Title of Lesson: Visualizing Reactions

Target Grades: High School Chemistry I and/or II

Time Required: 3 45-minute periods, plus embedded activities throughout curriculum

Alignment to Standards:
CHEM1.PS.1.3. Perform stoichiometric calculations involving the following relationship: mole-mole; mass-mass; mole-mass; and mass-particle. Show a qualitative understanding of the phenomenon of percent yield, limiting and excess reagents in a chemical reaction through pictorial and conceptual examples.
CHEM1.PS1.2. Demonstrate that atoms, and therefore mass, are conserved during a chemical reaction by balancing chemical equations.
CHEM1.PS2.1 Draw, identify, and contrast graphical representations of chemical bonds (ionic, covalent, and metallic) based on chemical formulas. Construct and communicate explanations to show that atoms combine by transferring or sharing electrons.
CHEM1.PS3.1. Contrast the concepts of temperature and heat flow in macroscopic and microscopic terms. Understand that heat is a form of energy and temperature is a measure of average kinetic energy of a molecule.
CHEM2.PS2.3. Investigate and use mathematical evidence to support that rates of chemical reactions are determined by details of the molecular collisions.

Materials Needed:

Paper
Colored Pencils
Copper II Sulfate
Aluminum Foil
Salt
Sand
Water
Iron Filings

The following chemicals can be used or videos of reactions can be found on youtube: Sodium bicarbonate, acetic acid, zinc, hydrochloric acid, hydrogen peroxide, manganese dioxide, magnesium, birthday candle

Background Information:
As scientists strive to make biotechnology processes more efficient to enable us to harness the power of intricate chemical reactions, an important area of research is using computer modeling to understand submicroscopic molecular reactions and their impact on processes at macroscopic scales. Just as scientists "visualize" these reactions, we can help our students visualize chemical reactions. A well-documented source of difficulty in Chemistry at all levels is the understanding of how the macroscopic (what we see), symbolic (equations and formulas), and submicroscopic (those molecular activities that we can't "see" in the traditional way) all interplay with one another. Students have a difficult time understanding all 3 views of the same processes simultaneously. By explicitly focusing on modeling and visualizing matter at the molecular level, some of these difficulties can be addressed.

Lesson Objectives:
Students will be able to describe matter using chemistry terms.
Students will be able to explain what is happening macroscopically and/or symbolically in a "visualization" drawing depicting molecules.
Students will be able to construct a molecular "visualization" drawing when given a macroscopic or symbolic scenario.
Students will be able to explain and use "visualization" to depict the effects of catalysts, concentration, temperature, and pressure on reaction rates in a system.

Instructional Process:

Introduction to Visualization:

Introduce Problem to Students
The following vocabulary terms should be introduced to students: Solid, Liquid, Gas, Pure, Mixture, Element, Compound, Homogenous, Heterogeneous, Binary, Monoatomic, Diatomic, Atom, Molecule

Prepare sample "visualization" pictures to show students as you ask them questions and work through the examples.

Solid, Liquid, and Gas

"What is the definition of Solid?" "Liquid?" "Gas?" (Students will tend to give the traditional answer regarding the shape and volume – fixed/unfixed – of the phase.)

"What does a solid look like on the molecular level?" "A liquid?" "A gas?" (Describe these to the students.)

Show sample "visualization" pictures to students and ask them to identify the phase.

Pure, Mixture

"What is an example of a pure substance?" (Table salt, water, sugar, gold, etc.)

"How would you draw a pure substance at the molecular level? What would you use to represent it?"

Show samples and ask if each is pure or a mixture. Start with pure elements, then create a potential discrepant event by showing a pure compound. Ask students to explain why this is a pure substance and not a mixture. (Every "particle" is the same.)

Pure Elements, Pure Compounds

Homogenous Mixture, Heterogenous Mixture

Direct students to describe the contents of a mixture. When a visualization picture is deemed a "mixture" students should say, "mixture of…" and list the substances present in the mixture.

Discuss the terms "atom" and "molecule" along with when we might have an element that is made of molecules. Then, introduce the terms "monoatomic" (element), "diatomic" (element), and "binary" (compound) to the students.

