What Is STEM?

STEM education is a trans-disciplinary curriculum connecting **S**cience, **T**echnology, **E**ngineering, and **M**athematics, the combination of which promotes students' understanding of each of these fields and develops their abilities to become self-reliant researchers, innovators, and inventors. When faced with an idea or a problem, students learn how to develop solutions, how to analyze and evaluate different solutions, and how to collaborate with others to construct and test a product.

What this looks like in the classroom, however, is not always clear. In some cases, "S" is presented but not "M"—the math that explains the science. In other cases, STEM curriculum and materials focus on the "S" and the "M," leaving out the "T" and "E"—the technology element that generates solutions and gives rise to a deeper understanding of the science and math components, and the engineering element that centers on solving problems. The four parts of STEM have historically been taught separately and most of the time independently from each other; with STEM, science, technology, engineering, and math all play an important part in teaching these subjects as a whole.

PASCO's Project-Based Learning Modules

Module Principles

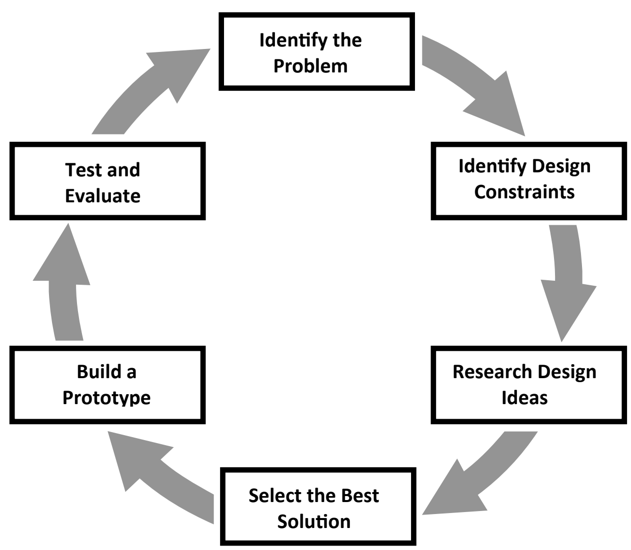
PASCO's Project-Based Learning Modules focus on all four components of S-T-E-M and are guided by various elements, including national standards; activity-, inquiry- and problem-based learning; the expectation of a tangible product or process as an outcome; and formative and summative assessments. They incorporate both independent and collaborative work, and rely on the engineering design process to bring all the pieces together.

A PASCO Project-Based Learning Module is centered on an open-ended Challenge in which students are given the task of designing, constructing, and implementing the solution to an engineering problem. The Challenge is based on fundamental science concepts in one or more genres of science: physics, chemistry, biology, and environmental science, and simulates a real-world problem that a modern engineer may encounter, with similar design constraints. Inside each Challenge are activities that focus on some or all of the key science and mathematics concepts of the Challenge and are part of the students' engineering design research.

These activities provide an opportunity for students to explore and research scientific concepts using PASCO's 21st Century Probeware and data collection systems. Students can then support their engineering designs with quantitative results from the activities. Through the activities, they obtain the science understanding, math skills, and familiarity with the techniques and tools of the field—background necessary to design and build the model or prototype.

Prototype development for a Challenge follows an engineering design process: students independently create initial solutions, they revise these solutions based on the results of the structured group activities, they analyze and evaluate the approaches of the students in their group, they finalize a group design, and they build a model or prototype for testing. Using the results of the test, they review their design and propose improvements.

Although the PASCO Engineering Design Process is shown (on the back of the title page) as a linear process that ends at the Design Review stage, engineering design is an iterative process, as shown in the circular diagram to the right. If time permits, students can use their analysis of the test results to begin again, creating an improved initial design, doing additional research, and building, testing, and analyzing the revised prototype.



Module Organization

A Project-Based Learning Module contains the student handouts and related information to assist the teacher in presenting, guiding, and assessing the students' work. Material is organized in a chronological manner, with the teacher information immediately following the handouts. For example, the pre-assessment handout is followed by the pre-assessment answer key and includes information that suggests ways to use the results and how to overcome misconceptions.

