# Energy of Reactions

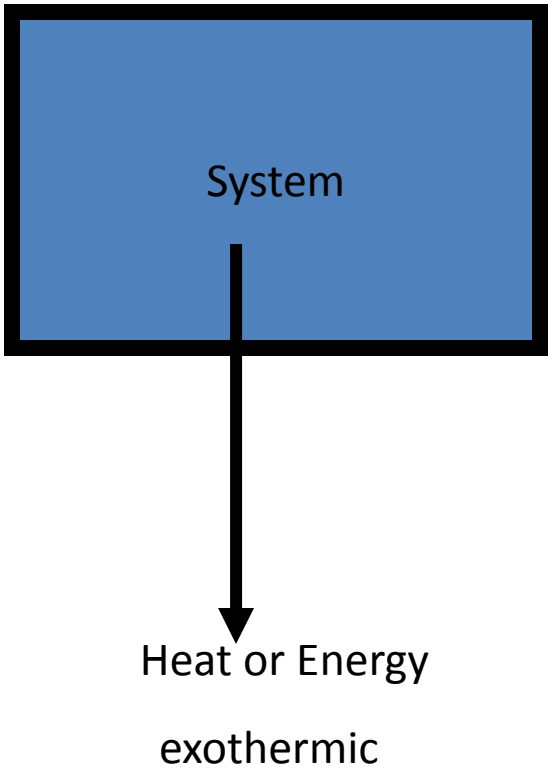
# Chemical Bond

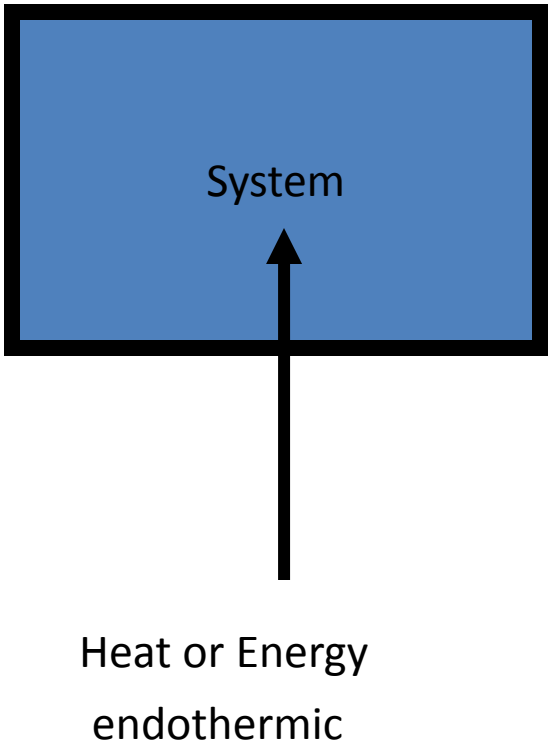
- Bonds have a certain amount of energy associated with them.
- This energy is stored energy that can be used to do work.
- This is called chemical energy.
- The weaker the bond, the more energy it takes to maintain.
- In order to break the bonds, energy must be put in called the “activation energy”.
- This raises the overall potential energy of the system, but allows the atoms to form new bonds.

# Thermochemistry

- Thermes is Greek for heat
- Endothermic - absorb heat (meaning there is more energy stored in the bonds of the products than the reactants)
- $C + H_2O + 113kJ \rightarrow CO + H_2$
- Notice heat is a “reactant” since it is necessary for the reaction to occur
- Exothermic - gives off heat (meaning there is less energy stored in the bonds of the products than the reactants)
- $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O + 2043kJ$
- Notice heat is a “product” since it is released.

# Exo vs Endo


System
Heat or Energy
exothermic


System
Heat or Energy
endothermic

# Enthalpy

- H = enthalpy

  We will use enthalpy and energy interchangeably
- $\Delta H$ = delta H = change in enthalpy
- $\Delta H = H_{products} - H_{reactants}$
- $\Delta H$ is positive = endothermic

