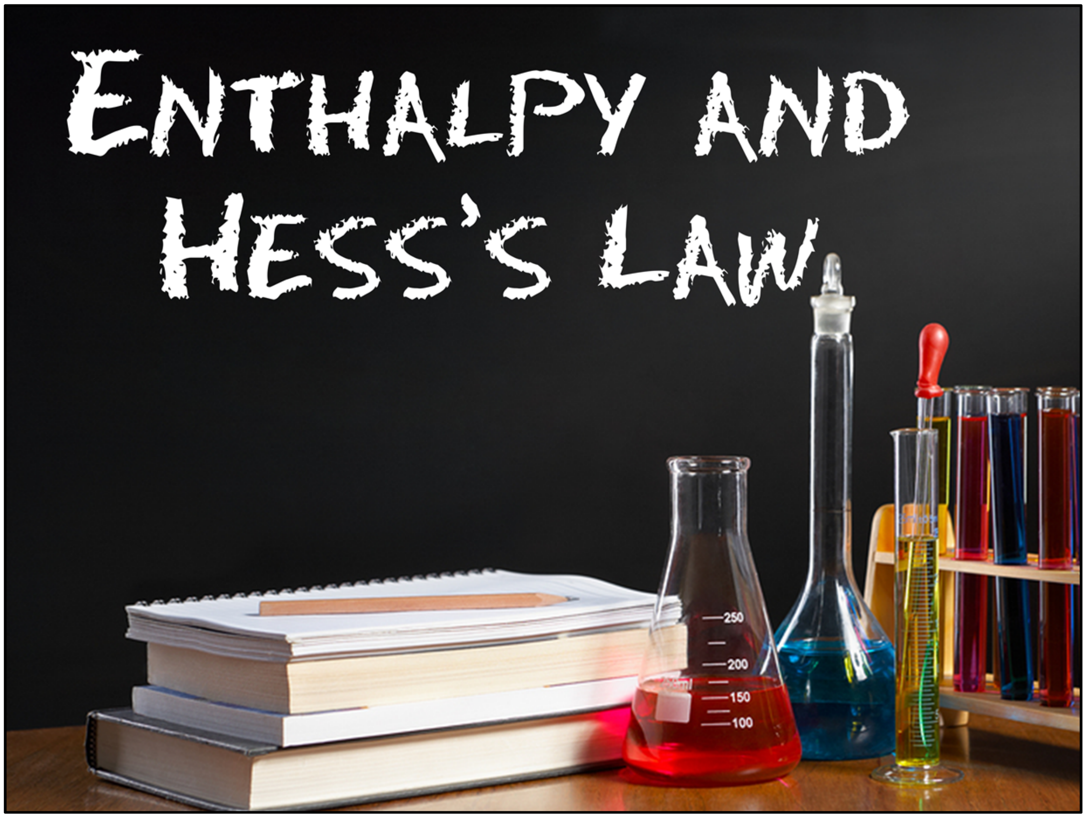
Module 8: Thermochemistry
Topic 1 Content: Enthalpy and Hess's Law Presentation Notes



Enthalpy and Hess's Law.

