Unit 11: Thermochemistry

Ms. Johnson
Prep Chemistry

Unit Learning Objectives: By the end of the unit students will be able to…

(1) Define temperature and heat and give appropriate units for each.
(2) Describe and graph the temperature changes for a heating or cooling curve, and label each part of the curve with the appropriate phase(s). Determine the melting/freezing point and boiling/condensing point from a heating or cooling curve. Describe what is happening to particles at each region of a heating/cooling curve including where particles begin to move faster/slower and where bonds between particles are broken/formed.
(3) Define heat of vaporization and heat of fusion and give the appropriate unit for each.
(4) Perform calculations involving heat of vaporization and heat of fusion for phase changes of substances. (5) Define specific heat capacity and give the appropriate units.
(6) Perform calculations involving specific heat capacity for heating and cooling of substances.
(7) Define heat of reaction/enthalpy and give the appropriate units.
(8) Define exothermic and endothermic reactions and give examples of each.
(9) Determine if a reaction is exothermic or endothermic from the chemical equation or ΔH value. Given the ΔH value, add the heat term to the appropriate side of a chemical reaction.
(10) Calculate the heat of a reaction from tabulated heats of formation.
(11) Interpret a potential energy diagram to determine heat of reaction and activation energy.

Monday	Tuesday	Wednesday	Thursday	Friday
April **4** Revise Discussions (Solubility Labs) **Demo**: Heat v. Temp.	**5** Temperature, Heat & Calculating ΔH	**6** Calculating ΔH	**7** Heat of Reaction	**8** **Spring Rally** **Partner Quiz:** Calculating ΔH
11 Heat of Formation	**12** **Lab:** Heat of Reaction	**13** Heating Curve for Water	**14** Heating Curve for water	**15** Potential Energy Diagrams **Partner Quiz:** heat of rxn./formation
18 *CST/CMA Life Science Testing (Periods1,3,5)*	**19** *CST/CMA Life Science Testing (Periods 2,4,6)*	**20** Review (al periods)	**21** **Unit 11 Test Part 1** *(Periods 1,3,5)*	**22** **Unit 11 Test Part 1** *(Periods 2,4,6)*
25 **Unit 11 Test Part 2** *(Periods 1,3,5)* **Homework Packet Due**	**26** **Unit 11 Test Part 2** *(Periods 2,4,6)* **Homework Packet Due**	*** Note: Testing will occur from Monday, April 18th- Friday April 29** *** Block Schedule from Monday, April 18th- Friday April 29** ** ODD periods meet on Mon & Thurs* ** EVEN periods meet on Tues & Fri* ** ALL classes meet Wed* ** AM meets @ regular time*		

Thermochemistry: ____

____

Temperature: ____

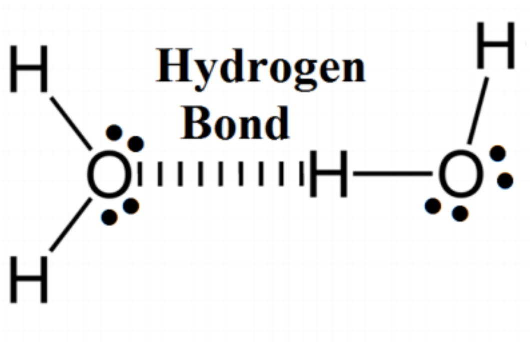
Heat, ΔH: ____

Heating and Cooling of Water:

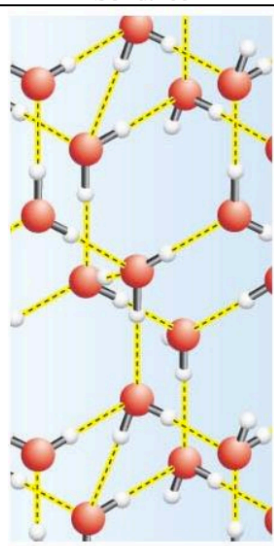
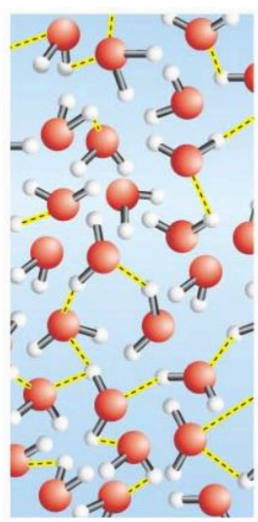
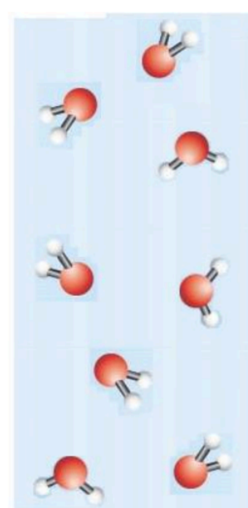
The Nature of Water:

