

TEACHER GUIDE for Lab: Water in Rocks?

(Please read comments throughout and notes to teachers at the end.)

Q. Could the water in Earth's oceans have originated from rocks?

Purpose: To observe and measure what happens when gypsum, a common mineral found in rocks, is exposed to high heat.

Background:

Gypsum is a sulfate mineral commonly found on earth's surface and in the crust. Its chemical formula is $(\text{CaSO}_4 \bullet 2\text{H}_2\text{O})$, so when heat (kinetic energy) is applied to it, it should release its water from the lattice and turn into a different mineral called *anhydrite* (CaSO_4). We use this as a proxy for what rocks from space went through when they arrived on the (very hot) young Earth.

Materials Needed:

- 3g of gypsum (**can be crystalline or pelletized, see notes below for where to purchase if needed**)
- Hotplate (we used a Fisher Scientific 3" x 3" sized one) ← **You could potentially use a bunsen burner but we have not tried that yet...**
- Mass balance
- 150mL Erlenmeyer flask
- Watch glass (**we used a 3in wide one, but a smaller one could have been used**)
- Gloves
- Tongs
- Timer

Hypothesis: If heat (kinetic energy) is applied to the gypsum, then we will see _____ happen inside the flask.

Procedure:

1. Collect all of your group's materials and make sure you read through these
2. instructions first- heat safety is very important in this lab!
3. Weigh your Erlenmeyer flask and record its mass in g.
4. Tare your flask and add gypsum piece(s). Record the mass of the gypsum in g.
5. Place flask + gypsum on hotplate. Carefully place watch glass on top of the flask,
6. making sure it is stable.
7. Turn heat dial up to 9/10 (essentially, as hot as it can go). Start timer.
8. Make sure you are at least 2 ft from hotplate- it gives off a lot of heat!
9. Watch the flask for fog- record the time when you start seeing it and record below.
10. Let the crystal heat up for 10 minutes total and record any observations you can below.



11. After 10 min, turn hotplate off but **leave the flask on- just let it cool down slowly.**
12. While you wait to measure the final mass, do your calculations (below).

Data:

Trial #	Flask Mass (g)	Gypsum Mass- before (g)	Gypsum Mass- final (g)	Time to fog/rain (min/sec)	Observations
1					
2					
3					

Calculations: *Be sure to scaffold these calculations as appropriate depending on your student population. You may choose to have groups collect data individually but work through the calculations as a class.*

We'll calculate the expected mass loss through the application of heat (kinetic energy) by using the known atomic masses of the elements in gypsum. Here's what you'll need:

Element	Atomic Mass
Ca (calcium)	39.92
S (sulfur)	32.07
O (oxygen)	15.99
H (hydrogen)	1.00

Plug those masses into the formula for gypsum ($\text{CaSO}_4 \bullet 2\text{H}_2\text{O}$) to get a total mass:

1) ____ (Ca) + ____ (S) + 4 * ____ (O) + 4 * ____ (H) + 2* ____ (O) = _____

Next we'll calculate the mass of just the 2 waters in the formula (which presumably is what we lost during the reaction of gypsum turning into anhydrite):

$$2) \quad 4 * \text{ ______ } (\text{H}) + 2 * \text{ ______ } (\text{O}) = \text{ ______ }$$

If we want to predict the % mass lost, we'll use total masses calculated in #1 and #2 to figure it out:

$$\text{Predicted \% Mass Lost: } \left(1 - \frac{\text{Gypsum total mass (\#1)} - \text{water mass (\#2)}}{\text{Gypsum total mass (\#1)}} \right) * 100 = \text{ ______ } \%$$

If your hot plate has cooled down, now you can now weigh your gypsum. Use gloves to carefully remove the watch glass from the flask, and use the tongs to measure the mass of the flask + gypsum. Using your initial flask mass, figure out your "final" gypsum mass and record in your table above.

Once you've recorded your final gypsum mass, you can now calculate your own % mass lost and compare it to the predicted above.

Here's the equation you'll use:

$$\text{Actual \% mass lost: } \left(\frac{\text{Before gypsum mass (g)} - \text{final gypsum mass (g)}}{\text{Before gypsum mass (g)}} \right) \times 100 = \text{ ______ } \% \text{ lost}$$

Trial #	Actual % Mass Lost (show your work below)
1	
2	
3	
Average	

Discussion Questions (please answer on a separate sheet of paper or in your notebook):

1. How did your average % mass lost compare to what you predicted? Explain.
2. Where did all the water in the flask come from?
3. What kind of changes did you observe in the gypsum itself?
4. How did your hypothesis work out? What was surprising in this experiment?
5. How does this connect to our driving question, "Where did Earth's oceans come from?"
6. What sources of error might exist in this lab?

Notes to Teachers:

- This is a stinky lab and requires appropriate ventilation. Be certain you've tried this on your own before presenting the task to students and modify the procedure as you see fit.
- The math involved in the calculations may be advanced for some your students, especially if you are presenting these materials in their first year of high school. Review the calculations yourself and decide how much you will expect students to attempt before moving into a guided conversation. But remember that the NGSS call us to connect to mathematics as a process and a means for analysis and understanding. There is an opportunity for students to engage in contextualized mathematical reasoning here. Math is often practiced in K-12 education devoid of purpose (outside contrived "word problems"). Seeing a reason to employ math to address a question in science may motivate some students to push their algebraic skills forward. Of course, you know your students best and our main goal here is to understand how there is enough water in rocks (amazingly) to explain our vast oceans. Use this learning goal as a guiding principle in revising the lab and ensuing conversations for your students.
- We used both a crystalline sample of gypsum and pellet-sized pieces and had similar results. You can order something like this from Amazon:
https://www.amazon.com/Espoma-GG6-Garden-Fertilizer-6-Pound/dp/B00AE23XOY/ref=sr_1_7?dchild=1&keywords=gypsum&qid=1600650857&sr=8-7
- It's very important for them to measure down to two significant figures in order to measure as accurate a mass change as possible. Make sure your balance can measure to that level.
- In the trials we did when piloting the unit, it took ~4 minutes to start seeing condensation in the flask, and ~6 minutes to see a visible change to the gypsum itself. It takes ~10 minutes for the hot plate to cool down, so doing three trials in one 50 minute period would be tight, thus making this a 1.5 period lab (on a 6 period schedule). It is important to do at least two trials so students can see it's not a fluke.
- Take a look at the **teacher resource video** (AO 03 Gypsum Lab Teacher Guide – Melting Time-Lapse Video.m4v) provided in the downloadable materials for this lab. (This video is mentioned again on the next page and can be used as part of a demo if needed.)

- **Key for the calculations:**

Plug those masses into the formula for gypsum ($\text{CaSO}_4 \bullet 2\text{H}_2\text{O}$) to get a total weight:

$$39.92 (\text{Ca}) + 32.07 (\text{S}) + 4 * 15.99 (\text{O}) + 4 * 1.00 (\text{H}) + 2 * 15.99 (\text{O}) = 171.21$$

$$\text{Just the water (what you'll lose in the reaction)} \quad 4 * 1.00 (\text{H}) + 2 * 15.99 (\text{O}) = 35.98$$

$$\text{Predicted \% Mass Lost: } \left(1 - \frac{171.21 - 35.98}{171.21}\right) * 100 = 22\%$$

At right, image of the lab in process (with crystalline gypsum).

A video has been included in the materials for this unit.

(AO 03 Gypsum Lab Teacher Guide – Melting Time-Lapse Video.m4v)

Check the materials you downloaded. The video may be useful in place of a demo, especially for remote teaching.

