Popcorn Laboratory

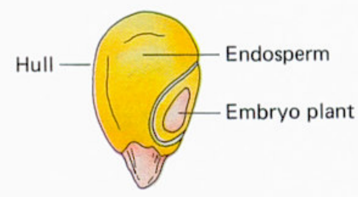
7-7 Application: Why Popcorn Pops

Almost everyone loves popcorn. Yet you may wonder: How does something as unappetizing as a kernel of corn become so delectable? Part of the answer lies in the starchy composition of corn and part in the physical behavior of gases.

A kernel of corn is composed mostly of carbohydrates and water. The kernel has three parts. The outer shell is called the hull (pericarp). The inside of the kernel is composed of starch (endosperm) and an embryo plant (see Figure 7-19). The endosperm acts as food for the embryo as it germinates.

When the kernels are placed into heated oil or a hot-air popper, the water inside the kernel becomes superheated, which means it is hot enough to vaporize but does not have the room to do so. The rapidly moving water molecules cause a tremendous increase in pressure on the hull (the kernel's container). The superheated water penetrates the starch structure under a pressure of about 900 kPa. Because the pressure is so great, the hull ruptures. The pressure surrounding the starch is then greatly reduced (to about 100 kPa, or atmospheric pressure). As the pressure drops, the water vaporizes and expands as described by Boyle's law. This change causes the starch to expand to about 30 times its original size. The expansion is so rapid that the kernel explodes, or pops.

Figure 7-19 Under proper conditions, a corn kernel produces a snack that so many people love to eat. The white fluff of the popcorn kernel is the expanded endosperm.



Problem: Popcorn kernels explode into delightful, edible parcels because of a build-up of pressure inside the kernel during heating. In this experiment you will try to calculate the pressure inside a kernel of corn. You will also try to determine the percentage of water inside the kernel.

Hypothesis : ____

____

Materials:

Procedure:

1.Record the mass of the Erlenmeyer flask(250 mL)
2.Add 17 kernels and reweigh.
3.Calculate the mass of the 17 kernels.
4.Using the water displacement method, find the volume of the kernels. Dry the kernels.
5.Add two drops of cooking oil and the 17 kernels to an empty dry Erlenmeyer flask(250 mL).
6.Determine the mass of the flask, the oil, and the popcorn.
7.Put the Erlenmeyer flask on a hot plate (3/4 of the power) and cover it with a gauze.
8.Shake the Erlenmeyer flask as it is heating with the tongue.
Do not burn the popcorn. If you do, you'll need to start over again.
9.Remove it from the hot plate when most of the kernels have popped.
Let the flask cool. If you see water condensed on the upper part of the flask, make sure it is gone before you mass it again.
10. Measure the atmospheric pressure in the classroom.

Results:

1. Mass of the 250 mL Erlenmeyer flask =	______	g
2. Mass of the 250 mL Erlenmeyer flask + 17 kernels =	______	g
3.Calculate the mass of the 17 kernels	______	g
4.Volume of the 17 kernels ______ mL=	______	L
5.Mass 2 drops of oil + 17 kernels of popcorn + 250 mL flask =	______	g
6.Cool the flask and mass its content after popping the kernels =	______	g
(remove wire lid and the water vapour at the top)		
7.Number of un popped kernels =	______	g
8.Mass of the popped kernels =	______	g
9.Atmospheric pressure	______	kPa
10.Molar mass of water(H_2O)	______	g/mol
11.Temperature of the boiling oil 273.15 K + 225˚C =	______	K

Calculations:

1.Determine the percentage of water in the kernel that popped.

Mass of water lost (Results #5 - #6) x 100 = _______%
Mass of 17 kernels (Result #3)

2.Determine the pressure (p) inside the kernels that popped (pv = nRT)

3.Calculate the % of kernels that didn't pop.

Number of un popped kernels x 100 =
Number total of kernels

Assessing Laboratory Learning:

1.How does heating popcorn affect the pressure inside the popcorn ?

2.a) Name four variables that characterize a confined sample of gas.

b) Which variables can be solved for by using the ideal gas equation ?

3.Calculate the pressure of 1.65 g of helium gas at 16˚C and occupying 3.25 L.

4.What mass of oxygen gas (in grams) is in 2-L container of this gas at 25˚C and pressure of 202.65 kPa ?

