

Chemistry: Reactions

The Self-Warming/Cooling Device

The following learning activities were backwards planned to facilitate the development of students' knowledge and skills for mastery of this NGSS Performance Expectation. Not all of the dimensions and CCSS are covered in the following activities and teachers are encouraged to address them where possible.

MS-PS1-6 Matter and its Interactions

Students who demonstrate understanding can:

- MS-PS1-6.** Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.* [Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride.] [Assessment Boundary: Assessment is limited to the criteria of amount, time, and temperature of substance in testing the device.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Education:

Science and Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.

- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.

Disciplinary Core Ideas

PS1.B: Chemical Reactions

- Some chemical reactions release energy, others store energy.

ETS1.B: Developing Possible Solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (*secondary*)

ETS1.C: Optimizing the Design Solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process - that is, some of the characteristics may be incorporated into the new design. (*secondary*)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (*secondary*)

Crosscutting Concepts

Energy and Matter

- The transfer of energy can be tracked as energy flows through a designed or natural system.

Connections to other DCIs in this grade-band:

MS.PS3.D

Articulation of DCIs across grade-bands:

HS.PS1.A ; HS.PS1.B ; HS.PS3.A ; HS.PS3.B ; HS.PS3.D

Common Core State Standards Connections:

ELA/Literacy -

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. (MS-PS1-6)

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS1-6)

Lesson Plans for Chemistry Unit

Lesson 1: Intro to Atom: What's Inside?

Objective: Students will be able to understand the relative size of an atom, examine properties that are used to identify objects, test for those properties, and form a hypothesis about the identity of an unknown object.

Learning Goal: Atoms are the tiny particles that make up all matter. Students conclude different materials have different properties because they are made of different atoms.

Vocabulary: matter, atom, physical property, chemical property, volume, mass, density

Engage:

1. Students are asked about the smallest object they have ever seen, and then share in their groups. Students are then asked, what is the object they chose made of? (i.e. paper, dirt, etc.) And then what is that object made of? And so on...until the class comes to the idea that objects must be made of smaller particles that we cannot see. So how small is this particle? (The ATOM)
2. Ask students, "If I gave you one atom of gold for every second that has elapsed since The Big Bang, how much or many atoms would you have? What would the pile look like or compare to?"
3. Ask students, "What are you thinking? A teaspoon of gold? A bucketful of gold? A truckful?" One atom for every second since the beginning of time, don't underestimate it! Second by second, we pass through the radiation dominated moments after the big bang, the era in which matter started to collapse into stars, the time that planets like our earth formed around the Sun; we pass the earliest periods of life on earth, and on and on. And with each second of these epochs an atom gets added to the offer.

Here is a gold coin weighing one ounce. How many of these would you have?



Not even one of these coins would be given.



At right is a fragment that is 1.5% of the original coin. It is about the smallest fragment that is easy to show.

The astonishing result is that even this fragment is too big. It is 3,000 times too big!

My offer turns out to be very far from generous. As many atoms of gold as seconds since the big bang amounts to a speck of gold weighing 0.14 milligrams and worth 0.21 cents.

- Teacher note: 1 milligram = the brain of a small worker bee or a very, very small snowflake, brand new dollar bill cut into 1000 pieces.

Explore: How can scientists gather information about a particle that is so small they cannot see it? Scientists must perform tests on the particle (or object).

4. Students are asked to brainstorm information that they need to know in order to identify an object? As a class, students develop a list of properties that can help identify an object.

- Teacher note: A class T-chart can be developed listing physical and chemical properties and ones that can be tested for in class.

5. Students are then presented with covered boxes that have objects with the same volume but different masses (density cubes made of different atoms), and asked to design and perform tests to eventually hypothesize about the identity of the object and what is made out of.

- Teacher note: a variety of different objects made of different materials can be used also

Explain:

6. Students record their observations on the handout and conclude about the identity of object.

7. Teacher leads class discussion on how properties can identify an object and how other tests may need to be performed to come to a conclusion (magnetism, conductivity, etc).

- Teacher note: Discussion can be extended to specifically talk about the experiments performed to gain information about the atom (Rutherford, Thomson, etc.)

