Science Assessment System
Through Course Task

Factors Affecting Balloon Deflation

Grade Level:
9, 10, 11, 12

Phenomena:
Gases Escape from Latex Balloons Due to Microscopic Holes

Science & Engineering Practices:
Asking Questions and Defining Problems
Planning Carrying Out Investigations
Analyzing and Interpreting Data

Crosscutting Concepts:
Cause and Effect

Designed and revised by Kentucky Department of Education staff
in collaboration with teachers from Kentucky schools and districts.

This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

Preparing to implement Through Course Tasks in the Classroom

What is a TCT?

- TCTs are 3-dimensional tasks specifically designed to get evidence of student competency in two dimensions, Science and Engineering Processes (SEPs) and Crosscutting Concepts (CCC), untethered from Performance Expectations (PEs)/standards. Tasks are sense-making experiences.
- Tasks are to be used formatively. The goal is for both students and teachers to understand areas of strength and improvement for the SEP(s) and CCC assessed within the task.

How do I facilitate a Through Course Task (TCT)?

- TCT facilitation is a collaborative process in which teacher teams calibrate understanding of the expectations of the task and refine strategies to be used during task facilitation.

Before the task:

1. Complete the TCT as a learner – compare understanding of task through the lens of success criteria (identified in the task) in order to understand expectations. Success criteria include:
   - What is this task designed to get evidence of?
   - What is the task asking the students to do?
   - What might a student response look like?
2. Identify the phenomenon within the task. Consult resources to assure teacher teams have a deep understanding of associated science concepts.
3. Collaborate to generate, review and refine feedback questions during facilitation.
4. Identify potential "trouble spots" and plan for possible misconceptions.

During the task:

5. Collect defensible evidence of each student's competencies in 3-dimensional sense-making for the task.
6. Ask appropriate feedback questions to support student access and engagement with the task in order to elicit accurate evidence of student capacities.

After the task:

7. Reflect on the task as a collaborative team.
8. Review student work samples to identify areas of strength and areas of need.
9. Determine/plan next steps to move 3-D sense making forward through the strengthening of the use of SEPs and CCCs.

Using the materials included in this packet:

- **Task Annotation:**
  - The task annotation is a teacher guide for using the task in the classroom. Additionally, the annotation gives insight into the thinking of developers and the task overall.

    - Each task has science and engineering practices, disciplinary core ideas, and crosscutting concepts designated with both color and text style:
        - **Science and Engineering Practices**
        - *Disciplinary Core Ideas*
        - Crosscutting Concepts
- **Student Task:** The materials to be used by students to complete the TCT.

Factors Affecting Balloon Deflation Task Annotation

After analyzing and interpreting data *about factors that affect deflation rate of latex balloons,* generate a testable question and justified directional hypothesis for the causal mechanism *for the factor you identified*.

Phenomenon within the task

Why do different balloons deflate at different rates? Deflation occurs as gas atoms/molecules diffuse through a latex balloon which is somewhat porous. This diffusion is a function of the probability of the gas molecules colliding with the surface. This probability is dependent on several variables that could potentially be investigated by students. These variables/factors include the surface area of the balloon, the temperature and the molecular mass of the gas.

How the phenomenon relates to DCI

HS-PS1-3 asks students to plan and conduct an investigation into the relationship between bulk properties and the atomic level interactions that underlie them. This task assesses student's ability to begin this process by selecting an investigable question into a bulk property that is being affected by atomic scale factors such as molar mass and molecular kinetics. PS1.A is a DCI connected to this performance standard which involves the effects of intermolecular forces and kinetic-molecular theory on bulk scale properties.

PS1. A Structure and Properties of Matter

By the end of 8th grade. Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
In a liquid, the molecules are constantly in contact with each other; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and vibrate in position but do not change relative locations.
The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.
By the end of grade 12. Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.

What information/data will students use within this task?

