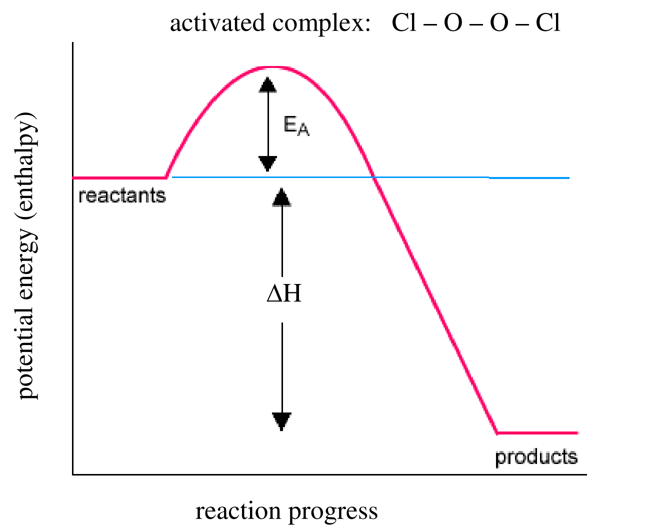
Unit 4, Lesson 03: Collision Theory and the Rates of Chemical Reactions Homework

Page 294, Q 13 – 16

13. Reaction: 2 ClO (g) $\rightarrow$ Cl_2 (g) + O_2 (g)

Potential Energy Diagram for Decomposition of ClO (g)

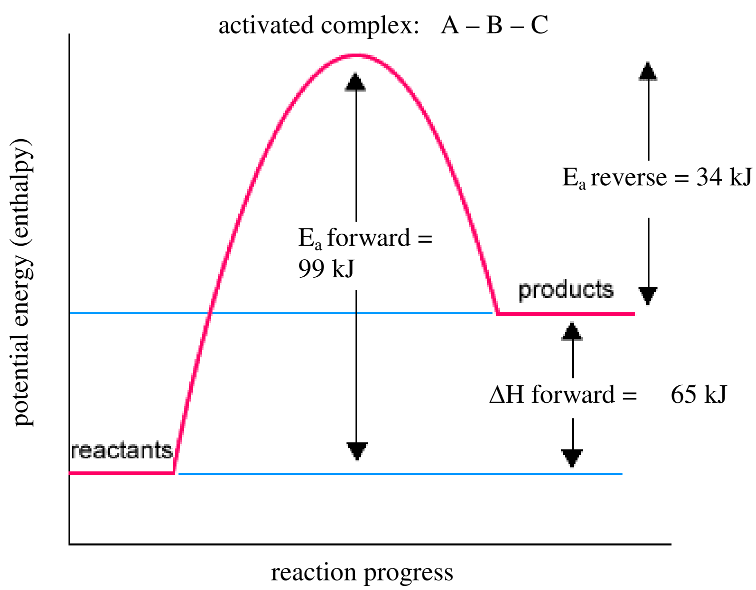


14. Reaction: AB + C $\rightarrow$ AC + B

$\Delta H = +65$ kJ, E_a reverse = 34 kJ

The potential energy diagram is the correct shape, but it is not drawn accurately to scale.

Potential Energy Diagram for Reaction of AB with C



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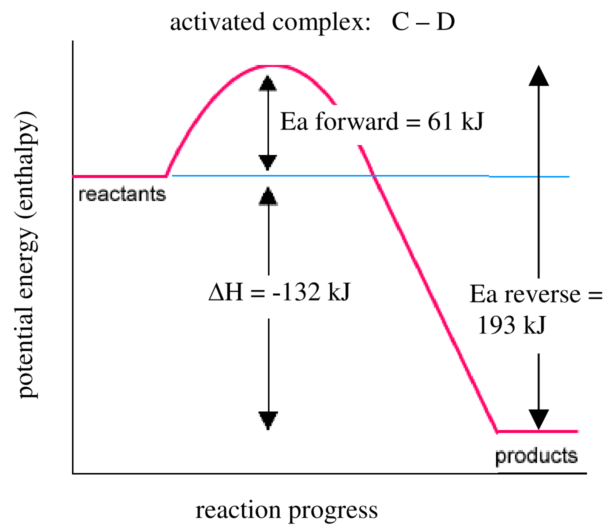
15. Reaction: C + D → CD

ΔH = - 132 kJ, E_a forward = 61 kJ

The potential energy diagram is the correct shape and drawn approximately to scale.

