STEM Takes Flight Professional Development Workshop

Post workshop practices

Topic: **The Air Up there**

Presenter(s): **Sandy Davis**

Date: **October 15 and 16, 2018**

Lesson Timeframe: Two and a half hours - during normal lab section

STEM Takes Flight Workshop Resources Used:

- The Air up there Jet Propulsion Lab lesion plan:

  https://www.jpl.nasa.gov/edu/teach/activity/the-air-up-there-making-space-breathable/

- Information from the CubeSat overview document, specifically the "Scrum" method of team management strategies.

Materials:

Index cards, pipe-cleaners, scissors, cotton balls, tape, binder clips, scale, cocoa powder, shoebox, fan, student worksheets

Please explain why these workshop materials were used in this lesson:

I wanted an exercise that promoted group work and creative thinking. I specifically wanted to introduce the students to the importance of Chemistry in real world situations in general and the NASA program in particular.

I thought that the Scrum method of team management worked very well and could be easily applied to this project.

Teacher level: The teacher should know CHM 111 material. The team management information is built into the student worksheet and so familiarity with it by the teacher would be helpful, but not essential.

Student level: This is presented in a CHM 111 course. The student must be able to get information from the periodic table and should be familiar with stoichiometry and gas laws.

Learning styles/intelligences supported:

Working together in a group. Creativity and problem solving. Mathematical calculations. Applying calculations to real world situations.

Overview of the lesson:

The purpose of this lesson is to have students work in groups of 5-6 to design and build an air-recycling system capable of capturing simulated carbon dioxide so that astronauts can breathe safely while on the International Space Station or a future Mars mission. The students will then calculate the efficacy of the filter and use stoichiometry to determine what kinds of chemicals or systems will be needed for human space missions.

Lesson Objectives:

Work as a group to build an air-recycling filter system.

Evaluate the system by testing it.

Use real world problems to solve stoichiometry problems

To learn more about space travel and all that is involved with keeping humans alive

Lesson Content:

I started by showing the following video found online:

https://www.colorado.edu/pathwaytospace/videos/klaus

Dr. Klaus does an excellent job of getting the students to think about what is required to send a person into space and what is required to keep them alive, healthy, happy and prouctive.

The handout I gave the students also had some background about how CO_2 is removed from the air in the international space station and suggests ways that CO_2 may be turned into O_2 on a future Mars mission.

Then I introduced the project that the students would be working on and provided them with a list of materials they would have to build a filter and what parameters they had to keep in mind when building the filter (that it had to fit in the shoebox, must not impede airflow, etc) This is also on the handout I gave them.

Finally I introduced the group management style that they would be using to accomplish the task. I told them about how long they would have and how the Scrum method would work.

Then I let them build. I kept time and stopped them at every 10-12 minutes for them to evaluate their progress check in with each other and figure out what problems there were. I also went to each group as the "director" to have them explain their progress.

They weighed their filters and then tested them by blowing cocoa powder at the filter. The filters were weighed again and the amount of "CO_2" collected was analyzed.

The students then worked through a number of problems associated with CO_2 removal, O_2 production and the problem of bone loss during missions.

Assessment: The students really enjoyed the lesson. The video got them interested and I have to admit that they got into the building better than I thought they would. I actually think they enjoyed doing the calculations afterwards because they were something practical that they could understand.

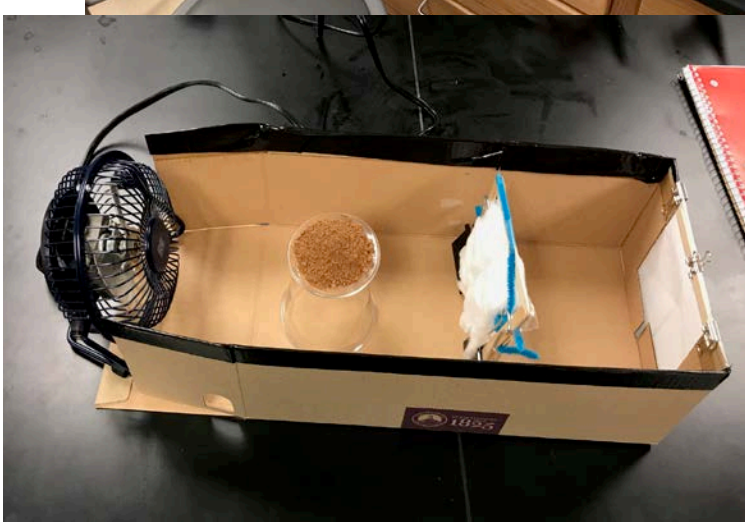
There are a few "tweeks" that I would like to make to the lesson, but overall it was a good activity. I had wanted to make it a bit of a competition but the cocoa didn't fly as well as I thought it would so it was hard to compare the filters because they were exposed to different amounts of cocoa. I think I found that putting a specific amount of cocoa and let the fan run for a specific amount of time worked the best. Then they could be compared equally. I also later thought that I could give them weight parameters as well since the filter should be as light as possible.

Approximately how many students do you anticipate this activity impacted? 38

Additional comments:

I already have another set of problems from the Jet Propulsion lab website that we will do on a different topic when the time comes.

Follow up: Pictures from the lesson:



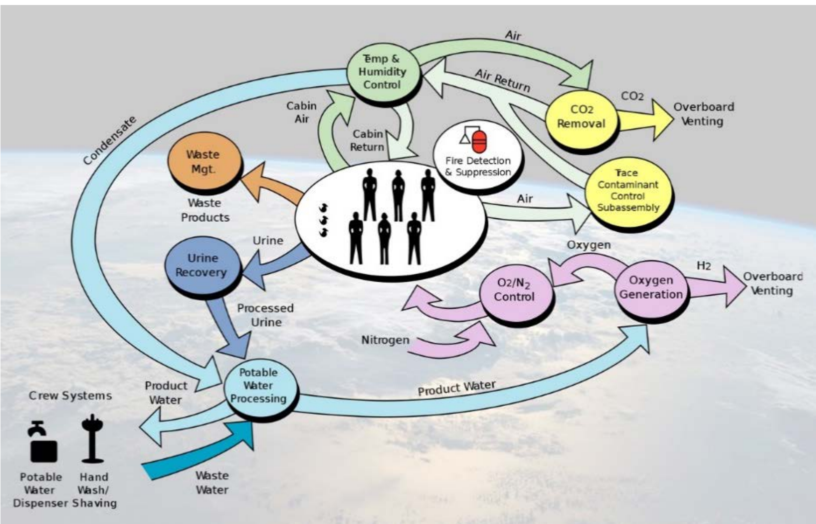
The Air Up There: Making Space Breathable

Background

Whether they're aboard the International Space Station or on a future mission to Mars, astronauts require systems that can create breathable air from their harsh surroundings. And chemistry plays an important role.

For every mission teams of highly qualified engineers, scientists, doctors and technicians known as flight controllers monitor the systems. They work together as a powerful team, spending many hours performing critical simulations as they prepare to support the flight. The flight controllers provide the knowledge and expertise needed to support normal operations and any unexpected events.

One of the flight control positions is the Emergency Environmental, and Consumables Manager (EECOM). One of the responsibilities of the EECOM flight controller is to monitor and regulate the cabin atmosphere, which includes gas concentrations and pressures within the cabin. Maintaining these parameters ensures a habitable cabin atmosphere and temperature onboard.



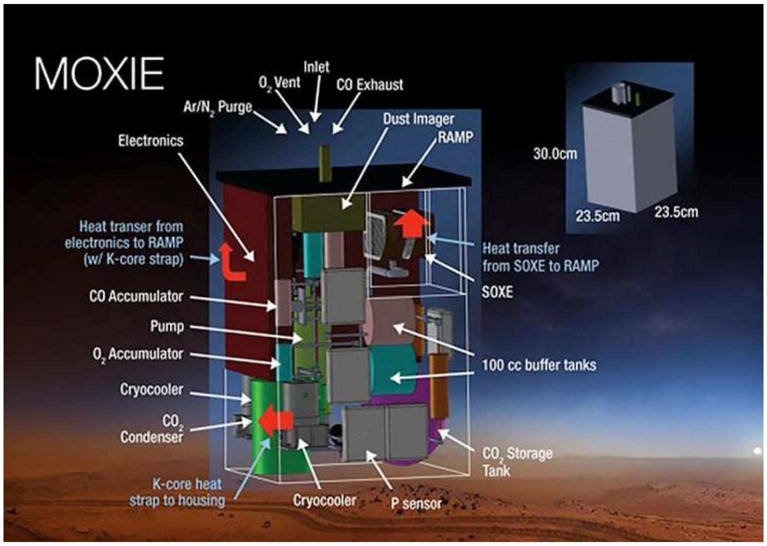
This diagram shows the interactions between the various life support systems on the International Space Station, including the air filtration system that removes toxic carbon dioxide from the air. Image credit: NASA

Astronauts Rominger and Jernigan during LiOH canister change out

Currently, the International Space Station (ISS) uses an absorption method to remove carbon dioxide (CO_2) from the air. The absorption is accomplished in a chemical reaction using a sorbent called lithium hydroxide (LiOH). This method relies on the exothermic reaction of lithium hydroxide with carbon dioxide to create lithium carbonate (Li_2CO_3)(s) and water (H_2O). Lithium hydroxide is an attractive choice for space flight because of its high absorption capacity for carbon dioxide and the small amount of heat produced by the reaction.

But when it comes to a future human mission to Mars, things get a bit more complicated. On the ISS, when filtration canisters are used up, we can send more on supply rockets. But on Mars, we can't easily resupply the LiOH canisters. That means we need technology capable of producing breathable air over a longer time period.

One technique under consideration for Mars is to use chemistry and catalysis to transform the Red Planet's harsh and unbreathable carbon dioxide atmosphere directly into oxygen. To test this technique, NASA will send a small instrument called Mars Oxygen In Situ Resource Utilization Experiment, or MOxIE, to the Red Planet in 2020 aboard the Mars 2020 rover. By the 2030s, it's possible NASA could send a larger version of MOxIE to Mars, and allow the system to run and create a safe, habitable area before astronauts even arrive. If successful, this technique will allow us to use an abundant resource on Mars to create a breathable environment for astronauts.



Procedures

In this activity, the class has been tasked by NASA to develop a device to recycle carbon dioxide into oxygen. This will allow a group of astronauts heading to Mars to survive in an atmosphere that would be otherwise inhospitable. The device, built by student engineers, should be able to capture simulated toxic carbon dioxide molecules represented by pepper, cocoa powder, etc. while allowing air to flow through to the other side of the device.

As a team, you will use the material provided (cotton balls, pipe cleaners, index cards, etc.) to build a filter cartridge capable of capturing simulated toxic carbon dioxide.

The filter cartridge

- must fit standing in the shoebox
- cannot completely impede airflow
- must be built only with the materials provided
- can be tested several times before final implementation

Details:

1. Draw out a design or blueprint before beginning construction
2. Weigh the filter cartridge before testing it and record on the student worksheet.
3. Test the filter cartridges by placing it in the shoebox and using the fan or hairdryer to blow the particulate across them. A successful trial will capture the particulate in the filter cartridge while maintaining airflow at the exit.
4. Once the test is complete, reweigh the filter cartridge and record the post-test mass on the student worksheet.

Time Management:

Each team will be given 3 “sprints” each consisting of 3 ‘days” (21 minutes long) in which to design the filter.

There will be different types of meetings throughout the activity

- Planning Meeting: This is an initial meeting to go over the project and set up initial tasks. (5 minutes)
- Daily SCRUM meeting- It occurs at the end of a “day” and is very brief. The Scrum master asks everyone on the team 3 questions: 1. What did you get done today? 2. What will you work on next? 3. Is anything in your way in order for you to continue? As these questions are being asked
    - Identify new tasks to be started
    - classify tasks that have been started as “doing”
    - classify tasks that have been completed as “done”.
- Sprint Review- at the end of a sprint review what is working/not working. At the end of the 2nd sprint, the team presents what is accomplished to the Product owner (the teacher)

Team Management:

One person will be chosen as the SCRUM master. This person will

- Represent management to the project
- Remove obstacles
- Ensure the team is fully functional and productive
- Shields team from external interferences.

