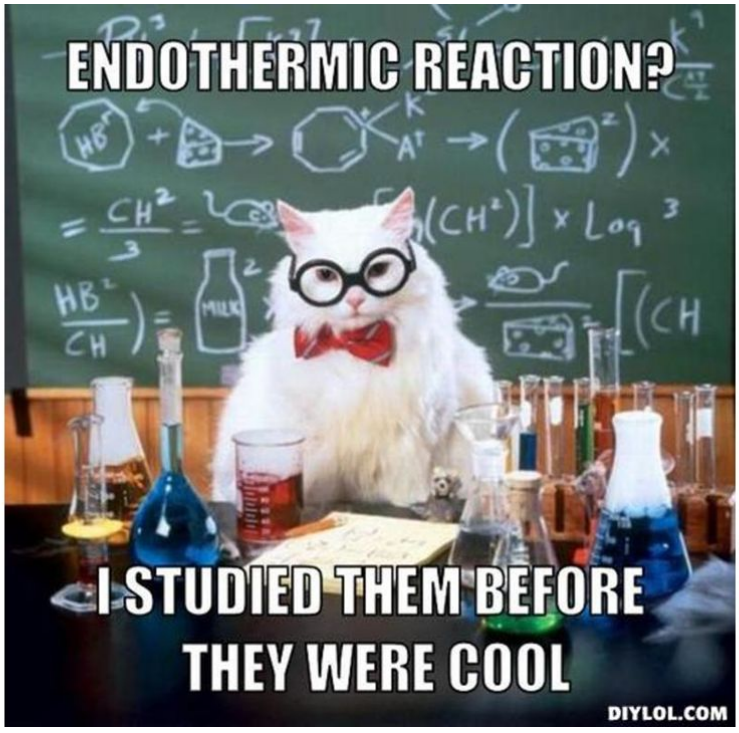
SCIENCE 10

UNIT 2: CHEMISTRY



BOOK 6: ENERGY CHANGES IN CHEMICAL REACTIONS

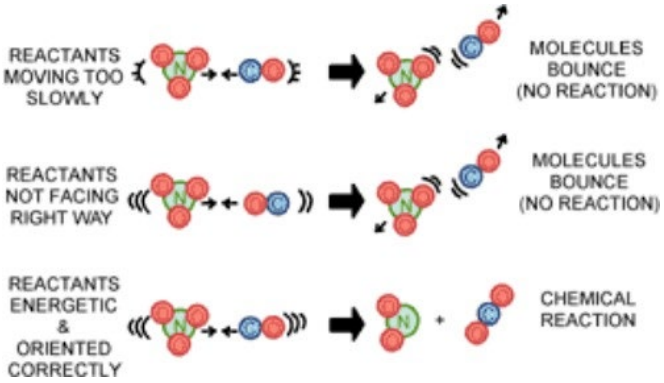
NAME: _____ BLOCK: _____

How is energy involved in chemical processes?

_____ and energy are continually interacting in the world around us.

For any chemical reaction to occur, the reactants must ____ _____ with the products with enough _____ _____to begin to break the bonds in the reactants.

This minimum amount of energy needed for a reaction to occur is called the _____energy.



It if often useful to think of the activation energy as a barrier or "hill" that **needs to be overcome** for a reaction to begin.

Many chemical reactions require an _____→ the reactant will not react by simply mixing them together.

<u>For example:</u> a bbq. The propane and oxygen do not spontaneously ignite as soon as the gas is turned on. A spark or a lighter is needed. The spark provides a few molecules of oxygen and propane with enough energy to overcome the energy barrier and react.

The SYSTEM and the SURROUNDINGS

Chemists think of energy changes in chemical reactions in terms of energy transfers between the _____ and the _____.

The system is the materials involved in the _____and <u>*everything else*</u> in the universe is the surroundings.

The Law _____states that the total energy of the universe is constant→energy cannot be _____ or _____.

In terms of a chemical reaction, it means that energy that _____ the system must **enter** the surroundings, and energy that _____ the system must **come from** the surroundings.

