Chapter 6 Review Problems

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6.1) A chemical reaction is a process in which chemical bond(s) are broken and/or new bonds are made, such that one or more new ____________________ are formed.

a) elements

b) phases

c) substances

d) crystalline solids

e) friendships

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6.1) A chemical reaction is a process in which chemical bond(s) are broken and/or new bonds are made, such that one or more new ____________________ are formed.

HINT:

a) elements

b) phases

c) substances

d) ~~crystalline solids~~

e) ~~friendships~~

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6.1) A chemical reaction is a process in which chemical bond(s) are broken and/or new bonds are made, such that one or more new ____________________ are formed.

a) elements

b) phases

c) substances

d) crystalline solids

e) friendships

EXPLANATION: Whenever a **new substance** has formed, a chemical reaction has occurred.

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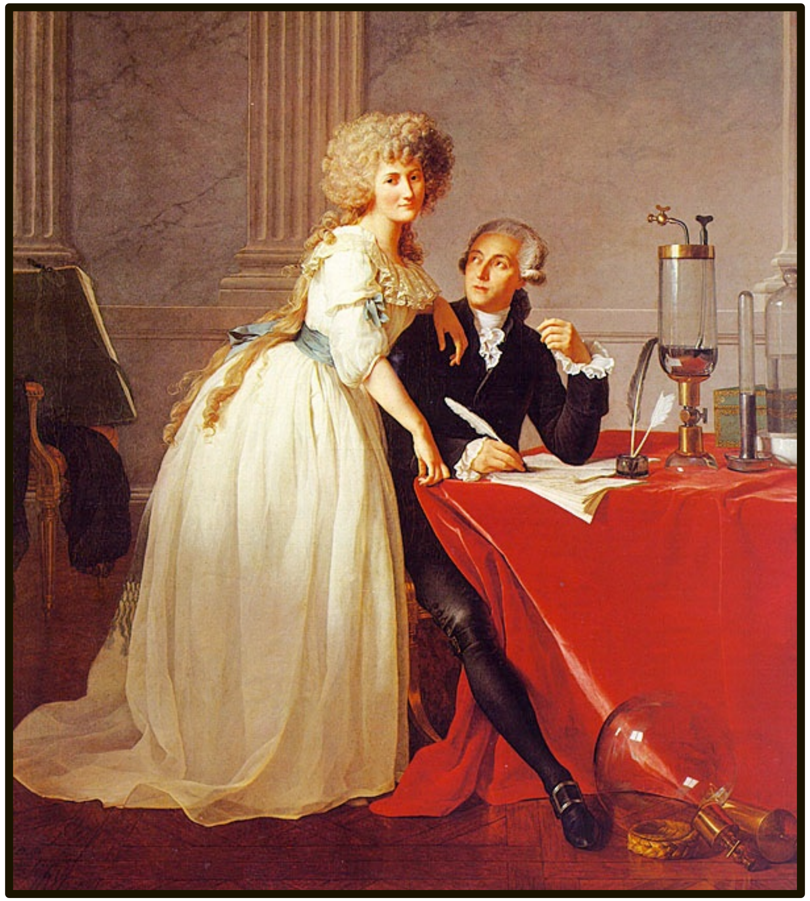
6.2) Antoine Lavoisier and his wife, Marie-Anne Pierette Paulze, and Mikhail Lomonosov are credited for proposing and verifying the **law of conservation of mass**. This law states that matter is neither created nor destroyed in a chemical reaction, only the chemical bonding changes.



Antoine Lavoisier (1743-1794) and Marie-Anne Pierette Paulze (1758-1836)

The *law of conservation of mass* requires that the same number of ___________ of each element appear on *both sides* of the chemical equation; when this is applied to a chemical equation, we say that the equation is "*balanced*."

a) molecules

b) atoms

c) reactants

d) products

In order to balance chemical equations, we ___________________________.

a) change the subscripts in the formulas of compounds

b) add product molecules

c) use stoichiometric coefficients

d) remove reactants or products from the chemical equation

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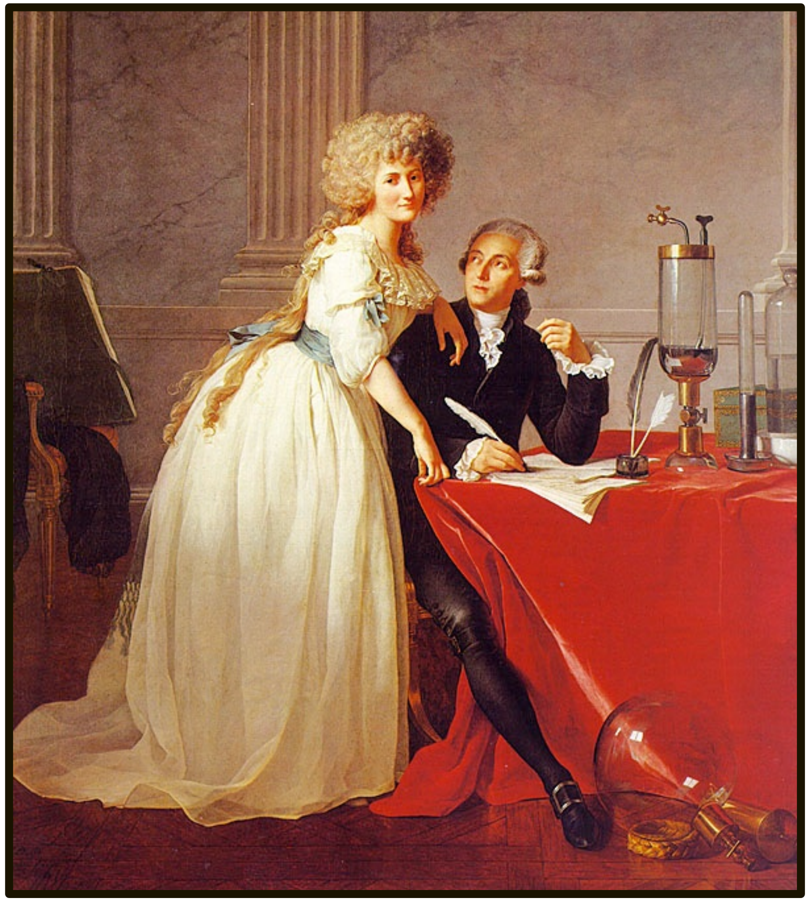

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HINT:

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b) atoms

c) ~~reactants~~

d) products

In order to balance chemical equations, we ___________________________.

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d) ~~remove reactants or products from the chemical equation~~

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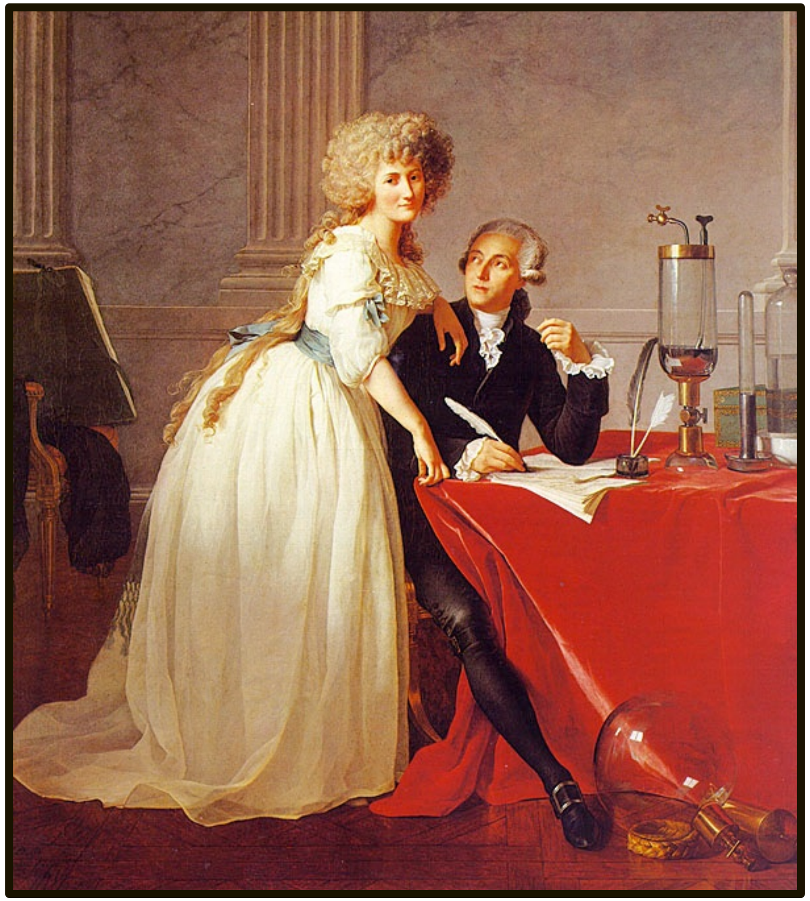

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a) molecules

b) atoms

c) reactants

d) products

In order to balance chemical equations, we ___________________________.

a) change the subscripts in the formulas of compounds

b) add product molecules

c) use stoichiometric coefficients

d) remove reactants or products from the chemical equation

EXPLANATION: The **coefficients** indicate the **multiples** of each reactant and each product needed in order to have a *balanced equation*.

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6.3) Answer the following questions about the chemical equation shown below:

$$N_2 + 3\ H_2 \rightarrow 2\ NH_3$$

a) What are the reactants?

b) What is the product?

c) What is the number "2" in front of the H_2 called?

d) Is the equation balanced?

e) Why is there not a coefficient for N_2?

f) How many nitrogen **atoms** are needed to produce **two** NH_3 molecules?

g) How many hydrogen **atoms** are needed to produce **two** NH_3 molecules?

h) How many hydrogen **molecules** are needed to produce **two** NH_3 molecules?

i) How many nitrogen **molecules** are needed to produce **two** NH_3 molecules?

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6.3) Answer the following questions about the chemical equation shown below:

$$N_2 + 3\ H_2 \rightarrow 2\ NH_3$$

HINTS:

a) What are the reactants? Reactants are written on the ***left hand*** side of the arrow in chemical equations.

b) What is the product? Products are written on the ***right hand*** side of the arrow in chemical equations.

c) What is the number "2" in front of the H_2 called?

d) Is the equation balanced? Are there the same number of nitrogen and hydrogen atoms on *both sides* of the equation?

e) Why is there not a coefficient for N_2? What is written if a coefficient is **1?**

f) How many nitrogen **atoms** are needed to produce **two** NH_3 molecules? **Each** NH_3 molecule contains one **nitrogen atom**.

g) How many hydrogen **atoms** are needed to produce **two** NH_3 molecules?

h) How many hydrogen **molecules** are needed to produce **two** NH_3 molecules?

i) How many nitrogen **molecules** are needed to produce **two** NH_3 molecules?

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6.3) Answer the following questions about the chemical equation shown below:

$$N_2 + 3\ H_2 \rightarrow 2\ NH_3$$

a) What are the reactants? N_2 and H_2 Reactants are written on the ***left hand*** side of the arrow in chemical equations.

b) What is the product? NH_3 Products are written on the ***right hand*** side of the arrow in chemical equations.

c) What is the number "2" in front of the H_2 called? a coefficient The **coefficients** indicate the **multiples** of each reactant and each product needed in order to have a *balanced equation*.

d) Is the equation balanced? yes The same number of nitrogen and hydrogen atoms appear on *both sides* of the equation.

e) Why is there not a coefficient for N_2? When the coefficient is **1**, it is omitted.

f) How many nitrogen **atoms** are needed to produce **two** NH_3 molecules? **two**
Each NH_3 molecule contains one **nitrogen atom**, so two NH_3 molecules contain **two** nitrogen atoms.

g) How many hydrogen **atoms** are needed to produce **two** NH_3 molecules? **six**
Each NH_3 molecule contains three **hydrogen atoms**, so two NH_3 molecules contain **six** hydrogen atoms.

h) How many hydrogen **molecules** are needed to produce **two** NH_3 molecules? **three**
The coefficients indicate that **three** hydrogen *molecules* are needed to produce two NH_3 *molecules*.

i) How many nitrogen **molecules** are needed to produce **two** NH_3 molecules? **one**
The *implied* coefficient of "**1**" indicates that **one** nitrogen *molecule* is needed to produce two NH_3 *molecules*.

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6.4) Balance the following chemical equations. You **do not** need to include the *states* of the reactants or products.

a) $Cu(NO_3)_2$ + $NaBr$ → $CuBr_2$ + $NaNO_3$

Reminder: When a *polyatomic ion*, such as $\mathbf{NO_3^-}$, appears on ***both sides*** of an equation, it may be counted as if it was one "element."

b) $FeCl_3$ + Na_2CO_3 → $Fe_2(CO_3)_3$ + $NaCl$

c) K + H_2O → KOH + H_2

d) $Al_2(CO_3)_3$ + MgI_2 → AlI_3 + $MgCO_3$

e) SnS_2 + O_2 → SnO_2 + SO_2

f) Ba + O_2 → BaO

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b) $FeCl_3$ + Na_2CO_3 → $Fe_2(CO_3)_3$ + $NaCl$

c) K + H_2O → KOH + H_2

d) $Al_2(CO_3)_3$ + MgI_2 → AlI_3 + $MgCO_3$

e) SnS_2 + O_2 → SnO_2 + SO_2

f) Ba + O_2 → BaO

HINT:

There are ***three steps*** involved in the *systematic balancing method*:

Step 1: Make a table that lists the elements that are present and count all atoms on each side of the *unbalanced* equation.

- If **H_2 or O_2** is present, list these elements last.
- A polyatomic ion may be counted as one "element" ***if it appears on both sides of the equation.***

Step 2: Balance an element in the table by adding ***coefficient(s)*** to the equation (start with the first element on the list).

Step 3: Recount each atom and update the table, then repeat **Steps 2 and 3** for all elements as needed until the equation is balanced.

For more details, see chapter 6 part 2 video or chapter 6 section 3 in the textbook.

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6.4) Balance the following chemical equations. You **do not** need to include the *states* of the reactants or products.

a) $Cu(NO_3)_2 + 2\ NaBr \rightarrow CuBr_2 + 2\ NaNO_3$

b) $2\ FeCl_3 + 3\ Na_2CO_3 \rightarrow Fe_2(CO_3)_3 + 6\ NaCl$

c) $2\ K + 2\ H_2O \rightarrow 2\ KOH + H_2$

d) $Al_2(CO_3)_3 + 3\ MgI_2 \rightarrow 2\ AlI_3 + 3\ MgCO_3$

e) $SnS_2 + 3\ O_2 \rightarrow SnO_2 + 2\ SO_2$

f) $2\ Ba + O_2 \rightarrow 2\ BaO$

EXPLANATION:

There are ***three steps*** involved in the *systematic balancing method*:

Step 1: Make a table that lists the elements that are present and count all atoms on each side of the *unbalanced* equation.

- If **H_2 or O_2** is present, list these elements last.
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For more details, see chapter 6 part 2 video or chapter 6 section 3 in the textbook.
If you are still struggling with balancing after that, *see you instructor for one-on-one help*.

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6.5) Write ***balanced chemical equations*** for each of the following *equation descriptions*. You **do not** need to include the *states* of the reactants or products.

a) Aluminum metal ***reacts with*** copper(II) bromide ***to produce*** aluminum bromide and copper metal.

b) Lead(II) nitrate reacts with sodium bromide to produce lead(II) bromide and sodium nitrate.

c) Barium metal reacts with oxygen gas to produce barium oxide
(Recall that oxygen is one of the diatomic molecules that are referred to by their element's name).

d) Aluminum sulfate reacts with barium iodide to produce aluminum iodide and barium sulfate.

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6.5) Write ***balanced chemical equations*** for each of the following *equation descriptions*. You **do not** need to include the *states* of the reactants or products.

HINT: Before attempting to balance the equations, you must first convert the ***compound names*** into the correct ***chemical formulas***. If you begin to struggle with that, you may wish to go back to chapter 3 and re-work the naming problems.

a) Aluminum metal ***reacts with*** copper(II) bromide ***to produce*** aluminum bromide and copper metal.

b) Lead(II) nitrate reacts with sodium bromide to produce lead(II) bromide and sodium nitrate.

c) Barium metal reacts with oxygen gas to produce barium oxide
(Recall that oxygen is one of the diatomic molecules that are referred to by their element's name).

d) Aluminum sulfate reacts with barium iodide to produce aluminum iodide and barium sulfate.

For more help, see chapter 6 part 2 video or chapter 6 section 3 in the textbook.
If you are still struggling with balancing after that, *see you instructor for one-on-one help*.

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6.5) Write ***balanced chemical equations*** for each of the following *equation descriptions*. You **do not** need to include the *states* of the reactants or products.

EXPLANATION: You must first convert the ***compound names*** into the correct ***chemical formulas***. If you struggled with that, you may wish to go back to chapter 3 and re-work the naming problems.

a) Aluminum metal ***reacts with*** copper(II) bromide ***to produce*** aluminum bromide and copper metal.

$$2\,Al + 3\,CuBr_2 \rightarrow 2\,AlBr_3 + 3\,Cu$$

b) Lead(II) nitrate reacts with sodium bromide to produce lead(II) bromide and sodium nitrate.

$$Pb(NO_3)_2 + 2\,NaBr \rightarrow PbBr_2 + 2\,NaNO_3$$

c) Barium metal reacts with oxygen gas to produce barium oxide
(Recall that oxygen is one of the diatomic molecules that are referred to by their element's name).

$$2\,Ba + O_2 \rightarrow 2\,BaO$$

d) Aluminum sulfate reacts with barium iodide to produce aluminum iodide and barium sulfate.

$$Al_2(SO_4)_3 + 3\,BaI_2 \rightarrow 2\,AlI_3 + 3\,BaSO_4$$

For more details on balancing equations, see chapter 6 part 2 video or chapter 6 section 3 in the textbook.
If you are still struggling with balancing after that, *see you instructor for one-on-one help*.

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6.6) For the combustion of methane reaction, how many moles of H_2O can be produced from 1.30 moles of methane (CH_4)? Assume you have an unlimited supply of O_2.

$$CH_4\,(g) + \mathbf{2}\,O_2\,(g) \rightarrow CO_2\,(g) + \mathbf{2}\,H_2O\,(g)$$

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$$CH_4\,(g) + \mathbf{2}\,O_2\,(g) \rightarrow CO_2\,(g) + \mathbf{2}\,H_2O\,(g)$$

HINT: We approach stoichiometry problems ***just as we did with unit conversion problems using our factor-label method.***

- In this problem, we are converting from units of "**moles of CH_4**" to units of "**moles of H_2O.**"
- The stoichiometric coefficients provide the relationship between "**moles of CH_4**" and "**moles of H_2O.**"
  - For every **1 mole of CH_4** that reacts, **2 moles of H_2O** are produced. This relationship is used as a ***conversion factor***.

1.30 moles CH_4		=

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6.6) For the combustion of methane reaction, how many moles of H_2O can be produced from 1.30 moles of methane (CH_4)? Assume you have an unlimited supply of O_2. **ANSWER: 2.60 moles** (three significant figures)

$$CH_4\,(g) + \mathbf{2}\,O_2\,(g) \rightarrow CO_2\,(g) + \mathbf{2}\,H_2O\,(g)$$

CLICK HERE to see the **complete solution** for this problem

6.6) For the combustion of methane reaction, how many moles of H_2O can be produced from 1.30 moles of methane (CH_4)? Assume you have an unlimited supply of O_2. **ANSWER: 2.60 moles** (three significant figures)

$$1\ CH_4(g) + 2\ O_2(g) \rightarrow 1\ CO_2(g) + 2\ H_2O(g)$$

EXPLANATION: We approach stoichiometry problems ***just as we did with unit conversion problems using our factor-label method.***

- In this problem, we are converting from units of "**moles of CH_4**" to units of "**moles of H_2O.**"
- The stoichiometric coefficients provide the relationship between "**moles of CH_4**" and "**moles of H_2O.**"
  - For every **1 mole of CH_4** that reacts, **2 moles of H_2O** are produced. This relationship is used as a ***conversion factor***.

$$\frac{1.30\ \text{moles CH}_4}{} \times \frac{2\ \text{moles H}_2\text{O}}{1\ \text{mole CH}_4} = 2.60\ \text{moles H}_2\text{O}$$

The stoichiometric coefficients are **exact**, so they have an ***infinite number of significant figures***.

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6.7) For the combustion of methane reaction, how many **moles of O_2** are needed to react with 7.80 moles of methane (CH_4)? Assume you have an unlimited supply of O_2.

$$CH_4\,(g) + \mathbf{2}\,O_2\,(g) \rightarrow CO_2\,(g) + \mathbf{2}\,H_2O\,(g)$$

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6.7) For the combustion of methane reaction, how many **moles of O_2** are needed to react with 7.80 moles of methane (CH_4)? Assume you have an unlimited supply of O_2.

$$CH_4\,(g) + \mathbf{2}\,O_2\,(g) \rightarrow CO_2\,(g) + \mathbf{2}\,H_2O\,(g)$$

HINT: We approach stoichiometry problems ***just as we did with unit conversion problems using our factor-label method.***

- In this problem, we are converting from units of "**moles of CH_4**" to units of "**moles of O_2.**"
- The stoichiometric coefficients provide the relationship between "**moles of CH_4**" and "**moles of O_2.**"
  - For every **1 mole of CH_4** that reacts, how many **moles of O_2 are needed?** Use this relationship as a ***conversion factor***.

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6.7) For the combustion of methane reaction, how many **moles of O_2** are needed to react with 7.80 moles of methane (CH_4)? Assume you have an unlimited supply of O_2. **ANSWER: 15.6 moles** (three significant figures)

$$CH_4\,(g) + \mathbf{2}\,O_2\,(g) \rightarrow CO_2\,(g) + \mathbf{2}\,H_2O\,(g)$$

CLICK HERE to see the **complete solution** for this problem

6.7) For the combustion of methane reaction, how many **moles of O_2** are needed to react with 7.80 moles of methane (CH_4)? Assume you have an unlimited supply of O_2. **ANSWER: 15.6 moles** (three significant figures)

$$1\ CH_4(g) + 2\ O_2(g) \rightarrow 1\ CO_2(g) + 2\ H_2O(g)$$

EXPLANATION: We approach stoichiometry problems ***just as we did with unit conversion problems using our factor-label method.***

- In this problem, we are converting from units of "**moles of CH_4**" to units of "**moles of O_2.**"
- The stoichiometric coefficients provide the relationship between "**moles of CH_4**" and "**moles of O_2.**"
  - For every **1 mole of CH_4** that reacts, **2 moles of O_2** are needed. This relationship is used as a ***conversion factor***.

$$\frac{7.80\ \text{moles CH}_4}{} \times \frac{2\ \text{moles O}_2}{1\ \text{mole CH}_4} = 15.6\ \text{moles O}_2$$

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6.8) Balance the chemical equation for the combustion of *pentane*: $C_5H_{12}\,(g) + O_2(g) \rightarrow CO_2\,(g) + H_2O\,(g)$

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6.8) Balance the chemical equation for the combustion of *pentane*: $C_5H_{12}\,(g)$ + $O_2(g)$ → $CO_2\,(g)$ + $H_2O\,(g)$

HINT:

There are ***three steps*** involved in the *systematic balancing method*:

Step 1: Make a table that lists the elements that are present and count all atoms on each side of the *unbalanced* equation.