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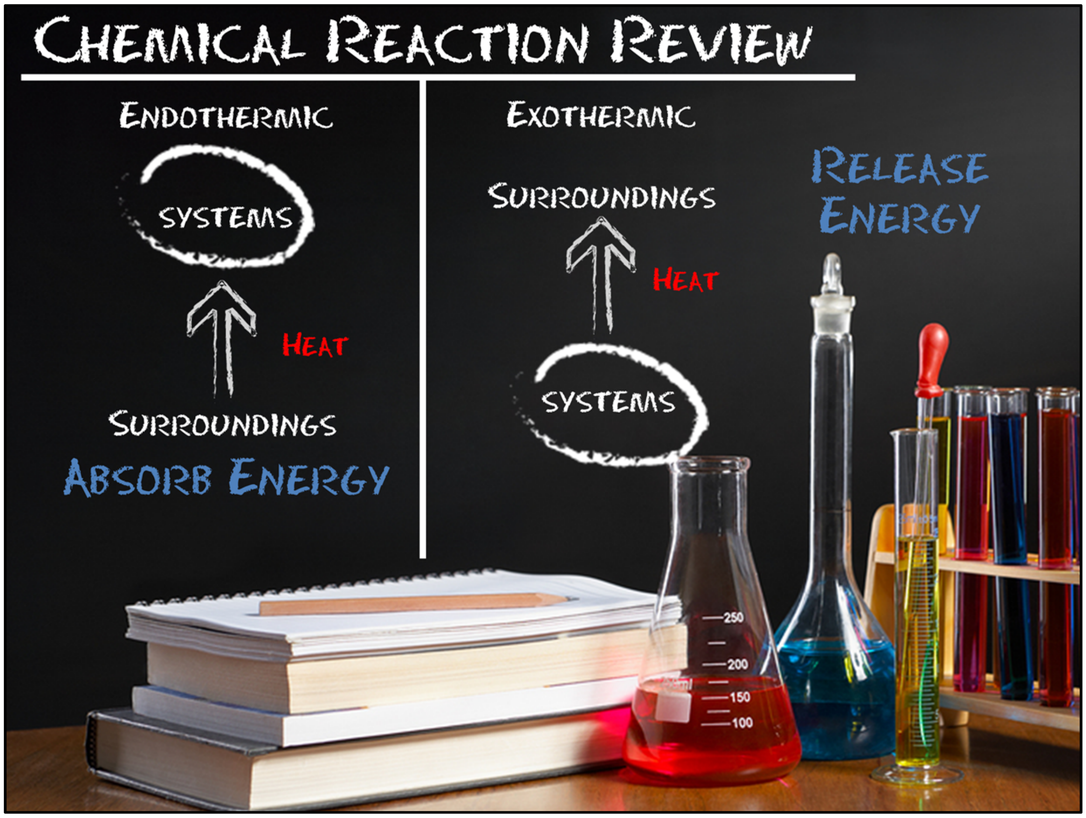
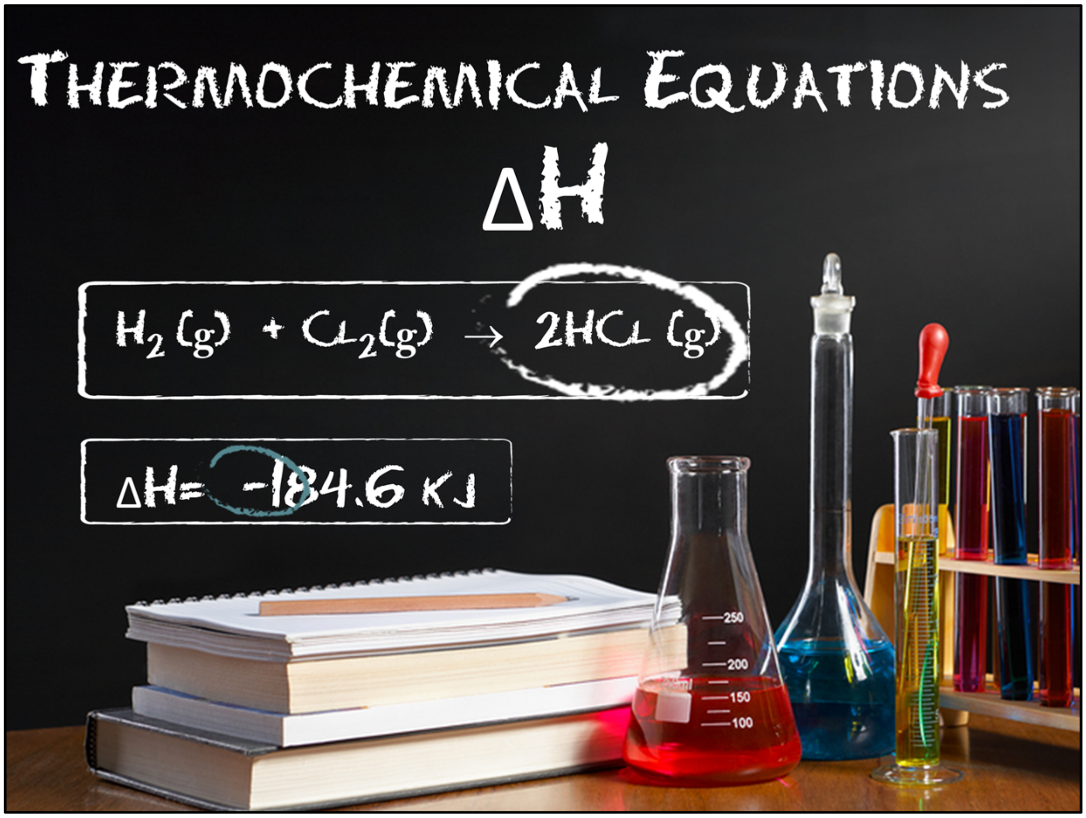
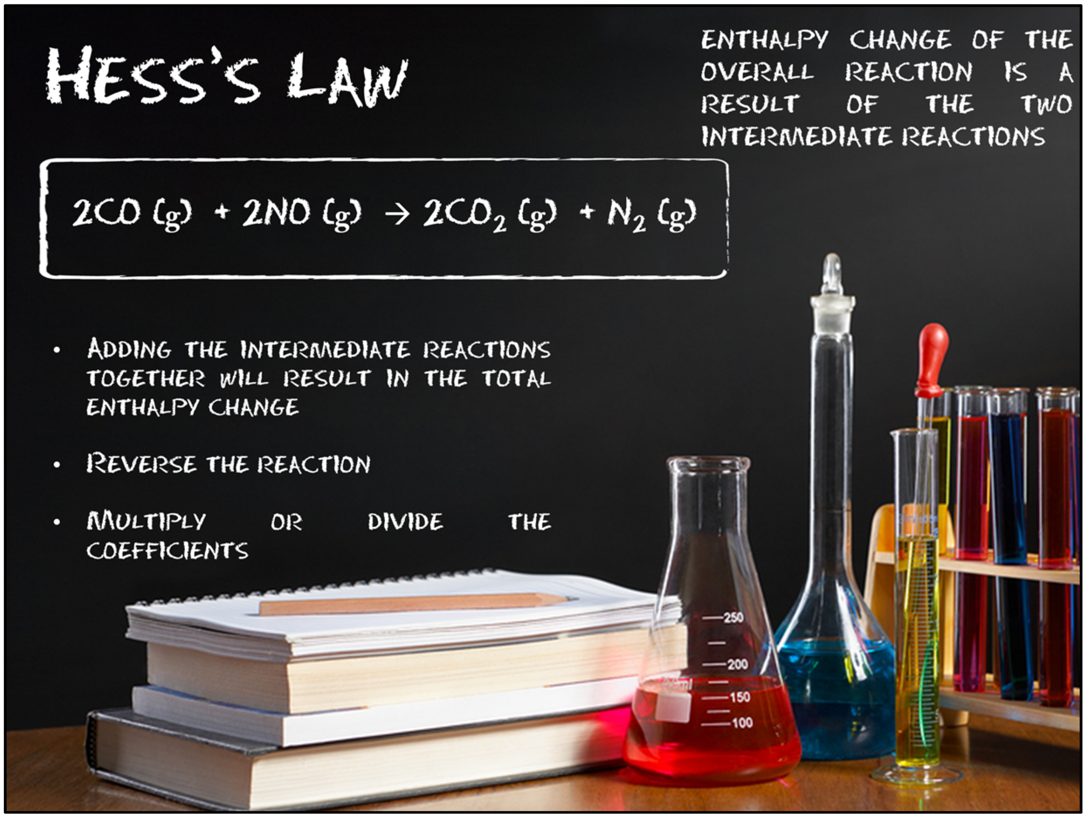