Video: https://www.youtube.com/watch?v=ygyaMUuEyJM **(start @ 2:15)**

While watching the video, follow along and fill in the blanks below:

Energy Transfers in Reactions:

- Chemical reactions become _____ or _____ as they proceed
- They give out or absorb heat because of the making and breaking of _____
- **Making** chemical bonds **releases heat energy** – _____
- <u>*Breaking*</u> chemical bonds <u>*requires energy*</u> -_____
- _____ input is often needed to start the reaction

1. Exothermic Reactions

EXAMPLE 1: What happens when the magnesium metal is placed in hydrochloric acid?

An ***energy diagram*** shows that in an _____ reaction the _____ have **LESS ENERGY** than the reactants, so the energy left over heats up the _____.

Many exothermic reactions _____ some heat energy to get them started, for example, rocket fuel.

The amount of energy it takes for a reaction to get going is called the _____.

Summary of Exothermic Reactions:

- More energy is _____ by the reactants than is needed by the products
- The excess energy is given off as _____
- Heat input is often needed to provide activation energy to start the reaction
- Heat from the reaction then keeps the reaction going

EXPERIMENT 2: What happens to the atoms when natural gas (methane CH_4) burns in air? *(combustion)*

- Heat provides energy to _____in methane and air (O_2)
- Now the atoms can rearrange and form _____ bonds, the reaction products, _____and ___ _____
- Water and carbon dioxide don't need as much energy as the reactants that formed them, so making bonds _____
- The spare energy goes out as _____, overall the reaction is _____

2. Endothermic Reactions

- An endothermic reaction is the opposite of an exothermic reaction
- It _____ heat

EXPERIMENT 3: What happens to the dry ammonium nitrate crystals and water when an instant ice pack is broken open?

An energy level diagram shows how the _____ have **LESS energy** than the products.

That means the reactants have a huge _____ hill to climb for the reaction to go ahead.

They must steal the energy they need from the _____causing the temperature to_____.

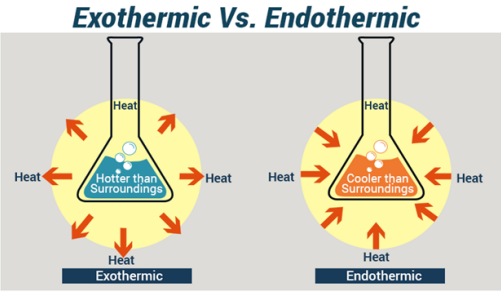
Summary of Endothermic Reactions:

- _____energy is needed by the _____ than is released by the reactants
- The energy shortage is taken in as heat from the surroundings
- This creates a _____ effect

Exothermic and Endothermic Reactions

In any chemical reaction:

1. _____
2. _____

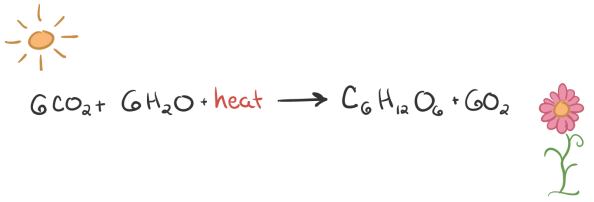


There are two kinds of energy changes in chemical reactions:

- In an ***endothermic reaction***, energy is _____ by the system from the surroundings.
- In an ***exothermic reaction***, energy is _____ from the system to the surroundings.

Endothermic reactions: Heat is absorbed.

1) _____: Plants absorb heat energy from sunlight to convert carbon dioxide and water into glucose and oxygen.
2) _____: Heat energy is absorbed from the pan to cook the egg.



Exothermic reactions: Heat is released.

1) _____: The burning of carbon-containing compounds uses oxygen, from air, and produces carbon dioxide, water, and lots of heat. *For example,* $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + heat$

Chemists experiment on chemical systems containing reactants and products which exchange energy with the surroundings - the container and the rest of the universe.

The ***First Law of Thermodynamics*** states that:

_____

This simple statement means that any energy lost by a system must simultaneously be gained by the surroundings (or vice versa).

Why is heat released or absorbed in a chemical reaction?

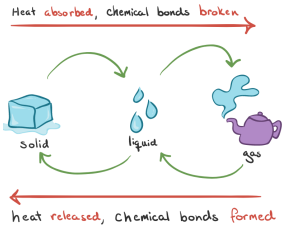
In any chemical reaction, chemical bonds are either _____ or _____.