Each section of the student Challenge—Initial Design Ideas, Research, Revise Design, Develop Group Design, Build a Prototype, Test and Evaluate, and Design Review—conveys both the students' and the teacher's role for that stage of the engineering design process. The science and math activities (both student handouts and teacher notes) are included in the Research section. The Concluding the Module section provides wrap-up questions to use for discussion and lists possible misconceptions in order to look for changed understanding. The module concludes with a post-assessment handout for the students and answer key for the teacher.

The Challenge and Activity handouts are designed to be copied and used for multiple classes. Students should record all work in their notebook. If desired, you can change the handouts to be used to record the data by modifying the Microsoft® Word documents provided.

Paper versus SPARKlab™ Activities

In addition to the conventional paper format found in the Research section of this module, each activity in the Airbag STEM Module is available on the accompanying storage device in an electronic SPARKlab format (".spk"). The content found in both the paper format and the SPARKlab format is nearly identical, with some small changes to the step sequence and wording. This provides you, the teacher, an opportunity to choose the format that will be best received by your students.

The SPARKlab activities are presented as fully configured, stand-alone activities used with either a SPARK Science Learning System™ or a computer running SPARKvue™ software. All instructions, procedural steps, data displays, and questions are pre-configured and included in the electronic file. There are two sets of electronic SPARKlabs provided on the accompanying storage device. The two sets of labs have identical content but different resolution.

SPARKlab folder	Airbag SPARK Science Learning System	Airbag SPARKvue
Sample file name	HS STEM Understanding Pressure.spk	HS STEM Understanding Pressure Sv.spk
Images	The images are optimized for the size of the SPARK screen.	The images have a higher resolution to take advantage of the size of a computer screen.
Copying files	Refer to your SPARK Science Learning System User's Guide, in the "Saving and Sharing" section under "Managing Files and Folders".	The files can be saved anywhere in your normal filing system. The labs are "read-only" to protect students writing over them.

For information on the different methods for submitting student work when using the SPARK Science Learning System or SPARKvue software, refer to the "Saving and Sharing" section of the appropriate User's Guide.

Projecting SPARKlab™ Activities Using the SPARKvue Emulator

The SPARKvue emulator can be used to demonstrate the SPARK Science Learning System interface. To model opening a SPARKlab, first save the SPARKlabs in the locations described below.

Windows XP :	C:\Documents and Settings\All Users\Documents\My SPARK Data\Experiments
Windows Vista/7:	C:\Users\Public\Documents\SPARK Data\Experiments
Mac OS X:	HD>Users>Shared>SPARK>Experiments

The Data Collection System

All activities are carried out on a PASCO data collection system. "Data collection system" refers to the data collection, display, and analysis device used to carry out the various PASCO Module activities. These include PASCO's DataStudio®, the Xplorer GLX®, SPARKvue™, and SPARK Science Learning System™.

Detailed explanations for using the data collection system to carry out these procedures are found in the Tech Tip file corresponding to your data collection system. You can find these files on the storage device that accompanies this printed module, on the stand-alone storage device, and available for download with the module content.

Data Collection System	Tech Tip File
SPARK Science Learning System™	SPARK Tech Tips.pdf
SPARKvue™	SPARKvue Tech Tips.pdf
Xplorer GLX®	Xplorer GLX Tech Tips.pdf
DataStudio®	DataStudio Tech Tips.pdf

Using Project-Based Learning Modules with PASCO's 21st Century Science Guides

Science is a process of inquiry; an ongoing search to explain what goes on around us. PASCO’s 21st Century Science Guides focus on students learning science through inquiry-based activities—presenting concepts in a way that develops critical thinking, procedural expertise, proficiency in design and construction, and analytical skills.

Using the Project-Based Learning Modules in conjunction with the 21st Century Science Guides further increases student skills and understanding. Students working on the Project-Based Learning Module Challenge are exercising the highest levels of critical and creative thinking: synthesis and evaluation—students design their prototypes by integrating the skills and knowledge gained in the activities, by comparing and discriminating between their own designs and those of others, and by appraising the strengths and weaknesses of their creation.

Teachers can use the Project-Based Learning Modules together with the 21st Century Science Guides in several ways. They can

- use only the Project-Based Learning Module to teach the unit
- extend a science unit with the activities in the Project-Based Learning Module after students complete related activities from the 21st Century Science Guide
- include additional activities from the 21st Century Science Guide to enhance the module
- use the Project-Based Learning Module as a capstone to review and integrate the topics already covered from the 21st Century Science Guide

In all of these approaches, challenging students with a Project-Based Learning Module enables them to apply their inquiry skills as they combine the science concepts and math skills to engineer something entirely new.

Content and Skills

The Airbag Project-Based Learning Module provides students an opportunity to learn about gas laws, chemical reactions, balancing chemical equations, stoichiometry, and reaction rate. After learning these individual concepts, the students apply and synthesize them as they design, build, and test a model airbag using a plastic bag and an acid-base reaction involving acetic acid and sodium bicarbonate. In this module, students develop the following skills and explore the following concepts:

Concepts	Skills
Pressure	Determine if variables are directly or inversely proportional
Kinetic molecular theory	Use a pressure sensor and a temperature sensor
Ideal Gas Law	Determine the maximum pressure from a graph of pressure versus time
Chemical reactions	Determine the reaction rate from a pressure versus time graph
Limiting reactants and excess reactants	Solve algebraic equations for given variables
Stoichiometry	Experimentally determine mole-to-mole ratios
Controlling the rate of chemical reactions	Perform stoichiometric calculations

The Airbag module includes a short pre-assessment to determine the students familiarity with the concepts and skills required to successfully complete this module. The pre-assessment starts with questions students should already be able to answer relating to balancing chemical equations, moles, and molarity. If the students answer these questions incorrectly, you may need to weave additional instruction throughout the module to make sure the students can successfully complete the activities.

The rest of the pre-assessment asks the students about content they will be learning during the activities. It is expected that most students will not do well on these questions. However, students who do well may benefit from additional challenges during the module or they can be paired with weaker students in order to help them.

The Airbag module also includes a post-assessment to help assess how much material students learned as a result of the module.

Prerequisites

The prerequisites listed below consist of terms and concepts used in the module, but never directly explained.

- Concentration
- Moles
- Molarity
- Law of Conservation of Matter
- Balanced chemical equations
- Ratios
- Line of best fit

Pacing Guide

Each lab-based activity is designed to fit one 45-minute block of time (one "Day"), unless otherwise noted. The table below indicates a recommended pacing for all lessons and activities within the module, in chronological order. Lessons and activities with the same number in the Day column can be carried out on the same day. Lessons or activities requiring an entire 45-minute block of time are the only ones listed on that day.

The module is designed to be completed in 14 "Days." The pacing guide lists what the students will be doing on each day. Days 1–12 are designed to be done consecutively. After day 12, the students may benefit from having additional time to plan and construct their airbags outside of class. Then the remaining two days, Day 13 and 14, can be done consecutively.

This module could be accelerated to be completed in fewer days, but the recommended pacing laid out below gives students time to think about and digest the concepts they learn before applying them. If time is a problem, the Stoichiometric Calculations activity can be done as homework, but some time in class should be used to review it before starting the Reaction Rate lab.

This module is designed to be completed in 14 "Days"

14-Day Sequence	Lessons/Activities	Instr. Led	Indiv. Work	Group Work	Lab Work
1	Pre-Assessment (assemble groups based on the results)		✓		
1	Introducing Students to the Challenge	✓			
1	Airbag Challenge: Initial Design Ideas		✓		
2–4	Activity: Understanding Pressure			✓	✓
5–6	Activity: Mole-to-Mole Ratios			✓	✓
7	Activity: Variable Volumes			✓	✓
8	Activity: Stoichiometric Calculations		✓		
9–10	Activity: Reaction Rate			✓	✓
11	Airbag Challenge: Revise Design		✓		
11–12	Airbag Challenge: Develop Group Design			✓	
13*	Airbag Challenge: Test and Evaluate	✓			
13	Airbag Challenge: Design Review		✓		
14	Concluding the Module	✓			
14	Post-Assessment		✓		

* The students may need one or two days outside of class to complete their airbags before testing and evaluating them. Depending on their design, they may need glue to dry or may have other design features that need additional time.