Potential Energy Diagram for Synthesis of CD

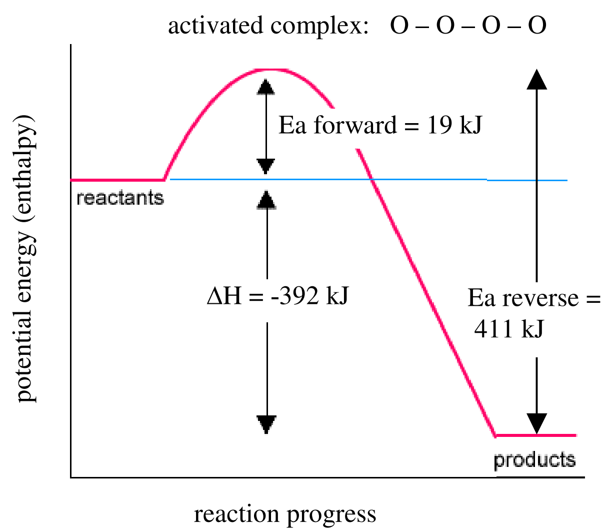


16. Reaction: O_3 (g) + O (g) → 2 O_2 (g)

ΔH = - 392 kJ, E_a forward = 19 kJ

The potential energy diagram is the correct shape but not drawn accurately to scale.

Potential Energy Diagram for Breakdown of Ozone



Page 296, Q 2, 3, 4, 6, 7

2. You could increase the rate of combustion by:

- burning the sample at a hotter temperature which would increase the average kinetic energy of the particles (their speed) so they will collide more forcefully and more often
- grinding the sample which will increase the surface area of the organic substance so there will be more available surface for oxygen to collide with the substance
- increasing the concentration of oxygen which will increase the number of collisions between oxygen and the organic substance because the particles are more crowded
- spreading the sample out in a thin layer in the furnace to increase the surface area of the solid that is exposed to react with oxygen
- adding a catalyst specific to the reaction which will provide an alternative reaction pathway with a lower activation energy, so the reaction will take place more quickly

Page 296, Q3

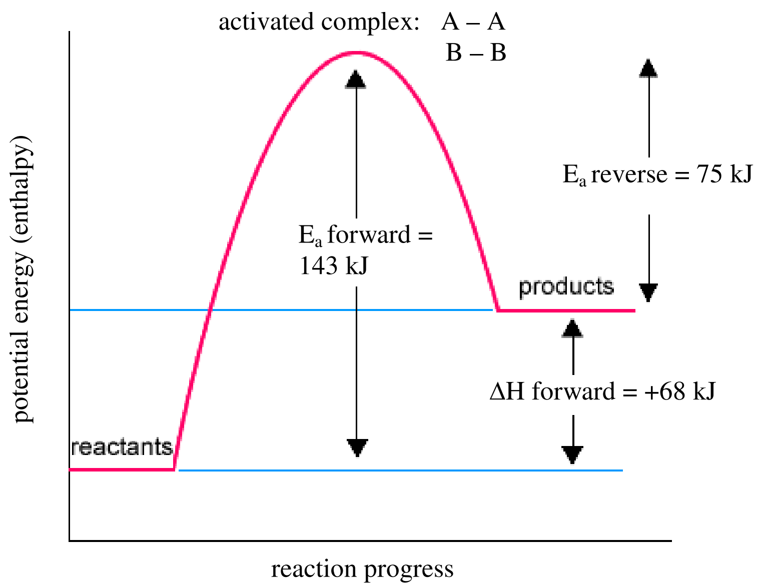
Reaction: $A_2 + B_2 \rightarrow 2\,AB$

E_a forward = 143 kJ
E_a reverse = 75 kJ

a) Ea for the forward reaction is higher than the Ea for the reverse reaction, so the forward reaction must be endothermic.