- If **H_2 or O_2** is present, list these elements last.
- A polyatomic ion may be counted as one "element" ***if it appears on both sides of the equation.***

Step 2: Balance an element in the table by adding ***coefficient(s)*** to the equation (start with the first element on the list).

Step 3: Recount each atom and update the table, then repeat **Steps 2 and 3** for all elements as needed until the equation is balanced.

For more details, see chapter 6 part 2 video or chapter 6 section 3 in the textbook.

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6.8) Balance the chemical equation for the combustion of *pentane*: $C_5H_{12}\,(g)$ + **8** $O_2(g)$ → **5** $CO_2\,(g)$ + **6** $H_2O\,(g)$

ANSWER

EXPLANATION:

There are ***three steps*** involved in the *systematic balancing method*:

Step 1: Make a table that lists the elements that are present and count all atoms on each side of the *unbalanced* equation.

- If $\mathbf{H_2}$ **or** $\mathbf{O_2}$ is present, list these elements last.
- A polyatomic ion may be counted as one "element" ***if it appears on both sides of the equation.***

Step 2: Balance an element in the table by adding ***coefficient(s)*** to the equation (start with the first element on the list).

Step 3: Recount each atom and update the table, then repeat **Steps 2 and 3** for all elements as needed until the equation is balanced.

For more details, see chapter 6 part 2 video or chapter 6 section 3 in the textbook.
If you are still struggling with balancing after that, *see you instructor for one-on-one help*.

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6.9) For the combustion of *pentane*: $C_5H_{12}\,(g) + \mathbf{8}\ O_2(g) \rightarrow \mathbf{5}\ CO_2\,(g) + \mathbf{6}\ H_2O\,(g)$

How many **grams** of H_2O can be produced from 15.0 **grams** of propane (C_5H_{12})?

- Assume you have an unlimited supply of O_2.

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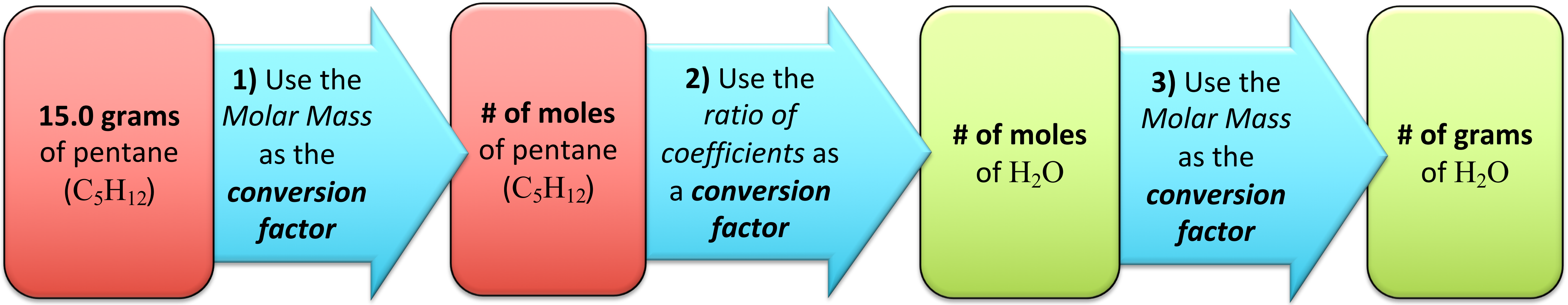
6.9) For the combustion of *pentane*: $C_5H_{12}\,(g) + \mathbf{8}\ O_2(g) \rightarrow \mathbf{5}\ CO_2\,(g) + \mathbf{6}\ H_2O\ (g)$

How many **grams** of H_2O can be produced from 15.0 **grams** of propane (C_5H_{12})?

- Assume you have an unlimited supply of O_2.

HINT:



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6.9) For the combustion of *pentane*: $C_5H_{12}\,(g) + \mathbf{8}\,O_2(g) \rightarrow \mathbf{5}\,CO_2\,(g) + \mathbf{6}\,H_2O\,(g)$ **ANSWER: 22.5 grams H_2O**

How many **grams** of H_2O can be produced from 15.0 **grams** of propane (C_5H_{12})?

- Assume you have an unlimited supply of O_2.

CLICK HERE to see the **complete solution** for this problem

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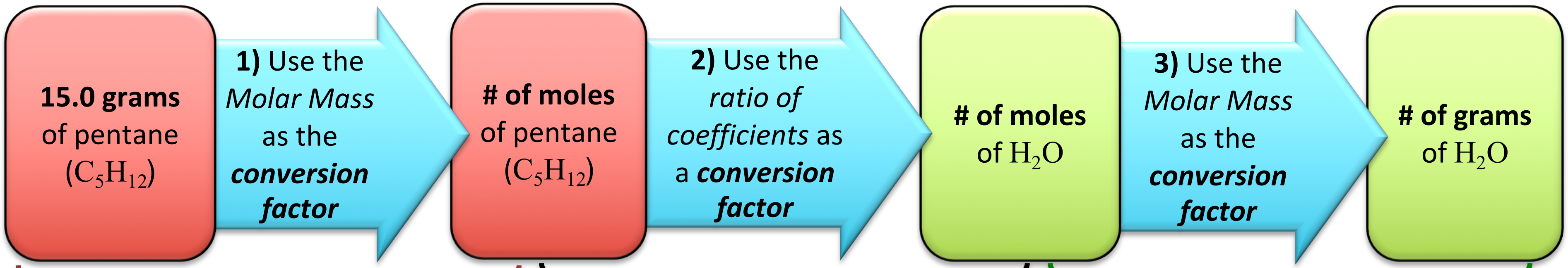
6.9) For the combustion of *pentane*: $C_5H_{12}(g) + 8\ O_2(g) \rightarrow 5\ CO_2(g) + 6\ H_2O(g)$ **ANSWER: 22.5 grams H_2O**

How many **grams** of H_2O can be produced from 15.0 **grams** of propane (C_5H_{12})?

- Assume you have an unlimited supply of O_2.



Step # 1:
Convert from grams of C_5H_{12} to moles of C_5H_{12}.
- Use the ***molar mass*** of C_5H_{12}:

$$\frac{15.0 \text{ grams } C_5H_{12}}{} \times \frac{1 \text{ mole } C_5H_{12}}{72.17 \text{ grams } C_5H_{12}} = 0.208 \text{ moles } C_5H_{12}$$

Step #2:
Convert from moles of C_5H_{12} to moles of H_2O.
- Use the *ratio of coefficients* as a ***conversion factor***

$$\frac{0.208 \text{ moles } C_5H_{12}}{} \times \frac{6 \text{ moles } H_2O}{1 \text{ mole } C_5H_{12}} = 1.25 \text{ moles } H_2O$$

Step #3:
Convert from moles of H_2O to grams of H_2O.
- Use the ***molar mass*** of H_2O:

$$\frac{1.25 \text{ moles } H_2O}{} \times \frac{18.02 \text{ grams } H_2O}{1 \text{ mole } H_2O} = 22.5 \text{ grams } H_2O$$

Alternative Solution: Combine all three of the conversions above into one equation:

$$\frac{15.0 \text{ grams } C_5H_{12}}{} \times \frac{1 \text{ mole } C_5H_{12}}{72.17 \text{ grams } C_5H_{12}} \times \frac{6 \text{ moles } H_2O}{1 \text{ mole } C_5H_{12}} \times \frac{18.02 \text{ grams } H_2O}{1 \text{ mole } H_2O} = 22.5 \text{ grams } H_2O$$

Step # 1 **Step # 2** **Step # 3**

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6.10) For the combustion of *pentane*: C_5H_{12} (*g*) + **8** O_2(*g*) → **5** CO_2 (*g*) + **6** H_2O (*g*)

How many **grams** of **O_2** are ***needed to react*** with 12.0 **grams** of propane (C_5H_{12})?

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Click here for a **hint**

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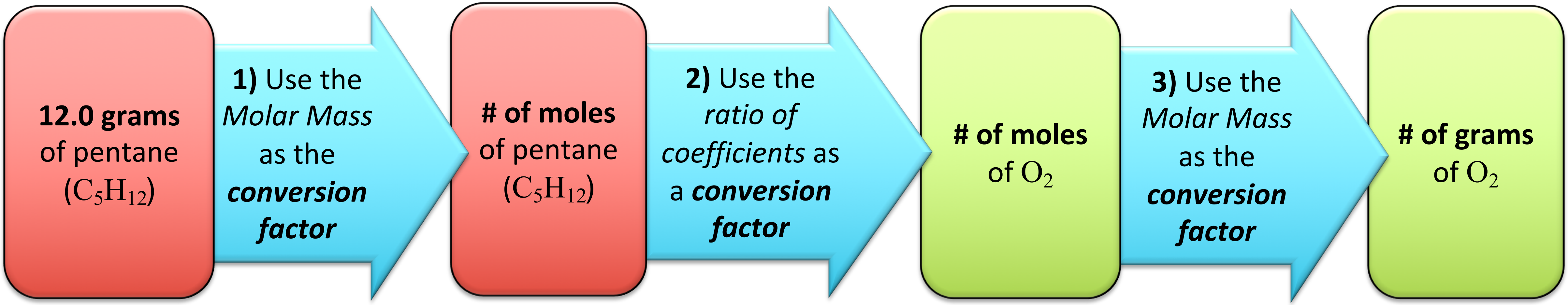
6.10) For the combustion of *pentane*: $C_5H_{12}\,(g) + \mathbf{8}\ O_2(g) \rightarrow \mathbf{5}\ CO_2\,(g) + \mathbf{6}\ H_2O\,(g)$

How many **grams** of **O_2** are ***needed to react*** with 12.0 **grams** of propane (C_5H_{12})?

HINT:



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Click here to **check your answer**

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6.10) For the combustion of *pentane*: C_5H_{12} (*g*) + **8** O_2(*g*) → **5** CO_2 (*g*) + **6** H_2O (*g*) **ANSWER: 42.6 grams O_2**

How many **grams** of **O_2** are ***needed to react*** with 12.0 **grams** of propane (C_5H_{12})?

CLICK HERE to see the **complete solution** for this problem

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6.10) For the combustion of *pentane*: $C_5H_{12}(g) + 8\ O_2(g) \rightarrow 5\ CO_2(g) + 6\ H_2O(g)$ **ANSWER: 42.6 grams O_2**

How many **grams** of **O_2** are ***needed to react*** with 12.0 **grams** of propane (C_5H_{12})?

12.0 grams of pentane (C_5H_{12}) → **1)** Use the *Molar Mass* as the ***conversion factor*** → **# of moles** of pentane (C_5H_{12}) → **2)** Use the *ratio of coefficients* as a ***conversion factor*** → **# of moles** of O_2 → **3)** Use the *Molar Mass* as the ***conversion factor*** → **# of grams** of O_2

Step # 1:
Convert from grams of C_5H_{12} to moles of C_5H_{12}.
- Use the ***molar mass*** of C_5H_{12}:

$$\frac{12.0\ \text{grams}\ C_5H_{12}}{} \times \frac{1\ \text{mole}\ C_5H_{12}}{72.17\ \text{grams}\ C_5H_{12}} = \mathbf{0.166\ moles\ C_5H_{12}}$$

Step #2:
Convert from moles of C_5H_{12} to moles of O_2.
- Use the *ratio of coefficients* as a ***conversion factor***

$$\frac{\mathbf{0.166\ moles\ C_5H_{12}}}{} \times \frac{8\ \text{moles}\ O_2}{1\ \text{mole}\ C_5H_{12}} = \mathbf{1.33\ moles\ O_2}$$

Step #3:
Convert from moles of O_2 to grams of O_2.
- Use the ***molar mass*** of O_2:

$$\frac{\mathbf{1.33\ moles\ O_2}}{} \times \frac{32.00\ \text{grams}\ O_2}{1\ \text{mole}\ O_2} = \mathbf{42.6\ grams\ O_2}$$

Alternative Solution: Combine all three of the conversions above into one equation:

$$\frac{12.0\ \text{grams}\ C_5H_{12}}{} \times \frac{1\ \text{mole}\ C_5H_{12}}{72.17\ \text{grams}\ C_5H_{12}} \times \frac{8\ \text{moles}\ O_2}{1\ \text{mole}\ C_5H_{12}} \times \frac{32.00\ \text{grams}\ O_2}{1\ \text{mole}\ O_2} = \mathbf{42.6\ grams\ O_2}$$

Step # 1 **Step # 2** **Step # 3**

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6.11) For the reaction of aluminum metal ***with*** copper(II) bromide: **2** Al + **3** $CuBr_2$ → **2** $AlBr_3$ + **3** Cu

How many **grams** of $AlBr_3$ can be produced from 12.0 **grams** of $CuBr_2$?

- Assume you have an unlimited supply of aluminum metal (Al).

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Click here for a **hint**

Click here to **check your answer**

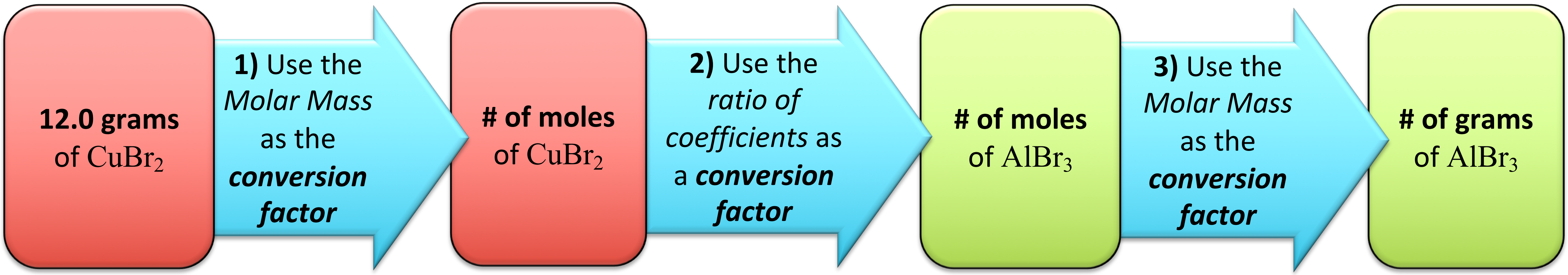
Go to next question

6.11) For the reaction of aluminum metal ***with*** copper(II) bromide: **2** Al + 3 $CuBr_2$ → 2 $AlBr_3$ + 3 Cu

How many **grams** of $AlBr_3$ can be produced from 12.0 **grams** of $CuBr_2$?

- Assume you have an unlimited supply of aluminum metal (Al).

HINT:



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Click here to **check your answer**

Go to next question

6.11) For the reaction of aluminum metal ***with*** copper(II) bromide: **2** Al + **3** $CuBr_2$ → **2** $AlBr_3$ + **3** Cu

How many **grams** of $AlBr_3$ can be produced from 12.0 **grams** of $CuBr_2$?

- Assume you have an unlimited supply of aluminum metal (Al).

ANSWER: 9.55 grams $AlBr_3$

CLICK HERE to see the **complete solution** for this problem

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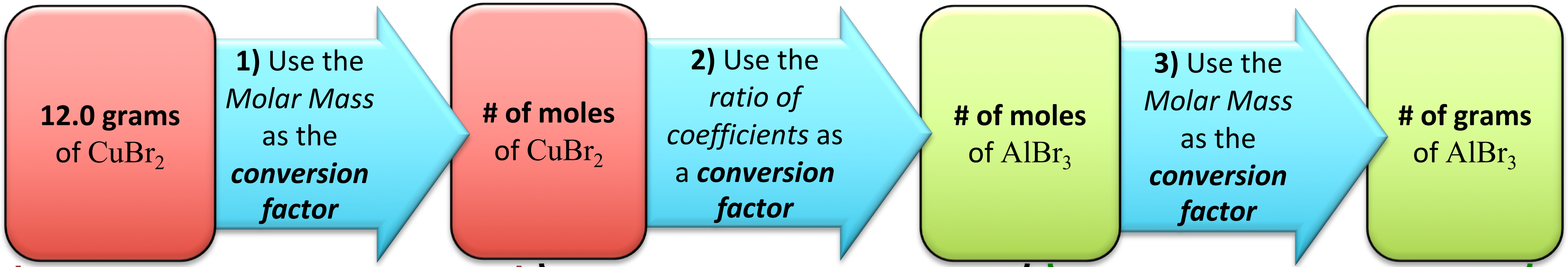
6.11) For the reaction of aluminum metal ***with*** copper(II) bromide: **2** Al + **3** $CuBr_2$ → **2** $AlBr_3$ + **3** Cu

How many **grams** of $AlBr_3$ can be produced from 12.0 **grams** of $CuBr_2$?

- Assume you have an unlimited supply of aluminum metal (Al).

ANSWER: 9.55 grams $AlBr_3$



Step # 1:

Convert from grams of $CuBr_2$ to moles of $CuBr_2$.

- Use the ***molar mass*** of $CuBr_2$:

$$\frac{12.0 \text{ grams } CuBr_2}{} \left| \frac{1 \text{ mole } CuBr_2}{223.35 \text{ grams } CuBr_2} \right| = \mathbf{0.0537 \text{ moles } CuBr_2}$$

Step #2:

Convert from moles of $CuBr_2$ to moles of $AlBr_3$.

- Use the *ratio of coefficients* as a ***conversion factor***

$$\frac{0.0537 \text{ moles } CuBr_2}{} \left| \frac{2 \text{ moles } AlBr_3}{3 \text{ mole } CuBr_2} \right| = \mathbf{0.0238 \text{ moles } AlBr_3}$$

Step #3:

Convert from moles of $AlBr_3$ to grams of $AlBr_3$.

- Use the ***molar mass*** of $AlBr_3$:

$$\frac{0.0358 \text{ moles } AlBr_3}{} \left| \frac{266.68 \text{ grams } AlBr_3}{1 \text{ mole } AlBr_3} \right| = \mathbf{9.55 \text{ grams } AlBr_3}$$

Alternative Solution: Combine all three of the conversions above into one equation:

$$\frac{12.0 \text{ grams } CuBr_2}{} \left| \frac{1 \text{ mole } CuBr_2}{223.35 \text{ grams } CuBr_2} \right| \frac{2 \text{ moles } AlBr_3}{3 \text{ mole } CuBr_2} \left| \frac{266.68 \text{ grams } AlBr_3}{1 \text{ mole } AlBr_3} \right| = \mathbf{9.55 \text{ grams } AlBr_3}$$

Step # 1 **Step # 2** **Step # 3**

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6.12) We call reactions that release energy, in the form of heat, _______________ reactions.

a) double replacement

b) single replacement

c) synthesis

d) exothermic

6.12) We call reactions that release energy, in the form of heat, ________________ reactions.

HINT:

a) ~~double replacement~~

b) single replacement

c) ~~synthesis~~

d) exothermic

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6.12) We call reactions that release energy, in the form of heat, _______________ reactions.

a) double replacement

b) single replacement

c) synthesis

d) exothermic

EXPLANATION:

All chemical reactions involve changes in energy. Some reactions ***release energy*** as heat, light, electricity, and/or mechanical energy (work). The energy that is released in a chemical reaction comes from ***potential energy*** contained in the ***reactant(s)***. Examples of reactions that produce heat and light are combustion reactions (burning).

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6.13) When a chemical reaction can continue to occur without an external input of energy, we say the reaction is ______________.

a) spontaneous

b) nonspontaneous

c) dangerous

d) efficient

6.13) When a chemical reaction can continue to occur without an external input of energy, we say the reaction is ______________.

HINT:

a) spontaneous

b) nonspontaneous

c) ~~dangerous~~

d) ~~efficient~~

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Click here to **check your answer**

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6.13) When a chemical reaction can continue to occur without an external input of energy, we say the reaction is ______________.

a) spontaneous

b) nonspontaneous

c) dangerous

d) efficient

EXPLANATION:

Consider concept of **spontaneity** by examining a reaction that that you are likely are familiar with - the combustion of propane gas. Propane gas is used throughout the world as a source of heat in gas ranges, ovens, climate control, outdoor cooking, and hot water tanks. During combustion, propane reacts with oxygen gas to produce carbon dioxide gas and H_2O vapor.

$$C_3H_8\ (g) + 5\ O_2\ (g) \longrightarrow 3\ CO_2\ (g) + 4\ H_2O\ (g)$$

Many of us have used propane gas in outdoor lanterns and barbecues. We know that once we use a spark or match to start the reaction, that the combustion reaction ***continues to occur without an external input of energy***. It is therefore a **spontaneous** reaction.

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6.14) Chemical reactions will occur spontaneously when the free energy (G) of the product(s) is ____________ the free energy of the reactant(s).

a) greater than

b) less than

c) equal to

6.14) Chemical reactions will occur spontaneously when the free energy (G) of the product(s) is ____________ the free energy of the reactant(s).

HINT:

a) greater than

b) less than

c) ~~equal to~~

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Click here to **check your answer**

Go to next question

6.14) Chemical reactions will occur spontaneously when the free energy (G) of the product(s) is ____________ the free energy of the reactant(s).

a) greater than

b) less than

c) equal to

EXPLANATION:

The law of nature that applies to total energy (E), also applies to free energy (G); matter tends to exist in the lowest possible free energy state, therefore chemical reactions will occur spontaneously when the total free energy of the products is less than the total free energy of the reactants.

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6.15) When the free energy (G) of the products of a reaction is less than the free energy of the reactants, we say that the reaction is ________________.

a) endogonic

b) exergonic

c) safe

d) potentially dangerous

Go back

Click here for a **hint**

Click here to **check your answer**

Go to next question

6.15) When the free energy (G) of the products of a reaction is less than the free energy of the reactants, we say that the reaction is _________________.

HINT:

a) endogonic

b) exergonic

c) ~~safe~~

d) ~~potentially dangerous~~

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Click here to **check your answer**

Go to next question

6.15) When the free energy (G) of the products of a reaction is less than the free energy of the reactants, we say that the reaction is _________________.

a) endogonic

b) exergonic

c) safe

d) potentially dangerous

EXPLANATION:

"Exergonic" is an important term to know and understand. You will likely see it again if you take a physiology course.

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6.16) Which of the following statements is **true** for *spontaneous reactions*:

a) The sign of ΔG is positive.
b) The sign of ΔG is negative.

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6.16) Which of the following statements is **true** for *spontaneous reactions*:

a) The sign of ΔG is positive.
b) The sign of ΔG is negative.

HINT:

The change in free energy (ΔG) for reaction is equal to the difference in free energy between the products ($G_{products}$) and the reactants ($G_{reactants}$):

$$\Delta G = (G_{products}) - (G_{reactants})$$

In ***spontaneous reactions***, the free energy of the products ($G_{products}$) of a reaction is less than the free energy of the reactants ($G_{reactants}$). When this is the case, will the change in free energy (ΔG) have a **positive** or **negative** value? Answer this question by examining the equation shown above.