The teams otherwise are self-organizing.

- There is no hierarchy of positions
- Each member contributes
- Students volunteer for tasks as they are identified
- The only identified member is the SCRUM master who is there to remove obstacles and lead meetings. Otherwise all decisions are made by the team.

Overview:

- Planning Meeting
- Sprint 1
    - After the each “day” have a SCRUM meeting
        - Not for problem solving
        - Only team members can talk
        - Everyone answers 3 questions
    - Sprint Review
- Sprint 2
    - Daily Scrum meetings
    - Sprint review for product owner
        - Team presents what has been accomplished/ demo
        - Whole team participates
- Sprint 3
    - Daily Scrum meetings
    - Sprint review
- Test product

Student Data Sheet:

Mass of filter before testing ____________________________________

Mass of filter after testing ______________________________________

Mass of CO_2 collected ____

On the International Space Station, a device called the Contaminant Control Cartridge, which contains lithium hydroxide (LiOH), removes carbon dioxide (CO_2) from the air. This process is represented by the following equation:

$$\mathbf{2\ LiOH(s) + CO_2(g) \rightarrow Li_2CO_3(s) + H_2O(g)}$$

1. Using the mass of carbon dioxide captured by your filter, determine how much lithium hydroxide each of your filter cartridges would need in order to effectively produce water.

2. A typical crew consists of six individuals and each Contaminant Control Cartridge (CCC) contains 750 g of LiOH. Assuming that each crewmember expels 42.0 g of CO_2 per hour on average and that a mission is scheduled to last 18 days, how many cartridges must be carried on board the station?

3. On the space shuttle, the CCC was changed daily or when the partial pressure of CO_2 reaches 5.0 mmHg. The space shuttle cabin has a volume of 65.8 m^3 and the total pressure inside is 1.0 atm and the temperature is 25 ^oC. When the partial pressure of CO_2 reaches 5.0 mm Hg, what mass of LiOH would be required to remove the CO_2?

On Mars, a device called the Mars Oxygen ISRU Experiment, or MOxIE, could convert the toxic carbon dioxide atmosphere to oxygen and vent out carbon monoxide in order to provide a breathable atmosphere for astronauts upon arrival.

Balance the equation below and answer the following questions:

$$CO_2(g) \quad \rightarrow \quad O_2(g) \; + \quad CO(g)$$

4. How many grams of oxygen would be produced by 1 kg of carbon dioxide? How many grams of carbon monoxide?

5. Presently, MOXIE is capable of producing oxygen at a rate of 12 g per hour. If the astronauts require 30 kg of oxygen per month, how many days would MOXIE have to run in order to supply one month's worth of oxygen for one astronaut?

6. The byproduct of MOxIE, carbon monoxide, is also very poisonous. Discuss with your group how you could design a system to be sure CO is kept away from the astronauts and handled safely.

Another stoichiometry issue facing astronauts on prolonged missions is loss of bone density. On Earth, we lose roughly 1% of bone mass (calcium carbonate) every year, yet astronauts lose 1-2% every month! One theory is this is due to buildup of sulfuric acid in our blood, arriving via amino acids obtained from animal protein.

7. Write a complete balanced equation for the reaction between sulfuric acid and calcium carbonate to form calcium sulfate, carbon dioxide and water.

8. While in space, an astronaut loses approximately 200 mg of calcium carbonate per day. Calculate the mass of sulfuric acid used in this process.

9. A visit to Mars is on the horizon, but the duration of time required for a Mars mission is a concern to NASA. Currently, astronauts spend an average of 6 months on an ISS mission. A trip to Mars, however, would require 18 months of round-trip travel and an extra two to six months of on-the-ground research. It is currently projected that an astronaut would lose 1.5% of his or her pre-flight bone mineral density per month while on a Mars mission. Assume that there are 1,500 g of calcium in an astronaut's bones pre-flight. Predict the mass of calcium that would remain after one year of a Mars mission.

.