

## Section 6.3: Explaining Reaction Rates

### Mini Investigation: Modelling Energy Distribution of Molecules, page 369

**A.** Answers may vary. Sample answer: No, I do not think you could have predicted how many tokens each person would have at the end of the activity. More experienced players will have a better idea of how to win at rock, paper, scissors, but because you change partners each time, it is not possible to develop an idea of the strategy your opponent is more likely to choose. (Rock, paper, and scissors don't have an equal probability of 33.33 % of being chosen. Rock is the most popular choice and scissors is the least common gesture. Choosing paper will give you a slight advantage, as it will cover rock, and it is slightly less probable that your opponent will use scissors. But because rock is the most popular choice, your opponent will start with paper more often than not, thinking that you'll go with rock, so the best choice to start with is scissors.)

**B.** Obtaining an additional token in Step 7 is similar to an increase in temperature because each token represents an effective collision between reactants, and increasing the temperature of a reaction mixture increases the number of entities capable of having effective collisions.

**C.** Answers may vary. Sample answer: After each round there were many students who had many more tokens than others. This models the kinetic energy of entities of a substance at a given temperature because, in any sample of a substance at a given temperature, the individual entities in the sample will have different kinetic energies, and only entities with kinetic energy equal to or greater than the activation energy can be involved in an effective collision.

**D.** Answers may vary. Sample answer: The results of this activity are similar to the effects of temperature on the probability of effective collisions in a reaction mixture because players with clever strategies (high kinetic energy) are more likely to win tokens (equal or exceed the activation energy and thus be involved in an effective collision). In any class of students, different students will have varying levels of skill at rock, paper, scissors, and at a given temperature, only a certain fraction of the reactant entities will possess enough kinetic energy to equal or exceed the activation energy.

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1. (a) rate decreases

(b) rate increases

(c) rate increases

(d) rate increases

(e) rate does not change

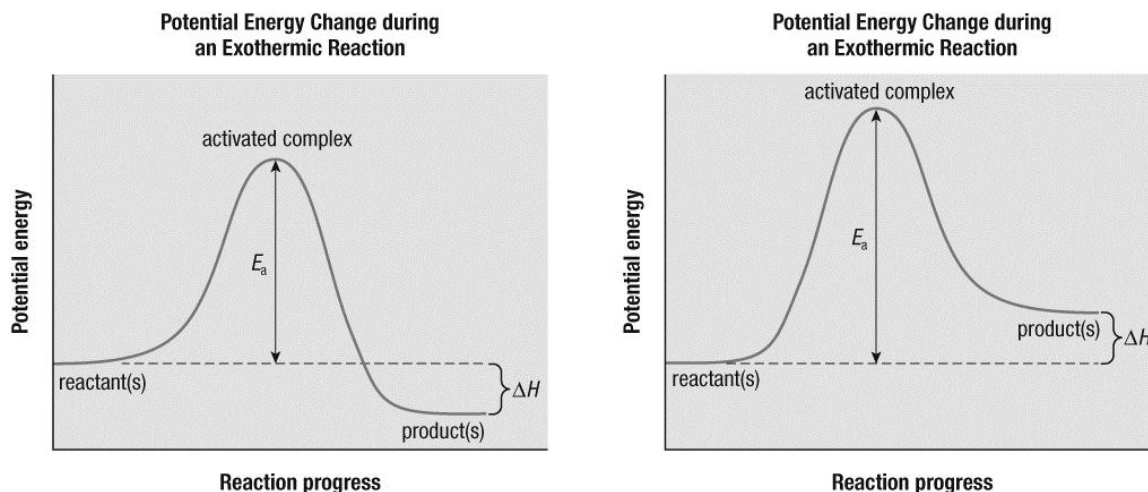
2. (a) Answers may vary. Sample answer: Collision theory states that a chemical reaction can only occur when two particles collide with the right orientation and enough energy to cause them to react.

(b) Every collision that occurs does not result in the formation of a product because if the particles do not line up in the right way or do not have enough energy, the collision does not result in a reaction.

(c) Increasing the temperature can affect the number of collisions as well as the percentage of effective collisions because the particles move faster at a higher temperature, there are more collisions, and a greater percentage of collisions have enough energy to cause a reaction.

3. Answers may vary. Sample answer: An example of an everyday activity that requires you to come in contact with something, to be lined up correctly, and to have a certain minimum amount of energy is a handshake. In a handshake, two people approach one another, facing toward each other and extending their right hands, and come close enough to be able to clasp hands and shake them up and down. If the two people are not facing toward each other, their outstretched hands will not connect. If they are not moving or do not come close enough together (for example, if they are standing far apart and not moving), they will not be able to clasp hands, even if they extend their arm. So if either of these factors is missing, a handshake cannot occur.

4. Answers may vary. Sample answer:



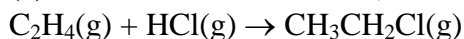
5. (a) A catalyst is a substance that increases the rate of a chemical reaction without being consumed during the reaction.

(b) A catalyst affects reaction rate by providing a reaction pathway with a lower activation energy. This increases the rate of the reaction.

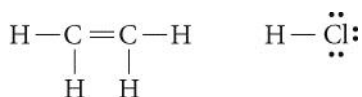
(c) Manganese dioxide is a heterogeneous catalyst because it exists in a different state of matter (solid) from the reactant, hydrogen peroxide, which is a liquid.

(d) Answers may vary. Sample answer: An experiment to prove that manganese dioxide is a catalyst for this reaction is as follows: Add a small amount of manganese dioxide powder to a clean, dry test tube. Using a dropper, add equal amounts of hydrogen peroxide to an empty test tube and to the test tube containing the powder. Observe the two test tubes for evidence of decomposition of hydrogen peroxide. Materials needed: two test tubes and holder, manganese dioxide powder, hydrogen peroxide.

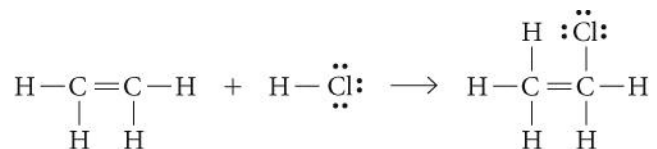
6. (a) Since ethene is an alkene, it will undergo an addition reaction with hydrogen chloride:



(b) Draw the substances involved in the reaction. Ethene has a double bond between the carbon atoms:



Determine where the added entities will attach. Markovnikov's rule states that the hydrogen atom from the hydrogen chloride molecule bonds to the carbon atom that has the most hydrogen atoms already attached to it—in this case, either carbon atom.



(c) Based on the Lewis structures, an orientation that would result in an effective collision would be when the molecules are lined up so that the hydrogen and chlorine atoms of hydrogen chloride are parallel to the carbon-carbon double bond.

(d) An orientation that would result in an ineffective collision is one in which the chlorine atom of hydrogen chloride approaches perpendicular the double bond.