Scientific Method Lab

Instructions:

1. Go to the Gas Laws Intro and select either option.
2. Answer the questions below to use the scientific method to design your experiment.
3. Each section is worth 4 points.

Variables

Use the simulation above to design an experiment. Identify one manipulated variable that you will change and one responding variable that you will *measure with numbers*. Label the variables clearly.

Answer: The **manipulated independent variable** that I will change is the number of particles. The **responding variable** that I will measure is the pressure. Initial conditions: P Pressure P = 0. V Volume is unknown, 5 nm width. n Number of particles n = 0. R is the Ideal Gas Constant 7.30240507295273 x 10^{-1} atm · ft^3 · $lbmol^{-1}$ · $°R^{-1}$. T Temperature is unknown, but will be kept constant in the experiment.

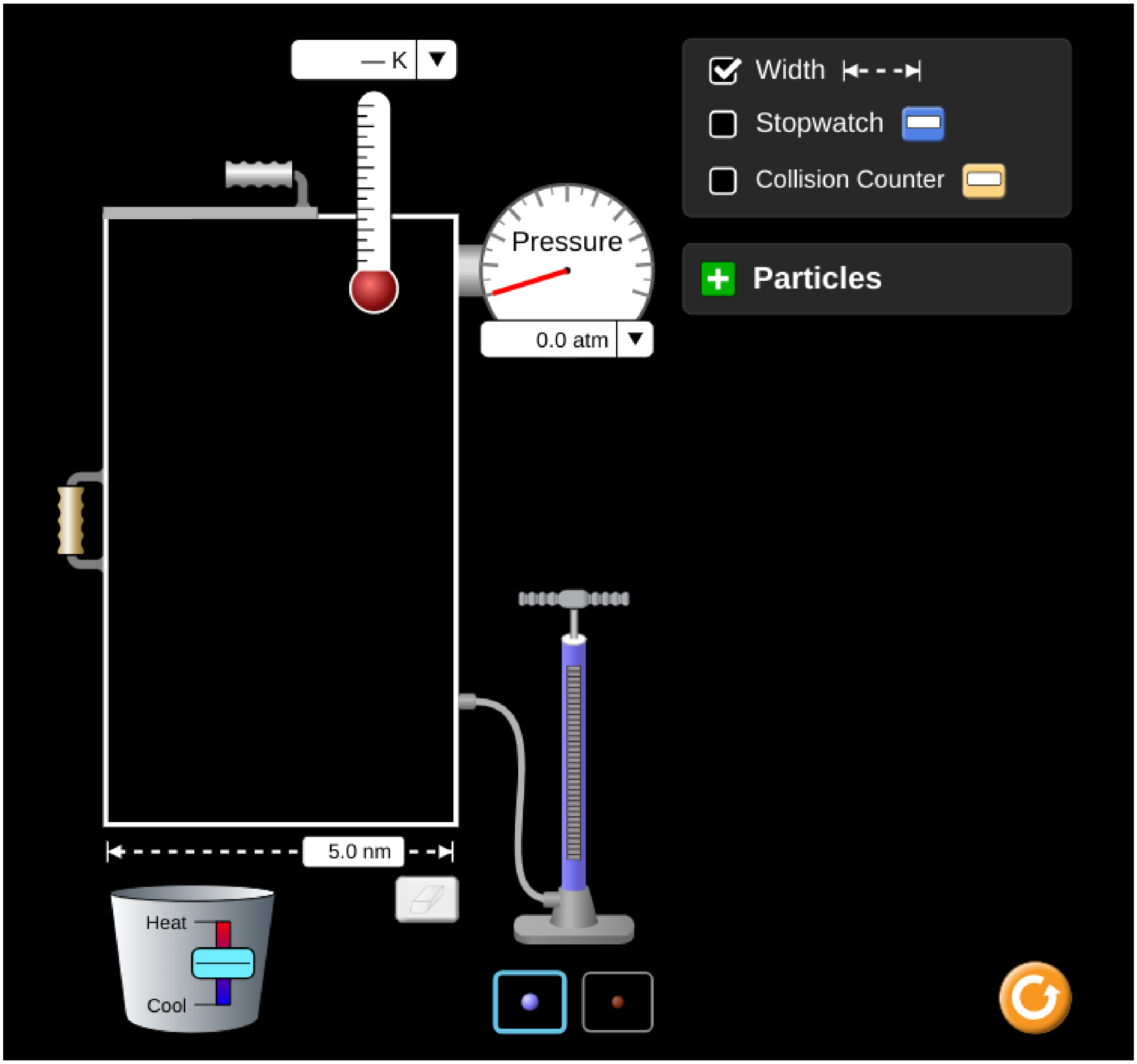

Figure 1. Initial set-up of the experiment

Hypothesis
Write a hypothesis predicting the result of an experiment. Be specific and use words like "increase" and "decrease" and not words like "change".

Answer: I will test the hypothesis that the gas behavior will conform to the Ideal Gas Formula below. It predicts:

If the number of particles is increased while temperature and volume are held constant, the pressure will increase.

$PV = nRT$ [Ideal Gas Formula]
**P is pressure. V is volume. R is the Ideal Gas constant. The number of particles is indicated by the n variable. T is temperature.*

Eventually pressure may exceed the maximum and the container will rupture. Then the pressure will decrease to 0 atm, or equilibrium pressure.

Procedure

Write a clear *list of numbered steps* that you will follow to perform the experiment. Another person should be able to follow these steps to repeat the experiment.

Answer:

1. Set the volume of the container so that the width is 5 nm.
2. Click the heavy particle source to increase the particle count by 50.
3. Allow the conditions to stabilize and record particle count and atmospheric pressure.
4. Record temperature.
5. Repeat steps 2 - 4 until the chamber lid blows open. Screen capture.
6. Monitor the pressure and temperature with the lid open for 60 seconds or until conditions reach equilibrium.