Water is a unique molecule because it has a "bent" structure which causes the molecule to be polar. Due to this polarity, the water molecules become attracted to one another and form a type of bond called *"hydrogen bonds*" ***<u>between</u>*** molecules.

Hydrogen Bonds can be represented as shown below.



Predict: What do you think happens to the hydrogen bonds when water boils? What do you think happens when water freezes?

Phase	Solid/Ice	Liquid	Gas/Steam
Diagram			
Percent of water molecules involved in hydrogen bonds			

Calculating Heat, ΔH: The formation or breaking of bonds

1. **Phase Changes**
   At a phase change, the temperature of a substance will remain constant. When a substance is melted or boiled, the heat energy added is used to break bonds ***between*** particles. When a substance is frozen or condensed, heat energy is released as bonds are formed ***between*** particles.

   The heat associated with a phase change can be calculated using the following equations.

Melting and Freezing

$$\Delta H = H_{fus} m$$

where: ΔH = Heat (J)
H_{fus} = Heat of Fusion (J/g)
m = mass (g)

The heat of fusion is the energy required to melt one gram of a substance.

Boiling and Condensing

$$\Delta H = H_{vap} m$$

where: ΔH = Heat (J)
H_{vap} = Heat of Vapourization (J/g)
m = mass (g)

The heat of vapourization is the energy required to boil one gram of a substance.

ex. Calculate the heat required to melt 0.500 g of ice.

Ex. Calculate the mass of water that can be boiled with 564 J of heat energy.

2. **Heating and Cooling**
   When a substance is heated, the energy added is used to increase the speed of the particles, so temperature is increased. When a substance is cooled, heat energy is released as the speed of the particles decreases.

The amount of heat associated with changing the temperature of a substance can be calculated according to the following equation:

$$\Delta H = m c \Delta T$$

where: ΔH = Heat (J)
m = mass (g)
c = specific heat capacity (J/g˚C)
ΔT = Temperature Change (Final Temperature – Initial Temperature) (˚C)

The specific heat capacity of a substance is the energy required to increase the temperature of one gram of the substance by 1ºC.

Ex. Calculate the amount of energy required to heat 100 g of water from 30.0 °C to 40.0 °C. How many kilojoules (kJ) is this?

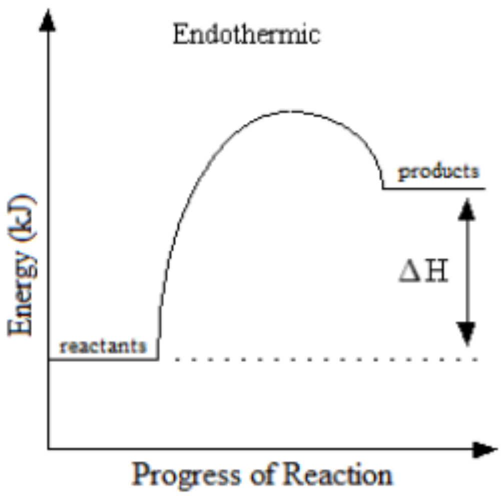
Ex. Calculate the mass of gold that requires 208 J to heat from 30 °C to 80 °C. How many moles is this?

Ex. Calculate the change in temperature if 2100 J of energy are used to heat 250 g of glass at 150 °C. What is the final temperature of the glass?

Heat of Reaction

Heat of Reaction: ____

____



ΔH = H products- H reactants

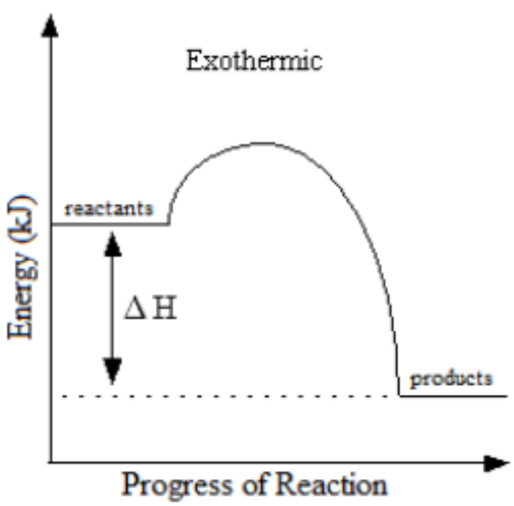
In an endothermic reaction, energy is ____________.

In an endothermic reaction, ΔH is _______________.

The reaction feels_______________.

In an endothermic reaction ΔH is ____________.

In an endothermic reaction ΔH is written as a __________.



ΔH = H products- H reactants

In an exothermic reaction, energy is ____________.

In an exothermic reaction, ΔH is _______________.

The reaction feels_______________.

In an exothermic reaction ΔH is ____________.

In an exothermic reaction ΔH is written as a __________.

Ex Classify each reaction as endothermic or exothermic and determine ΔH

a. $C\ (s) + O_2(g) \rightarrow CO_2\ (g)$+ 393.5 kJ/mol

b. $N_2(g) + O_2(g) + 180.5\ kJ/mol \rightarrow 2NO(g)$

Heat of Formation:

Heat of Formation, ΔHf: the heat released or absorbed when one mole of a compound is formed by a combination of its elements. The heat of a reaction is the total of the heats of formation of products, minus the total of the heats of formation of the reactants

$$\Delta H = (\text{total Hf products}) - (\text{total Hf reactants})$$

The heat of formation of elements in standard state is equal to zero. The standard state if an element is the form in which it exists at 25 °C and 1.00 atm. The heat of formation of a compound can be found on a table.

Ex. Use the heats of formation to calculate ΔH for each of the following reactions.

a. $ZnO\ (s) + H_2(g) \rightarrow Zn(s) + \ H_2O\ (g)$

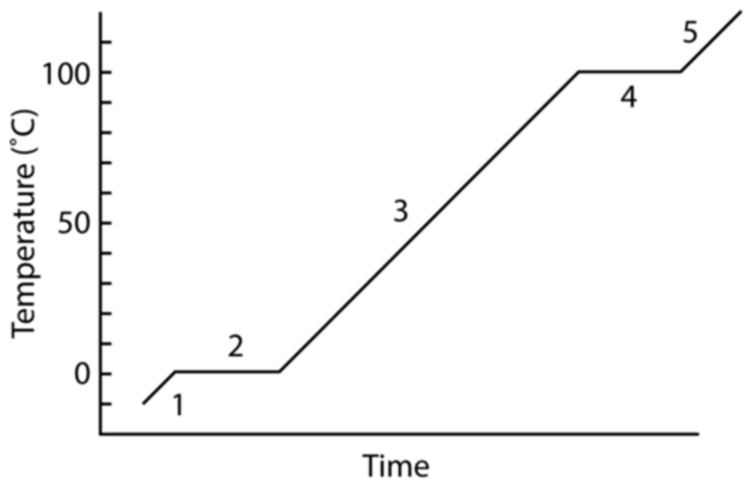
If there is a coefficient in the chemical equation, the heat of formation for the substance is multiplied by its coefficient.

b. $CH_4(g) + \ 2O_2(g) \rightarrow CO_2\ (g) + 2H_2O\ (l)$

c. $Fe_2O_3(s) + 3Zn\ (s) \rightarrow 2\ Fe\ (s) + \ 2ZnO\ (s)$

Consider the changes that take place over a temperature range for water.

Heating Curve for water



What happens during each stage that water is heated?

1.

