$\qquad$ Date: $\qquad$
Chemistry ~ Ms. Hart
Class: Anions or

Cations

### 7.4 Potential Energy Diagrams

## Remember:

- Chemical reactions can react in both the $\qquad$ and
$\qquad$ directions
- All chemical reactions need $\qquad$
- Reactions can either release energy ( $\qquad$ - energy is a PRODUCT) or absorb energy ( $\qquad$ - energy is a REACTANT)
- Heat of formation also known as $\qquad$ is difference in potential energy or
$\qquad$ between the reactants and products.
- We use the following equation to calculate the heat of formation =
- $\Delta \mathrm{H}=$ Potential Energy Products ( $\qquad$ ) - Potential Energy of the Reactant ( $\qquad$ )
- For HEAT of FORMATION.... THINK - $\qquad$


## Parts of a Potential Energy Diagram:

1. Reactants - this is what you start with
2. Products - this what you get
3. Activated Complex -
4. Heat of FORWARD Reaction $(\Delta \mathrm{H})$ /Heat of BACKWARD Reaction $(\Delta \mathrm{H})$
5. Activation Energy (also known as $\mathrm{E}_{\mathrm{a}}$ )- $\qquad$

Reaction Coordinate

If $\Delta H$ is positive, the reaction is $\qquad$
If $\Delta \mathrm{H}$ is negative, the reaction is $\qquad$
Example:

1. A reaction has a $\Delta \mathrm{H}$ of +100 kJ . Will this reaction be endothermic or exothermic? $\qquad$
2. A reaction has a $\Delta \mathrm{H}$ of -11 J . Will this reaction be endothermic or exothermic? $\qquad$

Lets do some group Practice! The diagram to the below represents the potential energy for the reaction: $\mathrm{N}_{2}(\mathrm{~g})+3 \mathrm{H}_{2}(\mathrm{~g}) \rightarrow 2 \mathrm{NH}_{3}(\mathrm{~g})$

1) What does (a) represent?

2) What does (b) represent?
3) What does (c) represent?
4) What are the "reactants" in this equation? Place a 1 where you would find them on the potential energy diagram.
5) What are the "products" in this equation? Place a 2 where you would find them on the potential energy diagram.
Bring it in! Base your answers to questions 6-10 on the potential energy diagram below.

6) What is the potential energy of the reactants?
7) What is the potential energy of the products?
8) What is the heat of the forward (left to right) reaction?
a. Heat of reaction $(\Delta \mathrm{H})=$ Potential Energy of Products - Potential Energy of Reactants
9) Is this reaction exothermic or endothermic?

10) What is the effect of the catalyst on this reaction?

## Quick Practice

11) What is the heat of the FORWARD reaction? (Hint: heat of products-heat of reactants...)
12) What is the heat of the BACKWARD reaction? (Hint: where are the products of the BACKWARD reaction found?)

## Classwork

1. An increase in temperature increases the rate of a chemical reaction because the
a. Activation energy increases
b. Activation energy decreases
c. Number of molecular collisions increases
d. Number of molecular collisions decreases
2. Label the following diagram:

PE reactants, PE products, and $\mathrm{E}_{\mathrm{A}}$.
3. If the potential energy of the reactants is 412 kJ , and the potential energy of the products is 212 kJ , what is the heat of reaction?
4. Is this reaction exothermic or endothermic?

Explain.

5. Draw a reaction coordinate diagram for an endothermic reaction. LABEL IT!
6. Base your answers on the information and diagram below, which represent the changes in potential energy that occur during the given reaction, $\mathrm{A}+\mathrm{B} \rightarrow \mathrm{C}$.


Reaction Coordinate
a) Does the diagram illustrate an exothermic or endothermic reaction? State one reason, in terms of energy, to support your answer.
b) On the diagram provided in your answer booklet, draw a dashed line to indicate a potential energy curve for the reaction if a catalyst is added.
7. Given the reaction, $\quad \mathrm{A}+\mathrm{B} \leftrightarrow \mathrm{AB}+210 \mathrm{~kJ}$

Is this reaction exothermic or endothermic?
Draw a potential energy diagram for the reaction above, assuming there is an activation energy of 21 kJ .