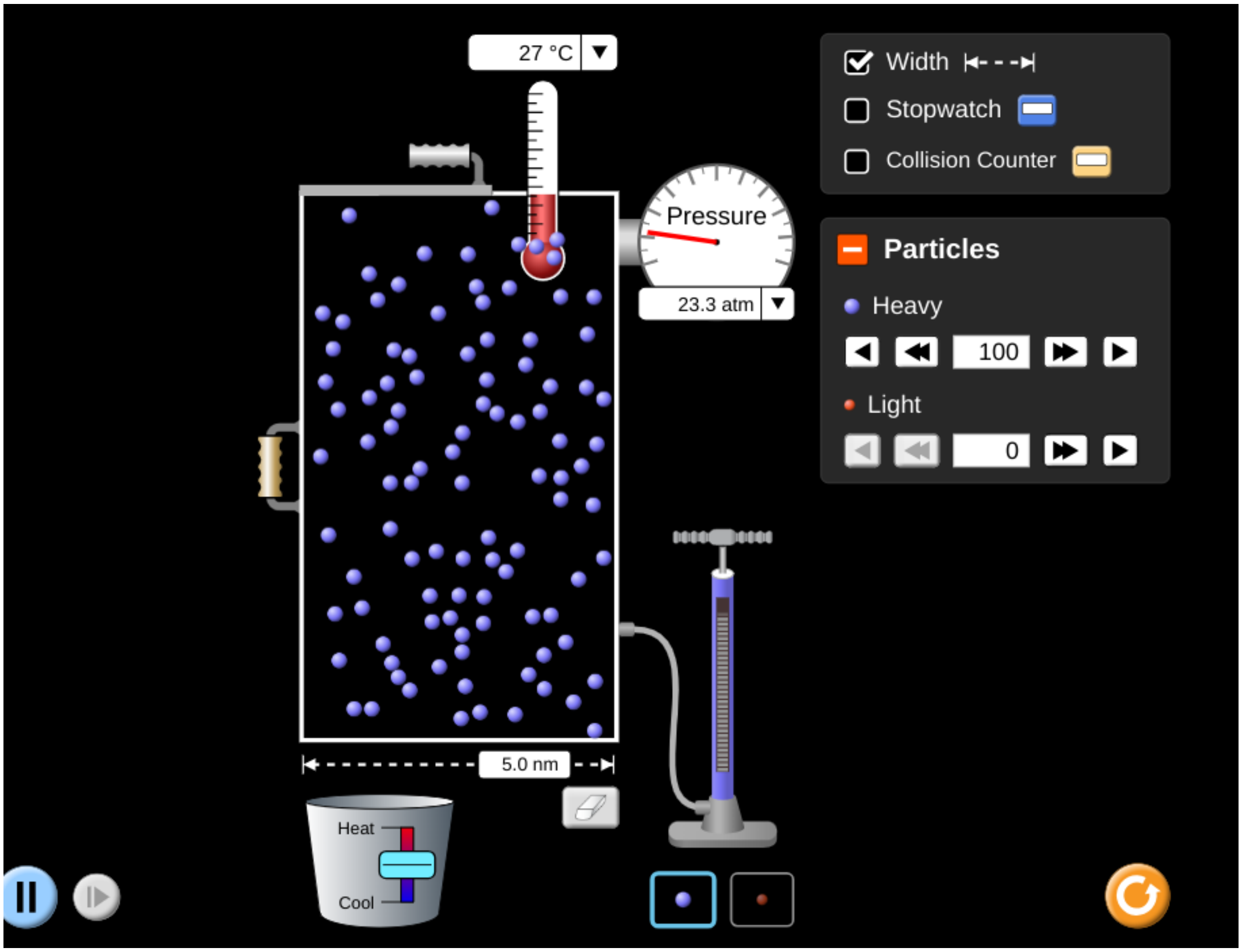

Figure 2. Progress of the experiment with 100 particles injected

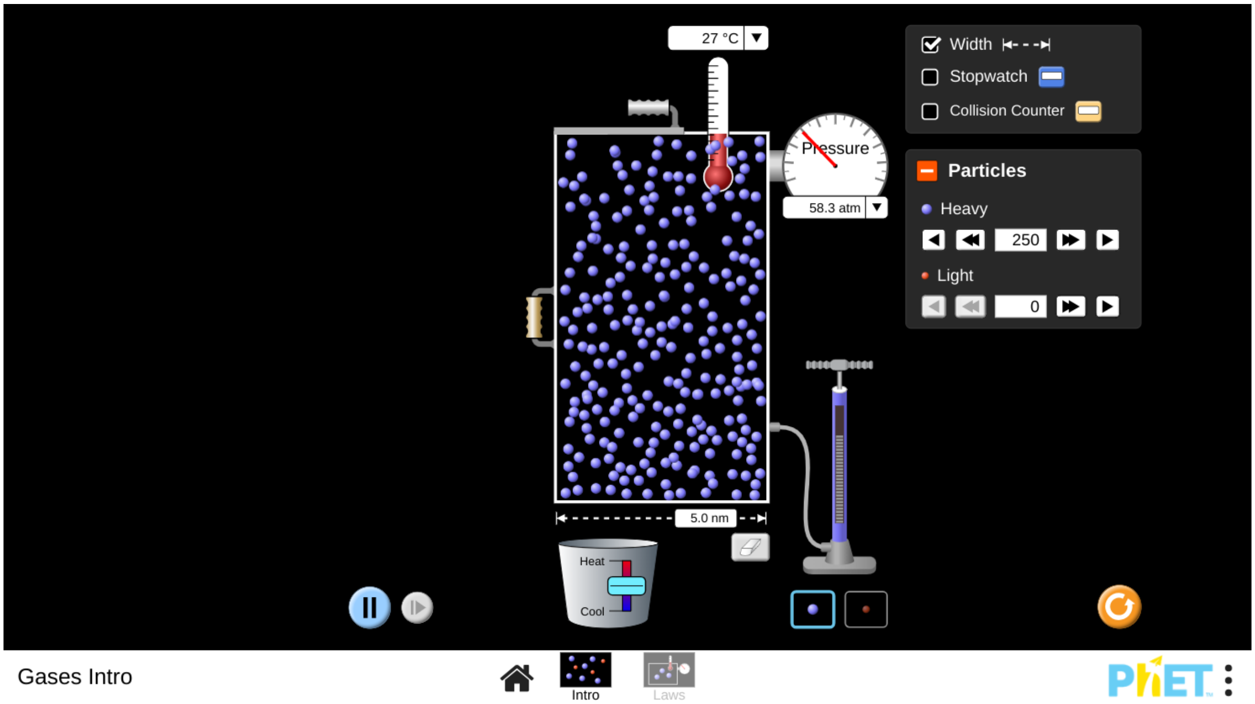

