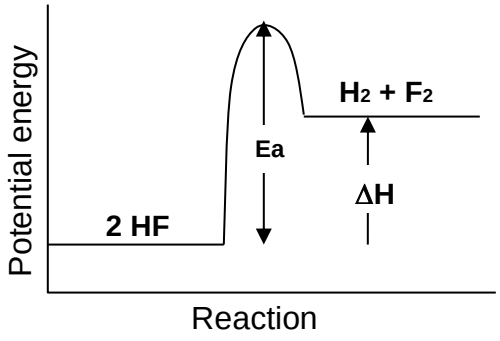
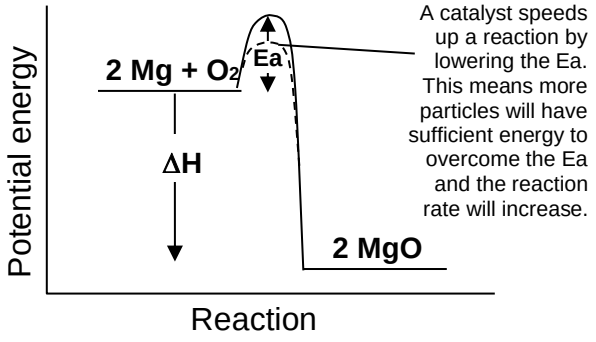
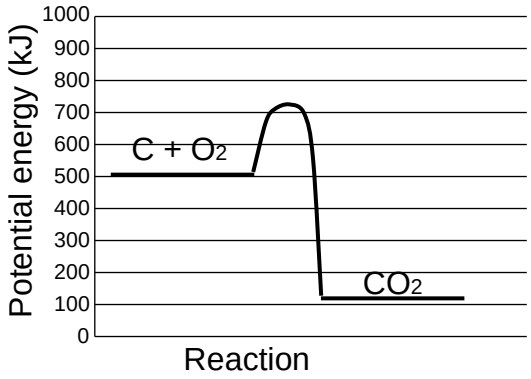
Heat of Chemical Reactions Info sheet.

Chemical reactions always take in or give off energy -- usually in the form of heat. Reactions that take in heat are called "endothermic." Reactions that give off heat are called "exothermic." There are many ways that this energy exchange can be described. The table below shows some of these ways.

1) One way is to write heat (Q) into the chemical equation:	If the reaction is **endothermic**, Q is written in on the reactants side (left side) of the equation – essentially meaning that, like a reactant, heat is being taken in and consumed during the reaction. **ex: Q + 2 HF → H_2 + F_2**	If the reaction is **exothermic**, Q is written in on the products side (right side) of the equation – essentially meaning that, like a product, heat is being produced and given off during the reaction. **ex: 2 Mg + O_2 → 2 MgO + Q**
2) Instead of "Q," the amount of heat (in kJ) can be written into the equation:	For the example above, **271 kJ + 2 HF → H_2 + F_2** This means that whenever two moles of HF react to form one mole of H_2 & one mole of F_2, 271 kJ are <u>taken in</u>.	For the example above, **2 Mg + O_2 → 2 MgO + 1204 kJ** This means that whenever two moles of Mg react with one mole of O_2 to form two moles of MgO, 1204 kJ are <u>given off.</u>
3) More often, the heat of reaction is written as ΔH after the equation.	Again, for the example above, **2 HF → H_2 + F_2 ΔH = +271 kJ** Note that when ΔH (the heat of reaction) is positive, it implies that the reaction is **endothermic** -- that heat is <u>taken in</u>.	Again, for the example above, **2 Mg + O_2 → 2 MgO ΔH = -1204 kJ** Note that when ΔH (the heat of reaction) is negative, it implies that the reaction is **exothermic** -- that heat is <u>given off</u>.
4) This can also be shown graphically in what is known as an energy diagram for a reaction. This graph shows how the potential energy of the particles change as the reaction proceeds from reactants (on the left) to products (on the right).		 A catalyst speeds up a reaction by lowering the Ea. This means more particles will have sufficient energy to overcome the Ea and the reaction rate will increase.
	The distance between the reactants' energy level and the products' energy level is the ΔH. Also, the energy "hump" in-between the reactants and products is called the "activation energy" (or Ea). Ea is the energy threshold that must be overcome to produce a reaction. Specifically, Ea is the distance from the reactants' energy level to the top of the hump.	
	For **endothermic** reactions, the energy diagram goes uphill: as heat is taken in, it raises the potential energy of the atoms. Again, ΔH is positive which means the energy possessed by the particles is increasing. Also, Ea is usually larger than it is for exothermic reactions.	For **exothermic** reactions, the energy diagram goes downhill: as heat is given off, it lowers the potential energy of the atoms. Again, ΔH is negative which means the energy possessed by the particles is decreasing. Also, Ea is usually smaller than it is for endothermic reactions.
5) The energy diagram can be shown more quantitatively. Given the graph at right, ΔH and Ea for the reaction can easily be determined.		The reactants' energy level is at about 500 kJ. The products' energy level is at about 110 kJ. Thus, for the reaction **C + O_2 → CO_2**, ΔH = 110 kJ - 500 kJ = **-390 kJ.** Also, the top of the hump is at about 720 kJ. So Ea for the reaction = 720 kJ - 500 kJ = **220 kJ**. *For the reverse reaction* (with reactants and products switched around), the energy diagram would simply be flipped over. Thus, for the reaction **CO_2 → C + O_2**, ΔH = 500 kJ - 110 kJ = **+390 kJ** and Ea = 720 kJ - 110 kJ = **610 kJ**.