Rule of thumb is:

"When chemical bonds are formed, heat is released, and when chemical bonds are broken, heat is absorbed."

Molecules want to stay together, so **formation of chemical bonds** between molecules requires _____ as compared to breaking bonds between molecules, which requires _____and results in heat being absorbed from the surroundings.

REMEMBER: Energy must be absorbed to break bonds and energy is released when bonds form.



1. Energy is _____ to break the bonds between the atoms in the reactants.

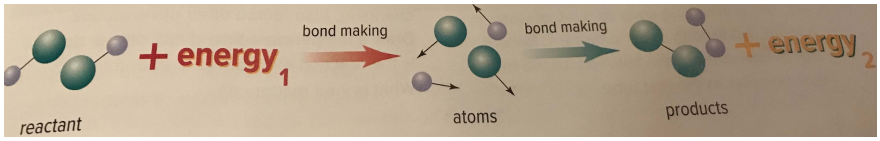
... and immediately afterward ...

2. Energy is _____as the new bonds form between the atoms in the products.

Summarizing:

Bond breaking is always endothermic.
Bond forming is always exothermic.
} *The reaction is either endothermic or exothermic depending on which of these is greater.*

By comparing the total energy required when bonds in the reactants are broken, with the total energy released when bonds in the products are formed, we can determine if there is an overall release of energy or absorption of energy.



Exothermic Reaction: Total energy ***absorbed*** in bond breaking < Total energy ***released*** during bond forming.

energy1 < energy2

Endothermic Reaction: Total energy ***absorbed*** in bond breaking > Total energy ***released*** during bond forming.

energy1 > energy2

Measuring Energy Changes

Energy changes in a reaction can be monitored by measuring change in temperature.

DEMO 1: Mg + HCl _____ + _____

Did the temper → ncrease or decrease?_____, the reaction is _____

DEMO 2: $Ba(OH)_{2(s)} + 2NH_4NO_{3(s)} \rightarrow Ba(NO_3)_{2(aq)} + 2NH_{3(aq)} + 10H_2O_{(l)}$

Did the temperature increase or decrease?_____, the reaction is _____

Enthalpy ΔH

The amount of energy stored in the bonds of the reactants or products in a system is called the _____ **(H)** (from the Greek word *enthalpein* meaning "to warm").

Since energy will either be ***lost or gained*** by the system during a reaction, the value of H will _____ _____between the reactants and the products.
In other words, there is a **change in energy.**

- In an **endothermic** reaction, more energy will be stored in the products than in the reactants: _____
  _____
- In an **exothermic** reaction, less energy will be stored in the products than in the reactants: _____
  _____

We can never really know the internal energy in a system but we ***can measure the change in this energy***.

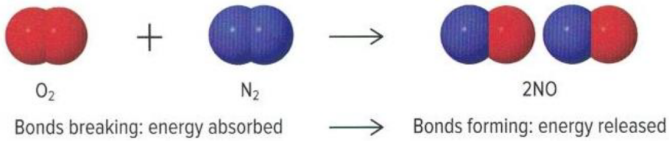
This **change in energy** is represented by **ΔH** where:

$$\Delta H = H_{\text{products}} - H_{\text{reactants}}$$

ΔH value negative --> energy released --> exothermic reaction
ΔH value positive --> energy absorbed --> endothermic reaction

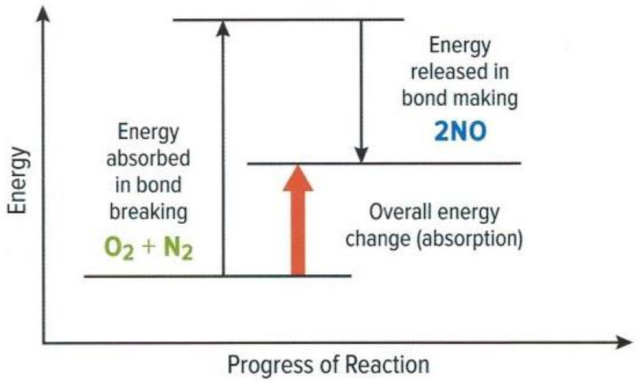
Energy-Level Diagrams

Consider the reaction below: for every molecule of nitrogen that reacts with a molecule of oxygen, 2 molecules of nitrogen monoxide are produced.