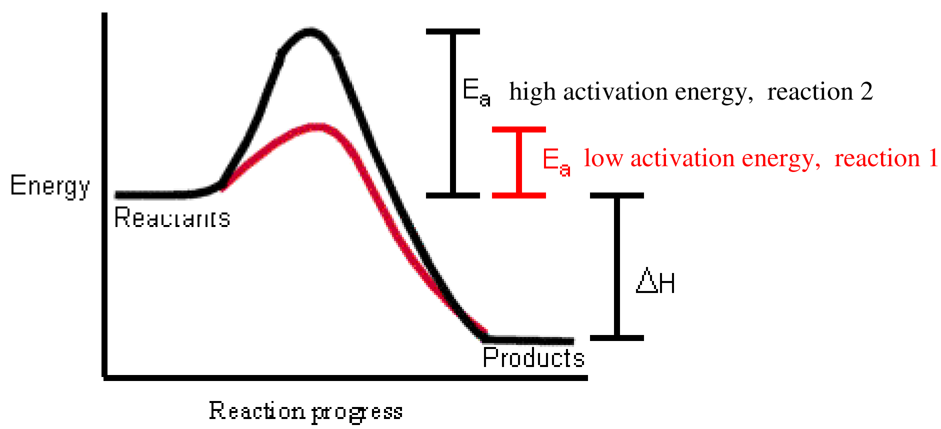
See graph for b) and c). The graph has the correct shape but is not completely accurate to scale.

Potential Energy Diagram for Reaction of A_2 with B_2



4a) The question did not say anything about ΔH, so I made it equal for both reactions. You could make ΔH any values you want as long as both reactions are exothermic. Remember, ΔH tells us if a reaction is likely to proceed, but it does not tell us anything about the RATE of the reaction.

Potential Energy Diagrams for Two Exothermic Reactions



b) Reaction 1 will have a faster rate than reaction 2. This is because the activation energy for reaction 1 is much lower, so more of the reactant particles are likely collide with sufficient energy to distort the bonds and cause a reaction.

Page 296, Q6.
Coal is pulverized before it is burned to increase its surface area. This exposes more of the coal particles to the oxygen, so there are more collisions between the coal and oxygen, and the reaction rate increases.

Page 296, Q7.
When people are submerged in very cold water, it decreases the temperature of their body so all of the body's reactions slow down, which decreases the body's demand for oxygen. The oxygen in the person's body is consumed more slowly and the person can stay alive longer on low levels of oxygen.

At warmer temperatures, the chemical reactions in the person's body continue to occur at the normal rate, so oxygen is rapidly consumed. There is irreversible brain damage due to lack of oxygen after about 4 minutes, and death occurs soon after.

Questions from homework sheet:

4. Define: activation energy and activated complex (aka transition state).

- activation energy is the minimum amount of energy required in order for a reaction to take place
- activated complex is the high energy and unstable complex formed when reactant molecules collide. The activated complex is the transition state between the reactants and products.

If the reactant molecules collide in the correct orientation and with sufficient energy, the activated complex will break down to form products. If the reactant molecules do not collide in the correct orientation, or collide without sufficient energy, then the activated complex will break down to reform the reactants.

5. Why, in general, does a reaction with a high activation energy have a low rate?

If a reaction has a high activation energy, it means that the reactant molecules must collide with extremely high energy in order to distort the existing bonds enough to allow the reaction to proceed. Because few of the particles in the system will have sufficient energy to collide this hard, very few collisions will produce products and the reaction rate will be low.

