UTAH OFFICE OF
ENERGY DEVELOPMENT

Helium

Grade/Subject: Chemistry

Standard CHEM.3.5 Develop solutions related to the management, conservation, and utilization of mineral resources (matter). Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution. (PS1.B, ESS3.A, ETS1.A)

Lesson Performance Expectations:

- Students will develop solutions related to the good drilling of helium, its conservation, and utilization.
- Students will focus on the geochemistry associated with nuclear decay that produces helium in granitic rocks and why drilling is used to recover the gas. Granitic rock is a common, coarse-grained, light-colored, hard igneous rock consisting chiefly of quartz used in monuments and for building and commonly referred to as granite.

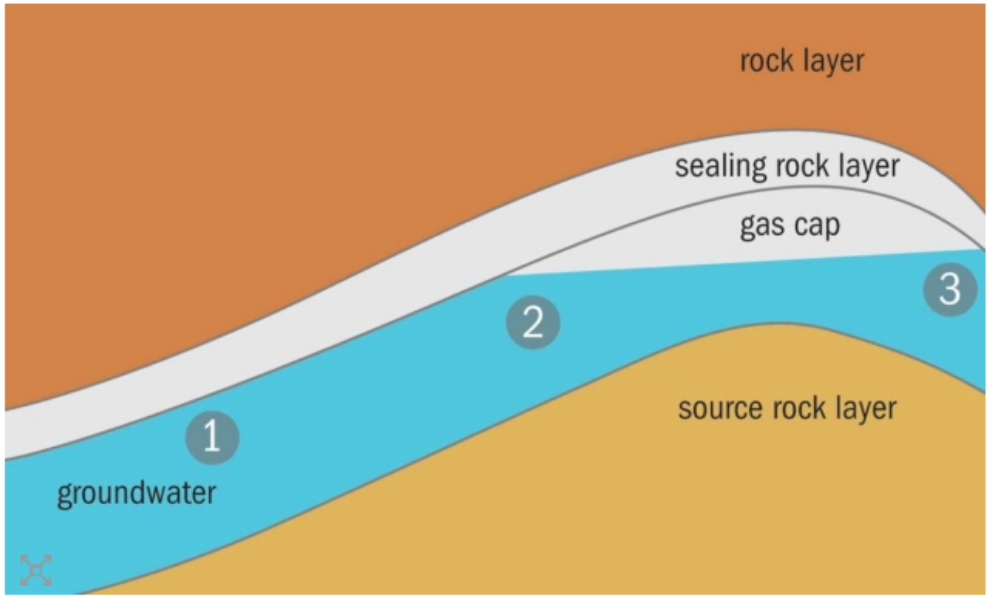
Materials: Students need a computer for each pair or individual student.

Time: 50 minutes

Teacher Background Information:

- Watch this video about helium
- Basic Geology
  - Helium is an element, which means that it cannot be manufactured under normal conditions.
  - Commercial helium concentrations are formed under unusual geologic conditions, often in conjunction with natural gas.
  - Helium often forms in Paleozoic-age rocks from the radioactive decay of uranium and thorium.
  - Following faults, fractures, and igneous intrusive, helium migrates upward into sedimentary rocks. Igneous intrusions form when lava flows cool and solidify before reaching Earth's surface.
  - The atomic radius of helium is so small that it easily moves upward through most of the Earth's layers. Helium can be trapped by non-porous cap-rock such as halite (rock salt) or anhydrite.
  - Igneous rock is one of the three main rock types, the others being sedimentary and metamorphic. Igneous rock is formed through the cooling and solidification of magma or lava.
- Helium Recovery
  - Helium is typically recovered during natural gas extraction and requires large gas fields to produce substantial quantities.
  - Very little helium is present in Earth's atmosphere. It is such a light element that Earth's gravity cannot hold it. When present at the Earth's surface, unconfined helium immediately begins rising until it escapes the planet. That's why party balloons rise!
- Conservation
  - In recent years, helium shortages have resulted in increased prices, leading to an interest in drilling helium-only wells.
  - The total terrestrial inventory of helium is estimated to be 17,000 trillion SCF (470 trillion SCM)
  - Most of this supply is in Earth's atmosphere at a concentration of only 5 ppm.