- N-N bonds and O-O bonds are **broken.**
- The breaking _____energy.
- _____bonds form, and this releases energy.

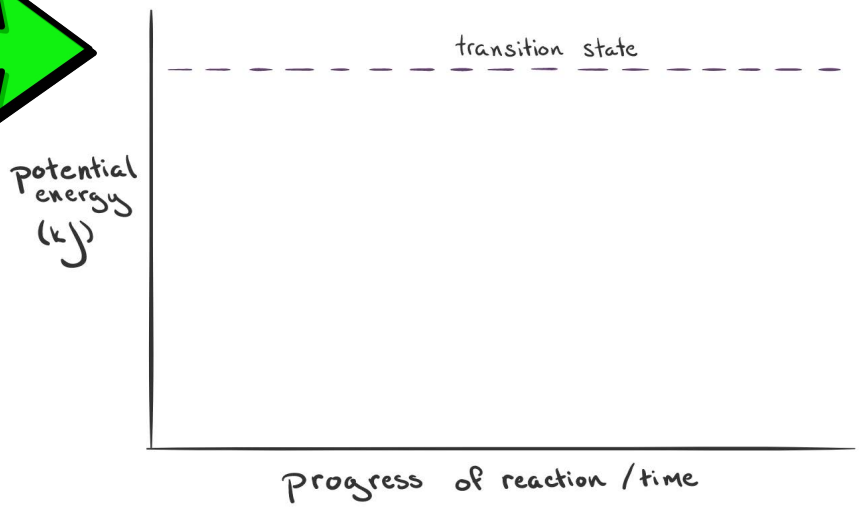
- The total energy absorbed to break each N-N bond and O-O bond is _____than the the total energy released when N-O bonds form.
- Therefore, there is an overall absorption of energy, and the reaction is _____.

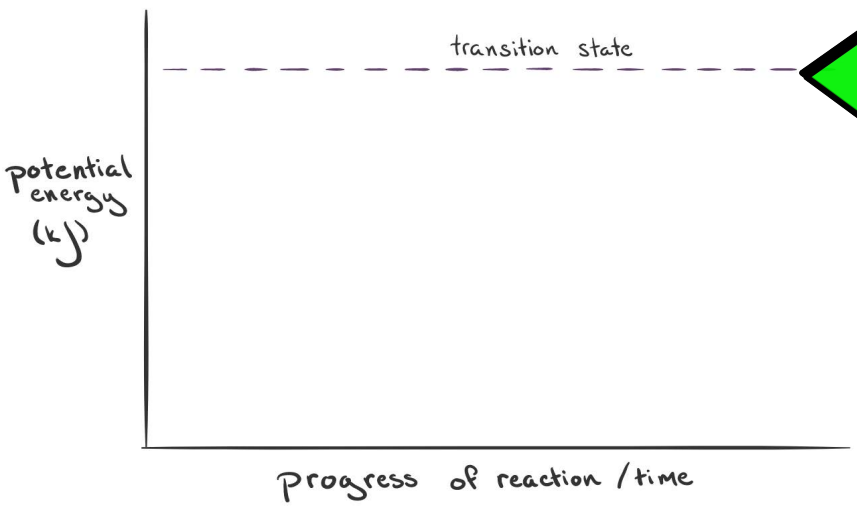


The activation energy (E_A) is the _____in the energy between the ***transition state*** and the reactants.
The enthalpy change (ΔH) is the _____in the energy between the ***reactants and the products***.

Endothermic Reaction

- The ***reactants are at a lower energy*** level compared to the products
- The ***products are less stable*** than the reactants.
- forcing the reaction in the forward direction towards more unstable species
- overall ***ΔH*** for the reaction is ***positive***,
- energy is absorbed from the surroundings.