Knowledge of the content behind PS1.A may allow students to more reliably predict the outcomes of an investigation stemming from this task, but it is not strictly necessary to complete the task itself. Instead the task focuses on developing an investigable question that would allow them to discover the relationships between atomic and bulk scale variables. However, to engage with the task, students must be familiar with composing a testable scientific question. Elements behind this process include being able to pose potential cause and effect relationships between a dependent variable and potential independent variable. To evaluate student's ability to pose questions probing these relationships, the task supports student thinking by listing several materials or conditions to use as possible independent variables.

Students will have to realize that they will get some information needed from the storyline of the task, including the diagram of the room, and hence, will have to use close reading skills. Consider preparing some questions prior to using the task to prompt student thinking about the information provided in the task.

Ideas for setting up the task with students

Teachers should ensure their students can distinguish between dependent and independent variables. Teachers should also discuss how to write a directional hypothesis. The task gives a scenario in which there are materials to use (gas type, shape of the balloon and temperature) as independent variables. While a prior knowledge of collision theory may help students to anticipate the results of the investigation, the task deals only with the formation of a testable question. Prior experience writing testable scientific questions will help students pose a question in a way that indicates the dependent variable is changed by the independent variable (directionality of cause and effect). Depending on the students' experience with developing investigations on their own, some scaffolding may be required. This could include distinguishing between independent and dependent variables, writing testable questions that isolate variables and selecting factors to keep constant. Included in the task folder are example slides for an activity to support students in writing testable questions and directional hypotheses.

Intent of the Task for Assessment

This task presents a general phenomenon that many students are familiar with: latex balloons deflate over time, whether they are filled with air or helium. This phenomenon is embedded with specific details into a storyline for the task. Students will have to analyze the storyline and supporting information, and combine that with background knowledge about the particle nature of matter and how matter is affected by energy, and perhaps other knowledge, in order to develop a testable question, develop a directional hypothesis as an answer to the question and identify a causal mechanism to justify their directional hypothesis. Provided that students understand the context clearly, you will get accurate evidence of whether they can ask a testable question, provide a directional hypothesis and justify (causal mechanism) their hypothesis. Thus, teachers should probe student's thinking as they engage with the task to ensure that they understand the context clearly.

Success Criteria

Evidence of Learning Desired based on Progression from Appendices

Analyze and Interpret Data

- Analyze and interpret data to provide evidence for phenomena (in this case to develop a question to explore the phenomena).

Asking Questions and Defining Problems

- Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.

Planning and Carrying out Investigations

- Make directional hypotheses that specify what happens to dependent variable when an independent variable is manipulated.

Cause and Effect

- Cause and effect can be used to explain phenomena in natural or designed systems. (The balloon is the system.)

Success Criteria

- Student poses a narrow question that could be answer within the constraints described in the scenario.
- Student makes a directional hypothesis that related changes to the factor identified in their question to the rate of balloon deflation.
- Student constructs a relevant explanation that identifies a potential cause for gas loss attributable their chosen independent variable.

Possible Student Responses

Asking Questions:

- Is there a correlation between a balloon's rate of deflation and the temperature of its surrounding?
- Does the gas escape faster from a balloon when it is warm?

- Will the gases affect the deflation rate of the balloon?
- Does the shape of the balloon affect the rate of deflation?

Making Hypotheses:

- If the balloon is spherical, then the rate of deflation will be lower.
- Spherical balloons filled with carbon dioxide at lower temperatures will have lower rates of deflation
- If the temperature around a balloon is hotter, the air will escape faster.
- If I use a gas with a higher molecular mass, then the air will stay in the balloon longer.

Causal Explanation

Any response that links frequency of molecule/surface collisions to the chosen independent variable.

Other information teacher teams might find useful when preparing to use this task in the TCT process

The majority of students were successful in both writing a testable question and making a directional hypothesis. However, students struggled in with offering an explanation that was fully relevant to the hypothesis that they posed. This task identified that our students needed additional opportunities to read texts with the purpose of identifying cause and effect relationships

Extensions and/or other uses after the task is implemented

Most students selected temperature as the factor to investigate. This lends itself to Charles Law (Volume/Temperature) activities. Additionally, for students curious about the effect of molar mass, labs to determine molar volume could be appropriate (collecting hydrogen gas generated by the reaction of magnesium with an acid or calculating the molar mass of butane released from a lighter).