    - Atmospheric helium is in dynamic equilibrium between the gain of helium diffusing from Earth's crust (as a product of radioactive decay and losses of helium into space.
- Helium Use
    - Helium is most commonly associated with balloons, but industrial uses include military, aerospace, and medical applications.
    - Because it is chemically inert and is a liquid at temperatures near absolute zero, it is used to cool the magnets in MRI machines and air-to-air missile guidance systems.
    - It is a carrier gas for gas chromatography and mass spectrometry.
    - Helium is also used for welding, medical imaging, and making semiconductors
- Utah Helium R
    - Utah is home to the first well in the United States in which helium extraction was the primary purpose.
    - The well is located in Grand County on land managed by the Bureau of Land Management (BLM).
    - This area is known as the Harley Dome and contains a high helium concentration. Designated as a federal helium reserve in 1934, it contains a mixture of nitrogen and up to 7% helium. Although this well was plugged in in 2019, additional development is occurring within the state.



Helium migration: Once released from the source rock, helium and nitrogen can interact with groundwater (1), which carries the dissolved gases as it ascends. When the groundwater contacts a pre-existing gas cap containing methane or carbon dioxide (2), the nitrogen and helium partition out of the groundwater into the gas cap (3).

Source

IACX started producing on-purpose helium in 2013 at the Harley Dome field in Utah.

- The Harley Dome Field is currently producing helium (Source).

Links:
OED Helium Video
physicsworld.com
cen.acs.org
NPR Helium

Student Background Knowledge:

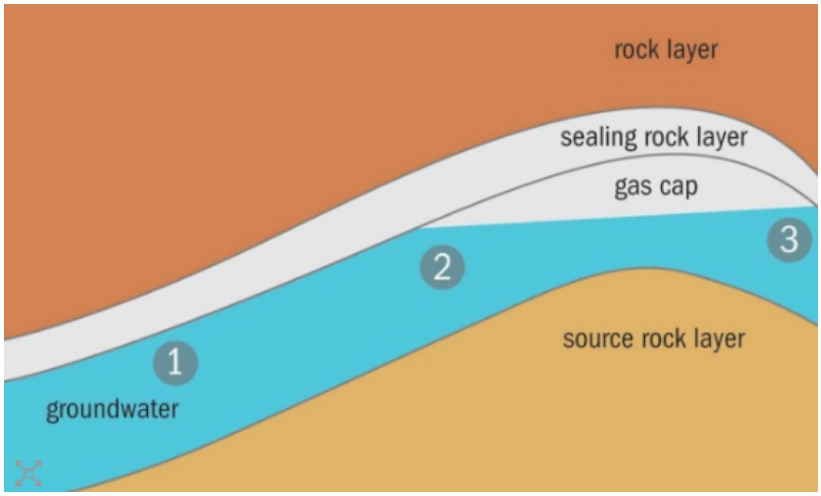
- Students should understand the particulate nature of matter and know the differences between atoms.
- Students should have a background in radioactive decay.

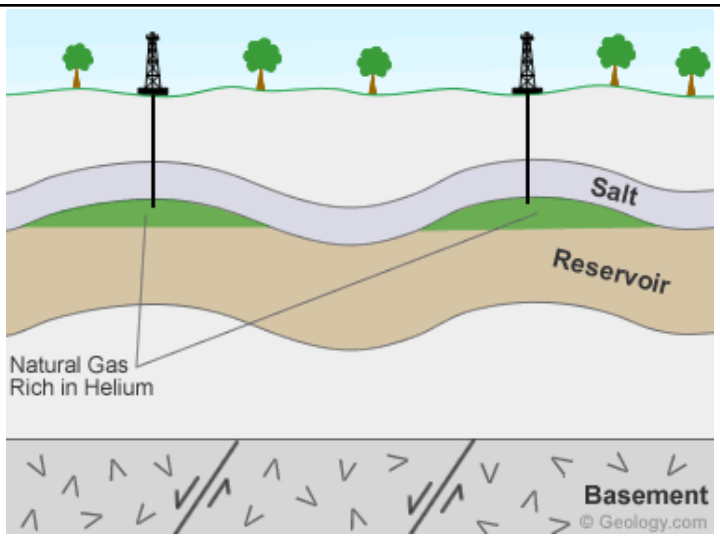
Teacher Step by Step: A 3-d lesson should insist students do the thinking. Provide time and space for the students to experience the phenomenon and ask questions. The student sheet provided below provides guidance but is only an example of how students might respond.

1. **Introduce *Phenomenon:*** Bring a helium-filled balloon to class or use a picture of floating balloons.
2. Ask students what they notice about the balloon or balloons pictured on the student sheet.

Assessment of Student Learning.

The diagram below demonstrates a gas cap trapped between source rock and a sealing layer. A drilling operation could release and capture helium gas and other gases.





1. Most geologists believe that the majority of **helium** in natural gas derives from a specific kind of source rock. What characteristic(s) must this source rock layer have to procure helium? Choose all that apply.
    a. It is formed from large crystals.
    b. It is porous and allows gases to flow through.*
    c. It contains radioactive atoms that decay into helium.*
    d. It contains a solid form of helium that evaporates into a gas.