Exothermic Reaction

- The ***reactants are at a higher energy*** level compared to the products
- The ***products are more stable*** than the reactants.
- Overall ***ΔH*** for the reaction is ***negative***
- ***Energy is released*** in the form of ***heat.***

Representing Energy Changes within Chemical Reaction Equations

- Enthalpy has units of _____ (***J***)
- Balanced reaction equations that include the enthalpy change are known as **thermochemical equations.**
- Enthalpy is an extensive property *(the energy lost or gained depends on reactant amounts)*
- There are two ways to write them, the *first shown being the preferred way:*

1. Writing the enthalpy change ***immediately after*** the equation - ***using the sign* of ΔH** to indicate whether the change is endothermic or exothermic.

This form distinguishes exothermic from endothermic by heat term sign

Exothermic Example: $2\,C_8H_{18} + 25\,O_2 \longrightarrow 16\,CO_2 + 18\,H_2O$; ΔH = _____

Endothermic Example: $6\,CO_2 + 6\,H_2O \longrightarrow C_6H_{12}O_6 + 6\,O_2$; ΔH = _____

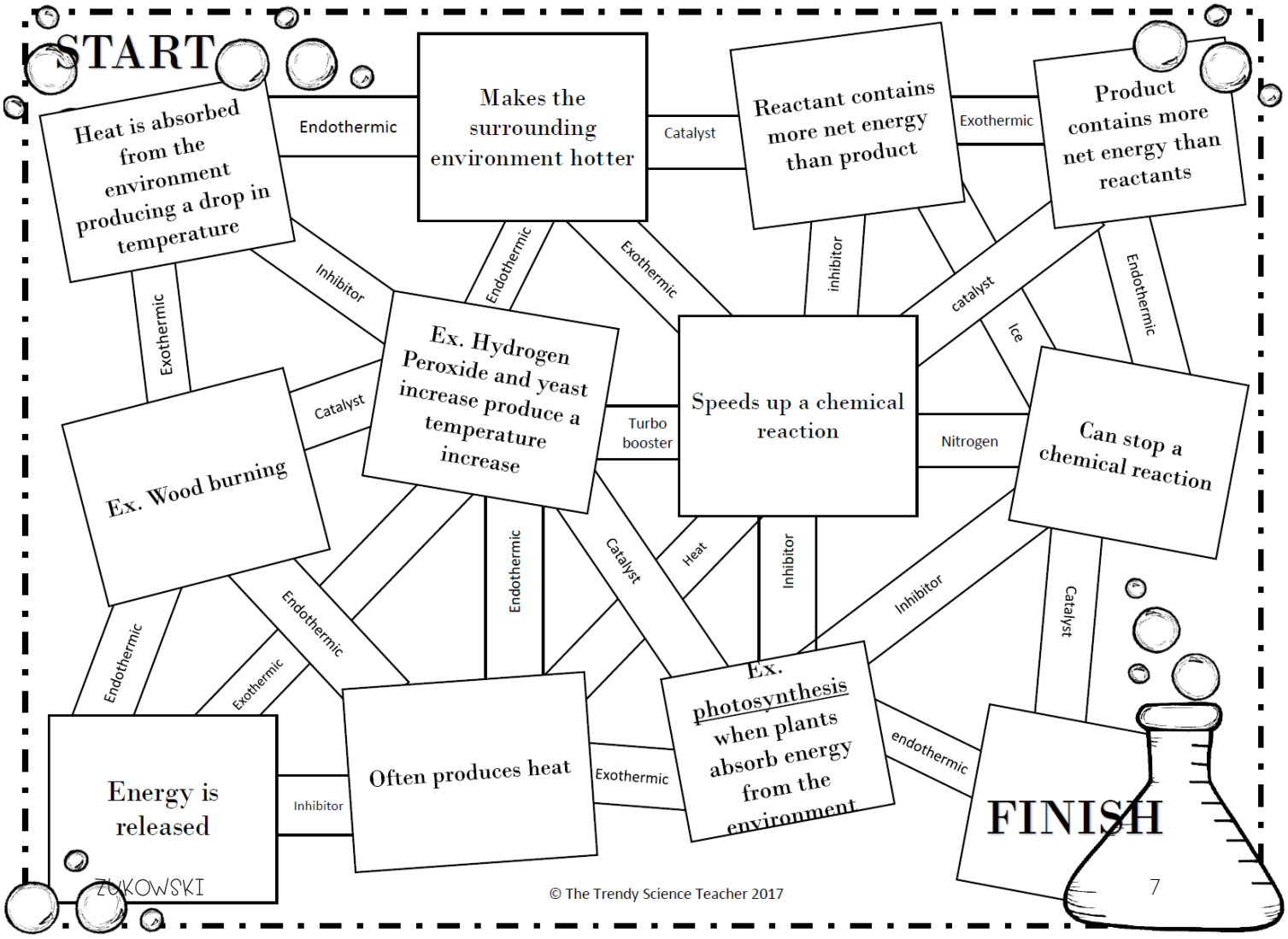
2. Writing the heat term ***within*** the chemical equation - ***using the side*** to indicate whether the change is endothermic or exothermic.