Figure 3. Progress of the experiment with 250 particles injected.

Figure 4. Progress of the experiment with 700 particles injected.

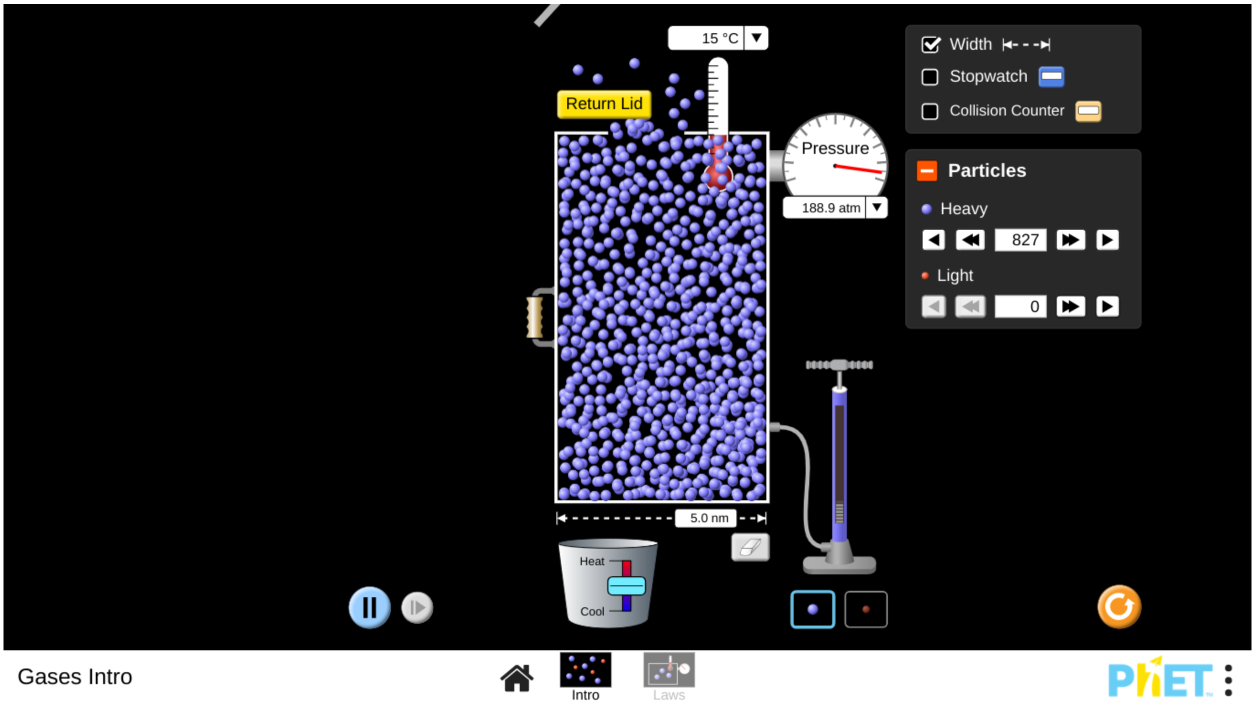

Figure 5: The container ruptured when there were more than 800 particles in the chamber.