Student Activity 1:

1. Each student will draw a visualization picture using a full sheet of 8.5 x 11 copy paper and colored pencils or markers.
2. Number each picture and place them around the room.
3. Students will "carousel" around the room and describe each picture.
4. Once students are done, go over the best answers as a class.

Student Activity 2:
Complete student practice handouts.

Visualization of Matter Separation:

Introduce Problem to Students
Show a sample of table salt. "What is the chemical formula for this?" (NaCl) "How would you draw it in a visualization picture?"
Show a sample of sand. "What is the chemical formula for this?" (SiO_2) "How would you draw it in a visualization picture?"
Show a sample of Iron Filings. "What is the chemical formula for this?" (Fe) "How would you draw it in a visualization picture?"
Show a sample of Water. "What is the chemical formula for this?" (H_2O) "How would you draw it in a visualization picture?"

"Now, if we mix all 4 of these substances, what happens?" Ask students to draw it in a visualization picture.

"How can we separate this mixture?"

Student Activity 3:
Ask students to write out a procedure for the separation of this mixture and "visualize" the matter at each step by drawing representative visualization pictures.

Visualization of a Chemical Reaction:

Introduce Problem to Students

Show a sample of Copper II Sulfate. "What is the chemical formula for this?" ($CuSO_4$) "How would you draw it in a visualization picture?"

Show a sample of aluminum foil. "What is the chemical formula for this?" (Al) "How would you draw it in a visualization picture?"

"What happens if we mix these two together?" Place the aluminum foil in a test tube with the $CuSO_4$. Allow students to observe the reaction.

Guide students through writing a chemical equation for this process. Ask students to identify the products in the macroscopic, observable reaction. Ask students to draw a visualization representation of this reaction.

Discuss the practicalities of bonds breaking and reforming in chemical reactions. Emphasize that atoms must be in proximity of each other and in the proper orientation in order to create bonds. You can use the analogy of a trapeze artist grabbing the hands of their partner to swing through the air.

Discuss the kinds of things that can create more opportunities for bonding, such as increased temperature, pressure, concentration – and the use of a catalyst.

Model the use of a catalyst by demonstrating the $CuSO_4$ and Al reaction with the addition of NaCl. Ask students to draw a visualization of a potential scenario in which NaCl acts as a catalyst. (The important aspect is that students attempt to model a scenario that aligns with what they are able to observe at the macroscopic level and that makes sense in their submicroscopic representation.)

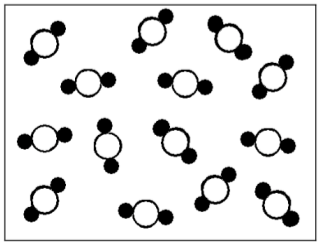
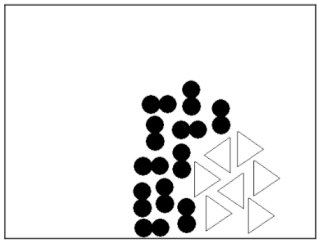
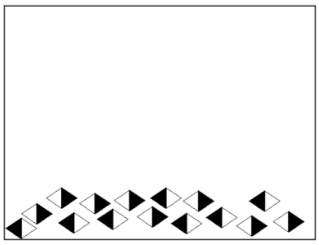
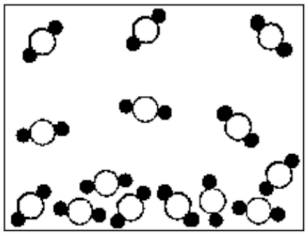
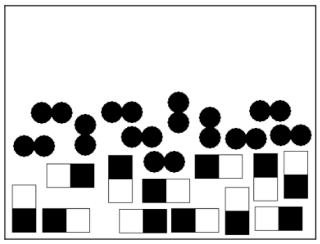
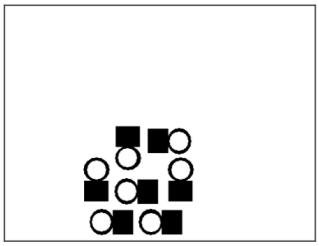
Student Activity 4:

Complete student practice handouts for visualizing reactions and catalysts. Demonstrate the reactions for the students, allow them to view them in rotation stations, and/or show videos of the reactions. You may need to give the students hints on chemical formulas. Modify the activity as necessary to match student ability level.