Safety

All normal safety procedures should be followed when performing the Airbag module. Most of the activities involve collecting data under pressurized conditions. It will be necessary to teach your students safety procedures related to pressurized systems including the possibility of stoppers and chemicals being expelled from sampling bottles.

Safety information is provided in each lab activity. However, the activities provided are templates. Each teacher should read through the entire activity and change the procedure as needed to ensure student safety.

Refer to the Normal Laboratory Safety Procedures appendix for a detailed list of safety precautions.

Pre-Assessment

Answer each question to the best of your ability.

1. There are two bags on a table. Bag A contains exactly one mole of carbon atoms and bag B contains exactly one mole of liquid water molecules. Both bags have the same ______________.

   A. volume B. number of particles C. mass D. all (A, B, and C)

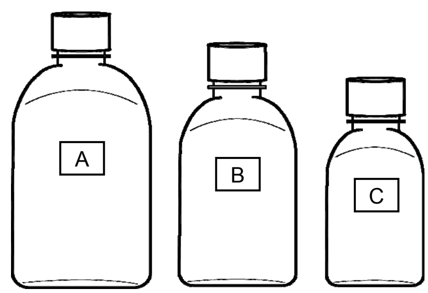
2. How do you make a 2.0 M solution of sodium bicarbonate?
   A. Add 168 grams of sodium bicarbonate to one liter of water.
   B. Add 2.0 moles of sodium bicarbonate to 100 milliliters of water.
   C. Add 2.0 grams of sodium bicarbonate to one liter of water.
   D. Add 0.23 moles of sodium bicarbonate to 100 milliliters of water.

3. Airbags in most automobiles inflate due to the incredibly fast decomposition of sodium azide. How many moles of nitrogen gas are formed to balance the following chemical reaction?

$$2NaN_3(s) \rightarrow 2Na(s) + \_\_\_\_N_2(g)$$

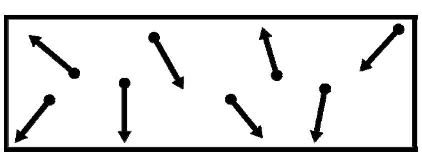
   A. 4 B. 3 C. 2 D. 1

4. If each sampling bottle is at the same temperature and contains the same number of molecules, which one has the highest pressure?
   A. Bottle A
   B. Bottle B
   C. Bottle C
   D. All the sampling bottles will have the same amount of pressure.

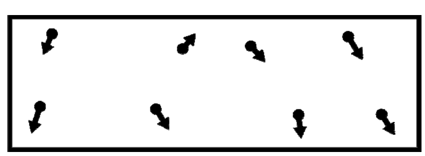


5. In the following diagrams, the volume is represented by the rectangles, each gas molecule is represented by a dot, and the speed each molecule is traveling is represented by the arrow. The longer the arrow, the faster the molecule is traveling.

   Which of the following statements is true about gaseous Sample A when compared to gaseous Sample B? The gas in both samples is the same.



Sample A



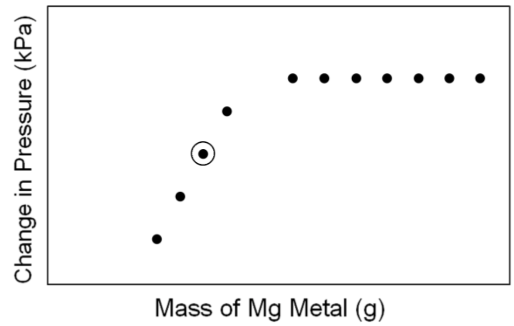
Sample B

   A. They occupy the same volume and have the same pressure, but have different temperatures.
   B. They have the same temperatures and the same pressure, but occupy different volumes.
   C. They have the same temperature and occupy the same volume, but have different pressures.
   D. They occupy the same volume, but they have different temperatures and pressures.

6. In a closed container, what change will cause the pressure to decrease?
   A. An increase in temperature
   B. The addition of more particles to the container
   C. An increase in the volume of the container
   D. All of the above

7. Various reactions were performed in which increasing amounts of magnesium metal were mixed with a constant amount of hydrochloric acid. The change in pressure for each reaction was measured and a graph of the change in pressure versus the mass of magnesium is shown below. Which best describes the data point that is circled?

A. Magnesium is the excess reactant and hydrochloric acid is the limiting reactant.
B. Magnesium is the limiting reactant and hydrochloric acid is the excess reactant.
C. There was exactly the right amount of reactants and neither was in excess or limiting.
D. There was an excess of each reactant in this trial.



8. What does it mean if two reactants are combined using their mole-to-mole ratio?

A. Equal numbers of moles of each reactant are combined to produce the most product.
B. One mole of each reactant is added to produce two moles of product.
C. The amount of one reactant is determined precisely and a large excess of the other reactant is added to ensure a maximum amount of product is formed.
D. A precise amount of each reactant is combined to form the maximum amount of product with the least amount of unused or wasted excess material.

9. How many moles of carbon dioxide gas are required to fill a 1.2 L plastic bag to its maximum volume? Use the data given below to determine your answer.

P = 101.1 kPa; T = 300.2 K; R = 8.314 (L·kPa)/(mol·K)

A. 0.027 mol CO_2 B. 0.049 mol CO_2 C. 0.54 mol CO_2 D. 20.5 mol CO_2

10. How many moles of sodium bicarbonate are in 10 mL of a 3 M sodium bicarbonate solution?

A. 0.03 mol $NaHCO_3$ B. 30.0 mol $NaHCO_3$ C. 0.003 mol $NaHCO_3$ D. 3 mol $NaHCO_3$

11. How many liters of hydrogen gas will form if you completely react 0.30 g of magnesium metal (Mg) with an excess of hydrochloric acid (HCl) at 298.2 K and 101.3 kPa according to the following reaction?

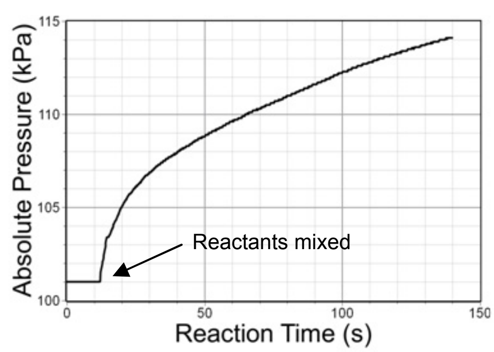
R = 8.314 (L·kPa)/(mol·K); the molar mass of Mg is 24.31 g/mol

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

A. 0.012 L H_2 B. 0.30 L H_2 C. 0.60 L H_2 D. 7.92 L H_2

12. What is the average rate of reaction for this run of data?

A. 0.10 kPa/s
B. 0.88 kPa/s
C. 140 kPa/s
D. 10 kPa/s



13. Which of the following reactants would magnesium metal react with the most quickly?

A. 1 M HCl B. 2 M HCl C. 3 M HCl D. 4 M HCl

Pre-Assessment Answer Key

The pre-assessment consists entirely of multiple choice questions to aid teachers with large class sizes or those who want to use a "clicker" response system for recording answers. The pre-assessment is available in an editable electronic format (HS STEM Airbag PreAssessment.doc) so you may edit questions to make them open-ended or to add or customize questions based on your students' familiarity with the curriculum.

The results of the pre-assessment may be used in several ways:

- To identify areas of weaknesses. These may be supplemented with extra class discussions or lab activities.
- To identify student strengths and adapt the activity accordingly.
- To place students in groups with similar skills and conceptual understanding or mixed skills and levels of understanding.
- To introduce students to the applicable concepts.
- Use the results of a specific question to start a class discussion after students carry out the corresponding activity. For example, tell students, "Half of the class said that answer 'a' was correct. How many of you agree with this answer now?" Then have students explain their reasoning using data from the activities.
- The answer key includes an explanation of each correct answer and in some cases explains what wrong answers may mean about a student's current conceptual understanding. The assessment information also indicates the activity in the module that addresses the concept assessed.

Question	Correct Answer	Assessment Information
1	B	A mole is 6.0×10^{23} particles. It is similar to using the word "dozen" to signify 12 of something. If you have a dozen cars and a dozen mice you have very different volumes and masses, but the number of objects is the same. A "mole" is similar. The molecules of a mole of water and a mole of carbon have different sizes and mass, but a mole of either contains the same number of molecules. Students who did not get this correct have not yet understood the concept of moles and will likely be confused with the more advance concepts required in this module. A review of this concept can be included during the Understanding Pressure activity, which asks the students to look at both volume and the amount of a gas (number of moles) as two different variables.
2	A	Sodium bicarbonate has a molecular weight of 84 g. To make a 2.0 M solution, add 168 g of sodium bicarbonate to one liter of water. Students may have to calculate the mass of solute needed for a specified volume of solution and then make the solution so it can be used in their airbag. Instruction for preparing a solution in the lab is not taught in this module, but depending on their airbag design, students may need to prepare solutions. If students struggle to answer this question, additional instruction may be required to teach them how to do this. Students who got the wrong answer may have forgotten the unit: molarity (M), which is "moles of solute per liter of solution."
3	B	$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$ Following the Law of Conservation of Matter, this equation shows 2 Na and 6 N atoms on both the reactant and product sides of the equation. It is expected that students already understand this concept before starting the module. Students will need review if they missed this question.
4	C	Bottle C has the smallest volume so the particles in it will collide with the sides of the container the most often, resulting in the highest pressure. The concept of pressure and how it varies with volume is addressed in the Understanding Pressure activity.
5	D	In these diagrams, the volume is represented by the rectangles, each gas molecule is represented by a dot, and the speed each molecule is traveling is represented by the arrow. The longer the arrow, the faster the molecule is traveling. As the molecules in Sample A are traveling faster, Sample A has a higher temperature and a higher pressure than Sample B. In this module, the students are asked to draw molecular level diagrams to illustrate different amounts of gas, temperatures of gas, and volume of gas. The students do not have to use the method shown here, but they should be able to explain their illustrations. These concepts are addressed in the Understanding Pressure activity.
6	C	Increasing the volume of a container will cause the pressure inside that container to decrease. Choices A and B will both cause an increase in pressure inside the container. These concepts are addressed in the Understanding Pressure activity.

7	B	Magnesium is the limiting reactant. This can be determined by looking at the data points that come after the one that is circled. The data points to the right of the circled data point, each representing a larger amount of magnesium, produced a greater change in pressure even though the same amount of hydrochloric acid was added. This means that, for the circled data point, the reaction ended when it ran out of magnesium. The graph shows that as more magnesium was added, the reaction produced more gas, showing a greater change in pressure, until there was an excess of magnesium and hydrochloric acid became the limiting reactant. The change in pressure didn't alter after that, regardless of the amount of magnesium used. The concept of limiting reactant and excess reactant is addressed in the Mole-to-Mole Ratios activity.
8	D	If reactants are combined using their mole-to-mole ratio, then the ideal amount of each reactant is used to obtain the maximum amount of product with the least amount of unused or wasted material. Answer A states that equal numbers of moles of each reactant are used. This could apply to an equation with a 1:1 mole ratio. While this can be the case, it is not always the case, depending on the chemical reaction. There could be any number of mole-to-mole ratios, including 1:2, 2:3, 4:7, etc. Students who answered B (one mole of each reactant is added to produce two moles of product) may be confusing a mathematical equation with a chemical equation. Answer C is restating the procedure of the experiment described in the previous question. If one reactant is in excess then the reactants were not combined using their exact mole-to-mole ratio. The concept of mole-to-mole ratios is addressed in the Mole-to-Mole Ratios activity.
9	B	The ideal gas law, $PV = nRT$, can be used to solve this problem. $n = \frac{PV}{RT}$ $n = \frac{(101.1\text{ kPa})(1.2\text{ L})}{\left(8.314\ \frac{\text{L kPa}}{\text{mol K}}\right)(300.2\text{ K})}$ $n = 0.049\text{ mol } CO_2$ Students derive the Ideal Gas Law in the Understanding Pressure activity and Ideal Gas Law calculations will be performed in the Variable Volumes and the Reaction Rate activities.
10	A	$10\text{ mL} \times \frac{1\text{ L}}{1000\text{ mL}} \times \frac{3\text{ mol NaHCO}_3}{1\text{ L}} = 0.03\text{ mol NaHCO}_3$ This type of calculation is not taught in these activities, but the students use it in the Stoichiometric Calculations activity.
11	B	$0.30\text{ g Mg} \times \frac{1\text{ mol Mg}}{24.31\text{ g Mg}} = 0.012\text{ mol Mg}$ $0.012\text{ mol Mg} \times \frac{1\text{ mol H}_2}{1\text{ mol Mg}} = 0.012\text{ mol H}_2$ $V = \frac{nRT}{P}$ $V = \frac{(0.012\text{ mol})\left(8.314\ \frac{\text{L kPa}}{\text{mol K}}\right)(298.2\text{ K})}{(101.3\text{ kPa})}$ $V = 0.29\text{ L H}_2$ Multi-step stoichiometry problems are practiced in the Stoichiometric Calculations activity.
12	A	$\text{Rate} = \frac{\Delta P}{\Delta t}$ $\text{Rate} = \frac{114\text{ kPa} - 101\text{ kPa}}{140\text{ s} - 10\text{ s}} = \frac{13\text{ kPa}}{130\text{ s}} = 0.10\text{ kPa/s}$ This concept is covered in the Reaction Rate activity.
13	D	The higher the concentration, the faster the reaction occurs. The affect of concentration on reaction rate is explored in the Reaction Rate activity.