This form distinguishes exothermic from endothermic by the side the heat term is written on.

Exothermic Example: $2C_8H_{18} + 25O_2 \longrightarrow$ $16\,CO_2 + 18\,H_2O +$ _____

Endothermic Example: $6\,CO_2 + 6\,H_2O +$ _____ $\longrightarrow$ $C_6H_{12}O_6 + 6\,O_2$

Assignment #2 Complete the following worksheets on Energy in Reactions: Endothermic & Exothermic Reactions



Part A: Endothermic and Exothermic Reactions

Below is a set of 20 questions and their answers. However, some of the words have been missed out - see how many of them you can find! You can use the words in the box more than once.

exothermic	temperature	alkali	acid	removed
combustion	reversible	collide	product	respiration
less	products	destroyed	increase	created
energy	reactants	bond	photosynthesis	energy
heat	endothermic	oxidation	bonding	

During a chemical reaction what is always transferred? - _____

Described what is meant by the "conservation of energy" - In a chemical reaction energy cannot be _____ or _____.

How is energy transferred in chemical reactions? - Through the breaking of chemical bonds in the _____ and creating new bonds in the _____

What name is given to reactions that transfer energy to the surroundings? -_____

How do you know that an exothermic reaction has taken place? - Through an _____ in temperature from the reactants to the products.

What is the name given to chemical reactions that transfer energy from the surroundings to the reactants? - _____

Name 2 examples of an exothermic reaction. - oxidation, _____, _____ or neutralisation

Name 2 examples of an endothermic reaction - _____, sodium hydrogen-carbonate and citric acid or thermal decomposition

What investigation would you do to find out if a reaction is endothermic or exothermic? - Record initial _____ of reactants and the final _____ to find a _____ difference.

When you put sherbet into your mouth your mouth feels slightly cool. Why? - During this reaction heat is being _____ from the surroundings.

What is a compound? - Substance made when two or more elements combine through chemical _____.

What does pH7 mean? - The solution is neutral, neither an _____ or an _____

What is meant by the _____ of a chemical reaction? - The chemical produced as a result of a chemical reaction.

What is meant by the "_____" in a chemical reaction? - The chemicals that you start off with, before the reaction takes place.

What is meant by "_____ _____"? - The amount of energy needed to break a particular chemical bond.

Part B: Interpreting Energy in Chemical Formulas

complete the table below by interpreting what it means what HEAT is a reactant or a product. The first one has been done for you as an example.

A Endothermic vs. Exothermic Changes Last _____ first _____

Chemical Changes (= chemical rxns)	**Heat is a Reactant: The Rxn is Endothermic** Heat is a Product : The Rxn is Exothermic	Rxn Takes, Uses & Absorbs Heat **Rxn Makes, Produces & Releases Heat**
$Zn + S \rightarrow ZnS + Heat$	Heat is a Product: Rxn is Exothermic	Rxn Makes, Produces & Releases Heat
$2H_2O_2 \rightarrow 2H_2O + O_2 + Heat$		
$Ba(OH)_2 + 2NH_4Cl + Heat \rightarrow BaCl_2 + 2NH_4OH$		
$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O + Heat$		
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + Heat$		
$2Fe_2O_3 + 3C + Heat \rightarrow 3CO_2 + 4Fe$		
$2Na + Cl_2 \rightarrow 2NaCl + Heat$		
$CitH_3 + 3NaHCO_3 + Heat \rightarrow CitNa_3 + 3H_2O + 3CO_2$		
$(NH_4)_2Cr_2O_7 \rightarrow N_2 + 4H_2O + Cr_2O_3 + Heat$		
$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe + Heat$		