8. Students record their observations on the handout and conclude about the identity of object.

- Teacher note: Pictures of how atoms are arranged differently in different materials can be shown <http://www.middleschoolchemistry.com/multimedia/chapter3/lesson1#metal>

Elaborate:

9. Students compare their methods and findings with other groups, revise any tests, identify any errors and revise their hypothesis

10. Students share their conclusions and find out what was inside the box.

Evaluate:

11. Students complete handout and answer questions:

- a) What are the smallest particles that make up all matter? How small are they?
- b) Why do different objects have different properties?

Students should make the connection that different objects are made of different atoms, and thus have different properties.

Lesson 2: Atomic Configuration: What do individual atoms look like?

Objective: Students will be able to compare and contrast the subatomic particles that make-up an atom, create a table organizing the information necessary to build an atom, and use the periodic table to analyze the atomic composition of the elements 1-20.

Learning goal: Atoms of different elements are composed of specific numbers of subatomic particles, which have different locations and charges. Also, you can identify an element's atom from the atomic number.

Vocabulary: Periodic table, atomic number, proton, electron, neutron, electron shell, electron cloud, nucleus, atomic mass, atomic number

Engage:

1. Students asked to define an atom in their own words (less than 8 words). Teacher records student responses on whiteboard and the class identifies common words/ideas (i.e. smallest particle)
2. Teacher then gives students a variety of materials and scissors, and asks students to cut the material in half until they get something that represents an atom of that material.
 - Teacher note: Students may not all get the same size piece of material (which is okay), this can lead to review that atoms of different materials have different properties (including size).
3. Optional: Teacher can then give students magnifying glass (or microscopes) to allow student to see their material even closer.

Explore:

4. In groups, students are given the periodic table, handouts with multiple images of an element's atom, and a word bank containing necessary vocabulary (Each group receives images of two different element's atom or if available students can use computers to look up images on their own.)
5. Students compare and contrast the pictures and deduce the subatomic particles that every atom is made of and how two atoms of different elements differ.
 - Teacher note: Students should also be led to use the periodic table to find patterns in the number of subatomic particles and information of the periodic table (students can record notes in notebook).
6. Students then make a poster of their element's atomic configuration and label it with the correct vocabulary.
7. Students complete a gallery walk analyzing each group's atom and vocab labels, and then evaluate the poster by leaving comments on post-it notes, and finally completing the handout about the composition of an atom.

Explain:

8. Whole class discusses what was learned and questions they still have. (possible missing information: number of neutrons, electron locations in shells vs. cloud.
9. Teacher leads class (or students work in groups to make) filling out a graphic organizer on subatomic particle information and demonstrates how to calculate the number of protons, neutrons, and electrons (if students did not figure it out in groups). Introduction to isotopes can be included here.

Elaborate:

10. Students are now asked to revise their original drawings of their atoms and include a drawing of an isotope of one of their atoms.
11. Time permitting: Students can do another gallery walk to evaluate the drawings of atoms and isotopes of other groups filling out a handout about lessons learned (ex. Give one – Take one)

Evaluation:

12. Students are given a handout with the first 20 elements and asked to draw the atoms of each.

Follow-up Activities:

- 1) Matching the element to the atom information. The first 20 elements are posted around the room and students are asked to place cards with information about an element's atom on the corresponding poster.
- 2) http://www.middleschoolchemistry.com/multimedia/chapter4/lesson1#protons_and_electrons
This website shows animations of how protons and electrons react to each other as a result of their charge. It also contains a lesson using a plastic grocery bag to demonstrate the charges of protons and electrons and how they react: <http://www.middleschoolchemistry.com/lessonplans/chapter4/lesson1>
- 3) <http://phet.colorado.edu/en/simulation/balloons>

This is also a simulation that shows the attractive force of static electricity

Interactive websites can also be used to reinforce content about atomic configuration.

Interactive Building Atoms Websites:

http://www.ljcreate.com/products/atom_builder.asp

<http://www.kscience.co.uk/animations/atom.htm>

<http://phet.colorado.edu/en/simulation/build-an-atom>

<http://www.pbs.org/wgbh/aso/tryit/atom/builder.html>

Overall Tutorial: http://www.teachersdomain.org/asset/lsp07_int_theatom/

Lesson 3: Atomic Configuration -- Building Atoms

Objective: Students will be able to construct three atoms using the information from the Periodic Table and analyze their compositions to identify trends/patterns in atomic configuration within groups and periods of the Periodic Table.

Learning Goal: Atoms of different elements are composed of specific numbers of subatomic particles, which have different locations and charges. Also, you can identify an element's atom from the atomic number. Trends identified: Atomic number (# of protons) increases across periods. Valence electrons are constant within a group.