Introducing Students to the Challenge

Begin by engaging your students in a discussion of automobile safety features, why they are designed, and how they help people. Focus the discussion on airbags and show your students a video of an airbag being activated. Have the students discuss how chemistry is involved in this process. After this discussion, distribute the Airbag Challenge handout and give the students some time to read through it.

The stages described on the handout follow, chronologically, the stages of the engineering design process, as listed in the Pacing Guide activities and lessons. Each stage is identified by title in the Challenge handout, which includes instructions or questions, or both, that require students to respond in their notebooks. When beginning the Challenge, make certain that students are aware of this and that they each have a notebook for their responses and data.

The first section of the Challenge handout (Identify the Problem) outlines the real world challenges engineers face when designing airbags. Discuss these challenges and then introduce the modified Challenge the students will solve. Be certain to discuss the design requirements and constraints (outlined on the Challenge handout) with your students, being clear that failure to stay within those requirements and constraints will affect their overall grade.

Students will work individually and in groups throughout the Airbag Challenge. After introducing the Challenge, it is a good idea to assign students to groups for the stages of the Challenge that are carried out in groups (Research, Develop Group Design, Build a Prototype, Test and Evaluate, and Design Review). Although you, as the teacher, will know what grouping method best suits your class, the Pre-Assessment results may provide additional insight. For example, if the Pre-Assessment reveals that your students have a variety of prior concept knowledge, they may benefit from being in groups that distribute this knowledge. We suggest that these groups be the same throughout all the stages of the Challenge where students work in groups.

Challenge Rubric

To give students a better understanding of what is expected of them throughout the Challenge, you may choose to pass out the Challenge Rubric with the Challenge handout, which will indicate the suggested grading criteria. If you feel that these grading criteria are not suitable for your class, the rubric is available in an editable electronic format (HS STEM Airbag Challenge Rubric.doc) that allows you to change it as you find necessary.

This rubric gives equal weight to each part of the engineering design process. The bulk of the class time, however, will be spent on the Research section. In addition to giving an overall grade for the entire project, you may also decide to give additional points to each individual activity.

Materials

Each student group will need the following materials to build its airbag:

- A plastic bag that does not exceed a maximum volume of 1.5 L.
- A maximum of 100 mL of 3 M acetic acid and 10 g of sodium bicarbonate.
- A 10-cm piece of tubing.
- Other materials will also be needed, including materials to seal the airbag around the attached tubing and materials to separate the reactants inside their airbag.

The Challenge handout is available in an editable electronic format (HS STEM Airbag Challenge.doc), making it easy to change material constraints in the Design Requirements and Constraints section.

The materials required for each activity of the module are listed in each activity handout and in the Master Materials and Equipment appendix. The Materials and Equipment appendix also includes a list of all the materials needed to complete the airbag module.