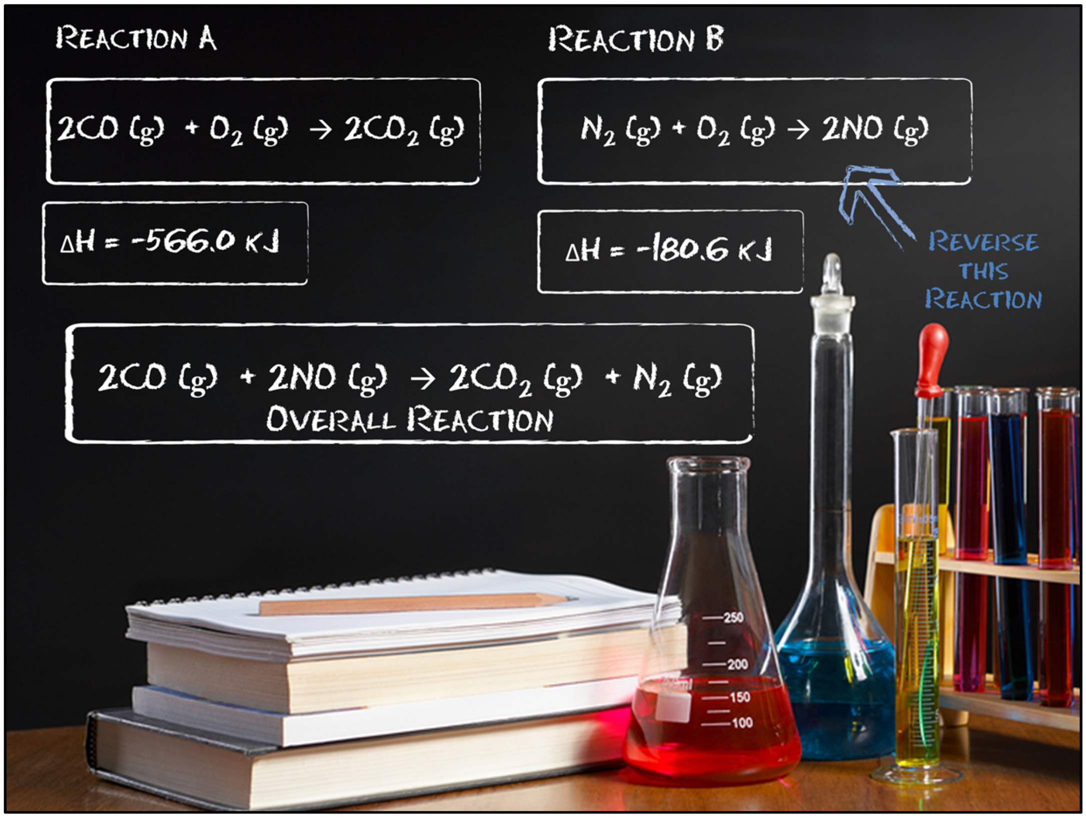
Chemical reactions involve the making and breaking of bonds. Bonds are stored energy, and when those bonds are broken, potential energy is released in the form of heat. If bonds are formed, then heat is absorbed and converted to stored or potential energy. All chemical reactions are accompanied by a change in heat content. Reactions that absorb energy would be considered endothermic. Reactions that release energy would be considered exothermic.



Thermochemical equations are chemical equations that include the energy change, along with the reactants and products. The change in heat is represented by the Greek letter delta and the capital letter H. You can identify if a reaction is exothermic or endothermic by reviewing the products and enthalpy change. If a reaction is exothermic, the energy appears on the product side of the thermochemical reaction. Since the heat is released, the enthalpy change of the reaction is negative. Notice the negative sign for the change in heat above. The opposite is true if the reaction is endothermic. The enthalpy change is positive in endothermic reactions.

