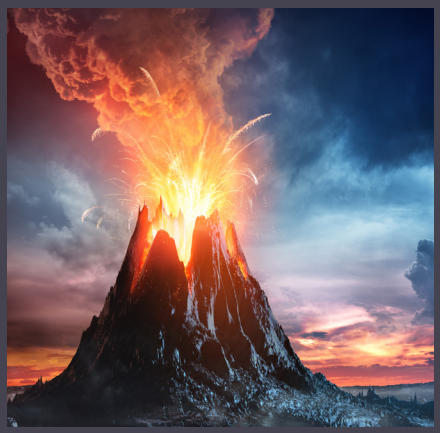
Energy in an NGSS-Aligned High School Chemistry Course

By: Mike Marvel, PhD

FLINN SCIENTIFIC

The Next Generation Science Standards (NGSS) identify energy as a cross-cutting concept because it is an important part of every science discipline. With specific respect to high school chemistry, there are many ways this concept can be integrated into traditional classes to better meet the performance expectations defined by the NGSS. For example, the second law of thermodynamics is part of Performance Expectation **HS-PS3-4**.

To satisfy this performance expectation, students must demonstrate that they can **"plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics)."** Students might elect to mix samples of water at different initial temperatures, or students might decide to heat chunks of metal in boiling water and then add them to room temperature water. In either scenario, they would note that the components in each system approach thermal equilibrium over time. In addition, giving students different-colored ice cubes helps them make observations about the movement of energy or heat.



To make this experiment align with the instructional strategies inherent to the NGSS, students would not empirically verify the existence of the second law. Rather, they might be given a set of starting materials and equipment and asked to explore, with close teacher oversight, energy transfer between components in a mixture. By careful experimentation and measurement of the materials' particle model over time, students would be able to articulate that the components in a thermodynamic system—though initially at different temperatures—do, in time, reach a shared temperature. Students could connect this observation to things learned in previous coursework, such as the idea that temperature is a measure of kinetic energy and that kinetic energy can be transferred from one object to another by atomic and molecular collisions. Studying phenomena, such as volcanoes and plate tectonics (basic convection), is also a method of introducing NGSS Earth Science standards. Chemistry and energy no

> "Science has always been a **messy, incremental** and sometimes **frustrating** process."

longer stand alone when it comes to NGSS, and many schools are placing Earth science standards into the core classes of biology, chemistry and physics. For example, volcanoes include phases of matter and energy phase changes with solid rock and magma. Students could even experiment with scale to see what happens when larger or smaller quantities of materials are used. The point is that students are asked to explore energy transfer rather than being told what the second law is and asked to verify it.

Some in the NGSS community describe this idea—that students explore rather than be told—as "a shift from learning about to figuring out." Implementation-wise, this idea is often easier said than done, particularly in classrooms filled with students of varying abilities and comfort levels. One way to mitigate this kind of challenge is to step in with guiding questions along the way. Lab groups that can't seem to get started may need a nudge in the form of phenomena-based questions, such as "What do you think will happen if you mix really hot water with room-temperature water?" or "What would you do if you were taking a bath and the water was too cold?" Given these prompts, students may still struggle with how much water to use in the experiment, when exactly to take temperature readings, etc. This is not necessarily a bad thing. Science has always been a messy, incremental and sometimes frustrating process. Many pharmaceutical chemists go their entire careers without making a compound that is ever given to a single human subject. The writers of the NGSS framework don't want students to feel like frustrated pharmaceutical chemists, so it is okay for teachers to provide more guidance to struggling students. Teacher judgement is the key to walking this line. The next time you introduce the second law of thermodynamics to students, give some of these ideas a try. At the very least, you will get a feel for how your students adapt, and you can begin to adjust accordingly as you progress on the path to NGSS implementation.

See more on **Navigating NGSS** at flinnsci.com

- Back to **Basics**
- Back to **Phenomena**
- Back to **Storylines**
- Back to **Glossary**
- Search for **Aligned Products**