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6.16) Which of the following statements is **true** for *spontaneous reactions*:

a) The sign of ΔG is positive.

b) The sign of ΔG is negative. ⟸ True

EXPLANATION:

The change in free energy (ΔG) for reaction is equal to the difference in free energy between the products ($G_{products}$) and the reactants ($G_{reactants}$):

$$\Delta G = (G_{products}) - (G_{reactants})$$

Note the use of our convention of defining change (Δ) as the final state (products only) minus the initial state (reactants only).

In ***spontaneous reactions***, the free energy of the products ($G_{products}$) of a reaction is less than the free energy of the reactants ($G_{reactants}$), therefore the change in free energy (ΔG) will have a **negative value**. You should be able to convince yourself of this by examining the equation shown above.

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6.17) Determine whether the following reactions are ***spontaneous*** or ***non-spontaneous***.

a) N_2 (g) + 3 H_2 (g) $\longrightarrow$ 2 NH_3 (g), ΔG = -32,960 J

b) 2 NH_3 (g) $\longrightarrow$ N_2 (g) + 3 H_2 (g), ΔG = 32,960 J

Click here for a **hint**

Click here to **check your answer**

6.17) Determine whether the following reactions are ***spontaneous*** or ***non-spontaneous***.

a) $N_2\ (g) + 3\ H_2\ (g) \longrightarrow 2\ NH_3\ (g)$, $\Delta G = -32{,}960\ J$

b) $2\ NH_3\ (g) \longrightarrow N_2\ (g) + 3\ H_2\ (g)$, $\Delta G = 32{,}960\ J$

HINT:

The change in free energy (ΔG) for reaction is equal to the difference in free energy between the products ($G_{products}$) and the reactants ($G_{reactants}$):

$$\Delta G = (G_{products}) - (G_{reactants})$$

In ***spontaneous reactions***, the free energy of the products ($G_{products}$) of a reaction is less than the free energy of the reactants ($G_{reactants}$). When this is the case, will the change in free energy (ΔG) will have a **negative value** or a **positive value**?

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Go to next question

6.17) Determine whether the following reactions are ***spontaneous*** or ***non-spontaneous***.

a) $N_2\ (g) + 3\ H_2\ (g) \longrightarrow 2\ NH_3\ (g)$, $\Delta G = -32{,}960\ J$ ⇐ spontaneous ($\Delta G < 0$)

b) $2\ NH_3\ (g) \longrightarrow N_2\ (g) + 3\ H_2\ (g)$, $\Delta G = 32{,}960\ J$ ⇐ non-spontaneous ($\Delta G > 0$)

EXPLANATION:

The change in free energy (ΔG) for reaction is equal to the difference in free energy between the products ($G_{products}$) and the reactants ($G_{reactants}$):

$$\Delta G = (G_{products}) - (G_{reactants})$$

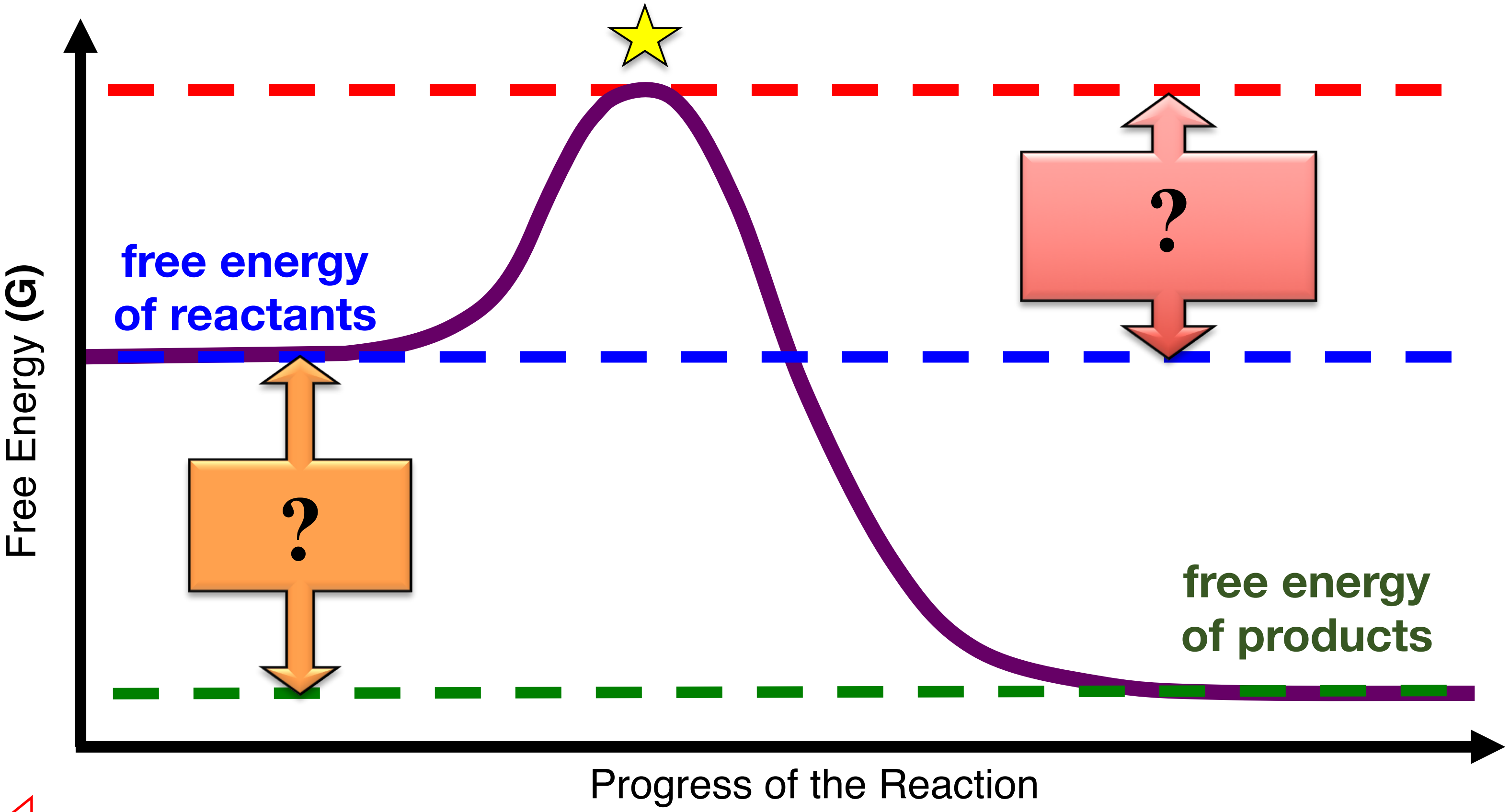
In ***spontaneous reactions***, the free energy of the products ($G_{products}$) of a reaction is less than the free energy of the reactants ($G_{reactants}$), therefore the change in free energy (ΔG) will have a **negative value**. Conversely, in ***non-spontaneous reactions***, the change in free energy (ΔG) will have a **positive value**.

6.18) In the reaction energy level diagram shown here:

a) Does the orange box represent the ***change in free energy*** (**ΔG**), the ***activation energy*** (**E_a**), or the ***transition state energy***?

b) Does the red box represent the ***change in free energy*** (**ΔG**), the ***activation energy*** (**E_a**), or the ***transition state energy***?

c) What does the yellow star represent? ________________



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6.18) In the reaction energy level diagram shown here:

HINT:

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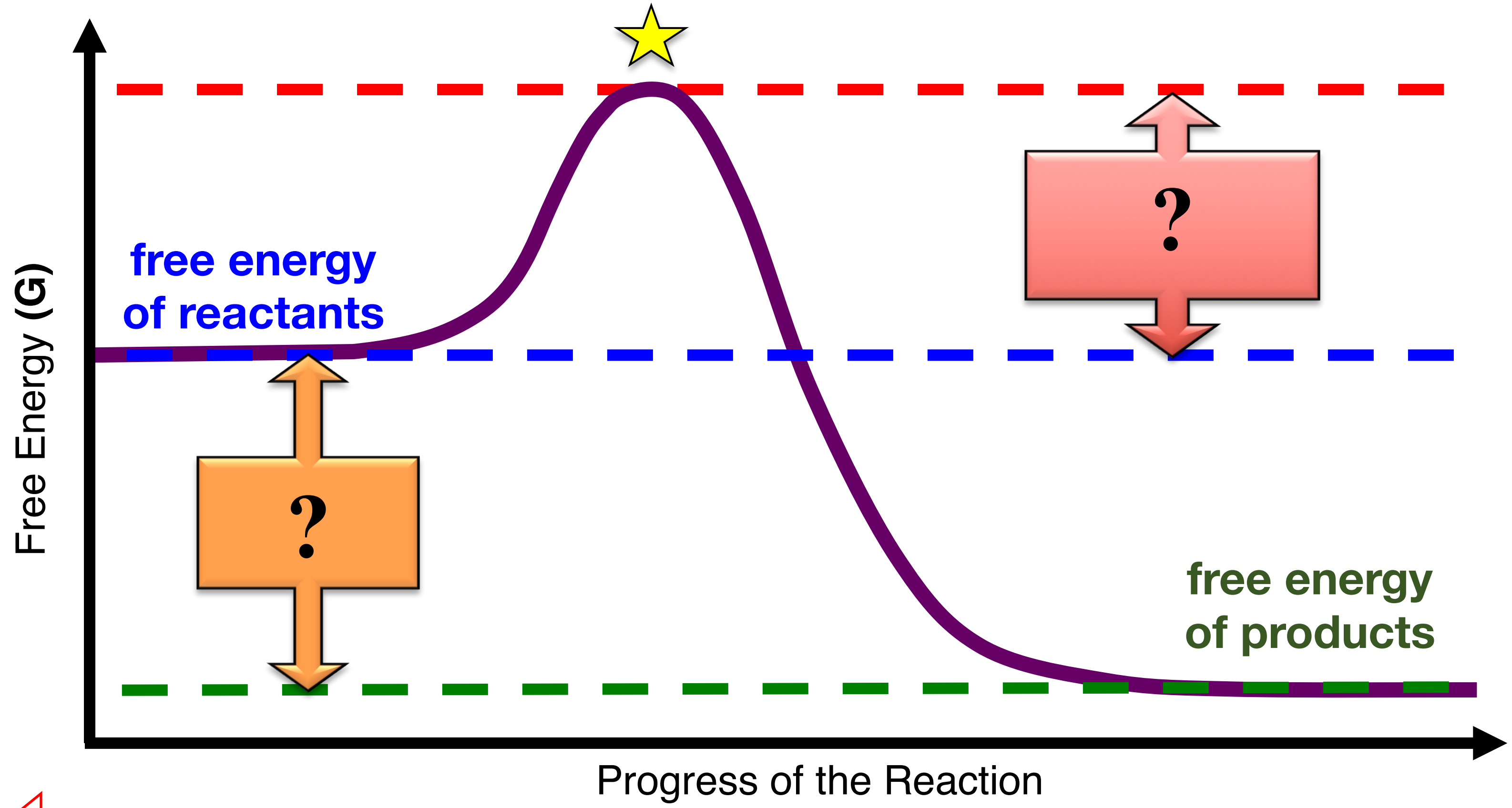

For more help:
See chapter 6 part 6 video or chapter 6 section 5 in the textbook.

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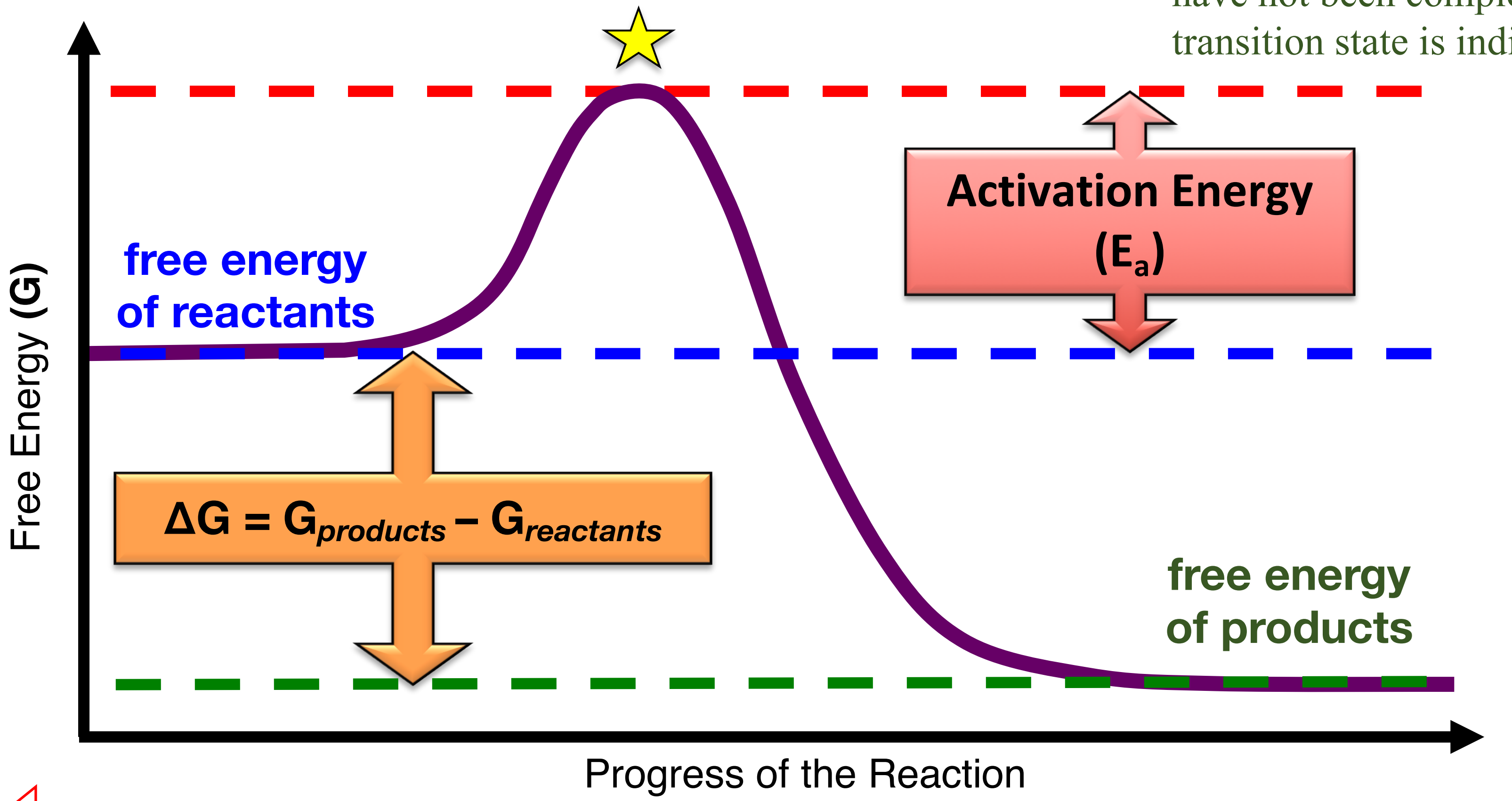
6.18) In the reaction energy level diagram shown here:

a) Does the orange box represent the ***change in free energy*** **(ΔG)**, the ***activation energy*** **(E_a)**, or the ***transition state energy***?

b) Does the red box represent the ***change in free energy*** **(ΔG)**, the ***activation energy*** **(E_a)**, or the ***transition state energy***?

c) What does the yellow star represent? ***the transition state***

In the transition state, the bonds in the reactants have not all been completely broken and/or the new bonds in the products have not been completely formed. The free energy of the transition state is indicated by the red dashed line.



For more details:
See chapter 6 part 6 video or chapter 6 section 5 in the textbook.

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6.19) The amount of free energy needed to progress from reactants to the transition state is called the activation energy (E_a). The rates of chemical reactions (how quickly the reactions happen) depend on the activation energy. The lower the activation energy, the ______________ the reaction rate.

a) slower

b) faster

c) more variable

d) less variable

Click here for a **hint**

Click here to **check your answer**

6.19) The amount of free energy needed to progress from reactants to the transition state is called the activation energy (E_a). The rates of chemical reactions (how quickly the reactions happen) depend on the activation energy. The lower the activation energy, the _______________ the reaction rate.

HINT:

a) slower

b) faster

c) ~~more variable~~

d) ~~less variable~~

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6.19) The amount of free energy needed to progress from reactants to the transition state is called the activation energy (E_a). The rates of chemical reactions (how quickly the reactions happen) depend on the activation energy. The lower the activation energy, the ______________ the reaction rate.

a) slower

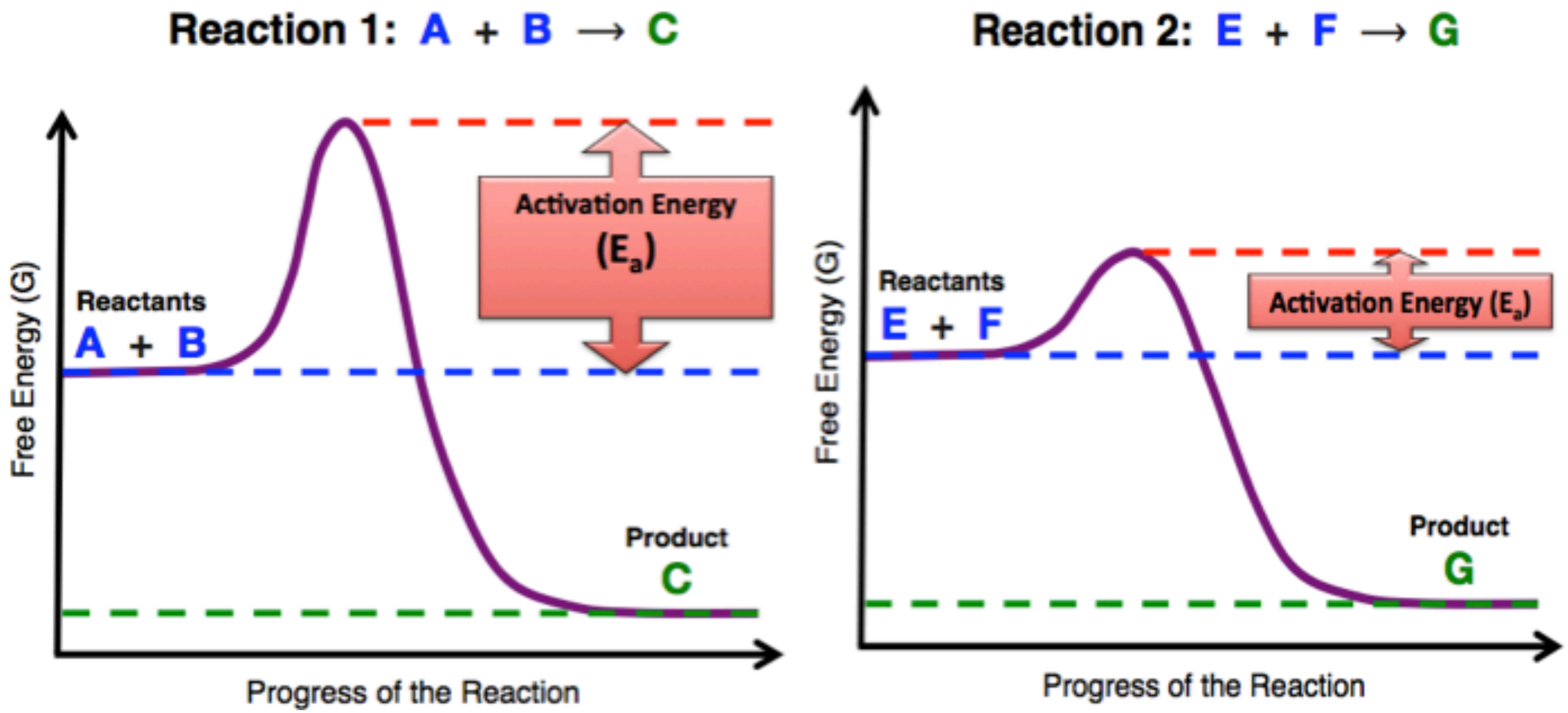
b) faster

c) more variable

d) less variable

EXPLANATION:

Consider the energy level diagrams for **Reaction 1** and **Reaction 2** below.



Because **Reaction 2** has a **lower** activation energy, it has the **faster** reaction rate.

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6.20) Label each of the following statements as **true** or **false**.

a) Reaction rates depend on the temperature.

b) As the temperature increases, the reaction rate decreases.

c) In general, for every 10 ^{o}C increase in temperature, the reaction rate increases by a factor of 10.

d) In general, for every 10 ^{o}C decrease in temperature, the reaction rate decreases by a factor of one-half.

e) Catalysts are reactants in a chemical reaction.

f) Living organisms produce catalysts consisting of large molecules, usually proteins, that are called enzymes.

6.20) Label each of the following statements as **true** or **false**.

a) Reaction rates depend on the temperature.

b) As the temperature increases, the reaction rate decreases.

c) In general, for every 10 °C increase in temperature, the reaction rate increases by a factor of 10.

d) In general, for every 10 °C decrease in temperature, the reaction rate decreases by a factor of one-half.

e) Catalysts are reactants in a chemical reaction.

HINT: Are catalysts *changed* in a reaction? Reactants are *always* changed into products in reactions.

f) Living organisms produce catalysts consisting of large molecules, usually proteins, that are called enzymes.

For more help:
Review chapter 6 part 6 video or chapter 6 section 5 in the textbook.

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6.20) Label each of the following statements as **true** or **false**.

a) Reaction rates depend on the temperature. **true**

b) As the temperature increases, the reaction rate decreases. **false**

- As the temperature increases, the reaction rate *increases*.

c) In general, for every 10 °C increase in temperature, the reaction rate increases by a factor of 10. **false**

- In general, for every 10 °C increase in temperature, the reaction rate *doubles*.

d) In general, for every 10 °C decrease in temperature, the reaction rate decreases by a factor of one-half. **true**

e) Catalysts are reactants in a chemical reaction. **false**

- Unlike reactants, catalysts are *not changed* in a reaction.

f) Living organisms produce catalysts consisting of large molecules, usually proteins, that are called enzymes. **true**

For more details:
See chapter 6 part 6 video or chapter 6 section 5 in the textbook.