What would the activation energy of the reverse reaction be?
8. Given the reaction: $\mathrm{S}(\mathrm{s})+\mathrm{O}_{2}(\mathrm{~g}) \rightarrow \mathrm{SO}_{2}+$ energy. Which diagram best represents the potential energy changes for this reaction?

(1)

(2)

(3)

(4)
9. Which statement correctly describes an endothermic chemical reaction?
(1) The products have higher potential energy than the reactants and the $\Delta \mathrm{H}$ is negative.
(2) The products have higher potential energy than the reactants and the $\Delta \mathrm{H}$ is positive.
(3) The products have lower potential energy than the reactants and the $\Delta \mathrm{H}$ is negative.
(4) The products have lower potential energy than the reactants and the $\Delta \mathrm{H}$ is positive.
10. The potential energy diagram below represents a reaction.


Which arrow represents the activation energy of the forward reaction?
(1) A
(2) B
(3) C
(4) D
11. Which information about a chemical reaction is provided by a potential energy diagram?
a. The oxidation states of the reactants and products
b. The average kinetic energy of the reactants and products
c. The change in solubility of the reacting substances
d. The energy released or absorbed during the reaction.
12. Which expression represents the $\Delta \mathrm{H}$ for the chemical reaction in terms of the potential energy, PE , of its products and reactants?
a. PE of products + PE of reactants
b. PE of products - PE of reactants
c. PE of products x PE of reactants
d. PE of products $\div \mathrm{PE}$ of reactants

### 7.4 HOMEWORK:

13) Match the following to the letters on the graph left:
(1) Potential Energy of the products
(2) Potential Energy of the reactants
(3) Heat of Reaction
(4) Potential Energy of the activated complex
(5) Draw in and label what the activation energy would be.


Reaction Coordinate

Given the reaction at equilibrium:

$$
2 \mathrm{NO}_{2}(\mathrm{~g})+7 \mathrm{H}_{2}(\mathrm{~g}) \rightleftharpoons 2 \mathrm{NH}_{3}(\mathrm{~g})+4 \mathrm{H}_{2} \mathrm{O}(\mathrm{~g})+1127 \mathrm{~kJ}
$$

57 On the diagram in your answer booklet, complete the potential energy diagram for the forward reaction. Be sure your drawing shows the activation energy and the potential energy of the products. [2]

58 Explain, in terms of Le Chatelier's principle, why the concentration of $\mathrm{NH}_{3}(\mathrm{~g})$ decreases when the temperature of the equilibrium system increases. [1]

Answer for 57:
58:


In the smelting of iron ore, $\mathrm{Fe}_{2} \mathrm{O}_{3}$ is reduced in a blast furnace at high temperature by a reaction with carbon monoxide. Crushed limestone, $\mathrm{CaCO}_{3}$, is also added to the mixture to remove impurities in the ore. The carbon monoxide is formed by the oxidation of carbon (coke), as shown in the reaction below:

$$
2 \mathrm{C}+\mathrm{O}_{2} \rightarrow 2 \mathrm{CO}+\text { energy }
$$

Liquid iron flows from the bottom of the blast furnace and is processed into different alloys of iron.

Using the set of axes provided in your answer booklet, sketch a potential energy diagram for the reaction of carbon and oxygen that produces carbon monoxide. [1]


## Reaction Coordinate

Given the potential energy diagram for a reaction:


Which interval on this diagram represents the difference between the potential energy of the products and the potential energy of the reactants?
(1) 1
(3) 3
(2) 2
(4) 4

43 Given the potential energy diagram for a chemical reaction:


Which statement correctly describes the energy changes that occur in the forward reaction?
(1) The activation energy is $10 . \mathrm{kJ}$ and the reaction is endothermic.
(2) The activation energy is $10 . \mathrm{kJ}$ and the reaction is exothermic.
(3) The activation energy is $50 . \mathrm{kJ}$ and the reaction is endothermic.
(4) The activation energy is $50 . \mathrm{kJ}$ and the reaction is exothermic.

43 The potential energy diagram below represents a reaction.


Which arrow represents the activation energy of the forward reaction?
(1) $A$
(3) $C$
(2) $B$
(4) $D$

Which information about a chemical reaction is provided by a potential energy diagram?
(1) the oxidation states of the reactants and products
(2) the average kinetic energy of the reactants and products
(3) the change in solubility of the reacting substances
(4) the energy released or absorbed during the reaction