6. Why, in general, does a reaction with a low activation energy have a high rate?

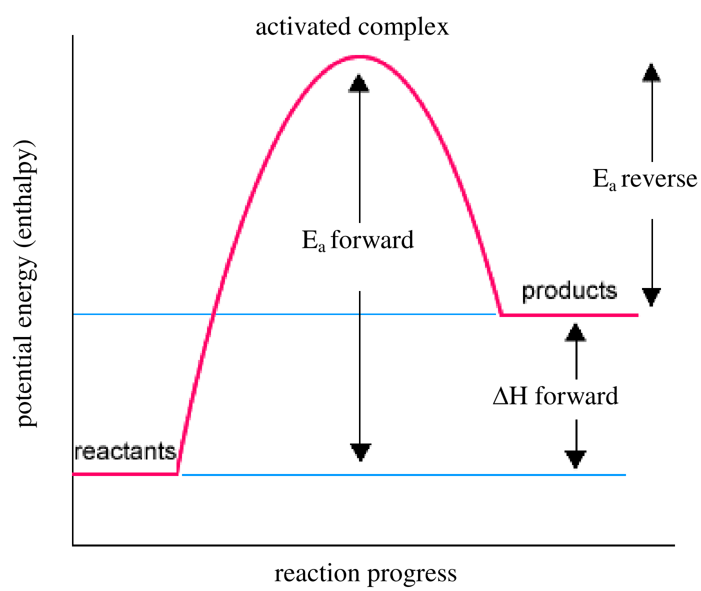
If a reaction has a low activation energy, it means that the reactant molecules can collide with only low energy in order to distort the existing bonds enough to allow the reaction to proceed. Because most of the particles in the system will have sufficient energy to collide this hard, most collisions will produce products and the reaction rate will be fast.

7. A certain reaction has a **very** high activation energy and is slightly endothermic.

a) Sketch a possible potential energy diagram (reaction pathway) for the reaction.

b) On the diagram label the reactants, products, activated complex, heat of reaction (ΔH) and the activation energy (E_a).

Potential Energy Diagram

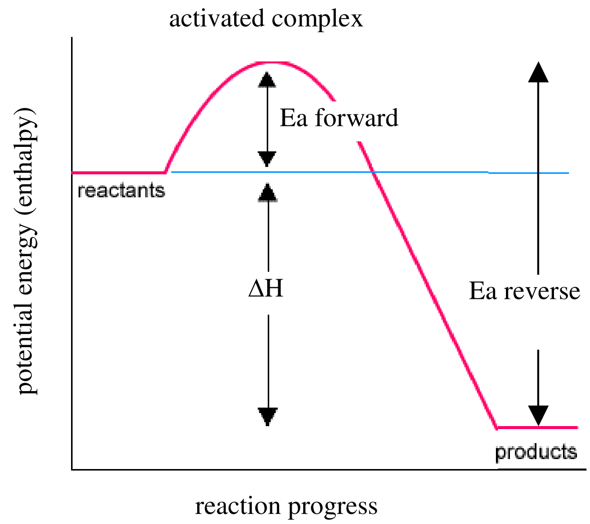


8. A certain reaction has a **very** low activation energy and is highly exothermic.

a) Sketch a possible potential energy diagram (reaction pathway) for the reaction.

b) On the diagram label the reactants, products, activated complex, heat of reaction (ΔH) and the activation energy (E_a).

Potential Energy Diagram



9. Many exothermic reactions (such as burning paper) require energy to get the reaction started, but they are able to sustain themselves one they start to burn. Explain why.

   Exothermic reactions produce energy as a product of the reaction. This energy causes the kinetic energy of the particles to increase, so their temperature goes up. Because this heats up the reactant particles, they move more quickly and collide with enough force to keep the reaction going. That is, the energy released by the reaction provides the activation energy for the reactants and sustains the reaction.

10. With regard to reaction rates, how might you:

a) food spoilage can be slowed down by keeping the food cold, so bacteria do not reproduce as quickly. Spoilage can also be slowed by minimizing the amount of oxygen available (for example by packaging food in vacuum packs). The lower concentration of oxygen will decrease the rate of spoilage reactions.

b) rusting of a car can be slowed by painting the car to prevent oxygen molecules from colliding with exposed metal. Similarly, oiling a car in the fall puts a protective barrier over the metal to prevent oxygen from reacting with the metal. Ideally, cars should be left outside in the winter so their temperature stays colder- keeping the car warm in the garage increases the rate of corrosion.

c) the rate of combustion for a campfire can be increased by chopping the wood into smaller pieces which will increase the surface area for collisions with oxygen, lighting the fire in many places so more of the particles obtain enough activation energy to burn, and fanning the fire to increase the concentration of oxygen for combustion (when the fire burns, it consumes oxygen, so fanning the fire forces air into the fire replace oxygen-depleted air).