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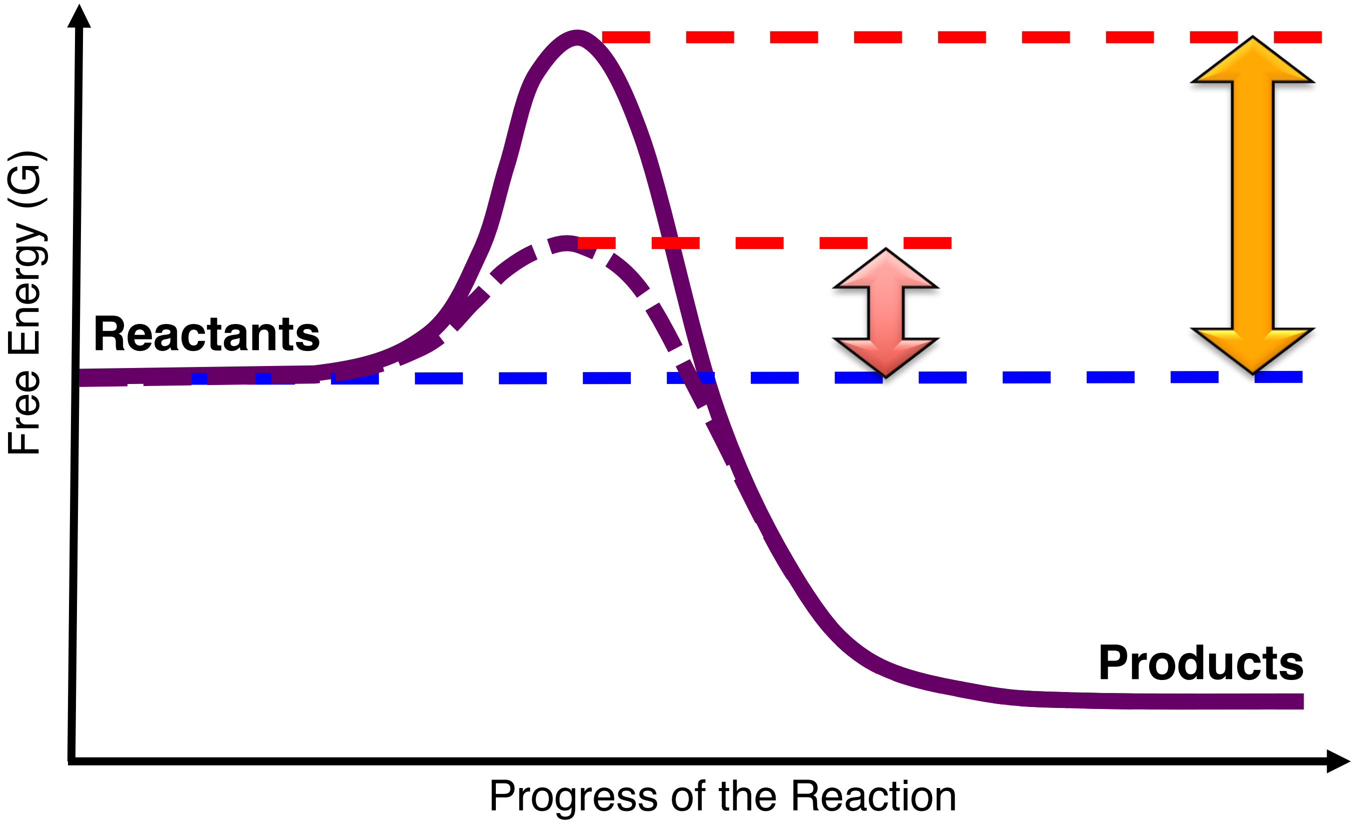
6.21) Two curves, one drawn as solid purple and the other drawn as dashed purple, are shown in the energy level diagram below. One curve is for a ***catalyzed*** reaction and the other is for the same ***un-catalyzed*** reaction.

Which double arrow, the orange double arrow or the red double arrow, represents the ***activation energy*** (**E_a**) for the ***catalyzed*** reaction.



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Click here for a **hint**

Click here to **check your answer**

Go to next question

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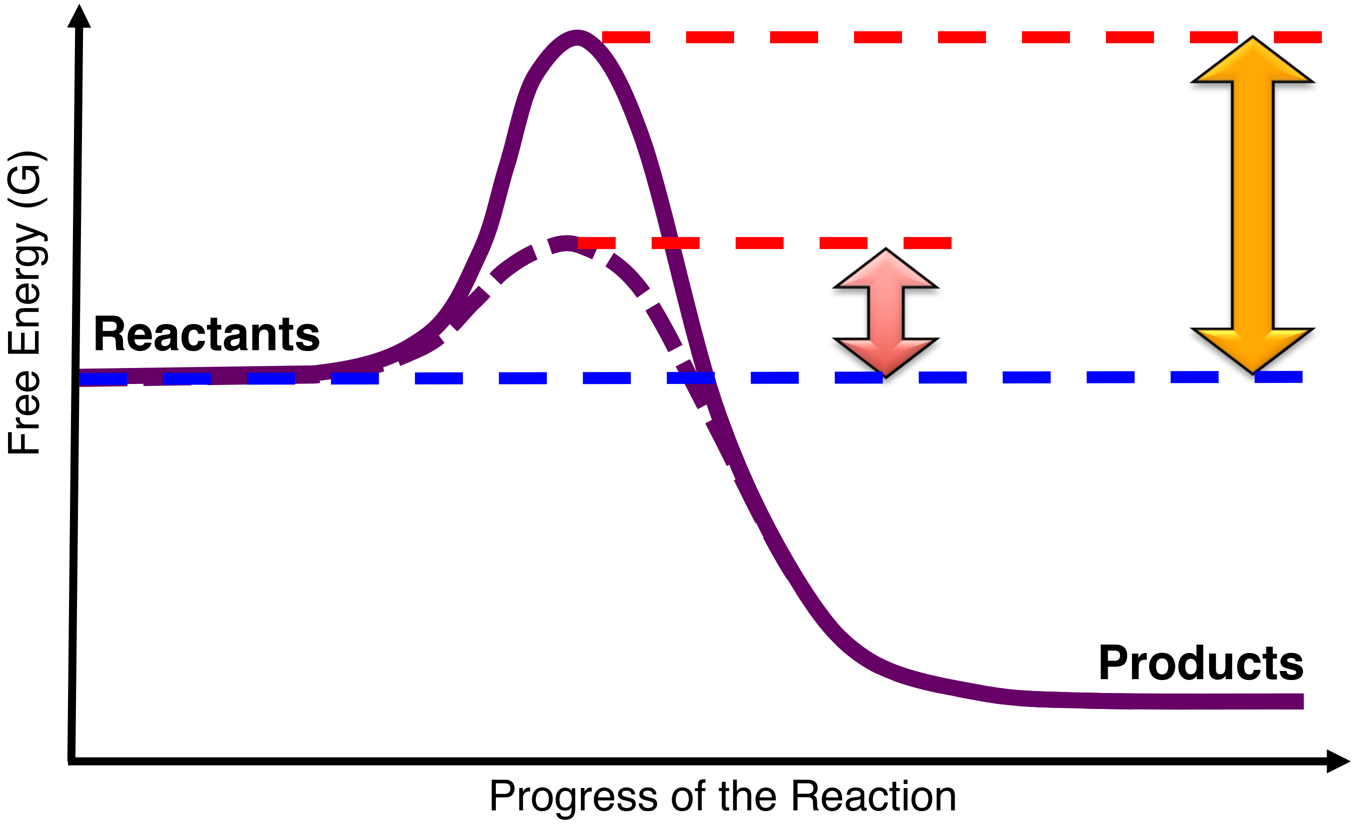
Which double arrow, the orange double arrow or the red double arrow, represents the ***activation energy*** (**E_a**) for the ***catalyzed*** reaction.



HINT:
Catalysts increase the rates of reactions by **decreasing** the ***activation energy*** (**E_a**).

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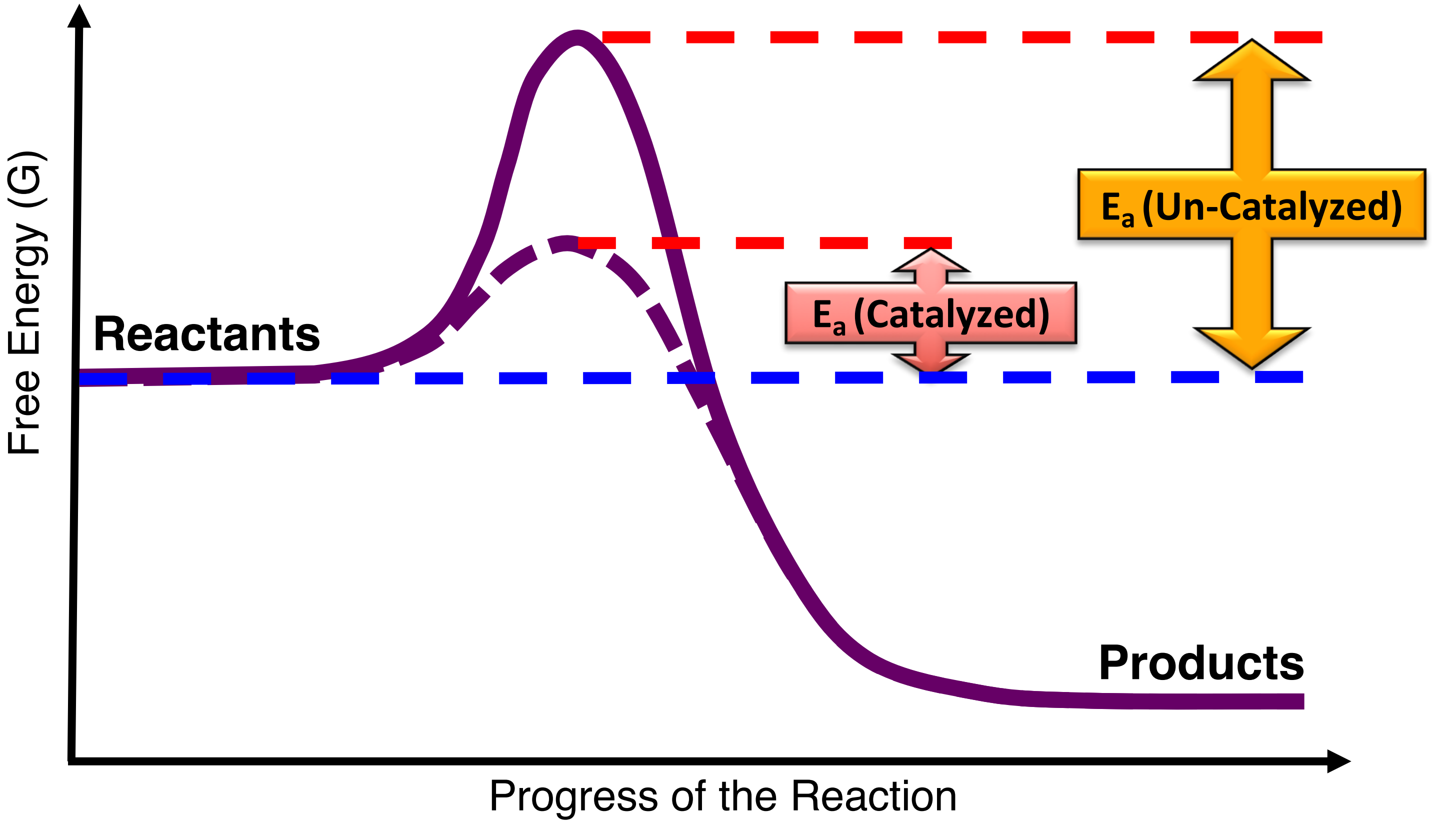
6.21) Two curves, one drawn as solid purple and the other drawn as dashed purple, are shown in the energy level diagram below. One curve is for a ***catalyzed*** reaction and the other is for the same ***un-catalyzed*** reaction.

Which double arrow, the orange double arrow or the red double arrow represents the ***activation energy*** (**E_a**) for the ***catalyzed*** reaction.



EXPLANATION:

Catalysts increase the rates of reactions by **decreasing** the ***activation energy*** (**E_a**). In the energy level diagram shown here, the solid purple curve represents the un-catalyzed reaction and a dashed purple curve is used for the catalyzed reaction. In the *catalyzed reaction*, the reactants require less energy to overcome the activation energy and are therefore converted to products at a faster rate. You will learn more details of how catalysts lower the activation energy in chapter 13.

For more details:
See chapter 6 part 6 video or chapter 6 section 5 in the textbook.

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6.22) Categorize each of the following reactions as either: synthesis, decomposition, single-replacement, or double-replacement.

a) $2\ H_2S \rightarrow 2\ H_2 + S_2$

b) $KCl + AgNO_3 \rightarrow KNO_3 + AgCl$

c) $2\ Ba + O_2 \rightarrow 2\ BaO$

d) $Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$

6.22) Categorize each of the following reactions as either: synthesis, decomposition, single-replacement, or double-replacement.

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b) $KCl + AgNO_3 \rightarrow KNO_3 + AgCl$

c) $2\ Ba + O_2 \rightarrow 2\ BaO$

d) $Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$

HINT:

A ***synthesis reaction*** is one in which a single compound is formed from two or more substances. The general form of a synthesis reaction is:

$$A + B \rightarrow AB$$

A ***decomposition reaction*** is a reaction in which a single reactant breaks down into two or more substances. The general form of a decomposition reaction is:

$$AB \rightarrow A + B$$

In a ***single-replacement reaction***, an element *replaces* another element from a compound. The general form of a single-replacement reaction, where **A** replaces **B**, is:

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

In a ***double-replacement reaction***, two substances "*switch partners*." The general form of a double replacement reaction, where **AX** and **BY** *switch partners*, is:

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

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Click here to **check your answer**

Go to next question

6.22) Categorize each of the following reactions as either: synthesis, decomposition, single-replacement, or double-replacement.

a) $2\ H_2S \rightarrow 2\ H_2 + S_2$

decomposition

A ***decomposition reaction*** is a reaction in which a single reactant breaks down into two or more substances. The general form of a decomposition reaction is:

$$AB \rightarrow A + B$$

b) $KCl + AgNO_3 \rightarrow KNO_3 + AgCl$

double-replacement

In a ***double-replacement reaction***, two substances "*switch partners*." The general form of a double replacement reaction, where **AX** and **BY** *switch partners*, is:

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

c) $2\ Ba + O_2 \rightarrow 2\ BaO$

synthesis

A ***synthesis reaction*** is one in which a single compound is formed from two or more substances. The general form of a synthesis reaction is:

$$A + B \rightarrow AB$$

d) $Zn + CuCl_2 \rightarrow ZnCl_2 + Cu$

single-replacement

In a ***single-replacement reaction***, an element *replaces* another element from a compound. The general form of a single-replacement reaction, where **A** replaces **B**, is:

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

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6.23) The term “**redox**” is an abbreviated combination (portmanteau) of the words “**reduction**” and “**oxidation**.” In a redox chemical reaction, an oxidation and a reduction occur simultaneously. Many of the reactions that you have seen in chapter 6 are redox reactions. The series of chemical reactions in which we metabolize food and the series of chemical reactions called photosynthesis both contain many redox reactions.

i) Oxidation is the ________ of electron(s) by an atom, ion, or molecule.

a) gain

b) loss

ii) Reduction is the _______ of electron(s) by an atom, ion, or molecule.

a) gain

b) loss

iii) An atom in a covalent compound is ______________ if it ***gains*** *bond(s)* to ***oxygen*** and/or ***loses*** *bond(s)* to ***hydrogen***.

a) transferred

b) reduced

c) oxidized

iv) An atom in a covalent compound is ______________ if it ***loses*** *bond(s)* to ***oxygen*** and/or ***gains*** *bond(s)* to ***hydrogen.***

a) transferred

b) reduced

c) oxidized

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Click here for a **hint**

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6.23) The term "**redox**" is an abbreviated combination (portmanteau) of the words "**reduction**" and "**oxidation**." In a redox chemical reaction, an oxidation and a reduction occur simultaneously. Many of the reactions that you have seen in chapter 6 are redox reactions. The series of chemical reactions in which we metabolize food and the series of chemical reactions called photosynthesis both contain many redox reactions.

i) Oxidation is the ________ of electron(s) by an atom, ion, or molecule.

a) gain

b) loss

HINT: A useful mnemonic to differentiate **oxidation** and **reduction** is the term "**OILRIG**" (**O**xidation **i**s the **L**oss of electrons; **R**eduction **i**s the **G**ain of electrons).

ii) Reduction is the _______ of electron(s) by an atom, ion, or molecule.

a) gain

b) loss

iii) An atom in a covalent compound is _____________ if it ***gains*** *bond(s)* to ***oxygen*** and/or ***loses*** *bond(s)* to ***hydrogen***.

a) transferred

b) reduced

c) oxidized

HINT: For ***covalent compounds***, such as organic and biological compounds, the gaining and losing of electrons is the result of a **gain** or **loss** of bond(s) to ***oxygen atoms*** or ***hydrogen atoms***.

iv) An atom in a covalent compound is _____________ if it ***loses*** *bond(s)* to ***oxygen*** and/or ***gains*** *bond(s)* to ***hydrogen.***

a) transferred

b) reduced

c) oxidized

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6.23) The term "**redox**" is an abbreviated combination (portmanteau) of the words "**reduction**" and "**oxidation**." In a redox chemical reaction, an oxidation and a reduction occur simultaneously. Many of the reactions that you have seen in chapter 6 are redox reactions. The series of chemical reactions in which we metabolize food and the series of chemical reactions called photosynthesis both contain many redox reactions.

i) Oxidation is the ________ of electron(s) by an atom, ion, or molecule.

a) gain

b) loss

ii) Reduction is the _______ of electron(s) by an atom, ion, or molecule.

a) gain

b) loss

In a *redox* chemical reaction, an *oxidation* and a *reduction* occur simultaneously. Electrons are ***transferred*** from one atom, ion, or molecule *to another* atom, ion, or molecule. The electron(s) that are "lost" by the *oxidized species* are "gained" by the *reduced species*.

iii) An atom in a covalent compound is ______________ if it ***gains*** *bond(s)* to ***oxygen*** and/or ***loses*** *bond(s)* to ***hydrogen***.

a) transferred

b) reduced

c) oxidized

For ***covalent compounds***, such as organic and biological compounds, the gaining and losing of electrons is the result of a **gain** or **loss** of bond(s) to ***oxygen atoms*** or ***hydrogen atoms***.

iv) An atom in a covalent compound is ______________ if it ***loses*** *bond(s)* to ***oxygen*** and/or ***gains*** *bond(s)* to ***hydrogen.***

a) transferred

b) reduced

c) oxidized

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Go to next question

6.24) Answer the questions below for the reaction of lithium with oxygen:

$$4\,Li\,(s) \;+\; O_2\,(g) \;\rightarrow 2\,Li_2O\,(s)$$

a) What is the charge of the **lithium atoms** in the reactant Li(s)

b) What is the charge of the **lithium ion** in the product?

c) Did **lithium** gain or lose electron(s) in this reaction? If so, how many?

d) Was **lithium** oxidized or reduced?

e) What is the charge of the **oxygen atoms** in the reactant O_2(g) ?

f) What is the charge of the **oxide ions** in the product?

g) Did **oxygen** gain or lose electron(s) in this reaction? If so, how many?

h) Was **oxygen** oxidized or reduced?

Go back

Click here for a **hint**

Click here to **check your answer**

Go to next question

6.24) Answer the questions below for the reaction of lithium with oxygen:

$$4\ Li\ (s) \quad + \quad O_2\ (g) \quad \rightarrow 2\ Li_2O\ (s)$$

a) What is the charge of the **lithium atoms** in the reactant Li(s) (all elements and compounds are uncharged)

b) What is the charge of the **lithium ion** in the product? (Li_2O is uncharged, however lithium is an ion in this compound)

c) Did **lithium** gain or lose electron(s) in this reaction? If so, how many?

d) Was **lithium** oxidized or reduced?

e) What is the charge of the **oxygen atoms** in the reactant O_2(g) ?

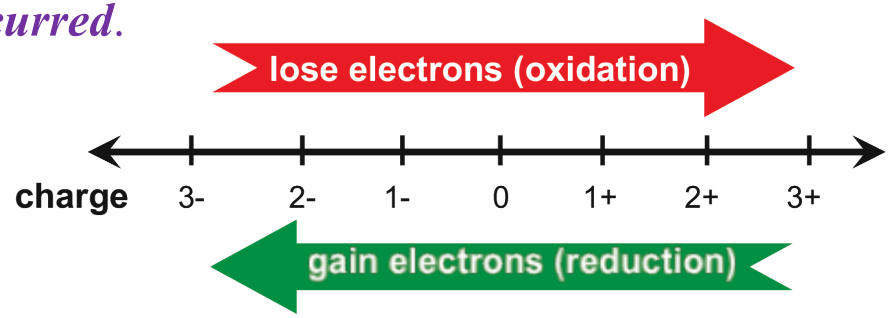
f) What is the charge of the **oxide ions** in the product?

g) Did **oxygen** gain or lose electron(s) in this reaction? If so, how many?

h) Was **oxygen** oxidized or reduced?

HINT: It is possible to identify redox reactions for inorganic compounds by inspecting the chemical equation and determining if electrons are *transferred from one species to another*.

- If the **charge** of an atom or ion in a reactant was ***increased*** (toward positive) in the conversion of reactants to products, ***an oxidation occurred***.
- If the **charge** of an atom or ion in a reactant was ***decreased*** (toward negative) in the conversion of reactants to products, ***a reduction occurred***.



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6.24) Answer the questions below for the reaction of lithium with oxygen:

$$4\ Li\ (s) \quad + \quad O_2\ (g) \quad \rightarrow 2\ Li_2O\ (s)$$

a) What is the charge of the **lithium atoms** in the reactant Li(s) **0** (all elements and compounds are uncharged)

b) What is the charge of the **lithium ion** in the product? **1^+ or just +**(Li_2O is uncharged, however Li^+ is an ion)

c) Did **lithium** gain or lose electron(s) in this reaction? **lost** If so, how many? **one**

d) Was **lithium** oxidized or reduced? **oxidized**

e) What is the charge of the **oxygen atoms** in the reactant O_2(g) ? **0** (all elements and compounds are uncharged)

f) What is the charge of the **oxide ions** in the product? **2^-** (Li_2O is uncharged, however O^{2-} is an ion)

g) Did **oxygen** gain or lose electron(s) in this reaction? **gain** If so, how many? **two**

h) Was **oxygen** oxidized or reduced? **reduced**

EXPLANATION: It is possible to identify redox reactions for inorganic compounds by inspecting the chemical equation and determining if electrons are *transferred from one species to another*.

- If the **charge** of an atom or ion in a reactant was ***increased*** (toward positive) in the conversion of reactants to products, ***an oxidation occurred***.
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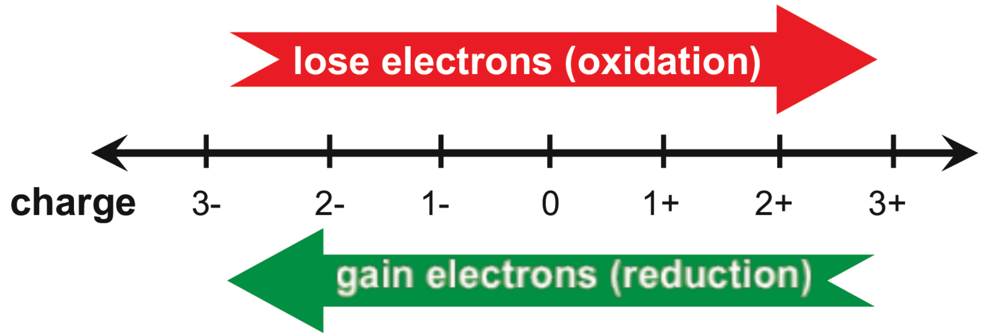

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Go to next question

6.25) Answer the questions below for the reaction of copper metal with silver nitrate:

$$Cu(s) + 2AgNO_3\ (aq) \rightarrow Cu(NO_3)_2\ (aq) + 2Ag\ (s)$$

a) What is the charge of the **copper** in the reactant Cu(s)
b) What is the charge of the **copper** in the product?
c) Did **copper** gain or lose electron(s) in this reaction? If so, how many?
d) Was **copper** oxidized or reduced?
e) What is the charge of the **silver** in the reactant ($AgNO_3$)?
f) What is the charge of the **silver** in the product?
g) Did **silver** gain or lose electron(s) in this reaction? If so, how many?
h) Was **silver** oxidized or reduced?