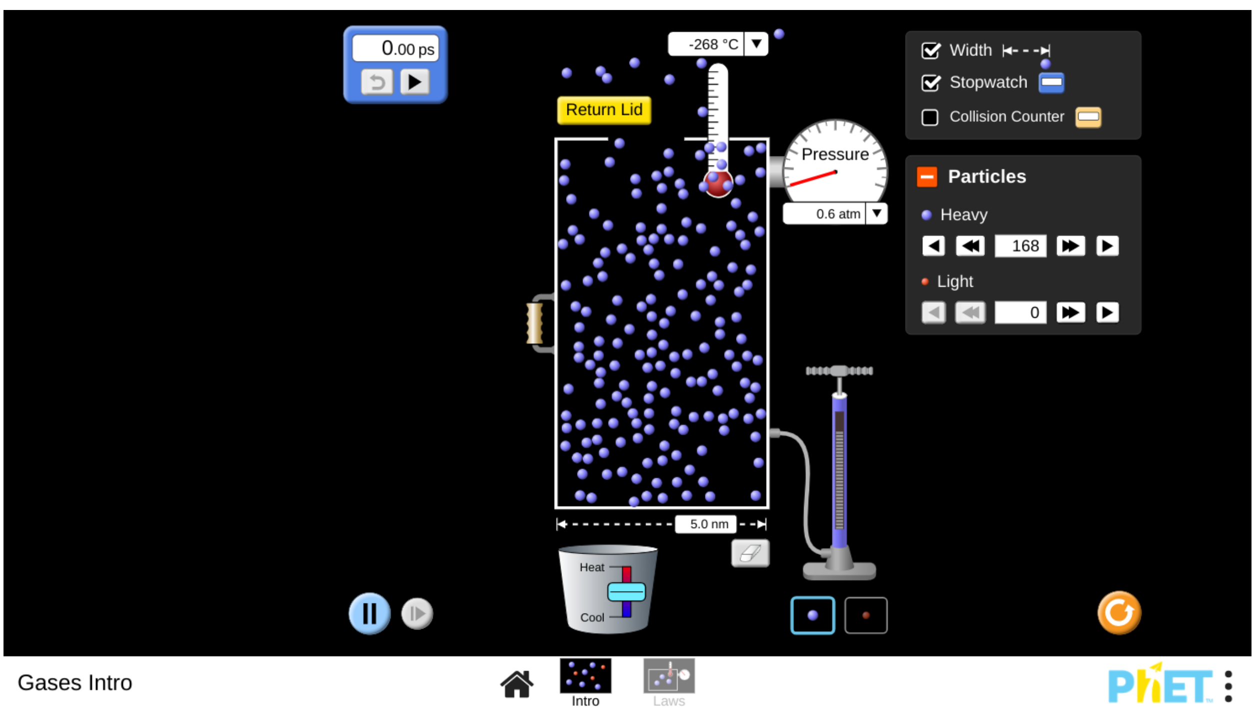

Figure 6. Progress of the experiment after the chamber ruptured and the refrigeration effect was observed as the gas cooled from 27 C to -268 C.

Collect and present your data. Use Insert > Table above to create a data table. Your data table needs to include numbers from the simulation.

Answer:

The pressure increased linearly as particles of gas were added to the chamber. Heavy particles were added in increments of 50. The pressure, the dependent responding variable, increased linearly with the increasing number of particles. With 0 particles the pressure was 0 atm. At 50 particles the pressure was 11.7 atm. At 800 particles, the pressure was 186.4 atm. At somewhere between 800 and 900 particles the maximum pressure was exceeded and the lid blew off the chamber.