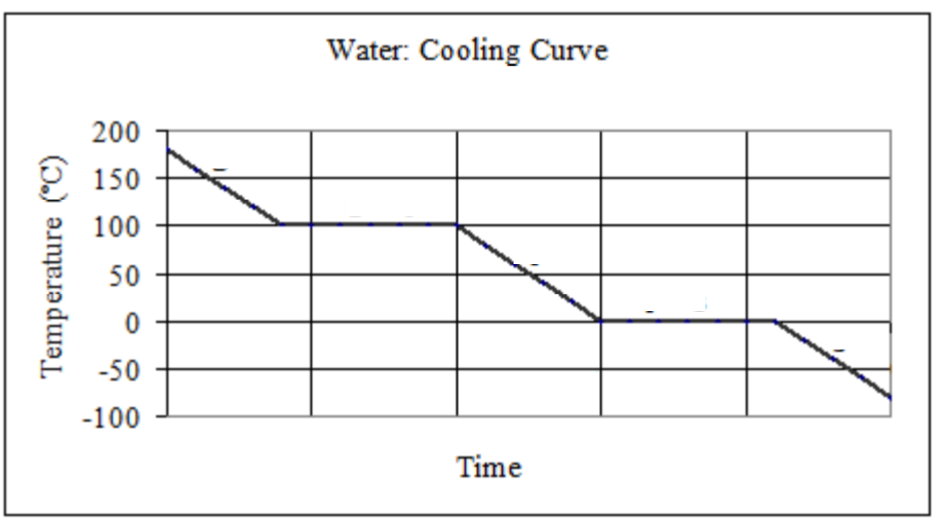
2.

3.

4.

5.

Ex. Cooling Curve for Water



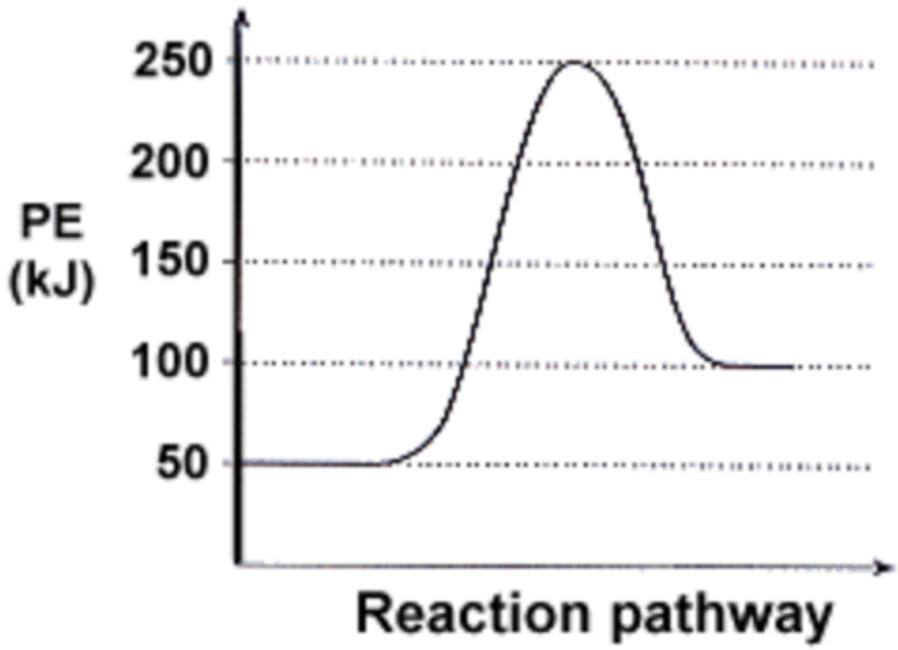
Label the following on the curve:

1. The phases of water
2. The phase changes of water
3. Where hydrogen bonds are formed/broken
4. The boiling point, and the melting point.

Potential Energy Diagrams

The energy changes in a reaction can be represented by a potential energy diagram.

Example: Use the following potential energy diagram to answer the questions below.



a. Label the reactants, products, and activated complex.

b. What is the potential energy of the reactants?

c. What is the potential energy of the products?

d. What is the potential energy of the activated complex?

e. What is ΔH for this reaction?

f. Is there reaction endothermic, or exothermic?

g. What is the activation energy for the reaction?