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Click here for a **hint**

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6.25) Answer the questions below for the reaction of copper metal with silver nitrate:

$$Cu(s) + 2AgNO_3\,(aq) \rightarrow Cu(NO_3)_2\,(aq) + 2Ag\,(s)$$

a) What is the charge of the **copper** in the reactant Cu(s)

b) What is the charge of the **copper** in the product? this **must be** deduced from the formula, $Cu(NO_3)_2$

c) Did **copper** gain or lose electron(s) in this reaction? If so, how many?

d) Was **copper** oxidized or reduced?

e) What is the charge of the **silver** in the reactant ($AgNO_3$)?

f) What is the charge of the **silver** in the product?

g) Did **silver** gain or lose electron(s) in this reaction? If so, how many?

h) Was **silver** oxidized or reduced?

HINT: It is possible to identify redox reactions for inorganic compounds by inspecting the chemical equation and determining if electrons are *transferred from one species to another*.

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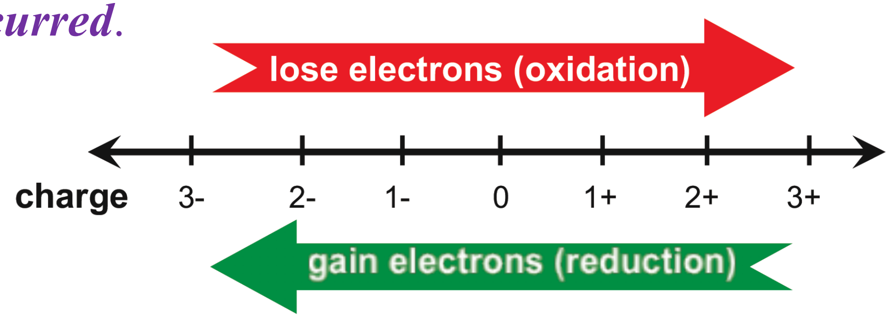

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a) What is the charge of the **copper** in the reactant Cu(s) **0** all elements and compounds are uncharged

b) What is the charge of the **copper** in the product? **2^+** this **must be** deduced from the formula, $Cu(NO_3)_2$

c) Did **copper** gain or lose electron(s) in this reaction? **lost** If so, how many? **two**

d) Was **copper** oxidized or reduced? **oxidized**

e) What is the charge of the **silver** in the reactant ($AgNO_3$)? **1^+** $AgNO_3$ is uncharged, however Ag^+ is an ion

f) What is the charge of the **silver** in the product? **0** all elements and compounds are uncharged

g) Did **silver** gain or lose electron(s) in this reaction? **gain** If so, how many? **one**

h) Was **silver** oxidized or reduced? **reduced**

EXPLANATION: It is possible to identify redox reactions for inorganic compounds by inspecting the chemical equation and determining if electrons are *transferred from one species to another*.

- If the **charge** of an atom or ion in a reactant was ***increased*** (toward positive) in the conversion of reactants to products, ***an oxidation occurred***.
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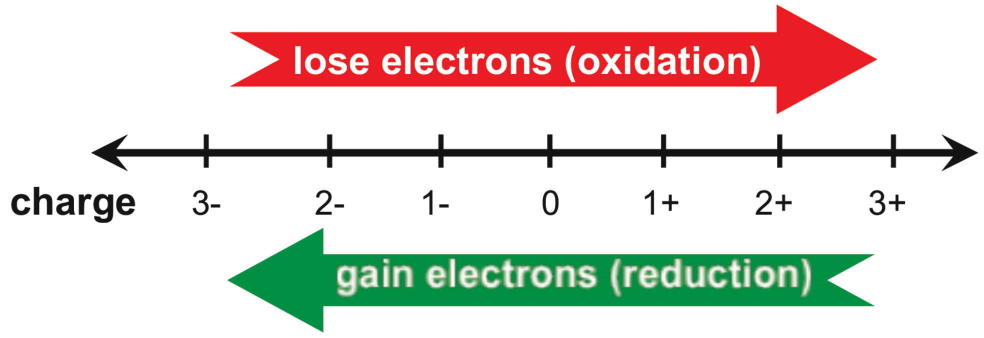

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6.26) In the reaction shown below, is **1-pentene** being ***oxidized*** or ***reduced*** ?

$$\underset{\textbf{1-pentene}}{CH_2{=}CHCH_2CH_2CH_3} + H_2 \longrightarrow \underset{\textbf{pentane}}{CH_3CH_2CH_2CH_2CH_3}$$

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Click here for a **hint**

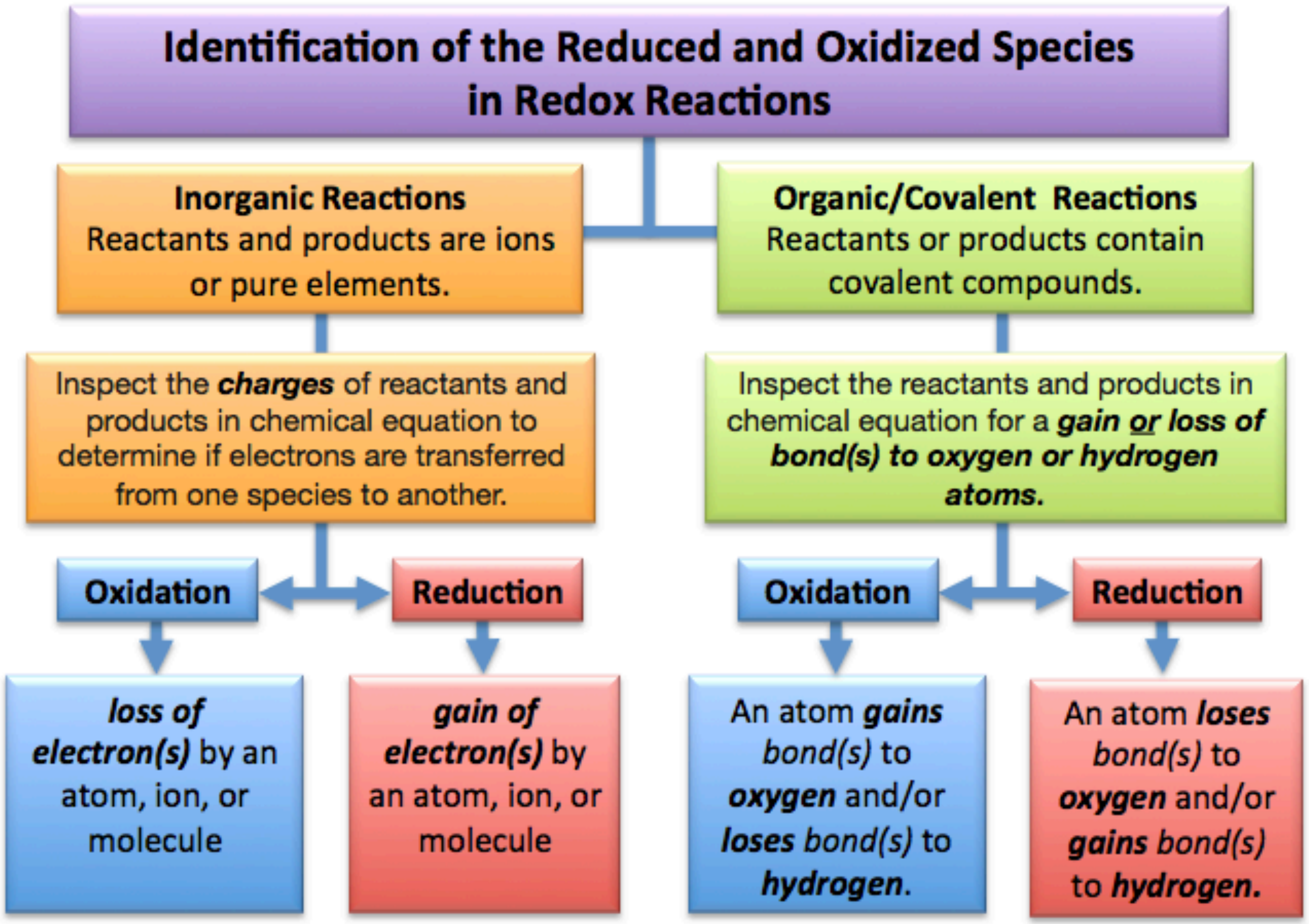
Click here to **check your answer**

Go to next question

6.26) In the reaction shown below, is **1-pentene** being ***oxidized*** or ***reduced*** ?

$$\underset{\textbf{1-pentene}}{CH_2{=}CHCH_2CH_2CH_3} + H_2 \longrightarrow \underset{\textbf{pentane}}{CH_3CH_2CH_2CH_2CH_3}$$

HINT:



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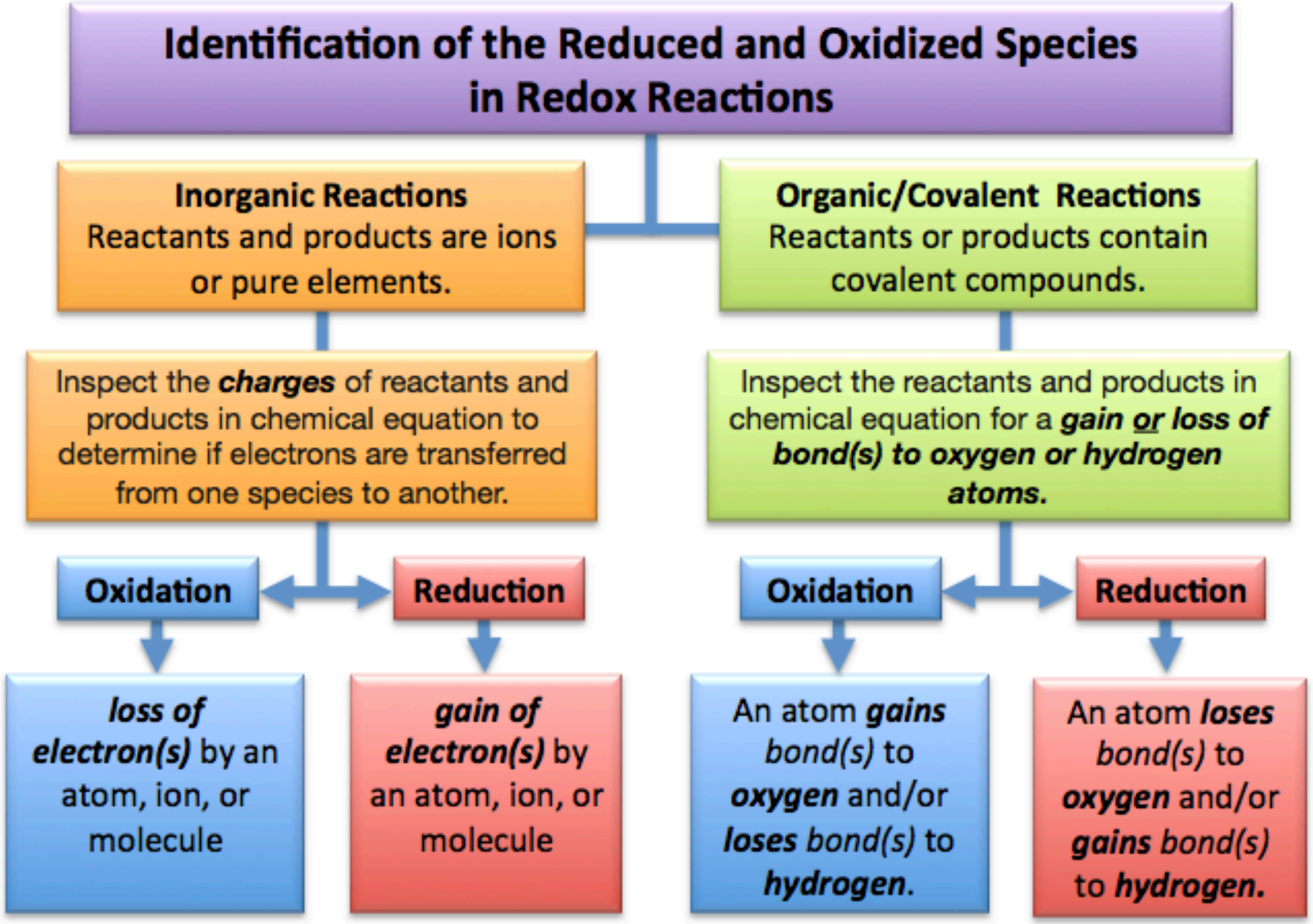
Go to next question

6.26) In the reaction shown below, is **1-pentene** being ***oxidized*** or ***reduced***?

$$CH_2{=}CHCH_2CH_2CH_3 + H_2 \longrightarrow CH_3CH_2CH_2CH_2CH_3$$

1-pentene → **pentane**



EXPLANATION: For **covalent compounds** such as organic molecules:

- An atom in a covalent compound is **oxidized** if it ***gains*** *bond(s)* to ***oxygen*** and/or ***loses*** *bond(s)* to ***hydrogen***.
- An atom in a covalent compound is **reduced** if it ***loses*** *bond(s)* to ***oxygen*** and/or ***gains*** *bond(s)* to ***hydrogen***.

In this reaction, the two left-most carbons in 1-pentene each ***gained*** a *bond* to ***hydrogen***, *therefore* 1-pentene *was* **reduced**.

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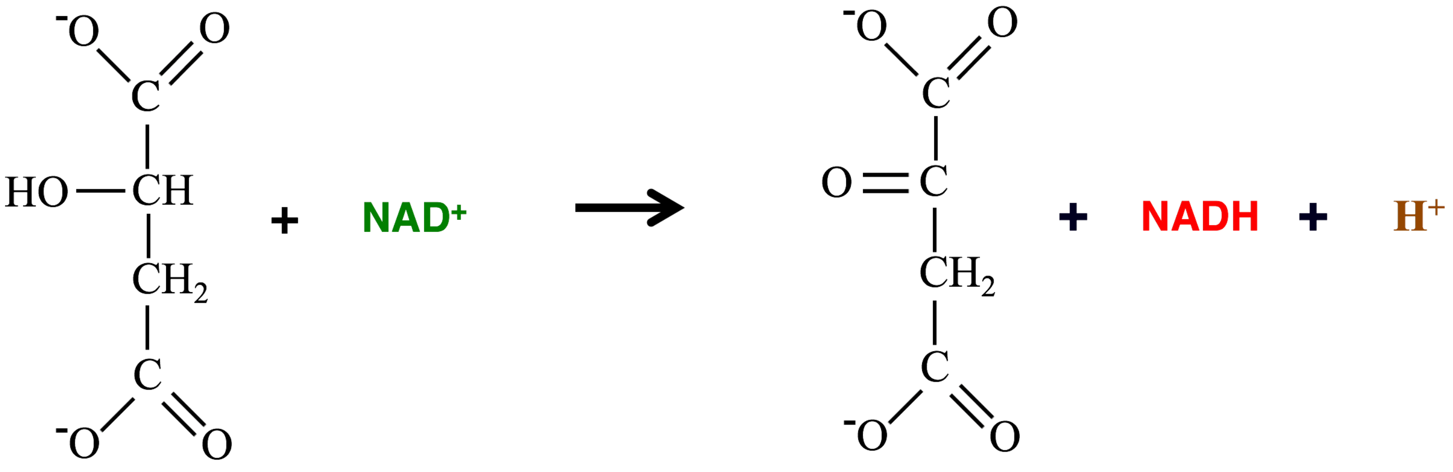
6.27) One of the reactions in the citric acid cycle is the reaction of *malate* with *nicotinamide adenine dinucleotide* (NAD^+) to produce *nicotinamide adenine dinucleotide hydride* (NADH) and *oxaloacetate*. The reaction is shown below.

Is ***malate*** being ***oxidized*** or ***reduced***?



malate ***oxaloacetate***

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Go to next question

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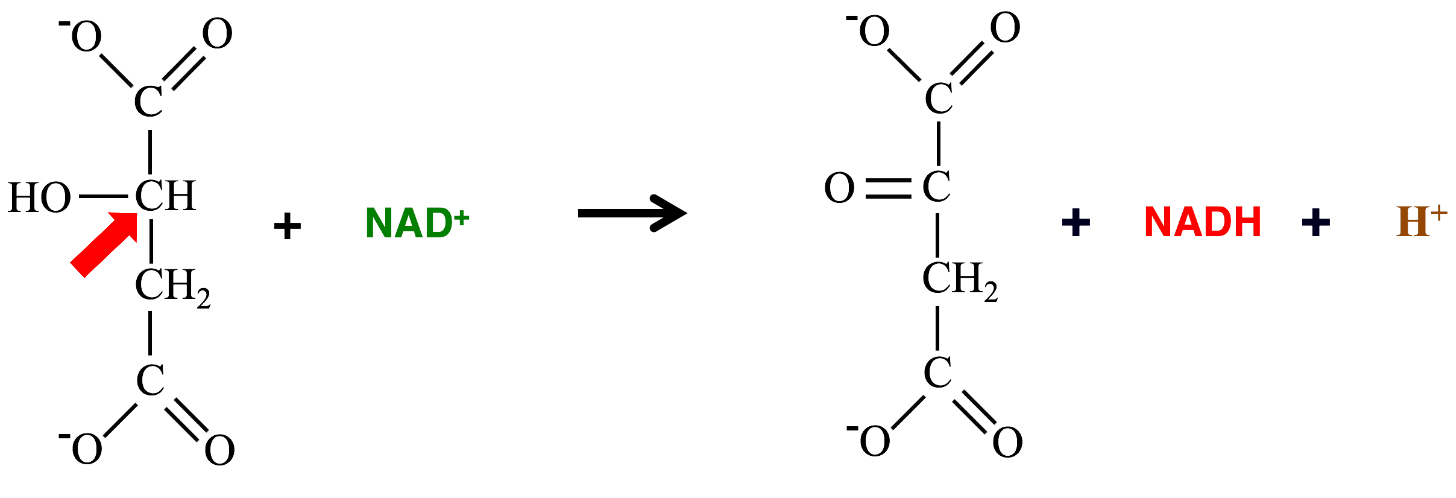

HINT: For **covalent compounds** such as organic molecules:

- An atom in a covalent compound is **oxidized** if it ***gains*** *bond(s)* to ***oxygen*** and/or ***loses*** *bond(s)* to ***hydrogen***.
- An atom in a covalent compound is **reduced** if it ***loses*** *bond(s)* to ***oxygen*** and/or ***gains*** *bond(s)* to ***hydrogen***.

Consider the carbon in malate indicated by the red arrow.

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Go to next question

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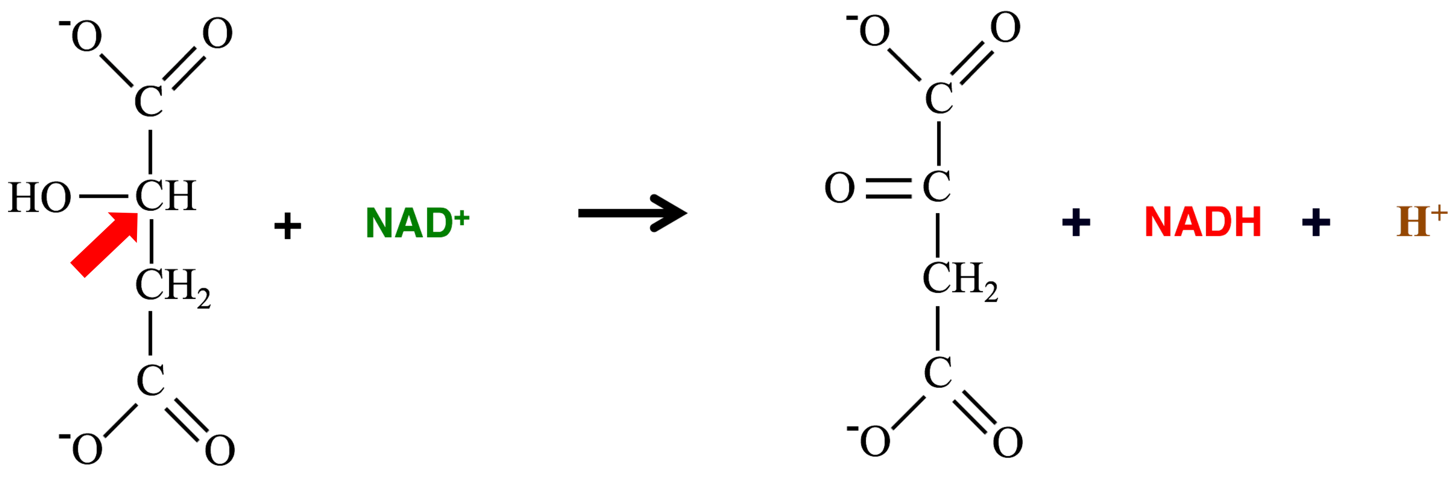

EXPLANATION: For **covalent compounds** such as organic molecules:

- An atom in a covalent compound is **oxidized** if it ***gains*** *bond(s)* to ***oxygen*** and/or ***loses*** *bond(s)* to ***hydrogen***.
- An atom in a covalent compound is **reduced** if it ***loses*** *bond(s)* to ***oxygen*** and/or ***gains*** *bond(s)* to ***hydrogen***.

In this reaction, a carbon in malate (see red arrow) ***lost*** a *bond* to ***hydrogen*** (***and gained*** *a* ***second*** *bond to the* ***oxygen*** that was already present), therefore ***malate*** was **oxidized**.

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Go to next question

6.28) You learned about ***four classes of organic reactions*** in this chapter. Match each **reaction description** (on the left) with an the appropriate **organic reaction class** (on the right).

Reaction Descriptions:

a) In this reaction, a water molecule breaks a bond to form a carboxylic acid and an alcohol.

b) An **H** and an **OH** are removed from the reactant to produce an alkene and $\mathbf{H_2O}$.

c) A hydrogen atom is added to each of the double bonded carbon atoms in the reactant to produce an alkane.

d) A hydrogen atom from $\mathbf{H_2O}$ is added to one of the double bonded carbon atoms and the **OH** from the $\mathbf{H_2O}$ is added to the other double bonded carbon atom in the reactant to produce the corresponding alcohol.

Organic Reaction Class Choices:

Hydrogenation: Reduction of Alkenes

Hydrolysis of Esters

Hydration of Alkenes

Dehydration of Alcohols

Go back

Click here for a **hint**

Click here to **check your answer**

Go to next question

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a) In this reaction, a water molecule breaks a bond to form a carboxylic acid and an alcohol.

b) An **H** and an **OH** are removed from the reactant to produce an alkene and $\mathbf{H_2O}$.