Through Course Task – Factors Affecting Balloon Deflation

A. Storyline

Nicole is planning a birthday party for her little sister. The night before the party Nicole sets up the decorations all around a room, including balloons filled with helium or air. The next day Nicole notices that the balloons for the party do not seem to have as much gas in them as they did when she initially inflated them. She also noticed that the balloons, despite having the same initial volume, have deflated by different amounts. Remembering her high school chemistry class, she knew that the gas inside the balloon could not have disappeared. The chemical law of mass conservation says that matter cannot be created or destroyed.

Perplexed, she began to research balloons on the internet. She found that balloons are somewhat porous. Although they appear solid to the naked eye, there are actually microscopic holes in balloons. If a gas molecule within the balloon strikes one of these microscopic holes it may escape the balloon. The faster the molecules move, the more frequently they will strike the walls and have a chance to escape the balloon. She finds this chart showing the average speed of different gas molecules under different conditions.

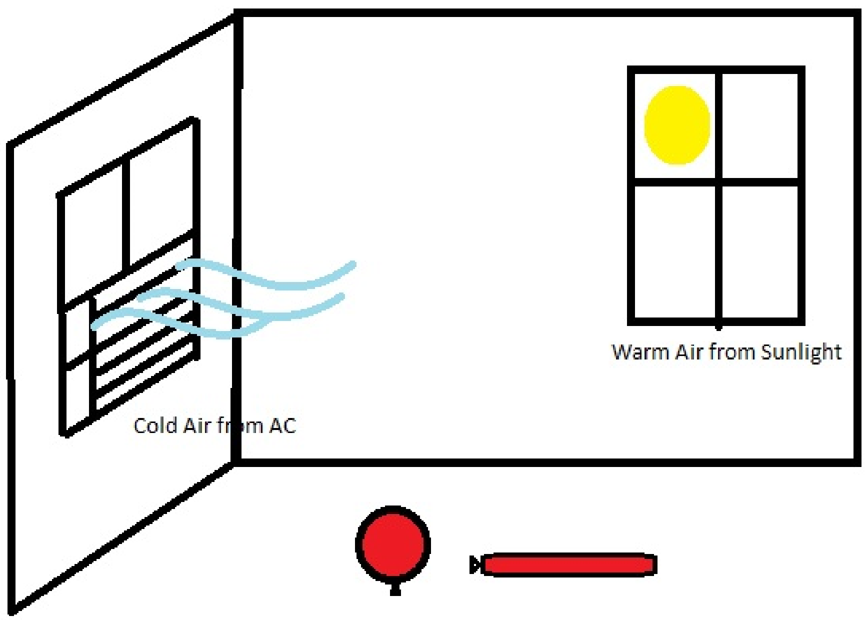
	Molecular Mass (amu)	Average Molecular Velocity (m/s) at 0 Celsius	Average Molecular Velocity (m/s) at 20 Celsius	Average Molecular Velocity (m/s) at 40 Celsius
Helium	4.00	1305	1363	1397
Nitrogen	28.01	493	511	528
Air	28.97*	485	502	519
Carbon Dioxide	44.01	393	407	421

Air's molecular mass is the average of the gases present

Nicole observes many different amounts of gas loss and concludes that several factors must be affecting the amount of gas each balloon lost overnight. She decides to investigate what factors affect how quickly balloons deflate. Nicole has the following materials at her disposal:

1) Cylinders of three different gases: helium, nitrogen and carbon dioxide.
2) Balloons of the same volume, but differing in shape. Some that are nearly spherical and some that are cylindrical.

Nicole will conduct her experiment in a room like this one:



B. Task

Write a testable question that can consider the relationship between a factor and the rate of balloon deflation.

Make a directional hypothesis for how the factor you choose will affect the rate gas escapes from a balloon.

Provide a causal explanation about why you think the factor will affect gas loss in that way.