Section 2: Scientific Methods

The following maps the videos in this section to the Texas Essential Knowledge and Skills for Science TAC §112.35(c).

2.01 Chemistry: A Natural Science

- Chemistry (2)(A)

2.02 Scientific Methods

- Chemistry (2)(B)
- Chemistry (2)(C)
- Chemistry (2)(D)
- Chemistry (3)(A)

2.03 Let's Test It: Conductivity

- Chemistry (2)(E)
- Chemistry (2)(F)

Safety Note: Any chemicals mentioned in these videos are potentially harmful and should be handled with the appropriate safety precautions.

2.01

Chemistry: A Natural Science

The National Academy of Sciences, a nonprofit organization founded in the United States in 1863, defines ***science*** as "the use of evidence to construct testable explanation and prediction of natural phenomena, as well as the knowledge generated through this process" (National Academies, n.d.). Many natural phenomena have not yet been explained by science, but the job of scientists is to strive to find an explanation for these phenomena to the best of their abilities.

Chemistry is the branch of science devoted to the study of the composition of matter in an effort to explain the physical and chemical behavior of matter. Along with biology, physics, and geology, chemistry is viewed as a ***natural science*** because it involves the study of the physical world. Chemistry has several subdivisions that focus on specific fields:

- ***General chemistry*** – The study of the composition, properties, and reactions of matter
- ***Organic chemistry*** – The study of substances that contain the element carbon
- ***Biochemistry*** – The study of chemical reactions that take place in biological systems
- ***Geochemistry*** – The study of the chemical composition of ores, soils, and minerals from the surface of the Earth and other planets
- ***Physical chemistry*** – The study of the physical nature of chemical systems, which includes energy changes

1. Which subdivision of chemistry involves the study of the element carbon?

   A. General
   B. Physical
   C. Organic
   D. Biological

<u>2.02</u>

<u>Scientific Methods</u>

***Scientific methods* are** the general approach that scientists use to solve problems. They generally involve four main steps, listed below.

1. Make ***observations***. Observations are what a scientist sees, smells, feels, or generally notices during some process.
    - ***Qualitative observations*** cannot be measured numerically. Some examples of qualitative observations include color change and bubbling.
    - ***Quantitative observations*** can be measured numerically. They are recorded as ***data*****.** These observations can be displayed using trends, charts, and graphs to present them more clearly to other scientists.
2. Construct a ***hypothesis***, which is a proposed explanation of an observation or set of observations. A hypothesis may not be correct, but it must be testable.
3. Design and perform an ***experiment***, which is a set of procedural steps used to test a hypothesis.
4. Develop a ***theory***. A scientific ***theory*** allows scientists to predict and describe the underlying causes of physical behavior. A theory is the result of an experimentally supported hypothesis that has been tested extensively.

Scientific methodology involves repeating these steps many times to analyze and critique tentative explanations for the behaviors of matter. Scientists use evidence from experiments and observations as well as logical reasoning and critical thinking to test the validity of hypotheses and theories.

Often, new technology arises that allows scientists to test a theory in a way that was not previously possible. In many cases, this leads to changes and, occasionally, to the rejection of a previous theory or hypothesis.

A scientific ***law*** is a brief statement that summarizes past observations and theories in order to predict future behavior. For example, the law of conservation of matter states that in chemical reactions, matter is neither created nor destroyed. A law does not offer much of an explanation for the behavior; it just gives a condensed summary of the observations.

1. Classify each observation below as qualitative or quantitative.
   i. A solution begins to vigorously bubble and smoke.

   ii. The mass of a compound decreases as a reaction proceeds.

   iii. Ice floats on water.

   iv. A turkey leg is combusted to test its caloric content.

2. When a solution of calcium chloride is mixed in a flask with a solution of sodium carbonate, a white powder appears and settles at the bottom of the flask. Propose a possible explanation for this behavior.

2.03

Let's Test It: Conductivity

In this section, we will design and execute an experiment to test the conductivity of different solutions of sodium chloride. The ***conductivity*** of a solution is a measure of how well the solution allows electrical current to pass through it. The SI unit of electrical conductivity is the ***siemens per meter (S/m)***.

Formulate a hypothesis about the relationship between the concentration of a solution of sodium chloride and the conductivity of that solution.

In the experiment, we will prepare five different 200-mL solutions of sodium chloride dissolved in distilled water. One additional sample of pure distilled water will also be needed. The solutions will contain 0.100 grams, 0.200 grams, 0.300 grams, 0.400 grams and 0.500 grams of sodium chloride, respectively. We will use a conductivity meter to measure the conductivity of each solution.

Materials

Create a list of the materials that you will need for this experiment. Make sure to choose the appropriate glassware needed, distinguishing among graduated cylinders, volumetric flasks, Erlenmeyer flasks, Buchner flasks, beakers, test tubes, and burettes.

Data Table

Using the space below, create a data table to record the measurements from the experiment.

Procedure

The ***procedure*** of an experiment is the list of detailed steps used to conduct the experiment. It is important to follow the proper safety guidelines in each step. For this experiment, the procedure is listed below:

1. Make sure that you are wearing your safety goggles.
2. Pour approximately 200 mL of distilled water into a 500-mL beaker.
3. Using the conductivity meter, record the conductivity of the pure water sample in the table on the previous page.
4. Set the sample of pure water aside for cleaning the probe.
5. Pour approximately 200 mL of distilled water to a 500-mL beaker.
6. Mass out 0.100 grams of sodium chloride.
7. Add the sodium chloride to the beaker of water and swirl.
8. Measure the conductivity of this solution and record it in the data table.
9. Dispose of the solution properly and rinse the probe in the sample of pure distilled water.
10. Repeat steps five through nine using 0.200 grams, 0.300 grams, 0.400 grams and 0.500 grams of sodium chloride.

Results and Analysis

1. In one to two sentences, summarize the results of this experiment.

2. Did the experiment support your hypothesis?

3. Provide a possible explanation for the results obtained in the experiment.

References

The National Academies of Sciences, Engineering, and Medicine. (n.d.). "FAQ." Retrieved from http://www.nationalacademies.org/newsroom/faq/index.html