  heat absorbed
- $\Delta H$ is negative = exothermic

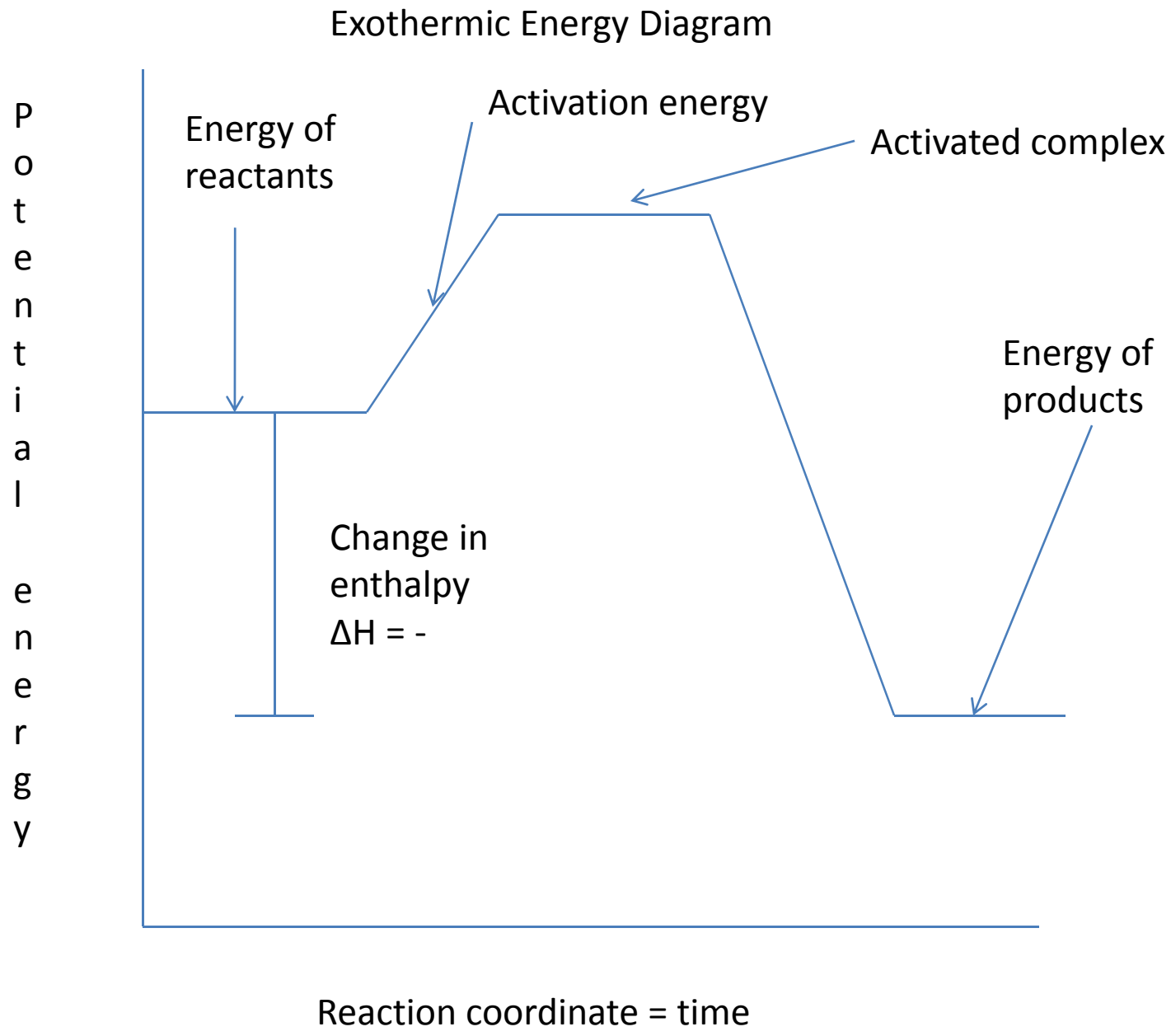
  heat released

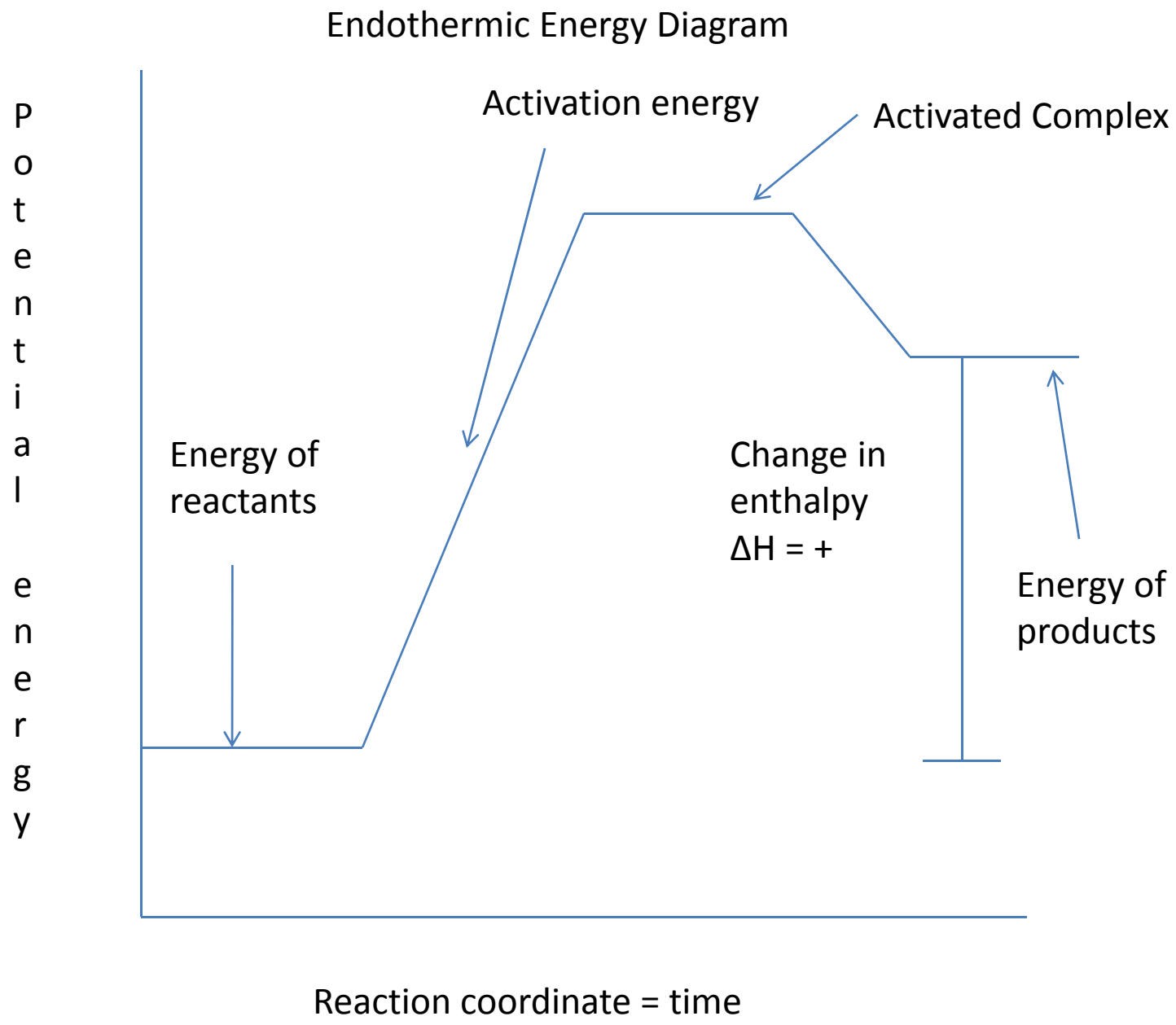
# Energy vs Enthalpy

- Energy and Enthalpy are similar concepts
- Enthalpy = energy + other “terms”
  - The other terms include pressure and volume
  - most reactions occur at atmospheric pressure
- At constant pressure

  Energy change = enthalpy change

  $\Delta E = \Delta H$


Exothermic Energy Diagram
Potential energy
Energy of reactants
Activation energy
Activated complex
Energy of products
Change in enthalpy
ΔH = -
Reaction coordinate = time


Endothermic Energy Diagram
Potential energy
Activation energy
Activated Complex
Energy of reactants
Change in enthalpy
ΔH = +
Energy of products
Reaction coordinate = time

# Energy Diagram Pieces

- The reaction coordinate is a representative time scale, it is not actually a time scale with units. (although it could be)
- The activated complex is the period of time where the potential energy is higher because all of the atoms are unbonded.
- The change in enthalpy only is looking at the difference in bond energies of the products verses the reactants.  Nothing in the middle matters.

# Things to notice in diagrams

- Activation energies are usually smaller for exothermic than endothermic reactions.
- Endothermic reactions require a constant supply of energy to continue, where exothermic reactions can reuse some of the energy that they produce to activate another reaction.
- Positive $\Delta H$ means more potential energy at the end of the reaction than the beginning (meaning weaker bonds), negative means the opposite.