2. What characteristic(s) does the sealing rock layer have? Choose all that apply.
    a. Helium gas cannot pass through it.*
    b. It is less dense than the surrounding rocks.
    c. It was formed after the gas cap was created.
    d. It is formed from rock containing large crystals.

3. What factors affect the location of the gas cap in the rock formation? Choose all that apply.
    a. Density*
    b. Porosity*
    c. Crystal type
    d. Temperature
    e. Regional geology*

4. What characteristics of helium make it useful in many applications? Choose all that apply.
    a. It is not flammable.*
    b. It has a low density.*
    c. It is non-reactive with other elements.*
    d. It has the ability to “carry” other gases.*
    e. It turns to liquid at extremely low temperatures.*
    f. It can be found in many locations and is abundant in nature.

Extension of lesson:

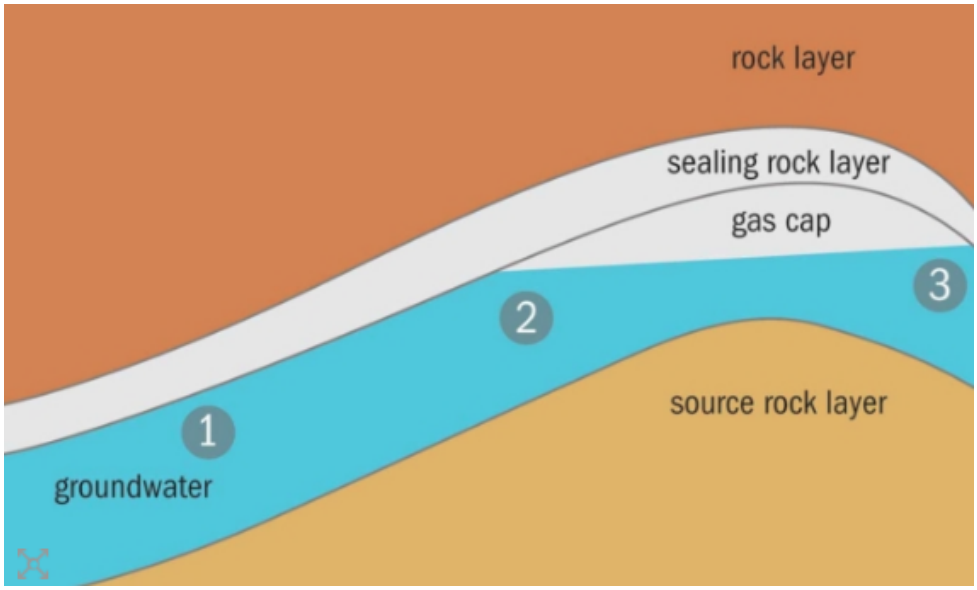
1. Have students design and perform an experiment to measure the density of helium, using balloons as a source of Helium. Check local stores for these balloons.
2. Have students research and report on how helium is used in various applications.

Career Connections: Potential career related to this activity is Mining Engineer

Getting Helium into the Truck

Name_____

Phenomenon: Helium is the gas under the “sealing rock layer”.



What do you notice?

What questions do you have?

1.

2.

3.

Guiding Questions: How can helium be mined and transported? Use some or all of the materials listed below to get the gas from dissolving Alka-Seltzer tablets (the “helium”) to the graduated cylinder for measurement. The container (bottle, flask) is the “sealing rock layer” in this experiment.

Materials:

1. 1-liter pop bottle or large test tube
2. Rubber stopper with one hole that fits into #1,
3. Glass tubing that fits the hole and plastic tubing

Or: Erylmeyer flask with one hose barb and solid stopper

3. Balloon
4. 40 cm plastic tubing
5. 1 Alka-Seltzer tablet
6. Ice cream tub or large plastic dish tub
7. 200 mL graduated cylinder
8. Turkey baster or large syringe
9. Water

Criteria: Who can get the most gas?

Constraints: You can only use the materials provided. Create the gas by adding water to the Alka-Seltzer tablet.

Your plan: Draw the methods you will use:

Your data: How much gas did you get?

Explore: Use the following websites to find out where helium gas comes from and what it is used for.
https://physicsworld.com/a/on-the-hunt-for-helium/
https://www.deseretnews.com/article/865577113/Nations-first-helium-well-planned-for-Utah-may-help-with-worldwide-shortage.html
https://cen.acs.org/articles/90/i29/Helium-Shortage-Affecting-Instrument-Users.html
https://cen.acs.org/articles/95/i30/helium-way.html

Explain

1. How is helium gas formed?

2. Why is there still helium on Earth?

3. What is helium used for?