Vocabulary: Period, group, valence electron, electrons orbitals (shells), electron cloud, mass number

Engage:

1. Students are shown quick video clip reminding/reinforcing information on atoms:

<http://ed.ted.com/lessons/just-how-small-is-an-atom>

2. Students are then given a handout with different sized objects and asked to use images to represent subatomic particles. (students can use graphic organizer from previous lesson)
3. More attention the relative sizes of the nucleus, protons, neutrons, and electrons for atom building. Which objects would best represent the subatomic particles based on size? Class discuss/defend their choices.

Explore:

4. Students are given periodic table and supplies for building models of atoms (and use graphic organizer from previous lesson)
5. In groups, students are asked to build 3-5 atoms from the 1st 18 elements of the periodic table. Elements are assigned by teacher to ensure that all 18 elements are built by the class. (Depending on size of class, you may have to split the class in half and have the two sides of the class building the 1st 18 elements, so you have two complete models of each of the 1st 18 elements.
6. Students construct models and put them in order according to the periodic table. The different groups come together and put all the models in order (models of elements 1-18). The students then analyze atomic models and identify the trends in atomic configuration across periods and down groups, and record their ideas on the handout.

Explain:

7. Teacher leads discussion of patterns found with atomic configuration within the periodic table.
8. Teacher introduces concept of valence electrons, and how they are related to the properties of the element, then asks students to revisit their atomic models to see if valence electrons show a trend.

Elaborate:

8. Teacher reminds students of the pattern within a group for valence electrons and asks students to predict if elements in the same group would be more or less similar to each other compared to elements in other groups and to justify their answer.
9. Teacher shows videos of sodium, potassium, calcium reacting with water and an acid. (Demonstrations can also be done if chemicals available)
http://www.middleschoolchemistry.com/multimedia/chapter4/lesson3#potassium_in_water
10. Students record observations about videos, and conclude about the similarities/differences in how elements react across period and down groups.

Evaluation:

11. Student handout is used for evaluation of student learning.

Follow-up Activities:

12. Students match element cards showing info about electron configuration with the correct element (1-20) poster around the room. This activity is similar to previous lesson, just with information now focusing on electrons.

Lesson 4: Atoms forming molecular compounds

Objective: Students will be able to construct simple and extended models of molecules choosing correct sized materials (based on size of atom).

Learning goal: Compounds are made from different atoms, which combine with one another in various ways. Atoms can bond together to form simple structures (only a few atoms) and extended structures with many atoms bonded together.

Vocabulary: molecule, molecular compound, chemical bonds, chemical formula, subscript

Engage:

1. Students are given images of molecular structures of various molecules (ex. Graphite, diamond, salt, hydrocarbons, water, etc.) along with corresponding chemical formulas and names, and then asked to match the pictures with the correct labels. Students asked to give reasons for their choices and to record any differences in the images of different molecular structures. (Hopefully students see that the chemical formula (subscript) gives number of atoms of each element, molecules can be bonded in different ways, and molecules can be small or large depending on amount of atoms)
2. Students can record thoughts on handout or notebook

Explore:

3. Students, in pairs, are then asked to build models of other common compounds with simple structures and with extended structure.
4. Students fill out corresponding handout that lists the chemical formulas. Students use the subscripts to count the number of atoms in each molecule and make a drawing that shows the structure of the molecule.
5. Teacher checks off on student handout when groups have correctly modeled the compound.

Explain:

6. Teacher discusses with class how the different bonding and structures that atoms can make can allow for the elements in the periodic table to make all the substances in the universe.
7. Teacher shows images of extended structures of very large molecules for students to see how big molecules can be (hundreds of atoms)

Elaborate: (Optional information)

8. Molecules can also include single, double, and triple bonds to allow for even more substances to be made. Students can be asked to make compounds containing single, double, and triple bonds.
9. Teacher relates Lewis-dot diagrams to number of bonds an element will form. Students are given handout showing Lewis-dot diagrams for elements 1-20 and compare it to the handout showing electron configuration
10. Students make connection that the Lewis-dot diagrams show electrons in the outer most electron level (or valence electrons) and teacher points out that these are the electrons involved with bonding.
11. Teacher shows students that atoms will make bonds to ensure that they have a full electron shell.
12. Students are asked to make models of some simple molecules that will have double and triple bonds (Examples include: C_2H_4 , C_2H_2 , etc.