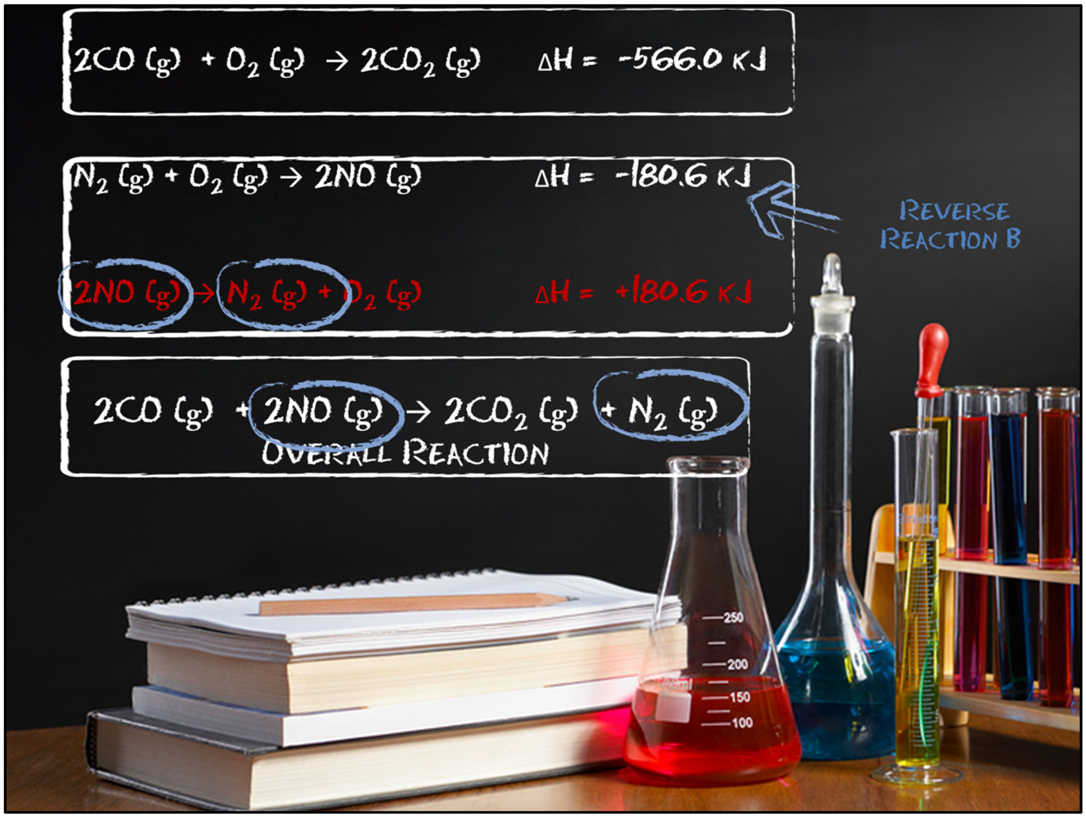


Using Hess's Law, the enthalpy change of the reaction shown is determined using the enthalpy changes of other reactions. The reaction shown here actually occurs in two steps. The enthalpy change of the overall reaction is a result of the two intermediate reactions. Simply adding the intermediate reactions together will result in the total enthalpy change. When solving problems using Hess's Law, not only do you change the sign of the enthalpy in reversing the reaction, but if you multiply or divide coefficients, you must also do this to the enthalpy to make the final equation match what was given.

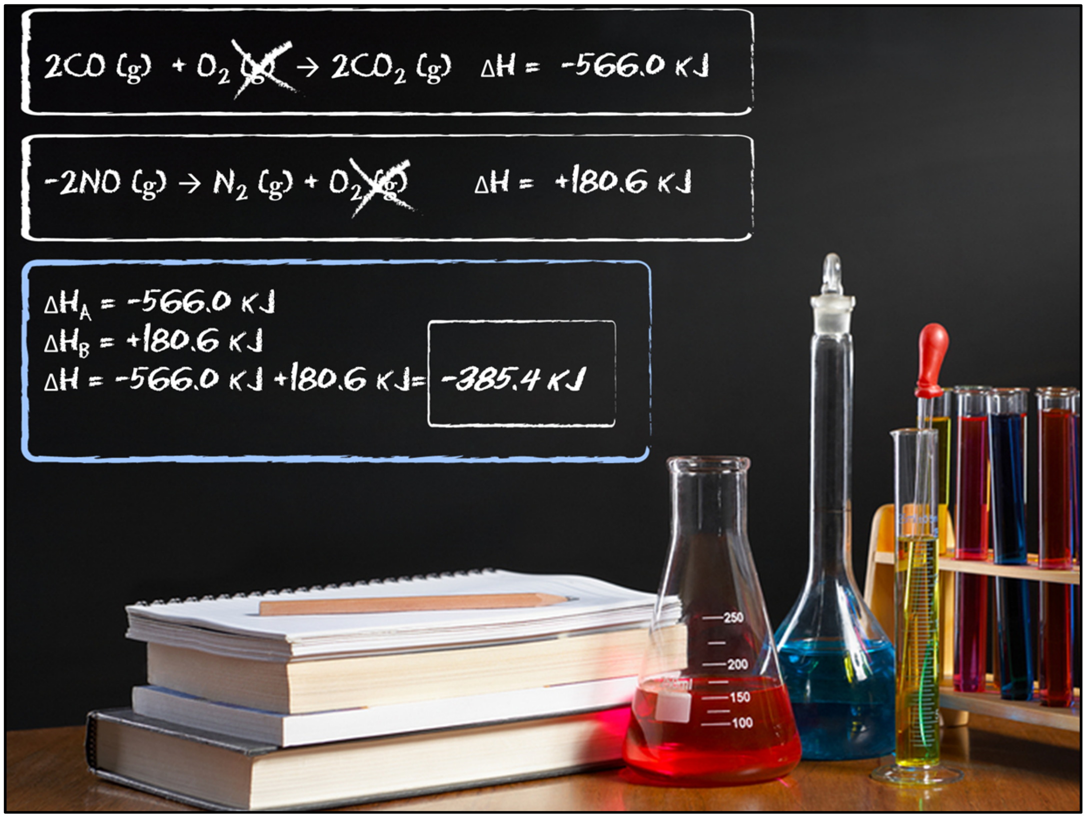


For the purpose of this example, the two intermediate reactions are labeled Reaction A and Reaction B. Notice that Reaction A combines carbon monoxide with oxygen, producing carbon dioxide. This reaction results in the release of 566.0 kJ of heat. The overall reaction also has carbon monoxide as a reactant and carbon dioxide as a product. Oxygen is not present in the overall reaction.

Now, take a look at Reaction B. This reaction shows the reaction of nitrogen gas with oxygen gas, producing nitrogen monoxide. This reaction is not the same as what is shown in the overall reaction. In the overall reaction, nitrogen gas is a product, not a reactant. Also, nitrogen monoxide is a reactant, not a product, as it is in Reaction B. This means that Reaction B must be reversed to create a match.



Notice that reversing Reaction B means that the reactants and products are switched and the reaction is now endothermic instead of exothermic. The reversal process aligns with the overall reaction, since nitrogen monoxide is now a reactant and nitrogen is now a product.



Before you calculate the total enthalpy of the reaction, you must add the two equations together to insure that they now match the overall reaction. Notice that the oxygen on the left of the first reaction is on the right of the second. Therefore, the oxygen cancels out. Now, the equation matches the overall reaction. The energy change is calculated by adding the two enthalpy changes together. The reaction will have an enthalpy change of -385.4 kj.

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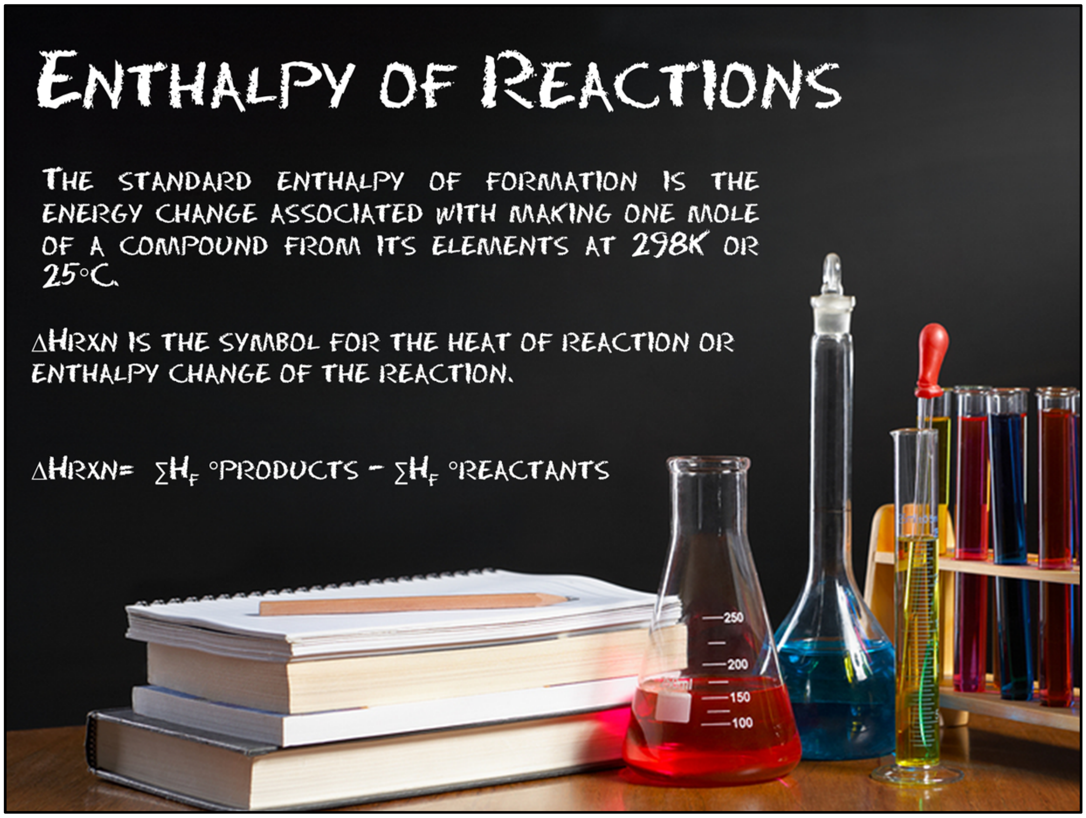
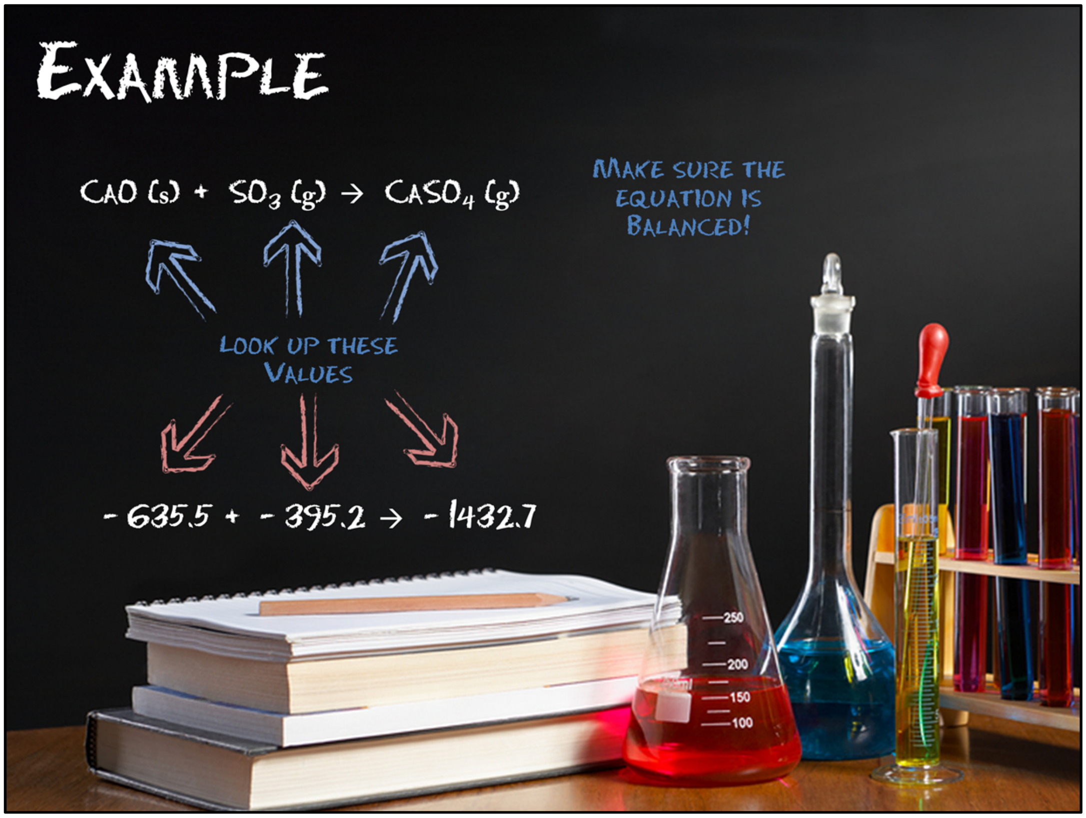


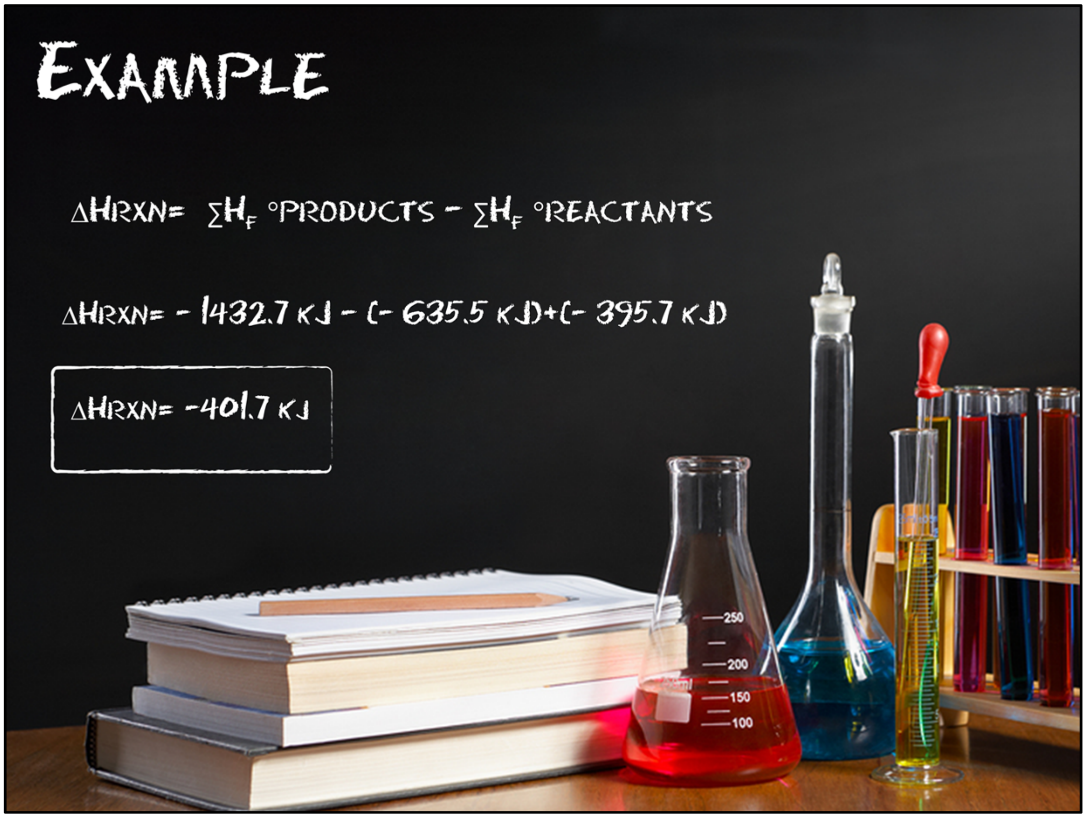
Calculating the heats of a reaction is rather simple. This calculation requires some basic subtraction, as well as knowing the standard enthalpy of formation, also known as the standard heat of formation. The standard enthalpy of formation is the energy change associated with making one mole of a compound from its elements at 298K or 25°C.

If you know the enthalpy of the reactants and the enthalpy of the products, then you can calculate the change in the enthalpy. All you have to do is reference the standard enthalpy of formation table to find the enthalpies of the reactants and products, and then calculate the change.

Click in the Resources link to view the formula to calculate the change in enthalpy of a reaction. ΔH_{rxn} is the symbol for the heat of reaction or enthalpy change of the reaction. This is the quantity for which you are trying to solve. The symbol for the sum of the standard enthalpies of the products in the reaction is shown here. The symbol for the sum of the standard enthalpies of the reactants in the reaction is shown here. Remember, these two quantities are found by referencing a standard enthalpy of formation table.



In this example reaction, you will want to calculate the change in enthalpy. In order to find the change in enthalpy, you will want to make sure the equation is balanced and that you know the states of the reactants and the products. Then, look up the enthalpy values for the reactants and products.



Once you have found the values, use the equation to solve to problem.

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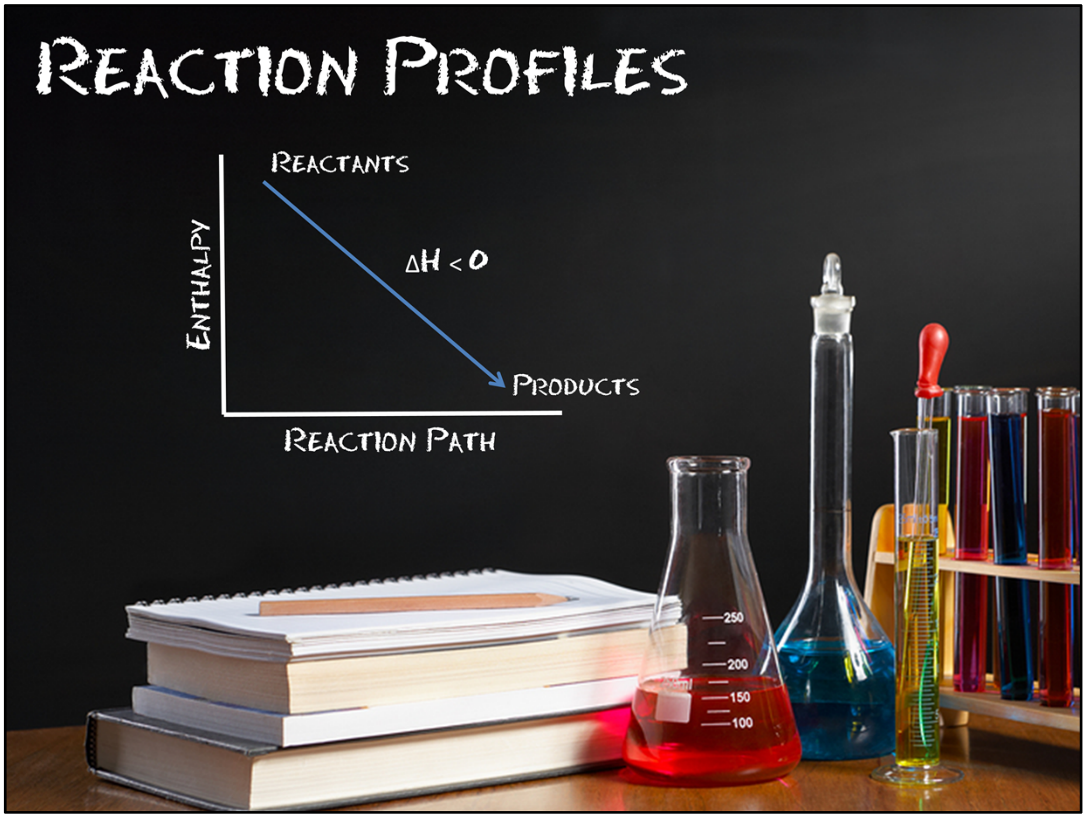
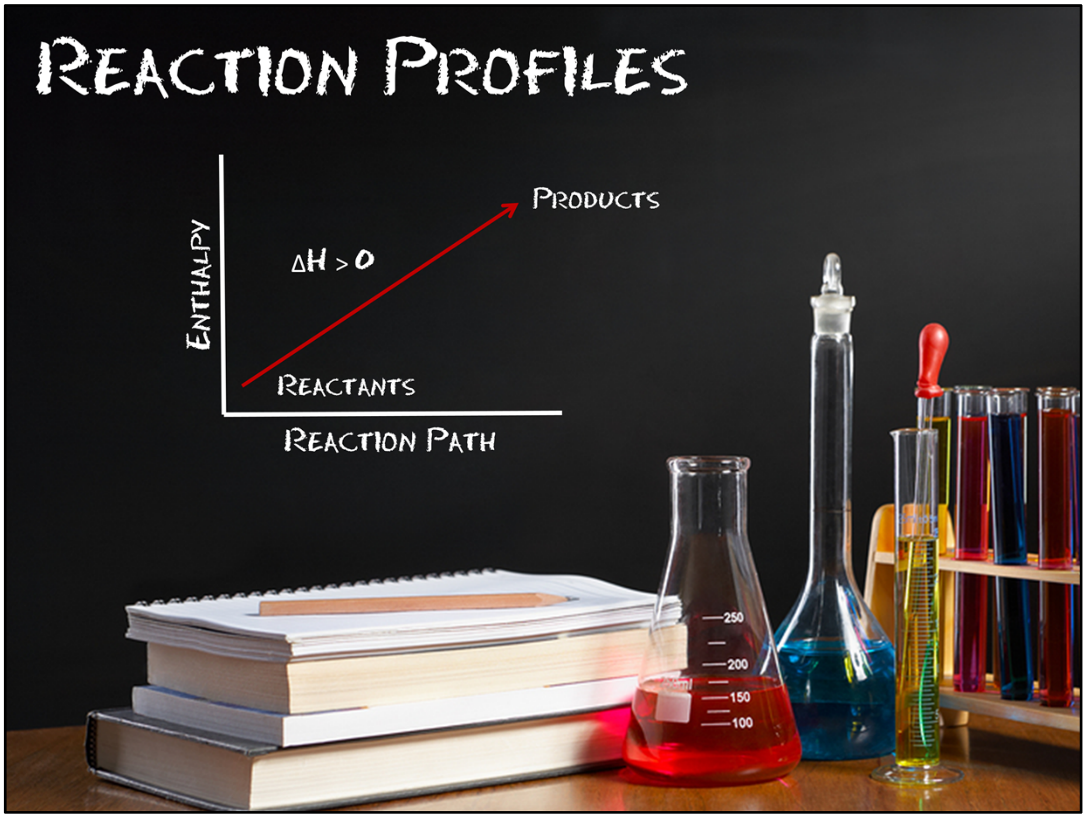


The enthalpies of reactions are shown graphically using profiles. The profile shows the enthalpy on the y-axis and time or reaction progress on the x-axis. As you can see from the profile, the reaction shown here is losing energy and has a negative change in enthalpy. This would imply that an exothermic reaction is taking place. Note that the reactants are on the left and the products are on the right. The change in enthalpy is negative or less than zero as the symbol ΔH implies.



Unlike the previous image, this profile shows an increase in the enthalpy. This means that the reaction is absorbing energy and storing it in the products. This is an endothermic process. The change in enthalpy is positive.