HINT: Dehydration of Alcohols

c) A hydrogen atom is added to each of the double bonded carbon atoms in the reactant to produce an alkane.

d) A hydrogen atom from $\mathbf{H_2O}$ is added to one of the double bonded carbon atoms and the **OH** from the $\mathbf{H_2O}$ is added to the other double bonded carbon atom in the reactant to produce the corresponding alcohol.

Organic Reaction Class Choices:

Hydrogenation: Reduction of Alkenes

Hydrolysis of Esters

Hydration of Alkenes

Dehydration of Alcohols

For more help: Review chapter 6 part 10 video and chapter 6 part 11 video or chapter 6 section 8 in the textbook.

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Click here to **check your answer**

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Reaction Descriptions:

a) In this reaction, a water molecule breaks a bond to form a carboxylic acid and an alcohol.
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b) An **H** and an **OH** are removed from the reactant to produce an alkene and H_2O.
   Dehydration of Alcohols

c) A hydrogen atom is added to each of the double bonded carbon atoms in the reactant to produce an alkane.
   Hydrogenation: Reduction of Alkenes

d) A hydrogen atom from H_2O is added to one of the double bonded carbon atoms and the **OH** from the H_2O is added to the other double bonded carbon atom in the reactant to produce the corresponding alcohol.
   Hydration of Alkenes

Organic Reaction Class Choices:

Hydrogenation: Reduction of Alkenes

Hydrolysis of Esters

Hydration of Alkenes

Dehydration of Alcohols

For more details: Review chapter 6 part 10 video and chapter 6 part 11 video or chapter 6 section 8 in the textbook.

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6.29) Draw **and** name the product for the *hydrogenation of* **3-hexene**.

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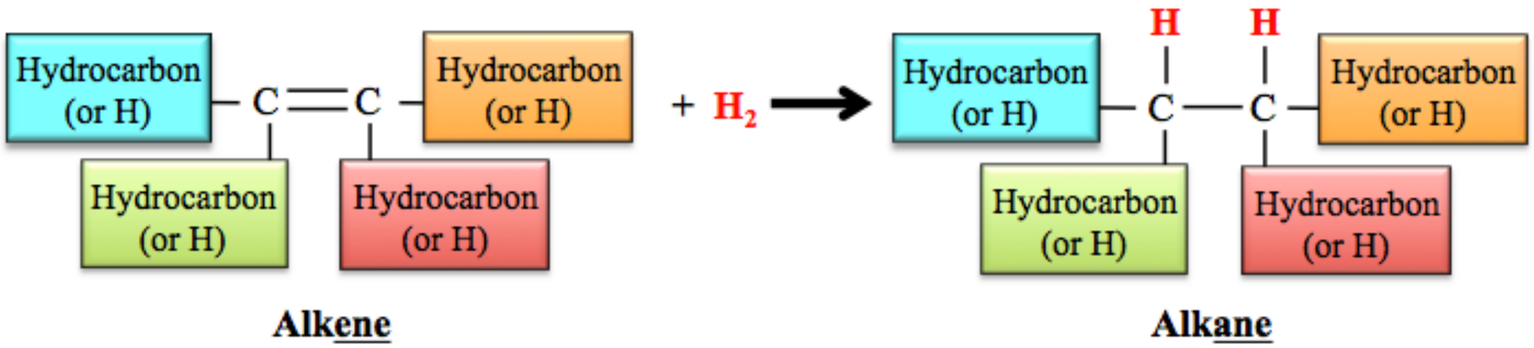
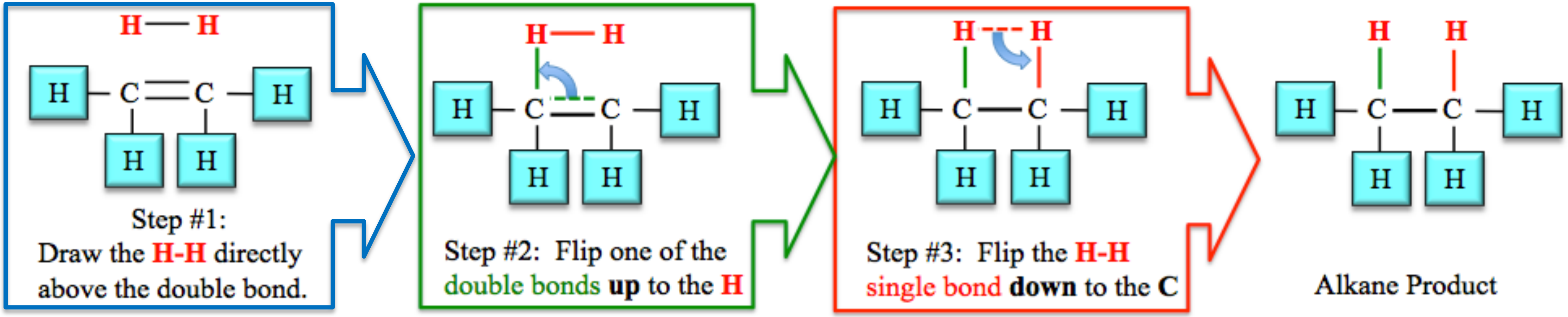
HINT: Knowing the "general form" of an organic reaction allows you to predict and draw the product(s) when given specific reactant(s). The general form for the hydration of alkenes is shown below.



Chemical reactions where new bonds are formed to atoms at each end of a double bond occur so frequently that organic chemist have a special name for it: "addition across a double bond." Products for reactions where *addition across a double bond* occurs can be easily predicted by "flipping" bonds, as illustrated below for the ***hydrogenation of ethene***.



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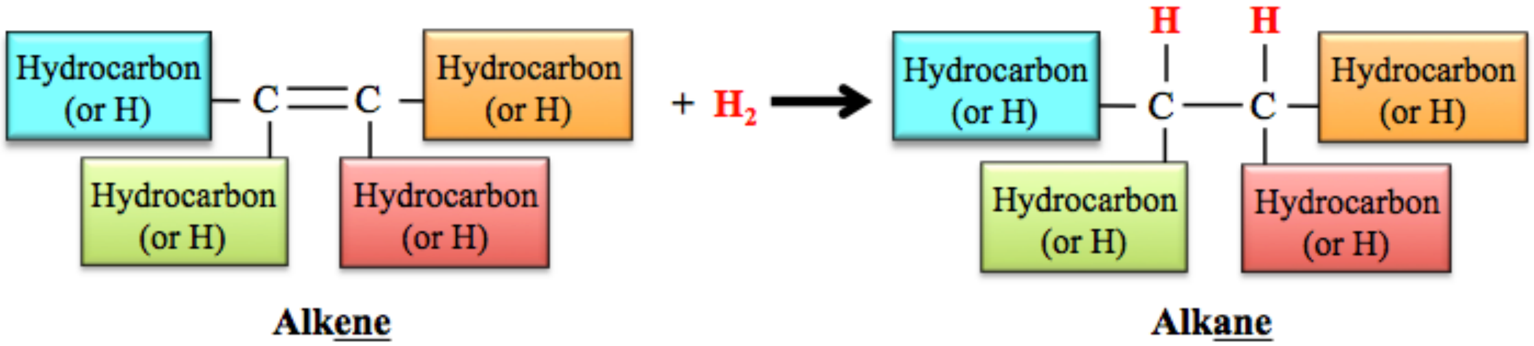
For more help: Review chapter 6 part 10 or chapter 6 section 8 in the textbook.

Click here to check your answer

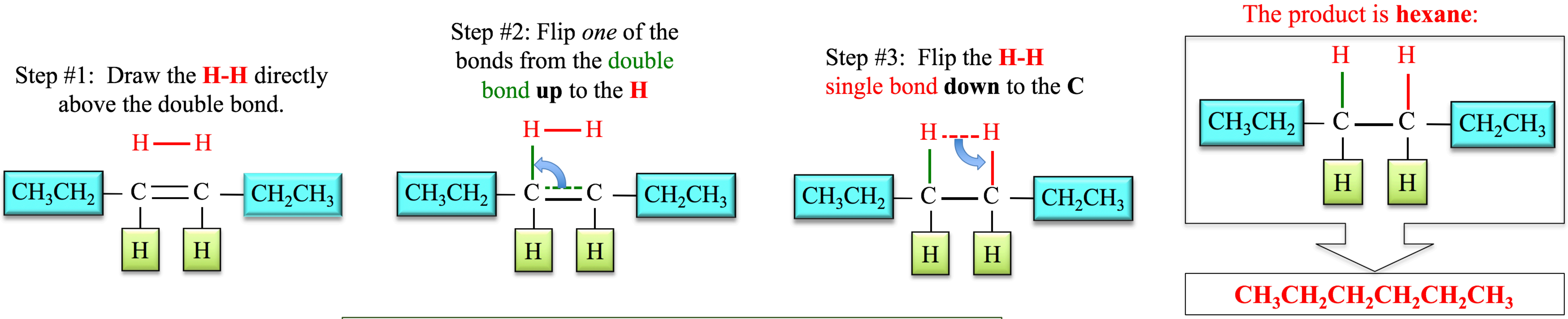
Go to next question

6.29) Draw **and** name the product for the *hydrogenation of* **3-hexene**. The product is **hexane**: $CH_3CH_2CH_2CH_2CH_2CH_3$

EXPLANATION: Knowing the "general form" of an organic reaction allows you to predict and draw the product(s) when given specific reactant(s). The general form for the hydration of alkenes is shown below.



Chemical reactions where new bonds are formed to atoms at each end of a double bond occur so frequently that organic chemist have a special name for it: "addition across a double bond." Products for reactions where *addition across a double bond* occurs can be easily predicted by "flipping" bonds, as illustrated below for the *hydrogenation of* **3-hexene** in this problem.



For more details: Review chapter 6 part 10 video or chapter 6 section 8 in the textbook.

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Go to next question

6.30) Draw **and** name the product for the *hydrogenation of* ***3,4-dimethyl-3-heptene***.

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Click here for a **hint**

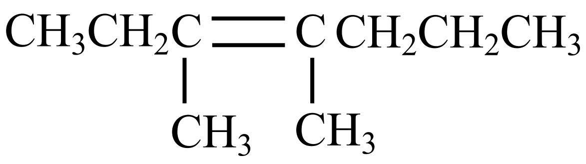
Click here to **check your answer**

Go to next question

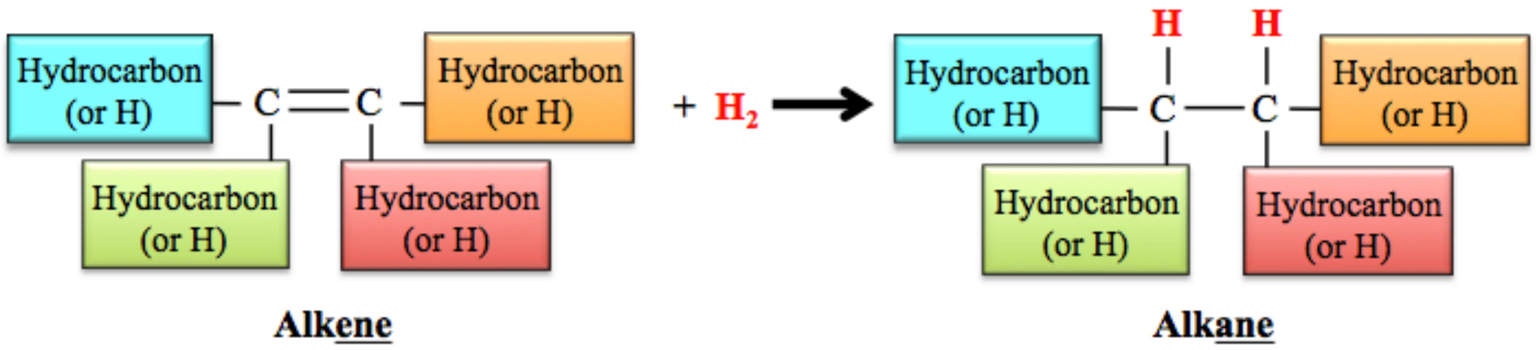
6.30) Draw **and** name the product for the *hydrogenation of* ***3,4-dimethyl-3-heptene***.

HINT:

The structure of ***3,4-dimethyl-3-heptene*** is:



Knowing the “general form” of an organic reaction allows you to predict and draw the product(s) when given specific reactant(s). The general form for the hydration of alkenes is shown below.



Products for reactions where *addition across a double bond* occurs can be predicted by using the “general form” of the reaction, or by “flipping” bonds, as illustrated in the hint and solution of the previous problem.

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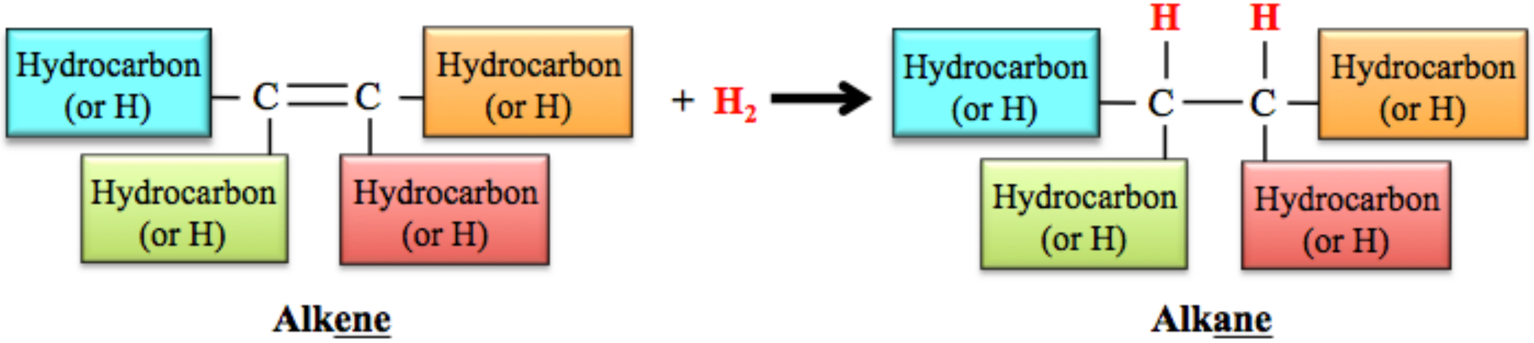
For more help: Review chapter 6 part 10 or chapter 6 section 8 in the textbook.

Click here to **check your answer**

Go to next question

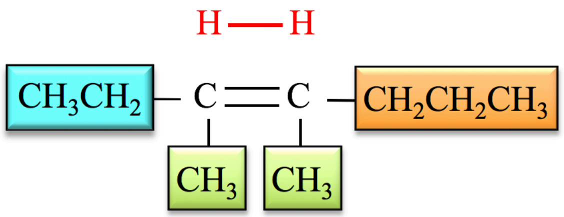
6.30) Draw **and** name the product for the *hydrogenation of* ***3,4-dimethyl-3-heptene***. The product is 3,4-dimethylheptane.

EXPLANATION: Knowing the "general form" of an organic reaction allows you to predict and draw the product(s) when given specific reactant(s). The general form for the hydration of alkenes is shown below.

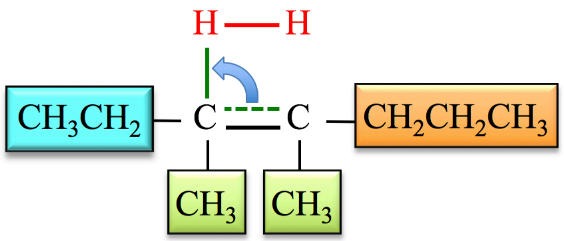


Chemical reactions where new bonds are formed to atoms at each end of a double bond occur so frequently that organic chemist have a special name for it: "addition across a double bond." Products for reactions where *addition across a double bond* occurs can be easily predicted by "flipping" bonds, as illustrated below for the *hydrogenation of* ***3,4-dimethyl-3-heptene*** in this problem.

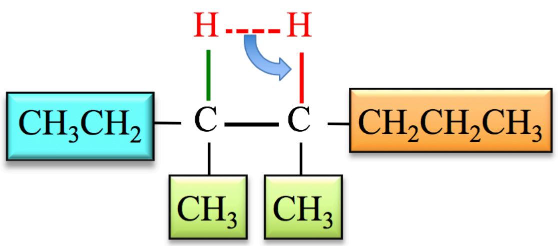
Step #1: Draw the **H-H** directly above the double bond.



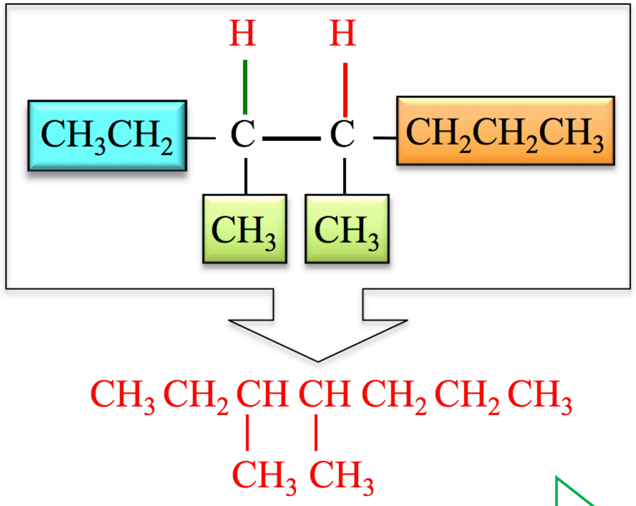
Step #2: Flip *one* of the bonds from the double bond **up** to the **H**



Step #3: Flip the **H-H** single bond **down** to the **C**



The product is 3,4-dimethylheptane:



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For more details: Review chapter 6 part 10 video or chapter 6 section 8 in the textbook.

Go to next question

6.31) An ester named *pentyl ethanoate* is used as an additive flavor ingredient in the food and beverage industry because it has a pleasant aroma similar to apples and pears. Draw the structural formula of both products in the hydrolysis of *pentyl ethanoate.*

$$CH_3\overset{\overset{\displaystyle O}{\|}}{C}-O-CH_2CH_2CH_2CH_2CH_3 \;+\; H_2O \longrightarrow \;?\; + \;?$$

pentyl ethanoate

Go back

Click here for a **hint**

Click here to **check your answer**

Go to next question

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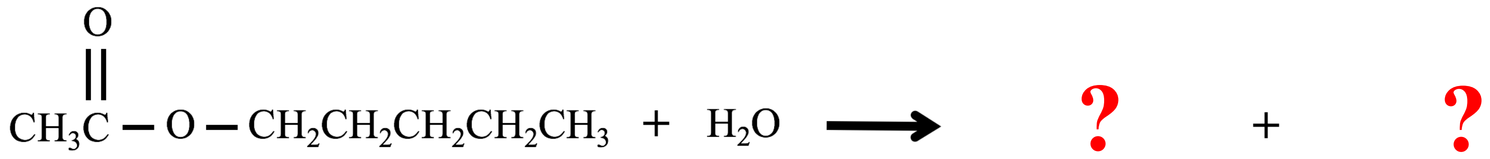


pentyl ethanoate

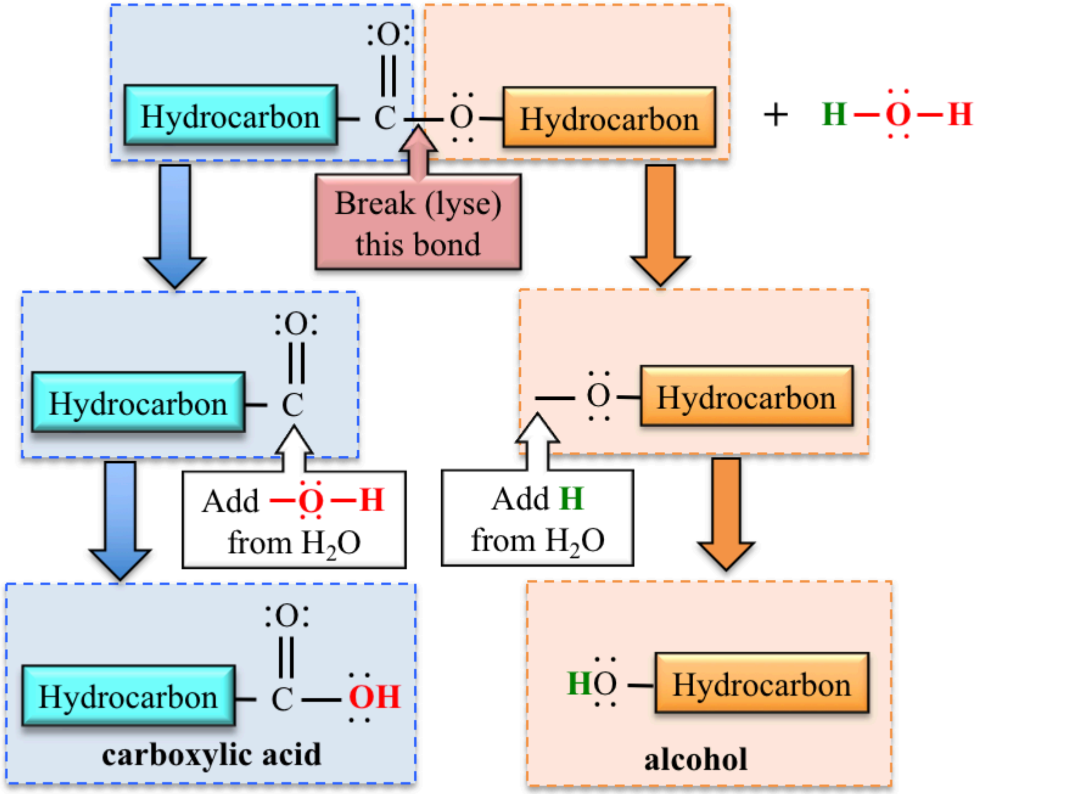
HINT: In the hydrolysis of an ester, a water molecule breaks a bond in the **ester** to form a **carboxylic acid** and an **alcohol**.

Method for predicting the products for hydrolysis of esters:

Step 1: Draw the structural formula of the ester and identify the hydrocarbon parts.

Step 2: Break (lyse) the carbon-oxygen ***single bond*** between the *carbonyl* carbon and the oxygen. The *carbonyl* carbon is the carbon that is double bonded to an oxygen.

Step 3: Add the **–OH** from the water to the *carbonyl* carbon and then add the **H** from the water to the oxygen on the ***other fragment***.



For more help: Review chapter 6 part 10 or chapter 6 section 8 in the textbook.

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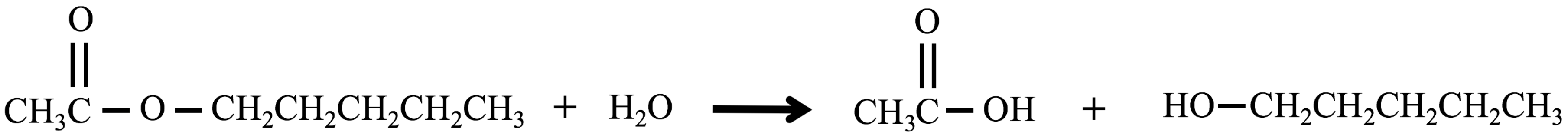
6.31) An ester named *pentyl ethanoate* is used as an additive flavor ingredient in the food and beverage industry because it has a pleasant aroma similar to apples and pears. Draw the structural formula of both products in the hydrolysis of *pentyl ethanoate.*



pentyl ethanoate

EXPLANATION: In the hydrolysis of an ester, a water molecule breaks a bond in the **ester** to form a **carboxylic acid** and an **alcohol**.

Method for predicting the products for hydrolysis of esters:

Step 1: Draw the structural formula of the ester and identify the hydrocarbon parts.

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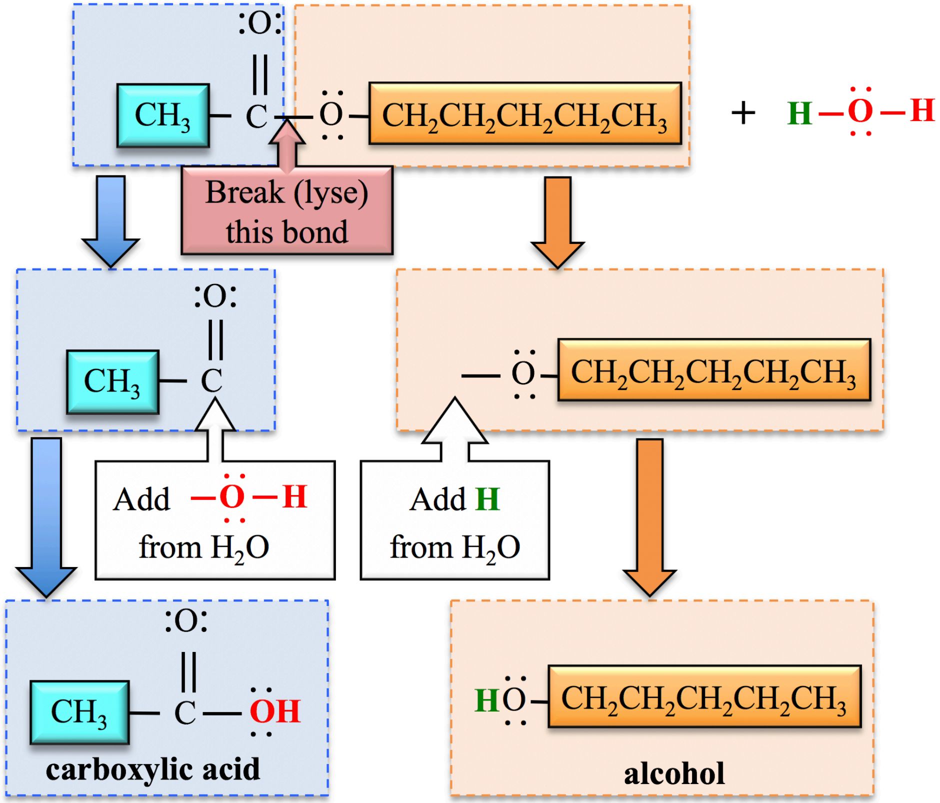

For more details: Review chapter 6 part 10 video or chapter 6 section 8 in the textbook.

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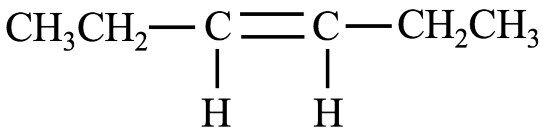
Go to next question

6.32) Draw the product formed by the **hydration** of this alkene: 

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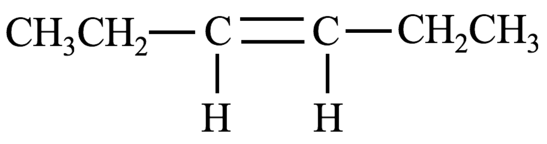
Click here for a **hint**

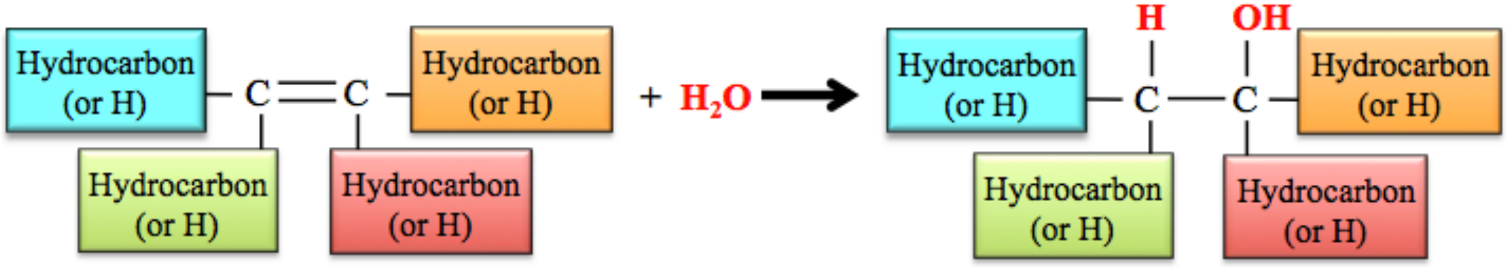
Click here to **check your answer**

Go to next question

6.32) Draw the product formed by the **hydration** of this alkene:

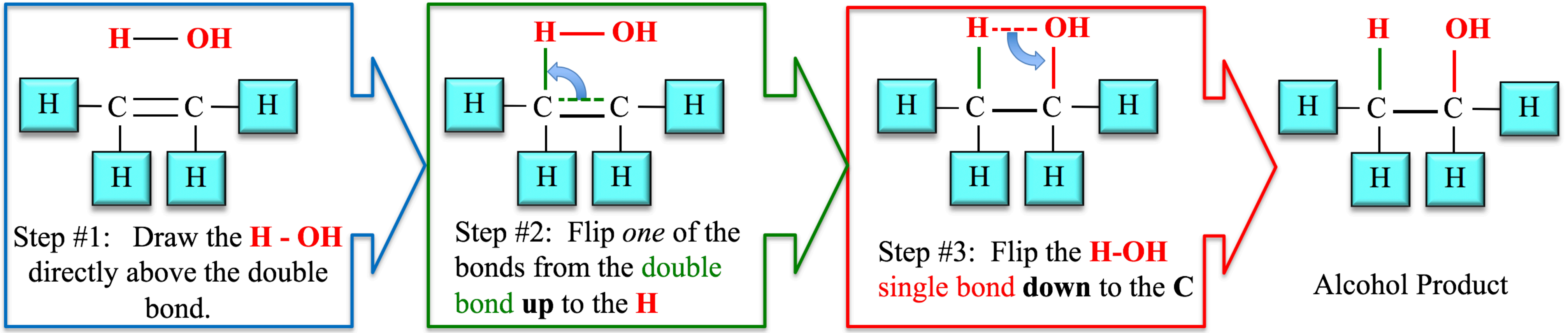


HINT: Alkenes react with water molecules to produce alcohols. A hydrogen atom from H_2O is added to one of the double bonded carbon atoms, and the -OH from the H_2O is added to the other double bonded carbon atom in the alkene to produce the corresponding alcohol. The double bond in the alkene is converted to a single bond in the alcohol. The general form for the hydration of an alkene reaction is shown below:



Alkene **Alcohol**

In the hydration of alkenes reaction, water is added ***across the double bond*** of an alkene, therefore we can use the bond flipping method to predict the structure of the alcohol that is produced. This is shown below for the hydration of ***ethene***.



Go back

For more help: Review chapter 6 part 11 video or chapter 6 section 8 in the textbook.

Click here to check your answer

Go to next question

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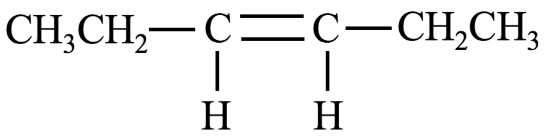

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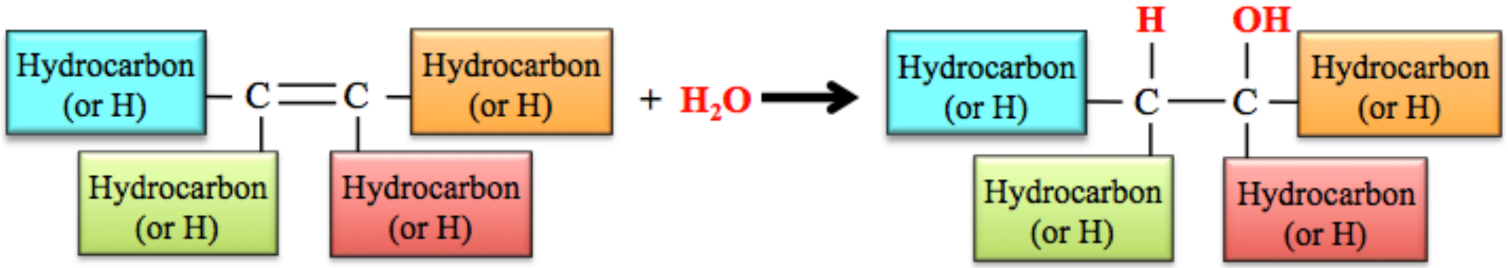

Alkene **Alcohol**

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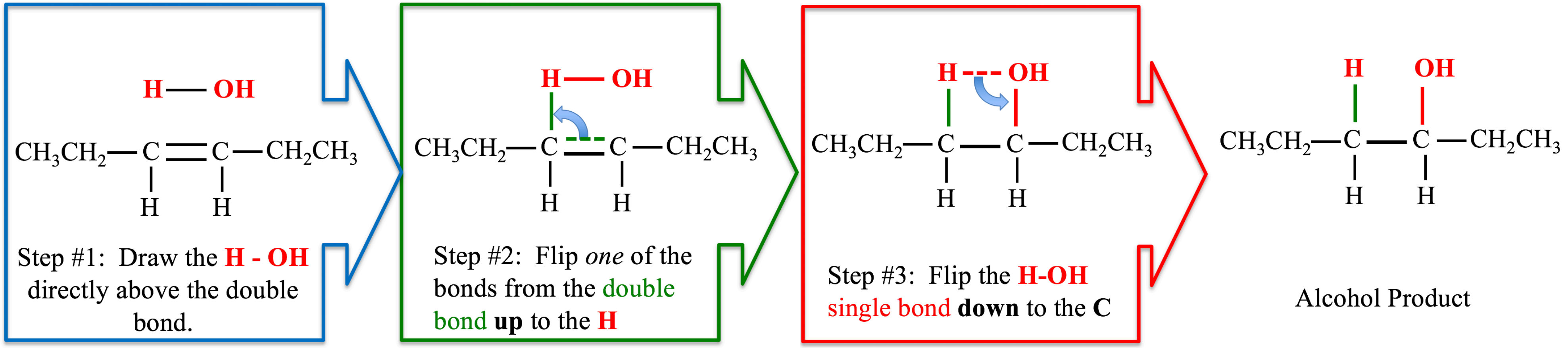

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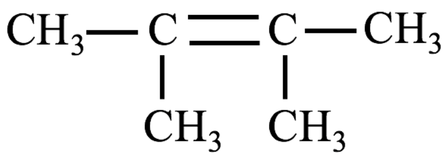
For more details: Review chapter 6 part 11 video or chapter 6 section 8 in the textbook.

Go to next question

6.33) Draw the product formed by the hydration of this alkene: 

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Click here for a **hint**

Click here to **check your answer**

Go to next question

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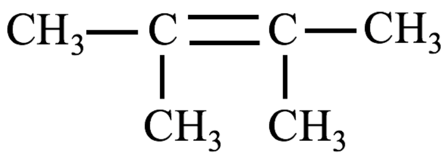

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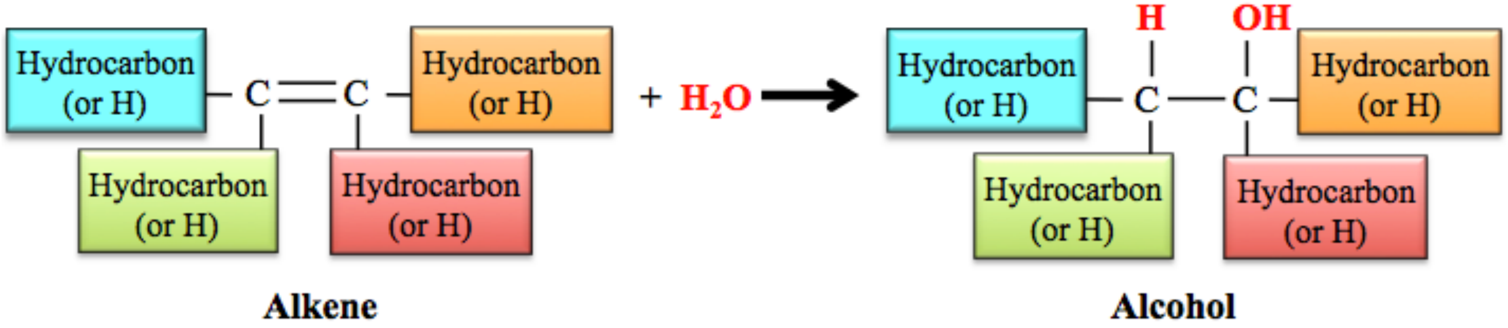

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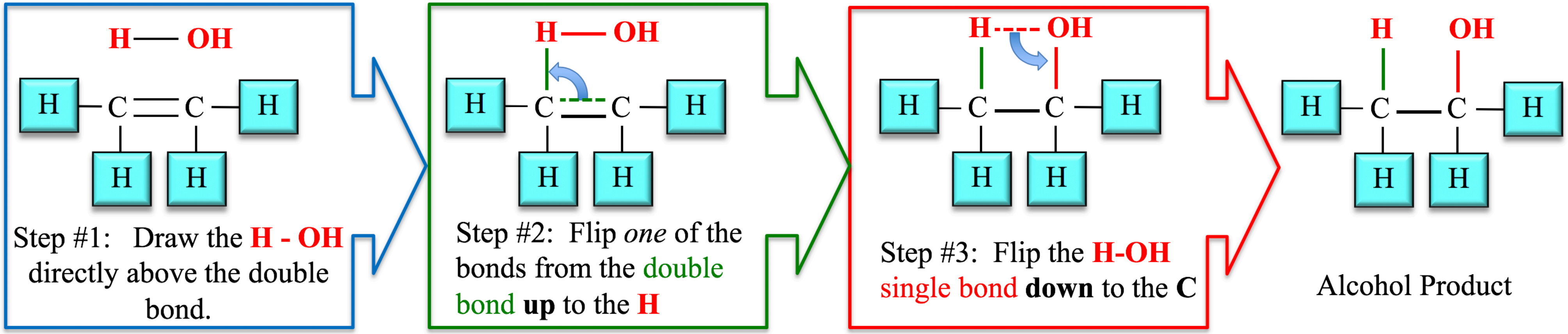

For more help: Review chapter 6 part 11 video or chapter 6 section 8 in the textbook.

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Click here to check your answer
Go to next question

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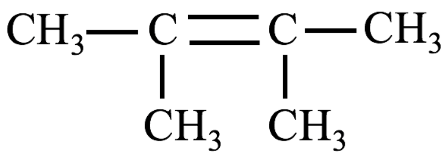

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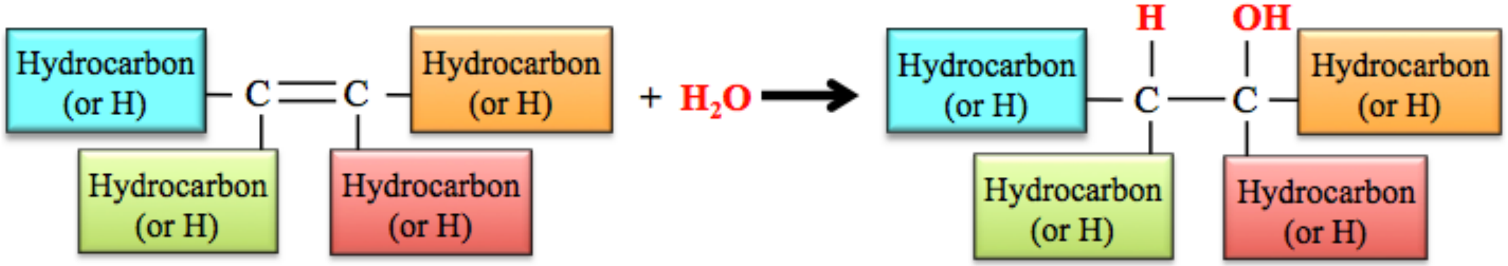

Alkene **Alcohol**

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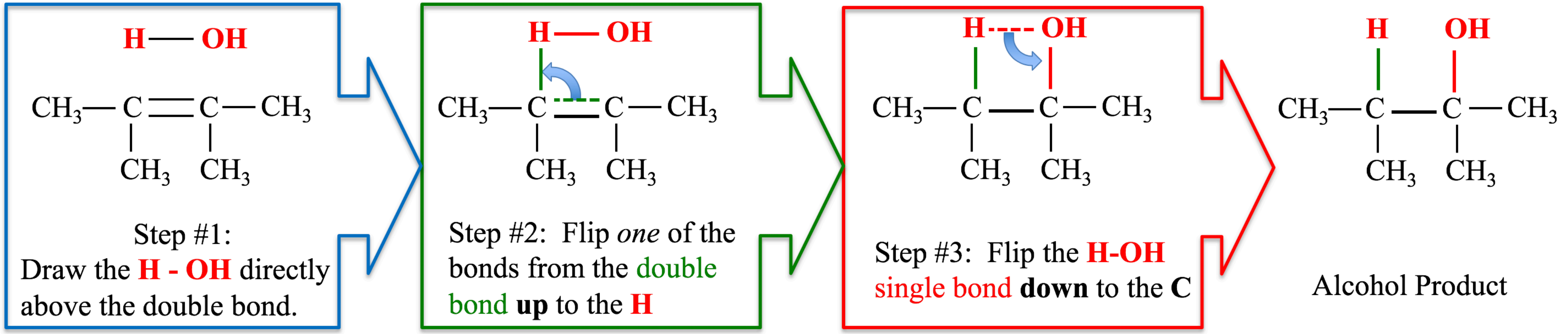

For more details: Review chapter 6 part 11 video or chapter 6 section 8 in the textbook.

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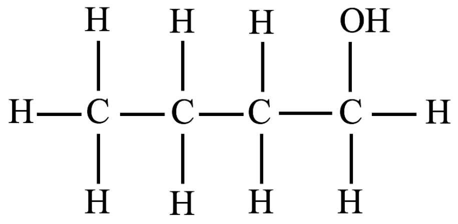
6.34) Draw **and** name the *condensed structural formula* for the alkene that is produced when *butyl alcohol* undergoes a dehydration reaction.



butyl alcohol

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[Click here for a **hint**](#)

[Click here to **check your answer**](#)

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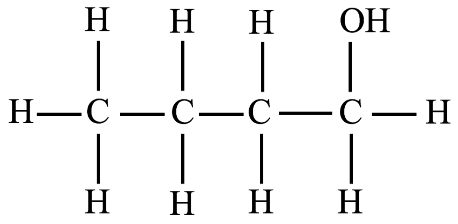
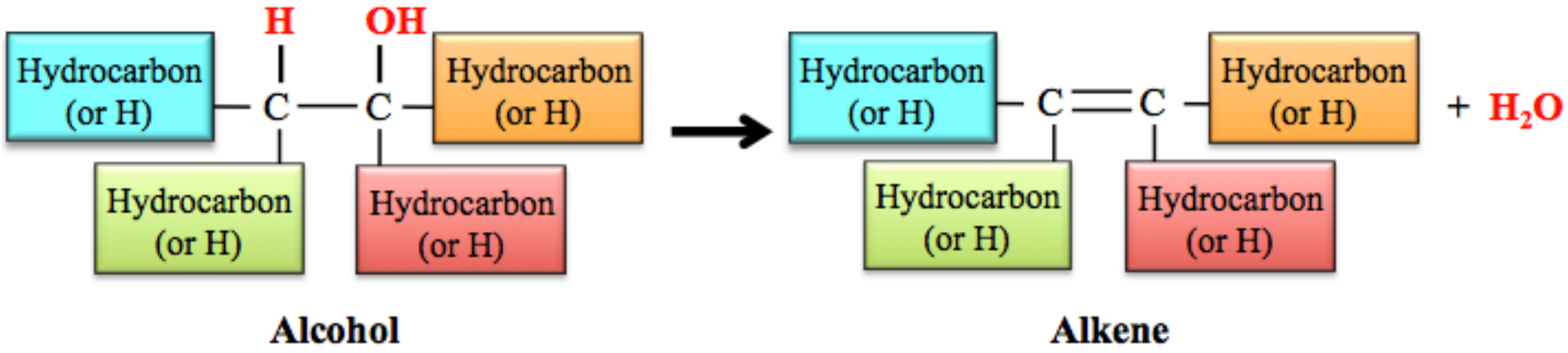


butyl alcohol

HINT: Dehydration of alcohols is the reverse of hydration of alkenes. **H_2O** is removed from an alcohol to form an alkene. A hydroxyl group (**-OH**) is removed from a carbon atom and a **H** is removed from a carbon that is adjacent to the carbon that was bonded to the hydroxyl group. A double bond forms between these two carbons.

The general form for the dehydration of an alcohol reaction is shown on the right:



If you wish, you can use a "bond flipping" method to solve this problem. Since this reaction is the *reverse* of the hydration of alkenes reaction, you can flip the bonds in the *opposite order* to that which we used when we added water across the alkene double bond. Doing so can be very helpful in determining the alkene product of dehydration of alcohol reactions.

Go back

For more help: Review chapter 6 part 11 video or chapter 6 section 8 in the textbook.

Click here to check your answer

Go to next question

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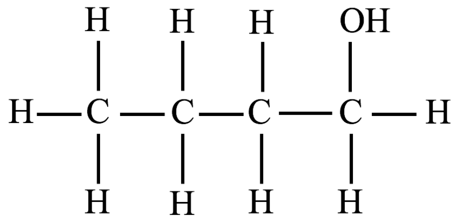

butyl alcohol

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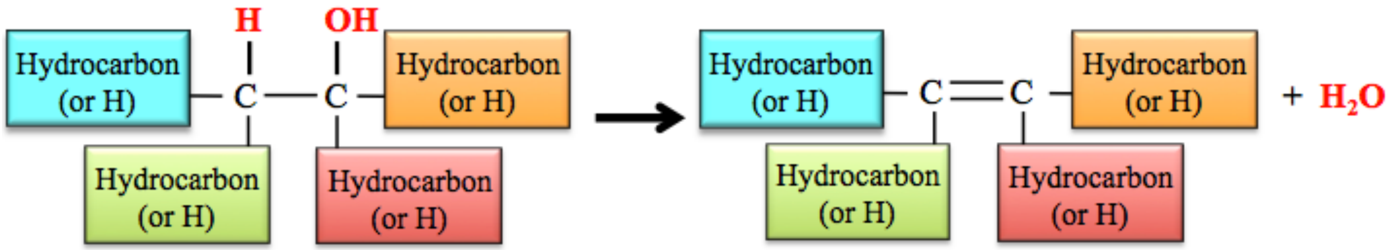


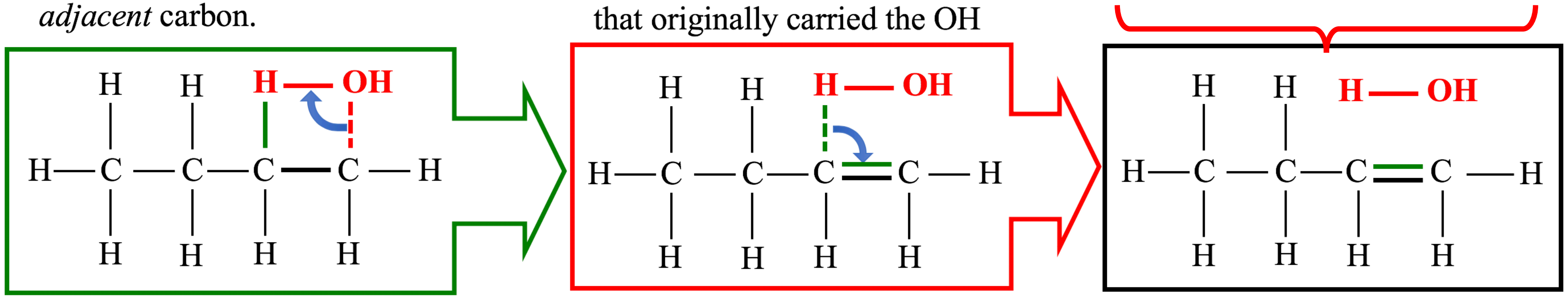
Alcohol **Alkene**

Since this reaction is the *reverse* of the hydration of alkenes reaction, we can flip the bonds in the *opposite order* to that which we used when we added water across the alkene double bond.

Step #1: Flip the bond between the C and **OH up** to an **H** on *an adjacent* carbon.

Step #2: Flip the **C--H** bond from the *adjacent* carbon **down** to make a double bond to the C that originally carried the OH

ANSWER: 1-butene



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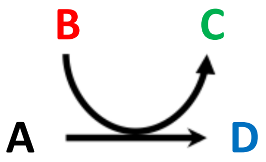
6.35) Biochemical literature often uses an *alternative* chemical equation format. For example, the reaction:

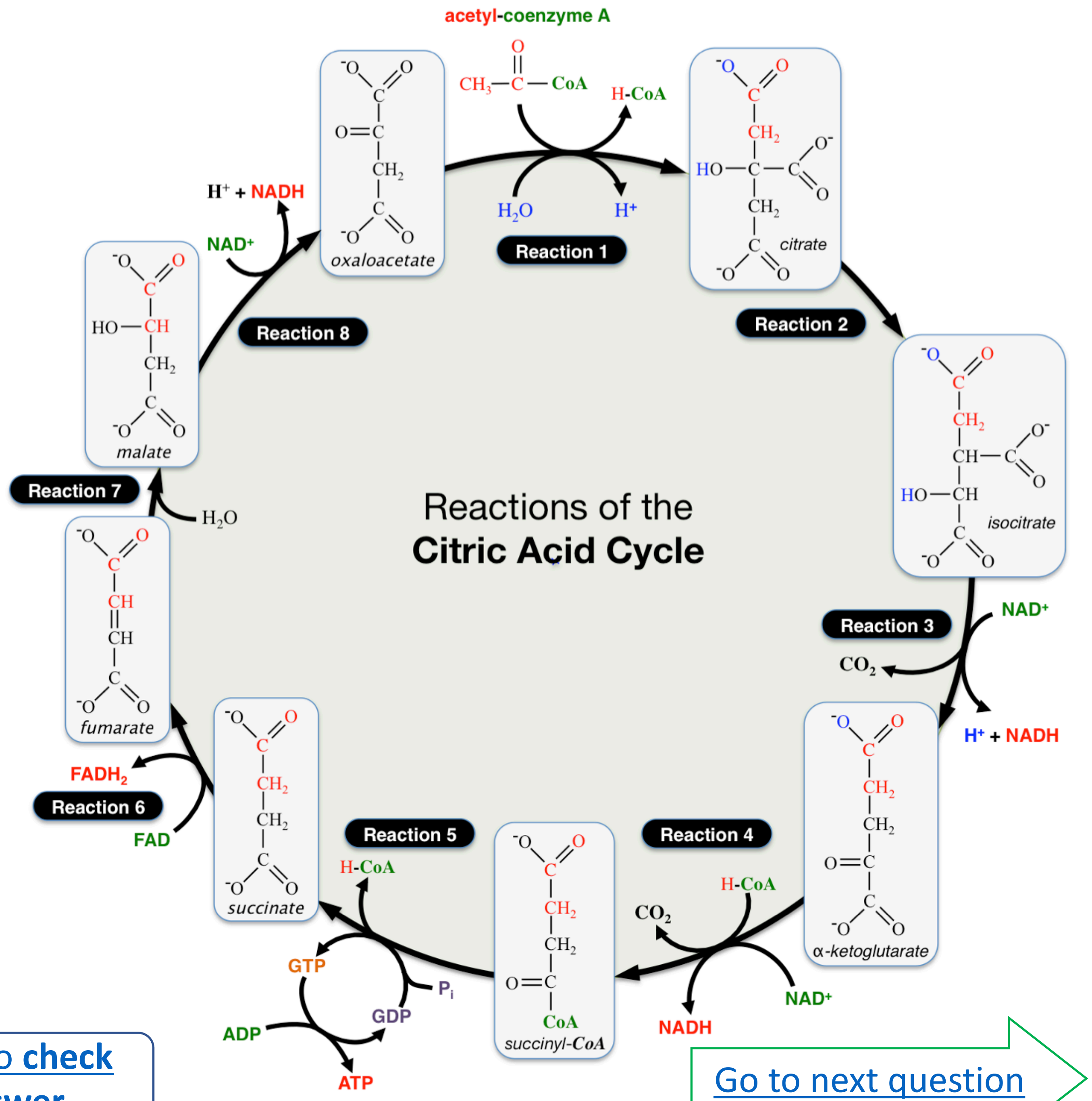
A + B ⟶ C + D

is often written as:



There are *eight* chemical reactions that occur in the **citric acid cycle** process. The reactions of the citric acid cycle are shown in the figure on the right.

Which reaction is a ***hydration reaction***?



Go back

Click here for a **hint**

Click here to **check your answer**

Go to next question

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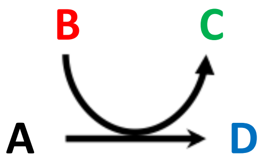
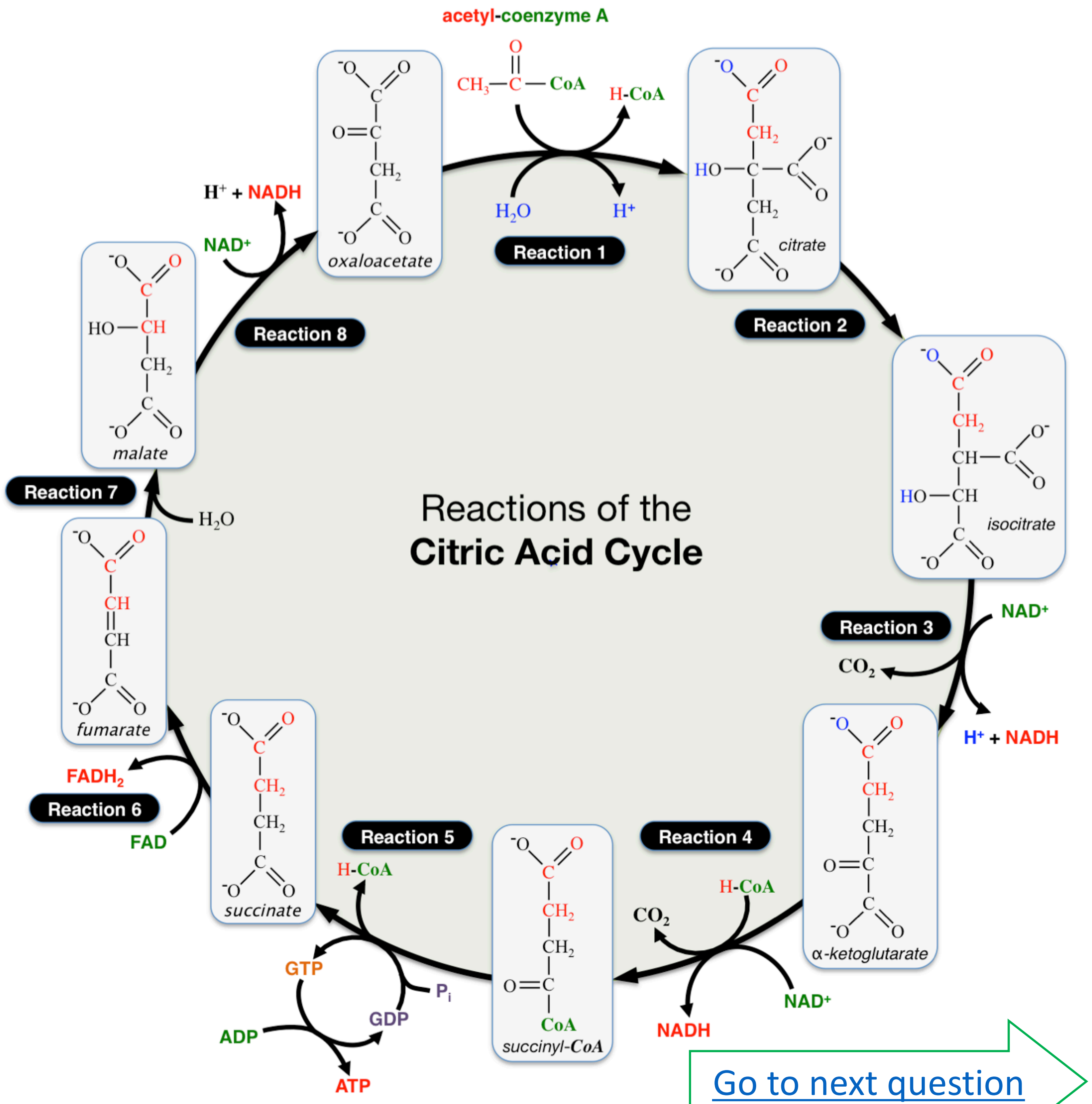


There are *eight* chemical reactions that occur in the **citric acid cycle** process. The reactions of the citric acid cycle are shown in the figure on the right.

Which reaction is a ***hydration reaction***?

HINT:

In hydration reactions, a hydrogen atom from H_2O is added to one of the double bonded carbon atoms in the reactant molecule, and the -OH from the H_2O is added to the other double bonded carbon atom. The double bond is converted to a single bond in the product. Find the reaction where this occurs.



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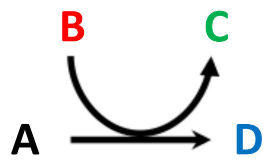


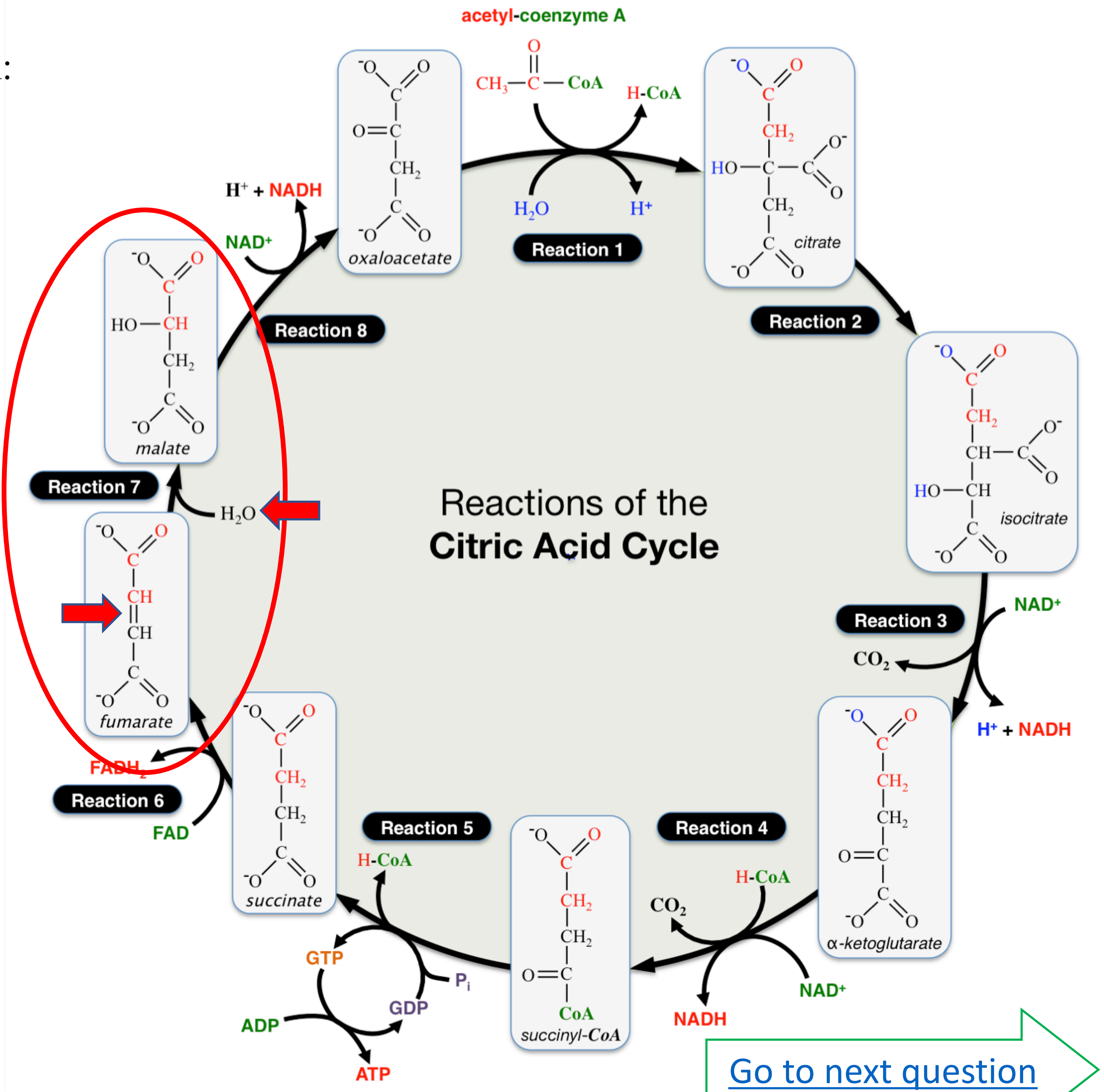
There are *eight* chemical reactions that occur in the **citric acid cycle** process. The reactions of the citric acid cycle are shown in the figure on the right.

Which reaction is a ***hydration reaction***?

ANSWER: Reaction 7

EXPLANATION:

In **Reaction 7**, **H_2O** is added "across the double bonded carbon atoms" in *fumarate*. The carbon-carbon double bond in *fumarate* is converted to a single bond in malate.



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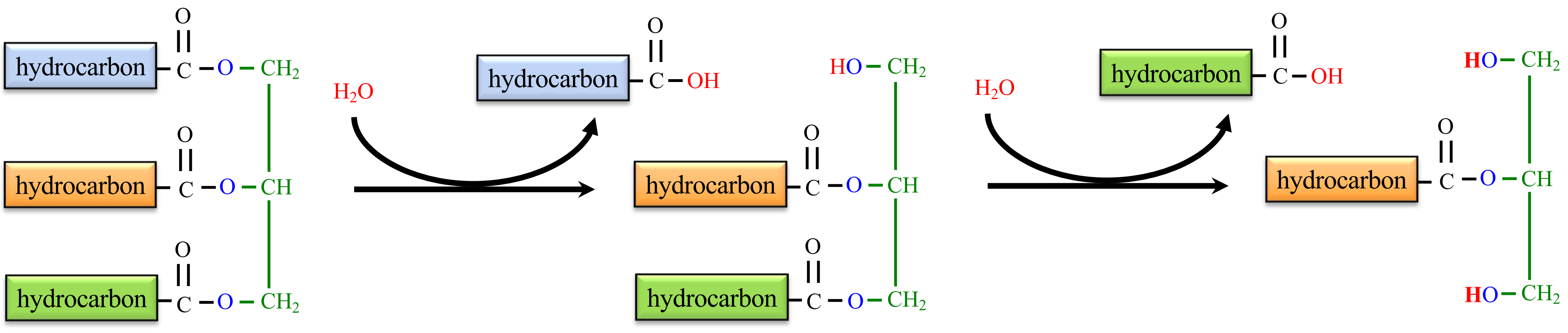
[Go to next question](#)

6.36) NOTE: You may find this question to be difficult. I would not ask this question on an exam because it may be difficult for students to determine the *family of organic compounds* in which the large reactant molecule belongs.

Dietary **triglycerides**, regardless of whether they came from plant or animal sources, are often referred to as **fat**. When triglycerides are catabolized, their chemical potential energy is converted to chemical potential energy in ATP. This process begins with the ***digestion*** of triglycerides. In digestion, triglycerides are first converted to diglycerides, and then to monoglycerides, as shown below.



a ***tri***glyceride a ***di***glyceride a ***mono***glyceride

You learned about ***four classes of organic reactions*** in this chapter. To which of these ***four classes of organic reactions*** (listed below) does this reaction belong?

a) Hydrogenation: Reduction of Alkenes

b) Hydrolysis of Esters

c) Hydration of Alkenes

d) Dehydration of Alcohols

Go back

Click here for a **hint**

Click here to **check your answer**

This is the last problem.

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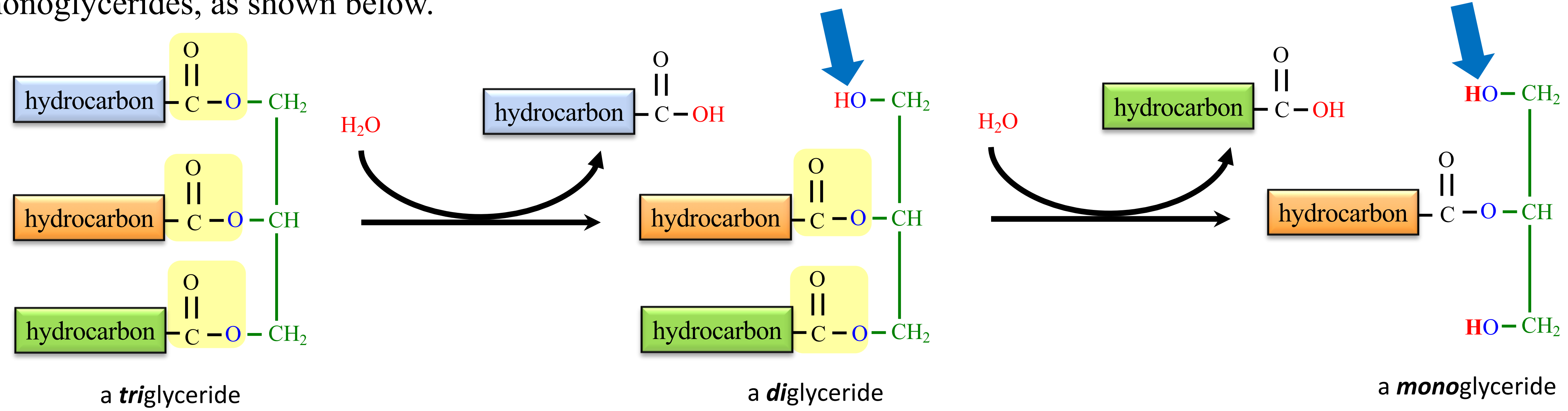

You learned about ***four classes of organic reactions*** in this chapter. To which of these ***four classes of organic reactions*** (listed below) does this reaction belong?

a) Hydrogenation: Reduction of Alkenes
b) Hydrolysis of Esters
c) Hydration of Alkenes
d) Dehydration of Alcohols

HINT: The key to this problem is to *recognize the family of organic compounds* in which the large reactant molecule belongs. I have highlighted the *important bonding pattern* in yellow. Also, note that the diglyceride and monoglyceride, contain OH groups that are characteristic of *a particular organic family* (see blue arrows).

Go back

Click here to check your answer

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6.36) NOTE: You may find this question to be difficult. I would not ask this question on an exam because it may be difficult for students to determine the *family of organic compounds* in which the large reactant molecule belongs.

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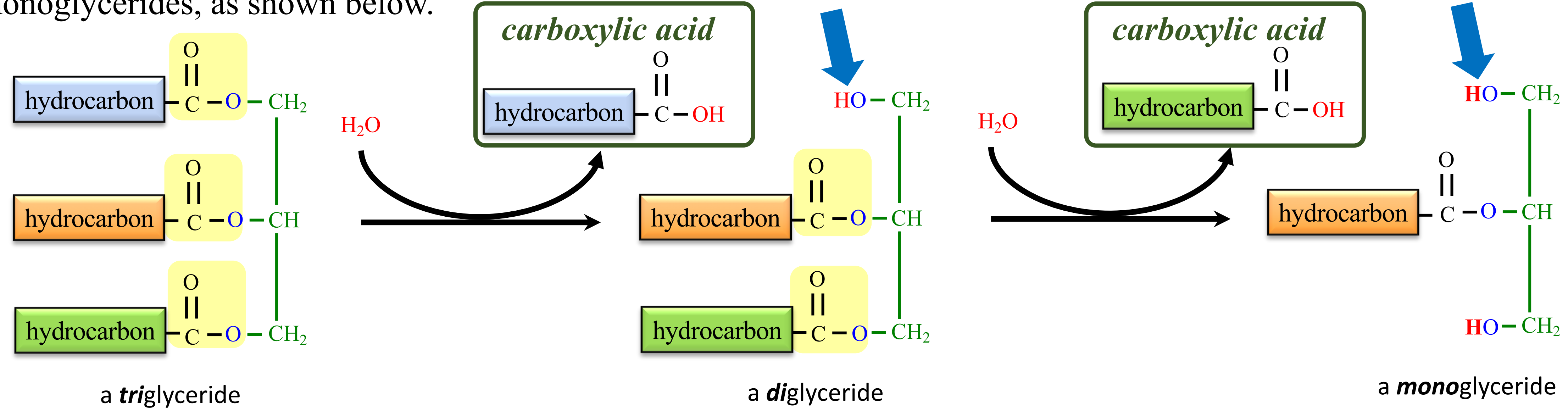

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a) Hydrogenation: Reduction of Alkenes
b) Hydrolysis of Esters
c) Hydration of Alkenes
d) Dehydration of Alcohols

EXPLANATION: The key to this problem is to *recognize the large reactant molecules* as ***esters*** and note the ***carboxylic acid products***. I have highlighted the *ester bonding pattern* in yellow. Note that the diglyceride and monoglyceride, contain OH groups that are characteristic of *the alcohol organic family* (see blue arrows).

Go back

This is the last chapter 6 review problem.