



## Grades 9–12

### 3.2.9-12.F Physical Science: Chemical Reactions

**Students who demonstrate understanding can** *refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*

**Clarifying Statement:** Emphasis is on the application of Le Chatelier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.

**Assessment Boundary:** Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
<b>Constructing Explanations and Designing Solutions</b> Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. <ul style="list-style-type: none"> <li>Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.</li> </ul>	<b>Chemical Reactions</b> <ul style="list-style-type: none"> <li>In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.</li> </ul> <b>Optimizing the Design Solution</b> <ul style="list-style-type: none"> <li>Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.</li> </ul>	<b>Stability and Change</b> <ul style="list-style-type: none"> <li>Much of science deals with constructing explanations of how things change and how they remain stable.</li> </ul>

**Pennsylvania Context:** N/A

**PA Career Ready Skills:** Analyze adverse situations for the purpose of identifying and selecting healthy coping skills.

### Connections to Other Standards Content and Practices

Standard Source	Possible Connections to Other Standard(s) or Practice(s)
Agriculture (AFNR)	CS.01.02.01.c: Solve problems in AFNR workplaces or scenarios using technology.



Standard Source	Possible Connections to Other Standard(s) or Practice(s)
<b>Science, Environmental Literacy and Sustainability (NAAEE)</b>	9-12 Strand 2.1.A. Earth's physical systems: Learners describe the major processes and systems that form Earth and relate these processes, especially those that are large-scale and long-term to characteristics of Earth. They explain how changes in one system (hydrosphere, atmosphere, geosphere, and biosphere) result in changes to another. They describe how human sustainability depends on Earth systems.
<b>PA Core Standards: ELA</b>	CC.3.6.9-12.F: Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.
<b>PA Core Standards and Practices: Math</b>	N/A
<b>PA Standards: Social Studies</b>	6.1.9.B: Identify the origin of resources and analyze the impact on the production of goods and services. Analyze how unlimited wants and limited resources affect decision making.
<b>Educational Technology (ISTE)</b>	1.4. Innovative Designer: Students use a variety of technologies within a design process to identify and solve problems by creating new, useful or imaginative solutions.
<b>Technology and Engineering (ITEEA)</b>	STEL-1R: Develop a plan that incorporates knowledge from science, mathematics, and other disciplines to design or improve a technological product or system.