Evaluation:

13. Student models and handouts are used for evaluation.

Lesson 5: Molecular compounds and their properties

Objective: Students will be able to compare and contrast the properties of individual elements and the properties of compounds that those elements form.

Learning Goal: Compounds are made of elements with their own individual properties that are different from the properties of the compounds they make up.

Vocabulary: Compounds, physical properties, chemical properties, density, melting point, boiling point (other properties as needed), reactivity

Engage: (Students introduced to final project: design of self-warming glove)

1. Students are given elements that will be used in the exo/endothemic reactions in later lesson (Teacher can have students look at pictures of elements, actual samples, or use Internet to research)
2. Students are asked “How are these elements different? How can we tell them apart?”
3. In pairs, students are asked to research and record the individual element’s properties (density, melting point, boiling point, solubility, color, magnetism, flammability, hardness/brittle, etc.) that make up the compounds. Each pair gets 2-4 elements, and told that they will share findings with other groups to have a complete list of the properties of the elements in the compounds.
4. Students fill out a table recording the properties of their elements.

Explore:

5. Students are given the chemical compounds that will be used and formed in the exo/endothemic reactions used in designing their self-warming/cooling device.
6. Students will then be assigned to research the properties of 2-3 compounds that they will use in their final project.
7. Students record the properties of the compounds, and compare them with the properties of the elements that make up the compounds.

Explain:

8. Students share their results with the class.
9. Students conclude about the relationship between individual elements’ properties and the properties of the compounds they make.
10. Teacher ensures that the connection is made: When elements combine to form compounds, the compounds have their own properties that are different from the individual atoms that make up the compounds.

Elaborate:

11. Students are given the actual chemicals to analyze and observe with magnifying glass (students can compare observational data with research), other tools to observe chemicals can be given if available (boiling point of liquids can be compared, density can be calculated, etc.)
12. Students continue recording observable properties on data sheet

Evaluate:

13. Student handout used as evaluation
14. Optional: Students asked to write a one sentence summary comparing the properties of individual elements and the compounds that they make.

Lesson 6: Physical vs. Chemical Changes

Objective: Students will be able to analyze a change to determine evidence present to classify changes as either physical or chemical.

Learning goal: Physical changes do not change the substance, only change appearance. Chemical changes result in the formation of a new substance with different properties (due to the rearranging of atoms).

Vocabulary: physical change, chemical change, reactant, product, chemical equation

Engage:

1. Students research (use textbook/internet) definitions of physical and chemical changes and an example of each. Teacher can give more examples if necessary.
2. Students are then given a handout with examples of both type of changes (written out and pictures) and asked to classify each as either a physical change or chemical change, and give a reason for their choice (i.e. what is the evidence a new substance is produced)
3. Student answers can be gone over, but will be revisited and revised later

Explain/Explore:

4. Teacher demonstrates the burning of a candle and explains the reaction using the terms: reactant, product, chemical reaction
5. Students are asked to identify the reactants and products in this reaction (handout)
6. Students are shown how atoms are rearranged in the combustion reaction of methane:
http://www.middleschoolchemistry.com/multimedia/chapter6/lesson1#chemical_reaction_methane
Students are asked, "Where do the atoms come from that make up the compounds in the products?" This is the introduction to the conservation of mass and the idea of atoms being rearranged during chemical changes.
7. Students are reminded that the formation of a new substance (the product) is the key evidence for chemical changes.
8. Students now go back to the chemical changes they looked at in the engage portion and asked to identify the new substance, and for evidence that can be observed that proves a new substance was formed.
9. Students are asked "How they know a new substance is formed?" "Where did the atoms come from that formed the new substance?"
10. In groups students create a list of possible evidence to look for that proves a new substance has formed.
11. Students share the list of criteria to look for to prove a new substance and thus a chemical change has occurred: gas produced, solid produced, temperature change, new color formed, new properties observed.

Elaborate:

12. Students are given a handout with the chemical equations that show the reactions they categorized above.
 - a. Ice melting, water boiling, apple turning brown, wood burning, water forming, photosynthesis, etc.
13. Students label the reactants, products formed during the chemical reaction along with the evidence that proves the chemical change

Evaluation:

14. Handouts used during lesson

Lesson 7: Chemical reactions: Investigating Temperature change as evidence

Objective: Students will be able to evaluate a change as either chemical or physical (based on criteria) and use evidence to prove if the change is exothermic or endothermic.

Learning Goal: Chemical changes must produce a new substance. Exothermic reactions release energy and endothermic reactions absorb energy.

Vocabulary: Chemical change, physical change, endothermic, exothermic, reactants, products

Engage:

1. Students are asked to build a simple model of water, H₂O, with any classroom supplies (idea is to make sure students have a something representing a chemical bond)
2. Students are asked to discuss in groups, “What holds the atoms in water together? Does it take energy to hold atoms together? Do you think energy is needed to form a chemical bond? What happens to energy when a chemical bond breaks?”
3. Teacher demonstrates an exothermic or endothermic reaction for class. Teacher presents students with the chemical equation, and drawings of the molecular compounds involved (to have students see the chemical bonds holding the atoms together). Teacher asks students, “What holds the atoms together in the molecular compounds? Just by looking at the chemical equation, what happens to bonds during the reaction?” Then, asks questions in above activity, “What do you think must be needed in order to break bonds or form bonds? So when bonds break, there must be a change in energy and when bonds form there must be a change in energy.”

Explore:

4. Students are reminded of culminating project: design of self-heating/cooling device for application of their choice i.e. glove, coaster, headband that cools or warms (Teacher can choose to go as in-depth as needed about project at this point, earlier, or later)
5. Teacher explains during chemical reactions chemical bonds are formed or break apart, and that there is a change in energy. Energy is either released or absorbed. (Final Project: Do students want a reaction that absorbs energy or released it.) Teacher discusses (and modeled earlier) how you can measure the energy released or absorbed (by touch, not very accurate, or with a thermometer).
6. Students are presented with various chemicals, supplies, etc. to design experiments in order to help them choose what chemicals to use in their self-warming/cooling device.
7. Teacher can divide chemicals as needed. This will depend of amount of chemicals available, number of students, time concerns, etc. (recommended amount is
8. Ideally, pairs of students will choose from the chemicals to design a test to see: Does a chemical reaction or physical change has occurred? What is the evidence? Is energy released or absorbed? How much energy is released or absorbed? Would this be a possible reaction you could use in you final project?

Exothermic/Endothermic Chemicals List:

Exothermic Reactions	Endothermic Reactions
Steel wool and vinegar (copper wool as another example)	Citric acid solutions and baking soda
Laundry detergent and water	Vinegar and baking soda
Calcium chloride and water	Ammonia chloride and water
Magnesium sulfate (Epsom salt) and water	

Other chemicals to investigate: alka-seltzer and water, etc

9. Students choose which chemicals they want to use and design an experiment to investigate if the chemicals they chose produce chemical changes (or just physical), and if there is an exothermic or endothermic reaction. Students limited to 3-5 grams of each chemical to carry out initial investigations.
- Teacher note: Depending on time, students can prepare a formal lab report or some shortened version to analyze and present their results of the experiment. Students should make a materials list and procedures for their experiment that is reviewed by teacher to ensure safety and reliability of results.
 - Groups share experimental procedures with other group (then checked by teacher) and revise as needed.
10. Students perform experiment and record observations/results on handout to report to class. Groups of students may pick the same chemicals for their experiment; however teacher should ensure that most chemicals are used to give students a variety of results to choose from when designing their self-warming/cooling device.
11. Students share results by one or more of the following (students record results of other groups on handout): 1) present results to whole class, 2) Gallery walk looking at results with group member explaining the results at each poster, 3) student pairs make appointments with other groups to share findings.
12. Students fill out handout (which includes table of reactants used, products formed, type of change, evidence of change, and temperature change) after sharing results of experiment

Explain:

13. Teacher goes over vocabulary to use when classifying the reactions (endothermic/exothermic) and some other common examples students may know about and asks them to classify as either exo/endo: burning wood or paper, etc.
14. Teacher has students label the reactions, done in pairs, as exo or endothermic on handout. Class discusses which reactions may be used in the self-warming/cooling device.
15. In groups, students brainstorm other factors that may influence choice of chemicals in design of device, for example: cost of chemicals, safety of chemicals, amount of chemicals needed, amount of temperature change, ideas to have chemicals mix in the device, etc.

Elaborate:

16. Students evaluate the results of the experiments, choose and justify the chemicals (two combinations of chemicals to use) that they will test to use in their self-warming/cooling device. (For example: One group of students may choose baking soda and vinegar, and magnesium sulfate and water to further investigate later.)
17. Students can research other chemicals (not available in class) that might make good choices or predict compounds (based on elements in the same group having similar characteristics) that could be used.
18. Students begin to brainstorm a device that could use the chemicals to self-warm or cool itself.

Evaluation:

19. Student choice and justification of chemicals serves as assessment.

Lesson 8: Conservation of Mass

Objective: Students will be able to choose the correct reactants and products that demonstrate the conservation of mass and justify their decision with evidence.

Learning Goal: The Law of Conservation of Mass states that atoms are not created or destroyed in a chemical reaction (mass of reactants must equal the mass of products).

Vocabulary: The Law of Conservation of Mass, mass, subscript, coefficient, chemical equation

Engage:

1. Teacher asks students about energy in a chemical reaction (teacher has students discuss the following questions in groups). What happens to energy in a chemical reaction? (energy is released or absorbed) What causes the release or absorption of energy? (chemical bonds are forming or breaking to form new substances) What has to be produced in order for you to know a chemical reaction occurred? What do you think happens to mass in a chemical reaction? Does the mass of reactants differ from the mass of products? Does the mass change (increase, decrease, stay equal)? If yes, where does it go? If no, how do you get a new substance?
2. Connection to final project: When you choose your chemicals for your self-warming/cooling device will the mass increase or decrease after the reaction?
3. In groups, students are then asked to make a hypothesis to answer the question: What happens to mass in a chemical reaction? Hypothesis takes the form of: If I mix baking soda and vinegar to produce a chemical reaction, then the mass of my reactants will be _____ than the mass of my products. Students are reminded of examples of chemical reactions: wood burning, cake baking, food digesting, iron rusting, etc. to use as a guide for their hypothesis.
4. The class will then use baking soda and vinegar (or another simple reaction) to design an experiment to test their hypothesis. (This can be done as a demonstration if time or supplies are an issue. Students should still be asked to prepare a procedure and the teacher can use 3-4 groups' procedures as a demo to show differences and compare for accuracy.)

Explore:

5. Teacher reviews procedure for experiments with students (teacher guides students with amounts to mix), and ensures students have a procedure that includes finding mass of reactants and mass of products.
6. Students (or whole class if done as demo) are given materials to carry out their experiment (Teacher may or may not guide students to capture the gas produced depending on procedures students come up with. It may be beneficial for some students to not capture the gas to lead to a class discussion of measurement error.)
7. Students record their results in data table, obtain two or three other groups results, and analyze results for trends and patterns in mass of reactants and products
8. Students use results to make a conclusion about the mass in chemical reactions.

Explain:

9. Teacher shows the balanced chemical equation for the reaction of baking soda and vinegar.
10. Teacher labels (or asks students to label) reactants and products, teacher then introduces students to the subscript and coefficients in the chemical equation and their definitions.
11. Teacher has students count the atoms on each side of the equation and relates this to being "balanced".
12. After the students count the atoms, teacher asks, "Based on the same number of atoms being present in reactants and products, what do you think should always happen to mass in a chemical reaction?"
13. Teacher again points out that chemical bonds are being broken and formed but the atoms are not lost or gained, they are just rearranged.

14. Teacher now performs baking soda and vinegar experiment to show students how mass is conserved and reminds students that the Law of Conservation of Mass is a scientific law (has not been proven otherwise to date).

Elaborate:

15. Students review their results and discuss reasons why some of their data does not show the conservation of mass.
16. Class shares reasons why the mass of product may not be equal in an experiment. Example: wood burning: gas (smoke) escapes into the air); measurement errors, etc.
17. Students given reactants and products of chemical equations (used in exo/endo experiments) on index cards and asked to match reactant and product to ensure conservation of mass is shown.
18. Students are then given unbalanced chemical reactions of varying difficulty depending on class.
19. Teacher goes over the steps to balancing chemical equations as a whole class
20. Students balance the chemical equations, and include a count of atoms as justification of the conservation of mass

Evaluation:

21. Student handout on balancing chemical equations serves as assessment.
22. Students asked to put the Law of Conservation of Mass in their own words.

Continued practice assignment: Students are given 10 cards each with a reactant and a product written on them and asked to count the atoms and match the correct reactant with the resulting product. Students must also show count of atoms as evidence of atoms being equal.

Website with steps to balance equations and handouts with equations to balance:

www.chemistry.about.com/cs/stoichiometry/a/aa042903a.htm

www.chemicalformula.org

Lesson 9: Modeling atoms in molecular compounds (subscripts and coefficients)

Objective: Students will be able to design models that represent reactants and products from chemical reactions.

Learning Goal: Students visually represent the difference between a subscript and coefficient in a chemical formula to justify the conservation of mass.

Vocabulary: molecular compound, coefficient, subscript, chemical formula, reactant, product, atom, conservation of mass

Engage/Explore:

1. In groups, students are given materials for making models of molecular compounds.
2. Students receive the index cards (from previous lesson) which have chemical formulas (of reactants and products) from the exo/endermic reactions previously performed and asked to make a model of the molecular compounds from the supplies given.
3. Students label each model with chemical formula.
4. Teacher circulates room guiding students as needed.
5. Students complete a gallery walk evaluating the models built by other groups (students can complete handout listing ideas learned or leave post-it notes with comments on other groups' models).
- Teacher note: Students can research the actual bonding and structure of the compounds (for accuracy).

Explain:

6. Teacher discusses with class the meaning of subscript with students using models to justify their answers.
7. Teacher ensures students understand no subscript is understood to be 1, and each new element is shown by a capital letter
8. (depending on materials) Teacher has students (take apart or leave models) attempt to build models when coefficients are used.
9. Teacher has students analyze other groups' models and evaluate, and redesign theirs.
10. Teacher goes over models and how coefficients affect the model (showing students how the amount of the compound changes, not the actual compound itself)

Elaborate:

11. Students are given chemical formulas to model that represent reactants and products from exo/endermic reactions.
12. Students use materials to model and show the addition of molecular compounds and the result of changing coefficients.
- Teacher note: Student extension could be done on the actual bonding and structure of the compound.

Evaluate:

13. Teacher circulates room to assess models students have made
14. Teacher asks students to draw models representing molecular compounds with multiple coefficients.

Lesson 10: Modeling a Balanced chemical reaction

Objective: Students will be able to develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.

Learning Goal: Coefficients are changed when balancing a chemical equation to ensure that atoms are equal on both sides of the equation (reactants and products). A balanced chemical equation shows an equal number of atoms for each element in the reactants and products.

Vocabulary: reactant, product, Law of Conservation of Mass, atom, chemical formula

Engage/Explore:

1. Students are given (or research) the chemical equations for the reactions that they have chosen to use in their design of a self-warming/cooling device.
2. Students are given assignment of making a model with justification of the balanced chemical equation of the chemical reaction they will possibly use for their final project.

Explain:

3. Teacher goes over criteria and rubric of assignment and gives materials for students to use.
4. Students prepare a written justification/explanation of their balanced equation.

Elaborate:

5. Students present their model to class and provide justification and explanation of their representation of a balanced chemical equation.

Evaluation:

6. Rubric is used to assess students' project and presentations.

Lesson 11: Experiment with choice of chemicals to use in final project design (Focus is on amount of chemical to use)

Objective: Students will be able design an experiment to test the amount of heat released by a chemical reaction, then choose chemicals (and amounts to use) for their final project and provide justification for their choice.

Learning Goal: Chemical reactions can be classified as exothermic or endothermic depending on if energy is released or absorbed.

Vocabulary: Exothermic, endothermic, reactant, product, compound, energy

Engage:

1. In groups, students are given the chemicals they chose to test for their final project design of self-warming/cooling device from lesson 7.
2. Students are asked to create a list of materials (and amounts) needed for the experiments and create a procedure that will serve as the directions for their experiment (students will be performing these experiments to justify their choice of chemicals for final project). Students will be given 25 grams and 50 mL of chemicals to experiment with. Students are asked to measure at least 2 different amounts of chemical to use with the same amount of liquid, and then to change amount of liquid at least once)
3. Students will then create a hypothesis to predict the result of the experiment.

Explore:

4. Students practice reading their procedure to other group members, and with materials (except for chemicals at this point) to see if members of group can follow the procedures and no steps are missing. -
-- Other option: Groups can give procedures to other groups to follow to ensure all steps are included and all safety procedures followed.