There was no temperature reading before particles were added to the chamber. Once 50 particles were in the chamber, the temperature read 27 C and stayed constant up until more than 800 particles were added.

Once the lid was opened, gas escaped. The pressure fell. The gas cooled rapidly until it reached -263 C.

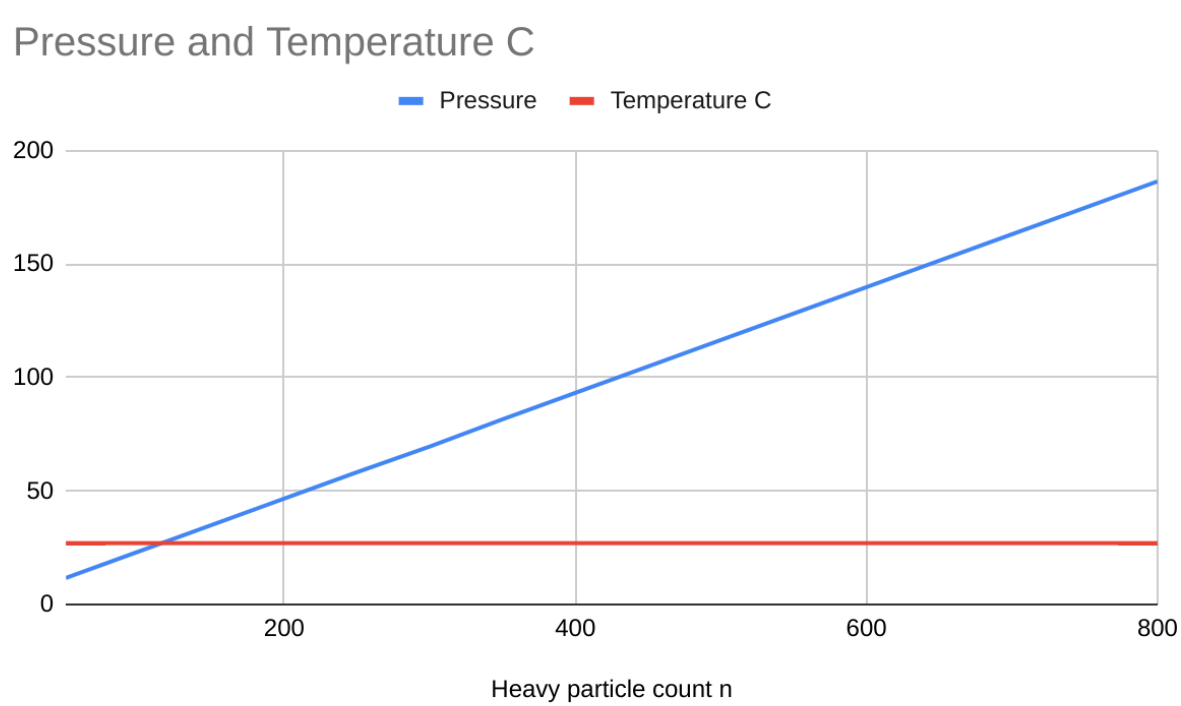

Figure 7. Graph showing the linear increase of pressure in proportion to the number of particles added. Temperature remained constant at 26 C.

Experiment Result Table

Heavy particle count n	Pressure	Temperature C
50	11.7	27
100	23.3	27
150	35	27
200	46.6	27
250	58.3	27
300	69.6	27
350	81.6	27
400	93.2	27
450	104.9	27
500	116.5	27
550	128.2	27
600	139.8	27
650	151.5	27
700	163.1	27
750	174.8	27
800	186.4	27
896	208.2	26
893		-3
786		-100
709	64.4	-157

605		-206
492	12.7	-240
283	2.5	-267
267		-263
220	1.3	-266

Table 1: Experimental results of gas pressure experiment.
The independent variable, particle count, was increased in increments of 50 until maximum pressure was reached. The container pressure relief lid opened and then particle count decreased as the gas escaped. The temperature was a constant 27 C in the initial phase, then dropped rapidly when the chamber opened.

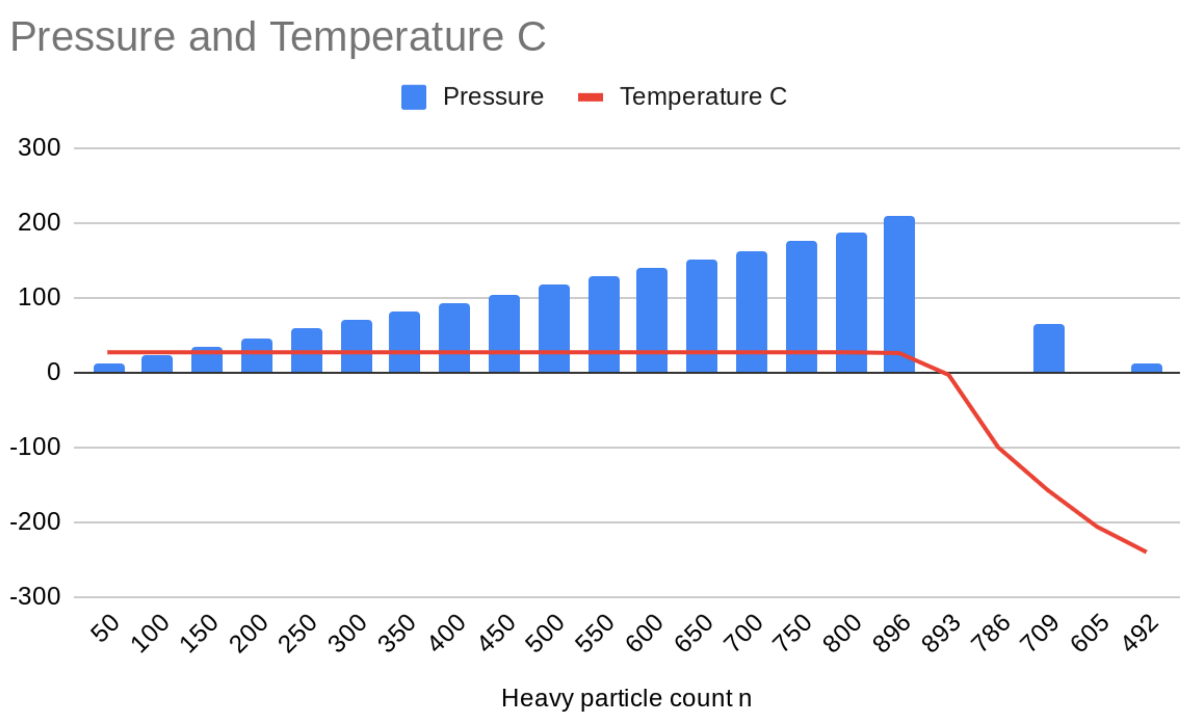

Figure 9. Graph showing that temperature dropped steeply after maximum pressure was exceed. The top of the chamber opened and gas escaped. Pressure reduced to 0.6 atm.

Conclusion

Summarize your experiment. Restate your hypothesis and whether or not the data supported your hypothesis. If your experiment was inconclusive, describe what further research would be needed.

Answer: The hypothesis that pressure would increase linearly as the number of particles increased was confirmed. The surprise of this experiment was how quickly the temperature cooled once the top blew off the chamber. There was a refrigeration effect. The temperature dropped from 27 C to - 268 C as the gas leaked out of the chamber and the pressure decreased, finally reaching an equilibrium of about 0.6 atm. The experiment confirmed the Ideal Gas Law and revealed a thermodynamic refrigeration effect.