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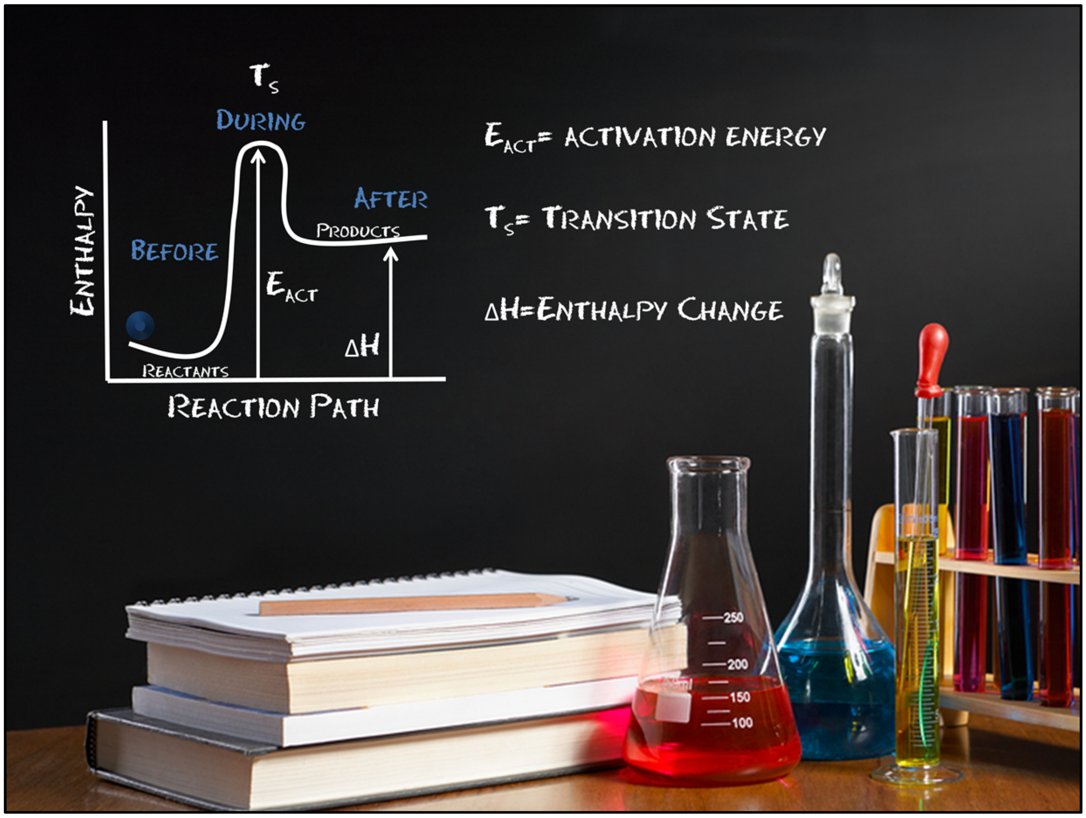

All reactions, whether endothermic or exothermic, will absorb some energy initially. This is called the activation energy. Because of this, a reaction profile really raises at first, and then decreases. As with the previous, simplified reaction profiles, the reactants are on the left and the products on the right. Basically, this is a visual depicting before, during, and after the reaction. The reactants are before, the transition state or activated complex is during, and the products are formed after. This profile shows a peak that represents the absorption of energy and then the subsequent release of energy. It may help to think of a ball that is being pushed up the hill and then rolls down the hill on its own. The peak represents the maximum potential energy. Some of the potential energy is released as kinetic energy as it rolls down the hill.

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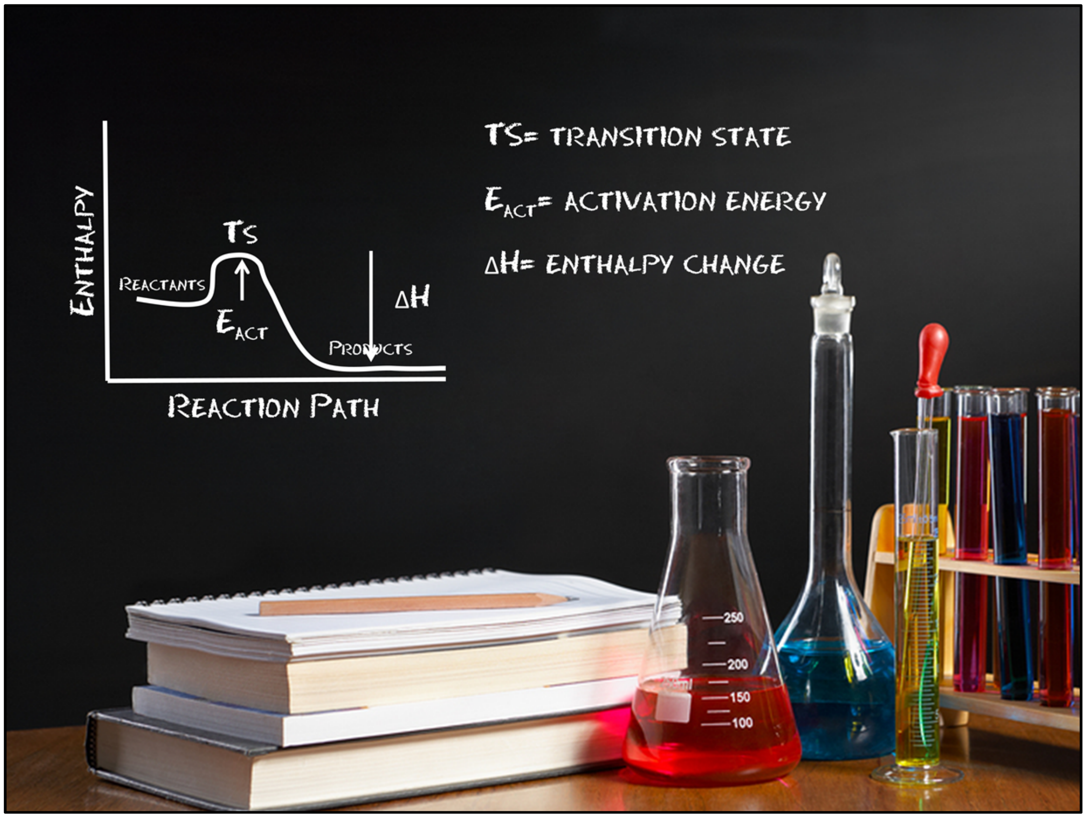

Now, analyze this reaction profile. Does it require more or less activation energy than the previous profile? Does it represent an absorbing or releasing of energy? Clearly, the amount of energy absorbed is less than the previous example. The amount released is much more than the amount absorbed so this is an exothermic process. The change in enthalpy is negative.