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| **TEAM Lesson Plan Template** |
| Teacher: Holland Brewer |
| Subject/Grade: High School Chemistry 1 |
| Lesson Title: Ideal Gas Law |
| **STANDARDS** | **Identify what you intend to teach.** State, Common Core, ACT College Readiness Standards and/or State Competencies; Enduring Understandings and Essential Questions. |
| CHEM1.PS1 6) Use the ideal gas law, PV = nRT, to algebraically evaluate the relationship among the number of moles, volume, pressure, and temperature for ideal gases. This lesson emphasizes:Engineering practice: Defining problemsCCC: Systems and system modelsLearning performance: Students will define problems as they use the ideal gas law to design an airbag model highlighting systems and system models |
| **OBJECTIVE(s)/Sub-Objectives** | **Connect prior learning to new learning.** Clear, Specific, Observable, Demanding, High Quality, Measurable, Aligned to Standard(s), and Integrated with other subjects, build on prior student knowledgeStudent-Friendly (I Can Statement) |
| I can balance a chemical reaction equation. I can safely handle hydrochloric acid. I can use the ideal gas law to calculate the amount of hydrochloric acid and the amount of baking soda to use to inflate a bag without popping it. I can measure the volume of a liquid using a graduated cylinder. I can measure the mass of a solid using an electronic balance.  |
| **MATERIALS AND RESOURCES**  | **Content-related:** Clearly supports lesson objective(s); rigorous & relevant; Incorporates multimedia & resources beyond the textbook.  |
| **Activities & Materials** **Per student**: 1 pair goggles, 1 pencil, 1 student worksheet, pages 1-4 (available on internet) (<https://docs.google.com/document/d/1dG3FtdHGA8rBcx_OqJWlOiGHMeRm7acT-E8yb7zxeyE/edit>)**Per group/pair**: 1 100 ml graduated cylinder, 1 weight boat, 1 quart size re-sealable bag, 1 gallon size re-sealable bag, 1 spatula, 1 table at which to work, unit conversion tables, calculator **Per class**: 1 electronic balance. Reactants: 1 liter 1 molar HCl; 1 lb baking soda. Eye wash station. Paper towels. White board and Projector/computer/screen/internet access. Teacher needs to know the temperature (presumably from looking at thermostat) and atmospheric pressure (from TV or <https://weather.com/weather>). **What if the technology is not working?** Delay the activity if the eye wash station is not operational. If the projector is not working, skip the video. **Routine for distributing materials:** Place each groups’ materials at the group table before class. Students will come to a central location to get HCl and a separate, nearby location with a balance to get baking soda. Students will carry HCl in their graduated cylinder and will carry their baking soda in a weight boat.  |
| **ACCOMMODATIONS/ADAPTATIONS** | **Learning styles and interests.** Anticipate learning difficulties, regularly incorporate student interests & cultural heritage; differentiate instructional methods. |
| **Modifications/Plans for Diverse Learners *(NOTE: Clearly identify where you will use each of these in your lesson; do not just check the box!)*****Differentiation****\_\_x\_\_ Flexible Grouping** The measurement task, the calculation task, and the communication task are each different and may be performed by different group members. **\_\_x\_\_ Other** Some groups may receive Page 4 (guided practice) of the worksheet as an example to follow. Students who are more comfortable with the task will receive only pages 1-3. **Accommodations****\_\_\_ Preferential Seating \_\_\_ Extended Time \_\_\_ Small Group \_\_\_ Peer Tutoring** **\_\_\_ Modified Assignments \_\_\_ Other** **Early Finishers:** Calculate the quantity of reactants necessary for a 1-gallon air bag. Calculate the quantity of reactants necessary for a 1-quart bag for the current atmospheric pressure but a temperature of 50 degrees C.  |

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| **MOTIVATING STUDENTS/ANTICIPATORY SET** | **“Hook”: Engage students’ attention and focus on learning.** Personally meaningful and relevant. |
| Present the following videos to students: <https://www.youtube.com/watch?v=KuRhYmMb-lg>After showing the video, write the following equation of the board: 2NaN3 2Na + 3N2. (Sodium Azide becomes Sodium and Nitrogen gas) Ask students to share some factors that engineers must consider when designing a safe and effective airbag in an automobile. Have students share things they believe airbags need to do to be effective and also limitations of airbags. Try to get students to identify temperature and pressure as important.Volunteer: Post the “I can” statements. **Ensure that students are wearing eye protection.** **Post the lab/classroom’s current temperature (degrees Celsius) and pressure (mmHg) so that these are visible to students.**  |
| **INSTRUCTIONAL PROCEDURES** | **Step-by-Step Procedures-Lesson Sequence: Basic to Complex.** Lesson includes visuals, modeling, logical sequencing and segmenting (beginning, middle, ending); essential information; concise communication; grouping strategies; differentiated instructional strategies to provide intervention & extension; seamless routines; varied instructional strategies; key concepts & ideas highlighted regularly. |
| ***Introductio*n** Previously we have learned to balance equations. We have learned how to convert mass to moles and vice versa. We have learned how to calculate the number of moles of a substance in a solution. You have learned how to use measuring equipment such as graduated cylinders and balances. We have seen the ideal gas law as an equation. Today we will use these ideas and these measuring devices to design and inflate an airbag. There should be a pair or triple at each table. Each group needs a facilitator, communicator, and reporter. The facilitator is responsible for collecting materials and keeping the group on task. The communicator is the only person within the group to ask the teacher questions. Group communication must happen first before the teacher is asked questions. The reporter is responsible for recording data to share with the group and submits any final paperwork required by the teacher. **Middle** Each of you has a worksheet. Follow the instructions to design an airbag. Student \_\_\_\_\_\_\_\_\_\_ Please read the instructions at the top of page 3. What do you have to do before getting chemicals or testing your airbag? Answer: wear goggles and check with the teacher. Students should begin work. The teacher will monitor their progress. Students should discuss the following: the pressure in the room, the temperature, volume of plastic bag, mass of baking soda, and the volume of hydrochloric acid. Students will have to do several conversions to accurately use the ideal gas law. After discussion, students will then be able to state step-by-step procedures by using the guided design questions for the creation of their model airbag. Students will need to show any necessary calculations. If students do not understand molarity, additional instruction may be needed to determine mole value. On page 3, when students check in with the teacher, the teacher should set parameters for the amount of baking soda and hydrochloric acid to use. Students cannot use more than (1 pound)/(number of groups) or (1 liter)/ (number of groups) to allow each group access to chemicals. With 15 groups, these are approximately 30 grams and 60 milliliters. This is actually far too much baking soda and too much acid, but students should not exceed these quantities simply out of fairness, not to mention engineering. The teacher also needs to caution students to use the gallon size bag as a container for their experiment. Place the small bag inside the large bag before inflation to prevent disaster in the classroom. **End/Closure**: Plan for time for an effective lesson closure AND cleanup. After the teacher has approved the design model, students are allowed to test their airbags. Students should determine if their airbag was successful or not and why or why not? If not, what improvements could be made to the procedure to make it successful next time? Bring the classroom back together and have a discussion as a whole on how the experiment went. Discussions will vary according to how the experiment was conducted. Most students forget that the bags need to be closed before preforming the experiment; therefore, all the pressure is released. **Motivating Students** \_x\_ Relate to Real World This airbag activity is linked to car airbags with which most students are familiar. The opening video helps remind them of the automotive application of airbags. \_x\_ Verbal Reinforcement The activity involves explicit directions to check in with the teacher at certain points in the design process. This is an opportunity to provide students with verbal reinforcement. **Presenting Instructional Content** \_x\_ Lecture/notes Display Lesson objectives and quantities such as Temperature and pressure.\_x\_ Video at the beginning of the activity relates the quart size zipper bag to automotive airbags \_x\_ Hands on \_x\_ Guided Practice This is a hands-on activity with step by step instructions to guide students through the design process. The instructions provide the steps, but not the answers. ***Instructional strategies:******Input -* Hook (Set)** The video about failed automotive airbags relates this activity to the real world. **Modeling and Guided Practice *–*** The worksheet lays out steps for students. The teacher will monitor their work and ask questions to prompt them if they are stuck. Throughout the exercise, ensure that each student is recording the calculations. Ask students to explain why certain units are appropriate for certain quantities (liters for liquid, grams for solids, degrees for temperature).  **Check for Understanding (CFU) –** ***What am I doing for students that progress at different rates?*** Encourage students to help each other within their groups. If one group is significantly ahead of another, ask one group to help the other. If necessary, provide help with the algebra (the algebra is necessary, but is not a central theme of this activity). ***What do I do if they get it?*** If students handle the activity smoothly, ask them to discuss other issues of airbag design (fabric for the bag has to fold and last for years; trigger has to be sensitive, but not too sensitive) or other applications (air conditioners; breathing ) of the gas law. ***What do I do if they don’t get it?*** If necessary, regain the whole group’s attention and work through individual calculations on the white board. Do one step, then have students attempt subsequent steps in their groups.  |
| **QUESTIONING/THINKING/PROBLEM SOLVING (embedded throughout)** | **Balanced mix of question types.** Utilizes Blooms Taxonomy/Webb’s Depth of Knowledge; high frequency; purposeful & coherent; require active responses; balance based on volunteers/non-volunteers, ability, & gender; lead to further inquiry & self-directed learning.  **Implement four types of thinking (Analytical, Practical, Creative, & Research-based) & Teach/Reinforce problem-solving types**. Provide opportunities for students to generate ideas & alternatives; analyze, evaluate & explain information from multiple perspectives& viewpoints. |
| **Questioning** These questions will occur throughout the activity as prompts based on groups’ or individual students’ progress. **Knowledge:**What does HCl stand for? Is it liquid or solid? What does NaHCO3 stand for? Which elements are part of this molecule? What are the units of temperature in the ideal gas law formula? After you test the airbag, can you see the salt? **Comprehension:** In the reaction equation before we fill in the blanks, how many atoms of hydrogen appear in the reactants to the left of the arrow? How many atoms of hydrogen appear in the products on the left? **Application:**What does the number of hydrogen atoms on the left and right hand sides of the reaction equation (before we fill in the blanks) suggest about the numbers to put in the blanks? How do we convert 1 quart to Liters? How do we convert degrees Fahrenheit to degrees Kelvin? **Analysis:** All of the questions on page 4 of the Student Activity for Chemistry Page 4.Does it matter which units we use for pressure in our calculations? How does our choice of unit for pressure affect the gas constant? Is polypropylene (our Ziploc bag material) a good material for actual automotive airbags? After you test the airbag, can you see the salt? Why or why not? **Synthesis:**Does the reaction of NaHCO3 and HCl release heat to warm the CO2 gas above the initial temperature in the bag (room)The Post-Lab Question on the worksheet. What are some other considerations for airbag design besides the volume of the airbag? ( long term storage and folding cannot weaken the bag; toxicity of inflation gasses; flammability of inflation gasses; . . . ) **Evaluation:** **Thinking**  \_x\_ **Practical** –This activity does not involve an automotive air bag, but it does involve an actual air bag, and students actually have to inflate it. \_x\_ **Creative**– The activity begins with students defining the problem of creating an airbag and designing a solution. \_x\_ **Analytical** – Students **compare** quantities in different units and convert moles to mass. Students **evaluate** the success or failure of their design and **explain** what went well or went wrong.  \_x\_ **Research-based** – Students design a solution, test it, and then evaluate the result. Then they update the design and test again. **\*What am I going to do to give Students an opportunity to?** **1. Generate variety of ideas:** Students begin the activity by creating questions they need to answer to design their airbags. They also have to write a procedure for preparing and testing the airbag. Each groups’ questions and procedure can vary. **2. Analyze problems from multiple viewpoints:** Students must consider the input of each member of their groups. The opening video challenges students to think of the economic and human costs of engineering mistakes. **Problem Solving *Note: Teach 2 or more types of problem solving (NOTE: Clearly identify where you will use each of these in your lesson; do not just check the box!)***\_x\_\_ **Abstraction** The reaction equation is an abstract model of the actual chemical reaction **\_x\_\_ Categorization** Students have to recognize the reactants and products as solid, liquid, or gas**\_x\_\_ Predicting Outcomes** Students calculate reactant quantities to inflate, but not pop, the bag. **\_x\_\_ Improving Solutions** Students get a second attempt to improve their design  |

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| **GROUPING** | **Maximize student understanding & learning** Varied group composition (race, gender, ability, & age); clearly understood roles, responsibilities & group work expectations; accountability for group & individual work; student opportunities for goal setting, reflection & evaluation of learning. |
| * Heterogeneous groups of two or three
* Roles. Facilitator: collect materials and keep group on task; Communicator: may ask teacher questions if no group member can answer the question. Describes group’s design to teacher for approval; Reporter: records data for group and submits paperwork required by teacher.
* Group members assign roles and acknowledge their understanding of their role during the lesson introduction.
* Transition to groups. Students will begin class at lab tables already separated into groups. The teacher will signal for the whole group’s attention or return students to group work.
* Product. The group will produce a completed worksheet to include “Five things to know,” “Written procedure to prepare and test airbag,” “Evaluation of outcome of airbag design,” and the calculations associated with the guided design page.
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| **ASSESSMENT** | **Formative and/or summative assessment.** A variety of assessments, including rubrics, measure achievement of objectives and informs instruction.  |
| ***Assessments: aligned with state stds; measurement criteria; measure student performance in more than 2 ways (project, experiment, presentation, essay, short answer, multiple choice test) (NOTE: Clearly identify where you will use each of these in your lesson; do not just check the box!)*****\_\_x\_ Teacher Made Test** A future test can include a question such as “Given the reaction equation \_\_\_ , how much HCl and NaCO3 are needed to fully inflate a 250ml bag at 28 degrees C and an atmospheric pressure of 930mmHg?”**\_\_x\_ Exit Ticket** described below *\****Students should achieve \_\_\_\_\_% mastery of this objective: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** |
| **CLOSURE** | **Reflection/Wrap Up.** Summarizing, reminding, reflecting, restarting, connecting. |
| * ***Review/Summary: wrap up what has been learned and accomplished in the lesson (even if they are in the middle of an exercise, it is still important to summarize to the point where they are now). Ideally involve students in this synthesis.***
* ***Preview for next lesson: link what they did to day with where they are going next.***
* ***Upcoming assignments: remind them of any upcoming assignments.***

***Today we…. Turn to your partner and…. Let’s review our I Can statements……*** **Here is your exit ticket for today**: Imagine that your airbag design has been accepted by an international automobile manufacturer. Unfortunately, after a few years, it is determined that the airbags are malfunctioning. There have been reports of the airbags exploding upon deployment. Malfunctions tend to occur in the summer, especially in very hot regions of the world where the temperatures in the car may reach 50° Celsius. Using your understanding of kinetic molecular theory, and the variables involved in the ideal gas law, identify the problem with your airbag design and propose a possible solution. You may provide a particle diagram to illustrate your answer**Follow-up Activities/Extension *These may be designed to create a longer or more intense lesson. For example, if the class is able to cover the material in a lesson much faster than expected, extensions may prove helpful. Extensions may also be useful in various parts of a lesson where the teacher (and class) decides they should spend more time on a skill or topic.******Reflection: You must reflect on every lesson you teach.*** |

**NOTES:**

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