## Experiment #1: Action of a Vacuum Pump and the Mass of Air

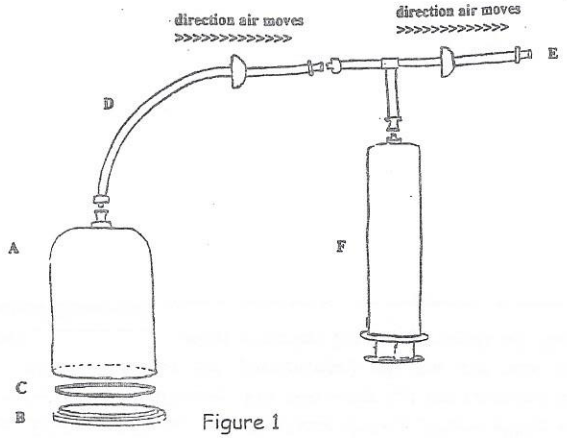


Figure 1

1. Study figure 1. The check valves will easily allow air to flow in the directions shown by the arrows, but not in the other direction. **What is inside the bell jar now?** (Hint: "Nothing" is not the correct answer).

   _____

2. Have your partner push down on the bell jar to make certain that the bell jar is pressing against the "O" ring at the base of the apparatus. While they are doing this, pull the piston of the syringe out to the 60 mark. **Where does the air come from that fills the syringe?**

   _____

3. Let go of the piston and watch what happens. Now quickly push the piston all the way back into the syringe. Listen for the sound of moving air. **Where did the air go that was in the syringe?**

   _____

4. Describe, in words, the amount of force that was required to pull out the piston.

   _____

5. What kind or kinds of forces resisted you as you pulled out the piston?

   _____

6. Repeat these steps five times:
   a. Pull the piston out to the 60 mL mark.
   b. Let go of the piston and see what happens.
   c. Push the piston all the way back in.

   **What happened to the amount of force required to pull out the piston? Try to explain why the amount of force changed in this manner.**

   _____

   _____

7. Pull the piston out of the syringe out to the 60 mL mark and push it all the way back in. Do this 24 times. You should not notice any sound of air movement by the end of this step. **What is in the bell jar now?**

   _____

8. Disconnect (D) from (E). Place the bell jar, with the hose (D), on to the balance. Make sure that the hose (D) is not touching anything. **Find the mass and record it.**_____

9. Loosen the connection between the hose (D) and the bell jar, remove the hose and then reconnect it. Did you hear the movement of air? **What was the air doing?**_____

10. Reconnect the hose and place the bell jar on the balance. Make sure that the hose (D) is not touching anything. **Find the mass and record it.**_____

11. Calculate the difference between the balance readings in steps 8 and 10. **What is this answer the mass of?**_____

## Experiment #2: The Density of Air

Think back to experiment #1 when you weighed the bell jar and the hose in step #8. **Was the bell jar really empty when you weighed it?**_____
The following experiment will help you to find out.

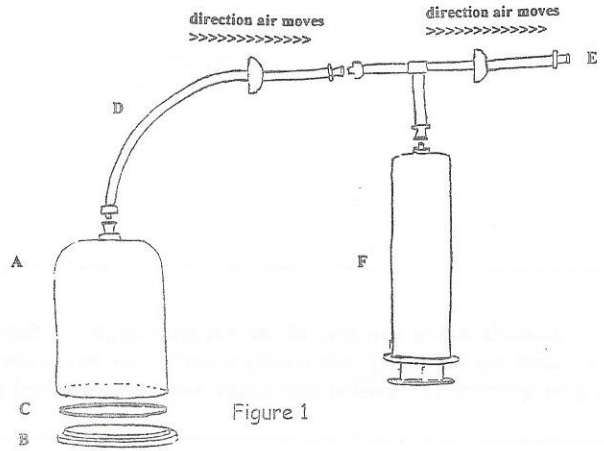

Figure 1

1. Reassemble the apparatus as in figure 1. Pump the piston of the syringe 10 times.

2. Disconnect hose (D) from hose (E). Hold the bottom portion of the bell jar and place entirely into water with the dome facing downward. Keeping the bell jar upside down in the water, disconnect the hose (D). **Describe what happens and explain why it happens.**
   _____
   _____.
   _____

3. Put your finger over the hose fitting on the bell jar and lift it out of the water. Keep your finger over the hose fitting. There will be some air left in the bell jar, showing that the pump has not removed all of the air. **What fraction (or percentage) of the air was left? (Estimate)** _____ **What fraction (or percentage) of the air was removed(Estimate)** _____

4. Use a graduated cylinder to measure the volume of water in the bell jar. This is equal to the volume of air removed. **Record this volume.**_____

5. Now you know the mass (experiment #1, step 11) and the volume of the air that you removed. **Calculate the density of air. Show your calculations. Remember to include units of measurement in your answer.**

6. Dry out the apparatus as well as you can with a towel.

Thought Question:

1. How would the density of air differ in locations of greatly different altitudes?

Experiment #3 Removing Atmospheric Pressure From Objects

1. You will obtain one marshmallow "peep" from your instructor. Air has been blown into the peep at the factory. Why is the peep now the size it is, and not bigger?

2. Place the peep inside the bell jar, and assemble the apparatus as shown in Figure 1. Start pumping the piston. What happens to the peep?

3. Why did the peep change in the way it did? Why didn't it do this before you started pumping?

4. Loosen the connection between the hose (D) and the bell jar until you hear the movement of air. What happens to the peep? Why does this change occur?

5. Open the apparatus and take out the peep. Eat it.

6. Now stick the suction cup to the center of the bottom plate, and put the bell jar over it, so the suction cup is inside. Have someone hold the apparatus with the hose down and the plate up. Why does the suction cup stick tightly to the bottom plate instead of falling off?

7. While holding the apparatus with the hose down and the plate up, pump the piston several times, until something happens to the suction cup. What happens? What is the explanation for this?

## Experiment #4: Liquids in a Vacuum

1. Imagine some water from the hot water tap, that has just been poured into a cup. Why isn't the water boiling?

2. Think about the boiling process. The water becomes gas (steam) bubbles that take up much more room than the water that made them. Do you think that the presence of atmospheric pressure helps the boiling process, or makes it difficult?

3. Can you predict what would happen if we put a container of hot tap water into the bell jar and pump the air out?

4. Fill the small clear transparent vial about halfway with hot tap water (ask your instructor – use water that is not hot enough to burn you). If a thermometer is available, measure the temperature of the water. Do this quickly so the water does not get cool. If the water temperature is safe, and you don't have a thermometer, you might judge its temperature by dipping your thermometer briefly into the water. Note any observations about the temperature.

5. Place the vial on the bottom plate, inside the bell jar, and assemble the apparatus as shown in figure 1. Have someone else hold the bell jar in position so it does not tip over. Start pumping the piston, and watch the vial of water. Something should happen after several strokes of the piston. What happens?