Explain:

5. Teacher demonstrates following a procedure to produce a chemical reaction (baking soda and vinegar or other reaction), highlighting important/necessary steps that must be included in all students' procedures and materials (i.e. safety precautions, temperature measured, amount of chemicals to use, etc.)
6. Optional: Teacher then asks a student group to read their procedure and to see if the procedures are complete.
7. Teacher ensures procedures include step to measure how long the reaction produces heat.

Elaborate:

8. Students revise procedures as necessary to ensure reliable results, no steps are missing, and safety precautions are followed.
9. Students create a data table that will be used to record their results (includes temp. change, amount of chemical used, and time of heat production).
10. Students identify other groups with the same chemicals used and different chemicals used to discuss results after experiments are completed.

Evaluation:

11. Students' procedures and experimental design will be assessed when experiments are performed.

Lesson 12: Experiment with choice of chemicals to use in final project design (continued)

Objective: Students will be able design an experiment to test the amount of heat released by a chemical reaction, then choose chemicals (and amounts to use) for their final project and provide justification for their choice.

Learning Goal: Chemical reactions can be classified as exothermic or endothermic depending on if energy is released or absorbed. Also, the type and amount of chemicals used effect on temperature change.

Vocabulary: Exothermic, endothermic, reactant, product, compound, energy

Engage:

1. Students are given materials to perform experiment from the list they've created.
2. Students review materials list and procedure to make sure no revisions are needed.

Explore:

3. Students perform experiments they have designed by following their procedures and recording the results in their data tables (Students have also made hypotheses previously to guide their thinking).
4. Students share results of their experiments with other groups so all students have the results of the experiments performed to inform their choice of chemicals for use in the final project.

Explain:

5. Teacher goes over student results with whole class, identifies and discusses measurement errors, differences in data, and/or experimental errors that may influence data.

Elaborate:

6. Teacher reminds students how the results of experiments are used to inform choices for final project design.
7. Teacher goes over other criteria students must consider besides just being an "exothermic reaction". Teacher asks students to brainstorm in groups what other factors must be considered when making a self-warming/cooling piece of device. Examples: safety of mixing the chemicals, how will the chemicals mix in your piece of clothing, amount of chemicals needed, how long do the chemicals stay hot, etc.
8. Students analyze results of the class's experiments, and taking into account the other factors involved make their final conclusion (choice) as to which chemicals they will choose for the design of their final project (self-warming clothing). Students should provide a justification for their choice

Evaluation:

9. Students complete a handout (form) that goes over plan for self-warming/cooling device providing justification for choice based on evidence gathered and class discussion.

Lesson 13: Design of self-warming/cooling device with use of exo/endothemic reactions

Objective: Students will be able to evaluate the results of their (and classes) chemical reactions and class discussions to design and then construct a self-warming/cooling device for use.

Learning Goal: Students undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.

Vocabulary: use and review all previously learned vocabulary from the unit.

Engage:

1. If available, teacher shows students a clip from EdTube or movie clip showing hypothermia and goes over areas most commonly affected. Students can also read article, etc. to gather some quick information about hypothermia, heat stroke, etc (other examples of cooling and warming devices) to inform their choice of a device.
2. If not done previously, students are given specific assignment criteria for final project design: self-warming clothing.
3. In groups, students decide on type of device they will design.

Explore:

4. If available, teacher gives students materials (from T4T) that they can choose from to make their device (ex. glove, coaster, headband, hat, etc.). If no materials, options for materials to be used can be researched, examples shown, or given to class.
5. EXTRA: Students can research properties of materials (given in class) to help decide on which would be best to use (i.e. melting point of material, cost, flammability, weight, etc.)
6. Students decide on material (or combination of materials) they will use in their design of their device.

Explain:

7. Teacher discusses with class the parameters and criteria for device (how will it be assessed/presented)
8. Teacher goes over assignment rubric with class.

Elaborate:

9. Students begin to design their device with a diagram first with labels and explanation of device.
10. Students make a poster diagram of their piece of clothing with appropriate labels, that address the following:
 - What type of device will they make? Why? What will it be used for?
 - How will the chemicals be kept separate? Stored?
 - How will the chemicals mix when device is being used?
 - What materials (fabric) will the device be made of? Will it be a combination of materials? Why?
11. Students complete a gallery walk analyzing and commenting on classmates' designs.
12. Students revise design diagram based on peer and teacher comments.
13. If materials available, students construct their piece of self-warming piece clothing

Evaluation:

14. Students' final design of self-warming clothing will be evaluated based on assignment rubric.