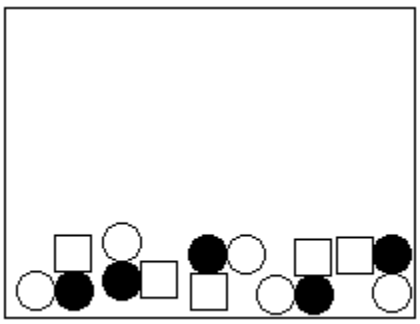
Visualization Activity

Name:_____ Date:_____ Period:_____

Thoroughly describe the following diagrams using the appropriate statements that describe matter.

For the pictures below: (1) describe the substance in each picture, (2) tell what is happening between the pictures, and (3) state whether this process represents an increase or decrease in kinetic energy.



(1)

(2)

(3)

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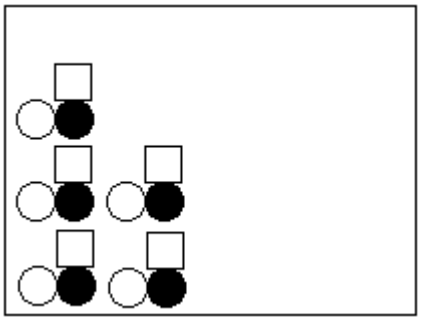
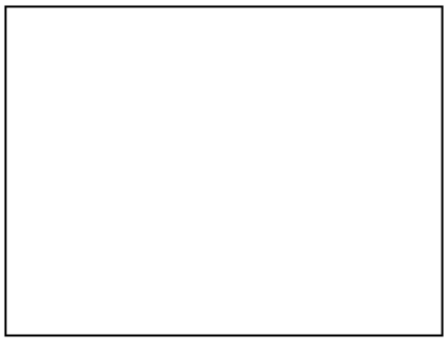
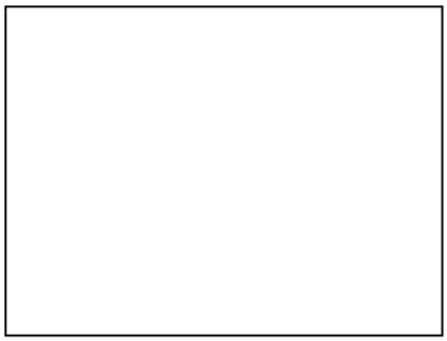


(1)

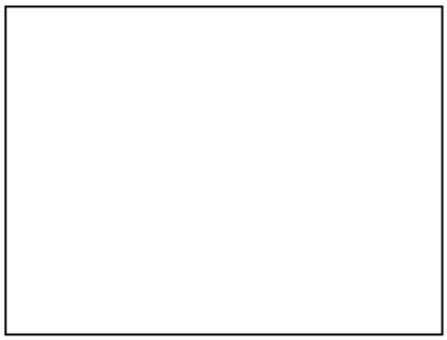
Draw the following:



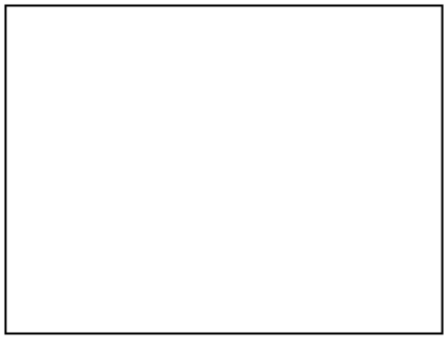
A pure monoatomic element in the solid phase.



A mixture of two different diatomic elements in the gaseous phase above a solid, binary compound.



A liquid compound that has a high vapor pressure.



A liquid element that has a low vapor pressure.

Visualization of Reactions Activity

Name:_____ Date:_____ Period:_____

For each of the following:

A. Write the chemical reaction.
B. Describe the observable physical properties of each substance.
C. Draw a visualization representation of the reactants and products.

1. Sodium bicarbonate reacts with Acetic Acid

Reactants: Products:

2. Hydrogen Peroxide decomposes catalyzed by MnO_2

Reactants: Products:

3. A candle burns ($C_{25}H_{52}$ is the chemical formula, so you may only want to draw one molecule)

Reactants: Products:

4. Mg reacts with oxygen in the air to produce MgO

Reactants: Products:

5. Zn reacts with Hydrochloric acid

Reactants: Products: