Inquiry-Based Activity 2: Filling Tank

Student Name _____

In this experiment, a vacuum desiccator will be used to simulate the filling of an evacuated tank. You will measure the temperature before and after evacuating the system and observe the temperature inside the "tank" both when air is removed and when it flows back in.

***Materials**:*

1 Vacuum Desiccator (referred to as "vessel" or "chamber")
1 Thermocouple with Thermocouple Reader
1 Vacuum pump or access to a house vacuum
1 vacuum tubing

***Safety**:*

As always, wear appropriate eye protection.

***Directions**:*

1. In this experiment, you will start with a chamber filled with air at ambient conditions.
   a. In the first part of the experiment, you will use a vacuum line to suck air out of the chamber until the pressure on your vacuum line and the pressure inside the chamber are equal. What do you think will happen to the temperature inside the chamber? Will it increase, decrease or remain the same? Why?

   b. After the vessel is put under vacuum, you will let it equilibrate. Then you will open the valve, and allow ambient air (room temperature, 1 atm) to flow into the chamber until the pressures are equal. While the tank fills from the atmosphere will the temperature inside the tank increase, decrease or remain the same? Why?

2. When you are finished with your predictions, place the thermocouple wire within the desiccator near the valve. If you are using an ultrathin thermocouple place only the wire. If it is a larger wire with a small thermocouple reader, place the whole unit within the desiccator. Make sure the thermocouple reader is on and that you can read it.
3. Attach the vacuum tube from the vacuum source to the desiccator. The desiccator should have a tight fit. Turn the three way valve so that it is open to the desiccator and the vacuum source.

4. Turn on the vacuum source or open the house vacuum valve and watch the temperature. What happened to the temperature as air left the system?

5. Let the temperature return to room temperature. This should only approximately 20 seconds.
6. Turn the valve so that the desiccator is cut off from the vacuum source. Then carefully remove the tube from the valve.
7. When you are ready, open the valve so that air fills the vessel at a moderate rate. What happened to the temperature inside the desiccator as the vessel filled?

8. Feel free to repeat this experiment.

***Analysis – to be completed after class and handed in**:*

1. Revisit your predictions in question 1 of the directions. How did your results compare with your predictions? If it was different from your prediction explain why. Feel free to discuss this with your group.
2. The Joule-Thompson coefficient for air is 0.232 °C/atm. For only at the "filling" part of the experiment, calculate what the temperature change is for the air filling the tank. You may assume that the container starts at 0 atm. How does it compare to the temperature change observed?
3. What about the change in kinetic energy? You may assume that the velocity of the air entering is 19.1 m/s and the density of air at STP is 1.17 g/L. Is this significant enough to change the temperature of the gas?
4. Draw a diagram of before and after for the tank and perform an energy balance on this system. You may assume the vessel is adiabatic on a short time scale and neglect changes in potential energy.
5. Find out from your professor or TA what the pressure of your "vacuum" is at (it is likely *not* 0 atm). With that value, calculate the temperature increase because of that pressure increase. How does it compare to your experimental results?
6. After all these calculations what is the reason for an increase in temperature when the desiccator fills?
17. Imagine you work for Air Products after graduation at a site that is responsible for filling compressed gas tanks. The tanks initially are empty, and then have gas pumped into them to a final pressure of 2000 psi_g (138 bar). What does the experiment you just performed tell you will be a significant issue for this operation?
18. Please visit the website link provided by your professor to answer a few questions about this activity. Don't forget to include your name / identifying number.