Popcorn lab teacher version

Material : -safety glasses, -Erlenmeyer flask 250 mL, -heating plate, -aluminum square, -kernels, -eye dropper, -oil, -tongue

Results:

1. Mass of the 250 mL Erlenmeyer flask.	**≈ 125.19 g**
2. Mass of the 250 mL Erlenmeyer flask + 17 kernels	**≈ 128.13 g**
3.Calculate the mass of the 17 kernels	**= 2.94 g**
4.Volume of the 17 kernels	**≈ 2 mL= 0.002 L**
5.Mass 2 drops of oil + 17 kernels of popcorn + 250 mL flask	**= 128.13 g**
6.Cool the flask and mass its content after popping the kernels	**= 127.78 g**
(remove wire lid and the water vapour at the top)	
7.Number of unpopped kernels	**= 2**
8.Mass difference after the kernels pop	**= 0.35 g**
9.Atmospheric pressure	**= ? kPa**
10.Molar mass of water	**= 18.02 g/mol**
11.Temperature of the boiling oil 273.15 K + 225˚C =	**≈ 498.15 K**

Calculations:

1.Determine the percentage of water in the kernel that popped.

$$\frac{\textbf{Mass of water lost (Results \#5 - \#6)}}{\textbf{Mass of 17 kernels (Result \#1)}} \times 100 = \frac{128.13 - 127.78}{2.94} = 11.91\ \%$$ **(usually between 2 & 10 %)**

2.Determine the pressure(p) inside the kernels that popped (pv = nRT)

p= ?
v= 0.002 L
m= 0.35 g
M= 18.02 g/mol
R= 8.31 kPa • L / mol • K
T= 498.15 K

$$pv = \frac{mRT}{M}$$

$$p \cdot 0.002 = \frac{0.35 \cdot 8.31 \cdot 498.15}{18.02}$$

$$p = 40\ 201.7 \text{ kPa}$$ **(usually over 30 000 kPa)**

3.Calculate the % of kernels that didn't pop.

$$\frac{\textbf{Number of unpoped kernels}}{\textbf{Total number of kernels}} \times 100 = \frac{2 \times 100}{17} = 11.76\ \%$$

Assessing Laboratory Learning:

1.How does heating popcorn affect the pressure inside the popcorn ?

As the popcorn heats , the water in the kernel vaporizes with about a thousand fold increase in volume. (The volume of 1 mole of liquid water is 18 mL where as a mole of vapor is about 22 000 mL. Since it is confined, the volume can't increase but pressure will in direct proportion.)

2.a) Name four variables that characterize a confined sample of gas.

Pressure, volume, temperature and number of moles are the variables which describe any sample of gas.

b) Which variables van be solved for by using the ideal gas equation ?

$$p\,v = n\,R\,T \quad \text{or if} \quad n = \frac{m}{M} \quad \text{then } p\,v = \frac{m\,R\,T}{M}$$

3.Calculate the pressure of 1.65 g of helium gas at 16˚C and occupying 3.25 L.

p= ?
v= 3.25 L
m= 1.65 g
M= 4.00 g/mol
R= 8.31 kPa • L / mol • K
T= 273.15 K + 16˚C= 289.15 K

$$p\,v = \frac{m\,R\,T}{M}$$

$$p \cdot 3.25 = \frac{1.65 \cdot 8.31 \cdot 289.15}{4.00}$$

$$p = 304.98 \text{ kPa}$$

4.What mass of oxygen gas (in grams) is in 2-L container of this gas at 507.21˚C and pressure of 202.65 kPa ?

v = 2 L
T = 273.15 K+ 507.21˚C= 780.36 K
p = 202.65 kPa
m = ?
M = 32 g / mol

$$p\,v = \frac{m\,RT}{M}$$

$$202.65 \cdot 2 = \frac{m \cdot 8.31 \cdot 780.36}{32}$$

$$m = 2 \text{ g}$$

Glowing Drink

Material:

Tonic Water

7-up or Sprite

Cherries with or without a stem

Clear less glasses

Ice

Procedure:

1-Add 1/3 of tonic water to the glass.

2-Add 1/3 of 7-up or sprite to the glass.

3-Add 1/3 of ice to the glass.

4-Add 1 or 2 cherries