Class: Chemistry 122

Lesson Title: Formation of Water – Reaction Mechanism & Rate Factors

Class Size: **24**
Time: **60 mins**

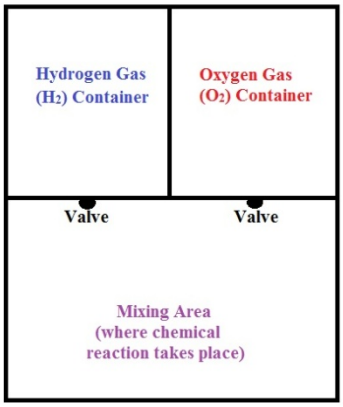
Curriculum Outcomes:
ACC-2 describe a reaction mechanism and catalysts' role in a chemical reaction

Learning Objectives:
1. To assist students in visualizing/understanding the reaction mechanism of a simple chemical reaction.
2. Students should be able to understand the role of a catalyst and its effect on a chemical reaction.

Materials:
- 12 "H" signs (representing Hydrogen atoms)
- 6 "O" signs (representing Oxygen atoms)
- 2 "Catalyst/Chemistry Police" props (representing Catalysts)
- 2 "Valves" signs (representing the valves for the Hydrogen and Oxygen containers: 1 – teacher, 1 - student)
- 22 bits of String (to hang the signs on each student)
- Computer & Speakers
- Slow music (for normal reaction): "I'm Not the Only One – Sam Smith"
- Fast music (for reaction w/ catalyst): "Hey Ya – Outkast"
- Tables to block students off and represent containers

Preparation beforehand:
- Set up the room into three clear sections, one being twice the size of the others (see image to the right)

Classroom Set-Up:



Suggestion:
- **Role of the teacher:**
  Teacher will facilitate the activity by providing initial instructions and special details or rules of the interaction. The teacher should not reveal any specific mechanism traits, but should give detailed instructions to the "Chemistry Police/Catalysts" as described above. The teacher may provide hints along the way if the concept is a little difficult at first.

Introduction:
1. Briefly remind students about *BrINClHOF* (ask them if they know what the acronym stands for and reminds us of): these are diatomic elements meaning that they pair up naturally (so they are never found in the real world existing by themselves as single atoms).
2. Assign students to the positions of hydrogen (12), oxygen (6), valve (2), or catalyst (2):
   a. Hydrogen atoms – They should locate to the designated part of the classroom and pair up by holding hands to signify the bond (as hydrogen atoms do).They should only be holding one hand between the two to represent a single bond.
   b. Oxygen atoms – They should locate to the designated part of the classroom and pair up by holding hands to signify the bond (as oxygen atoms do). They should be holding both hands to represent a double bond.
   c. Valves- They should be assigned to either the oxygen or hydrogen container and control release of the molecules to the open container.
   d. Catalysts – Will be "Chemistry Police" in the first demonstration (instruct them to look for any loose oxygen or hydrogen atoms; if they see any violations to BrINClHOF at any point, they are to notify the authorities: teacher) and released into the mixing area in the second demonstration. See attached document for instructions.
3. Explain what a kinulation is (broken up into kinesthetic and simulation). Tell them that these are used to help students learn difficult concepts that are otherwise difficult to picture. It allows students to become part of the demonstration, and therefore easier to learn. Ask students if they would like to try one.

Activity #1 – "Hydrogen gas + Oxygen gas → Water gas, no catalyst:"

1. Explain that the only way to break the bond between the oxygen atoms is to successfully bond to two hydrogen atoms each. In addition, the only way to break a hydrogen bond is to form a successful oxygen bond. Instruct the "Chemistry Police" privately that if they ever see a free floating oxygen or hydrogen atom, they are to notify the teacher (as this doesn't happen naturally).
2. Make sure to instruct students to freely move about the open space (do not seek out your bonding partners right away; this is not natural).
3. Instruct the valves to release oxygen or hydrogen molecules at their own leisure and hit *Play* on the "slow music."
4. At this point it is up to the students to determine the reaction mechanism (how do the water molecules form mechanically).
    a. *What are we leading them to?*
        i. Students should be able to figure out the reaction mechanism for this reaction: that two hydrogen atoms will approach one of the oxygen atoms in a pair and try to bond with it. The only way they can successfully do this is for another pair of hydrogen atoms to be doing the same thing with the other oxygen atom in the pair.
5. If necessary, the activity can be started over if they have difficulties at first and want to try it again.

Activity #2 – "Hydrogen gas + Oxygen gas → Water gas, with catalyst:"

1. Have everyone reset themselves in their original location and repeat the activity again, this time the "Chemistry Police" will have the role of "Catalysts" and help bring hydrogen and oxygen molecules together in order to complete the reaction. Hit *Play* on the "fast music."
    a. What are we leading them to?
        i. This time students should realize that the addition of the catalyst helps them find their bonding partners much more quickly, i.e. speeds up the reaction.

Conclusion – Possible wrap-up questions:

1. What is your interpretation of the reaction mechanism in this simple reaction?
2. What is the role of a catalyst?
3. What other factors might speed up or slow down a reaction?

Helpful Hints

- Remind the students of *BrINClHOF* as previously mentioned
- Make sure that students try to take on the physical role of their molecule (i.e. do not go looking for bonding partners as molecules cannot consciously search; it's a matter of collision theory, which they have already covered in previous classes)
- Make a general announcement about expected behaviour in these types of activities
- If at all possible, color coordination of Oxygen vs. Hydrogen atoms is encouraged (if students could be assigned roles in a previous class and come wearing their colors, or gather pinnies from the Phys. Ed. Teacher).

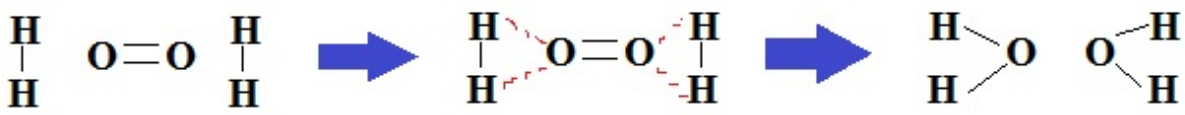
Chemistry Police/Catalyst Instructions:

Demonstration 1: Keeping in mind that the BrINClHOF elements are diatomic when in their natural state, you must keep an eye out for any "chemistry violators." If you ever see an oxygen or hydrogen atom on its own (unbounded to anything, i.e. bond broken prematurely), you should let the students know they are violating the laws of chemistry (and alert a teacher, see below for violations).

(violations)

Demonstration 2: You are acting as the catalysts, you will bring the necessary hydrogen gas pairs to the oxygen gas molecule in order to form water (H_2O). Because you are a catalyst, you are speeding up the reaction, meaning you should try to do this in a timely manner (as opposed to demonstration 1 where the molecules were free floating and needed to collide). As catalysts, you will be given the correct reaction mechanism:

An H_2 molecule will align near one of the oxygen atoms in the oxygen molecule. Another H_2 molecule must be positioned near the other oxygen atom. Once a pair of hydrogen atoms is positioned at both ends of the oxygen molecule, the bond may form between hydrogen-oxygen-hydrogen and the subsequent bonds between hydrogen-hydrogen and oxygen-oxygen will break. The reaction happens in the ratio $2\ H_2 + O_2 \rightarrow 2H_2O$ (see below for diagram).



(partial bonds)