustion



Combustion

https://www.youtube.com/watch?v=UygUcMkRy_c&ab_channel=MrLundScience

Combustion

$$C_xH_yO_z + O_2 \rightarrow CO_2 + H_2O$$

Candle wax:

$C_{31}H_{64}$

Discussion

Why does water sometimes drip out from car tailpipes?

General Notes

- Balance your equations!
- Beware diatomic elements!
  (H, I, Br, O, N, Cl, F)
  - Decomposition
  - Single replacement

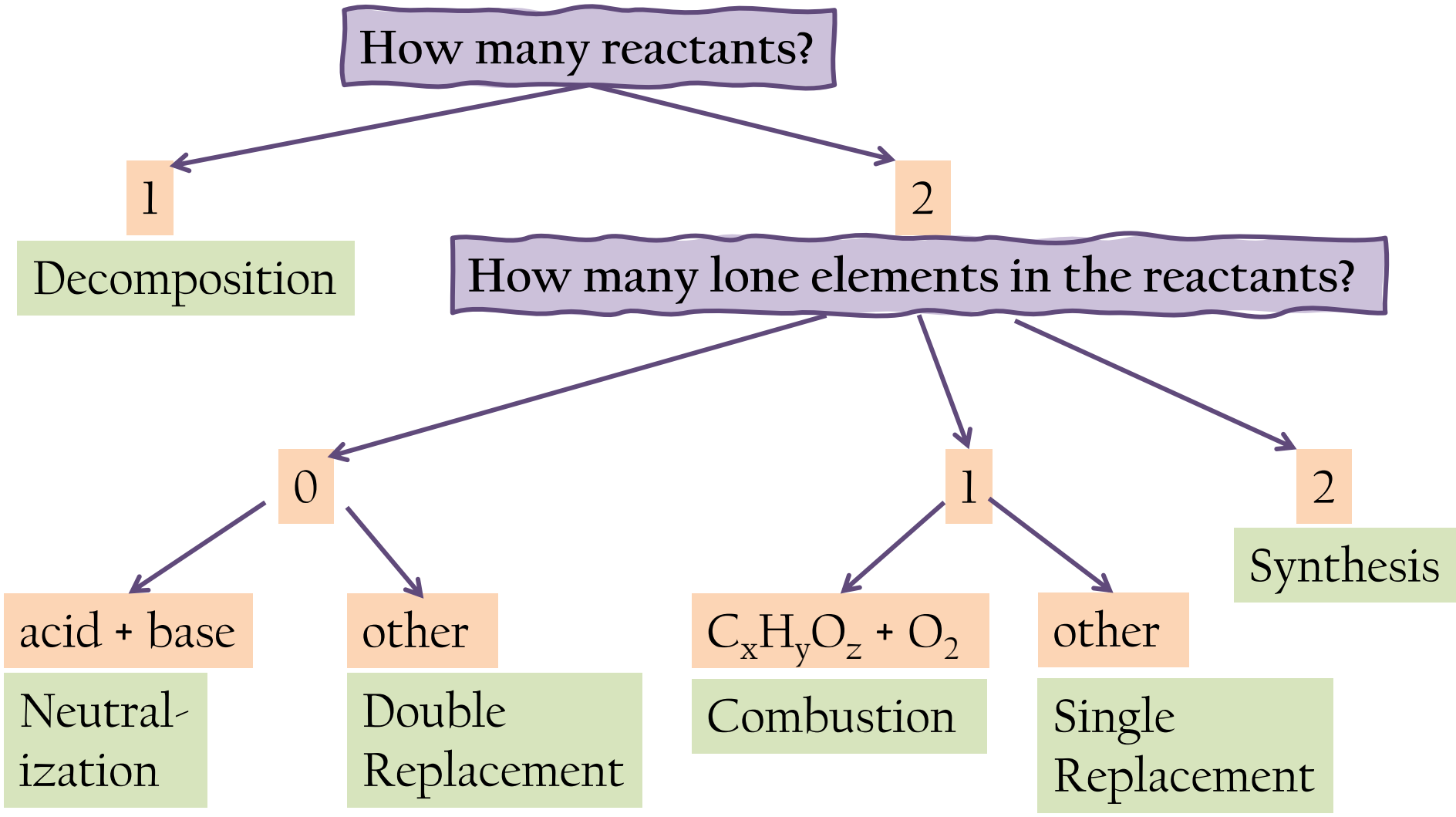
Exit Slip (/5)

- Observations: Before, During, After (/1)
- Chemical Equation
  - Reactants (/1)
  - Products (/1)
  - Balancing (/1)
- What type of reaction?
  - Synthesis, Decomposition, Single Replacement, or Double Replacement? (/1)

Summary Types of Reactions

Reaction Type	Reactants	Products	Tips for Predicting Products
Synthesis	□+□ →	□	Ionic compound between two elements. E+E→IC
Decomp-osition	□ →	□+□	Two elements. Remember diatomic. IC→E+E or CC→E+E
Single Replacement	E + IC→	E+IC	Replace like with like. Ionic compound has cation and anion. Remember diatomic.
Double Replacement	IC+IC→	IC+IC	Replace like with like. Ionic compound has cation and anion.
Neutralisation	HY + XOH→	H_2O + XY	Ions that are not hydrogen or hydroxide combine to form ionic compound salt.
Combustion	$C_xH_yO_z$ + O_2→	H_2O + CO_2	Very easy. Is always the same.

Summary Types of Reactions



Resources

Lots of videos on youtube! Some among many...

Most reaction types (missing neutralisation):

https://www.youtube.com/watch?v=aMU1RaRulSo&t=194s

https://www.youtube.com/watch?v=2qX9MOQOmAM

Synthesis (lots of examples)

https://www.youtube.com/watch?v=X-yVwNeb0aI

Synthesis/decomposition (goes slowly)

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

Synthesis/decomposition (has cool demos)

https://www.youtube.com/watch?v=yS8noHTIJ_E

Single/double replacement

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

Combustion

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

Resources

Khan Academy!

Single Replacement:

https://www.khanacademy.org/science/chemistry/chemical-reactions-stoichiome/types-of-chemical-reactions/a/single-replacement-reactions

Double Replacement:

https://www.khanacademy.org/science/chemistry/chemical-reactions-stoichiome/types-of-chemical-reactions/a/double-replacement-reactions