Heat of Chemical Reactions Worksheet. Name: _____

1. a) What is an endothermic reaction? _____

b) What is an exothermic reaction? _____

2. a) Aside from the definition above, list three things you know about an endothermic reaction:

b) List three corresponding things you know about an exothermic reaction:

3. Consider the reaction: **CH_4 + 2 O_2 → CO_2 + 2 H_2O + 953 kJ.**

a) Is the reaction endo or exo? _____ How can you tell? _____

b) Does the reaction take in or give off heat? _____

c) ΔH = _____ What does the sign (+/ -) on ΔH tell you? _____

d) In the box at right, sketch a rough drawing of the energy diagram for this reaction.

On the diagram label ΔH and Ea.

e) What type of reaction is the one shown above: comp, decomp, SR, DR or comb?

f) How does your answer for 3e relate to your answer for 3b? _____

4. For the reaction **2 CO_2 → 2 CO + O_2**, ΔH = +566 kJ.

a) Is the reaction endo or exo? _____ How can you tell? _____

b) Does the reaction take in or give off heat? _____

c) Write this heat of reaction into the equation as shown in part (2) of the info sheet

d) In the box at right, sketch a rough drawing of the energy diagram for this reaction.

On the diagram label ΔH and Ea.

5. At right is the energy diagram for the reaction **CuO + H_2O → $Cu(OH)_2$**.

a) Write in the substances on their appropriate lines.

b Is the reaction endo or exo? _____ How can you tell? _____

c) Is ΔH positive or negative? _____

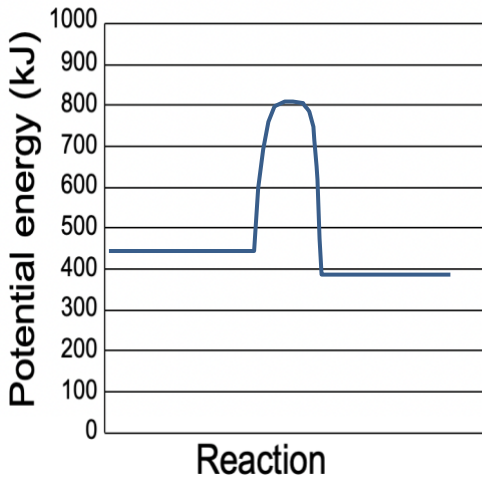
d) The reaction...(circle one) a) takes in a lot of heat b) takes in a little heat
c) gives off a lot of heat d) gives off a little heat.

e) The reaction has.... (circle one) a) a high Ea b) a low Ea

f) This Ea would probably make the reaction quite a) fast b) slow

g) A catalyst is added to the reaction. What does that do to the activation energy? _____ What does it do to the reaction rate? _____

f) On the energy diagram, draw in a line that shows the effect of adding a catalyst.



6. When a reaction is exothermic , it gives off heat. If an exothermic reaction is happening in a beaker, would the beaker feel hot or cold? _____ Some students figure that since the reaction is giving off heat, it will get colder. This is wrong! The reaction is giving off heat energy to the surroundings -- the surroundings are absorbing that heat and so the temperature of the surroundings is going up. Think of a fire. All fires are exothermic: they give off heat. If an endothermic reaction is occurring in a cup of water, will

the water's temperature increase or decrease? _____

Why? _____

7. $N_2 + 6\ HF \rightarrow 2\ NH_3 + 3\ F_2 \quad \Delta H = -1534\ kJ$

a) How much energy is (released/absorbed) when 0.173 moles of nitrogen react with excess HF?

b) What mass of HF gas would be needed to produce 37.2 kJ of heat?

c) The reaction above takes place and all the energy goes into heating up 75.0 g of water from 12.0*C to 38.7*C. What volume of NH_3 at 12.0*C and 795 torr was produced?

8. a) Write a balanced equation for the decomposition of silver oxide. _____

b) 679 J of heat must be added to decompose 5.15 g of silver oxide. Determine ΔH for the reaction.

9. a) Write a balanced equation for the reaction between calcium nitrate and potassium phosphate. _____

b) When 1.32 g of calcium nitrate is added to 75.0 mL of 0.0825 M sodium phosphate, the solution's temperature increases from 24.50*C to 32.10*C. Determine ΔH for the reaction above. Since the solution is about 97% water, assume it has the same physical properties of water