Question: A balloon has a volume of 4.39 L at 44 °C and a pressure of 729 torr. The balloon is cooled until its volume is reduced to 3.78 L (at constant pressure). What is the final temperature of the gas in the balloon?

A. 0 °C
B. 38 °C
C. 72.9 °C
D. 273 °C
E. 546 °C

HINT: What variables are constant during this process?

Concepts: To determine which gas law applies, we must look at the information given, determine what is constant and what is changing and then utilize the law that governs those conditions that are changing.

Connections:

What is given? We are given information about a sample of gas. We are provided with initial and final volumes, an initial temperature and a pressure (which is held constant).

What do I want to know? We want to know what the final temperature of the gas sample is going to be after the volume has changed (the gas has been compressed).

What else do we know? Since our gas sample is in a balloon (a closed container) the quantity of gas will not change during this process. This means n (# of moles of gas) is constant. So both P and n are constant, while T and V change.

To determine which gas law applies, we must look at the information given, determine what is constant and what is changing and then utilize the law that governs those conditions that are changing.

All of the variables are related via the ideal equation of state: $PV = nRT$.

In this problem, n and P (and of course R are constant). Therefore we can write:

$PV_1 = nRT_1$ and $PV_2 = nRT_2$

We can rearrange putting the constants on the same side to get:

$nR/P = V_1/T_1$ and $nR/P = V_2/T_2$

Since the ratio P/nR is the same for both situations we can set these two equal and we arrive at Charles' Law:

$V_1/T_1 = V_2/T_2$

When using the ideal gas law it is essential that we use T in K. The temperature in K is obtained by adding a constant to the temperature in °C. In a ratio (such as Charles' Law) the additive factor does not cancel. Since the ideal gas Law is derived using temperature in K, the correct answer can only be obtained when T is in K.

Be sure you understand everything above before moving on to the solution below.

Solution:

In this question we are dealing with a volume vs. temperature relationship. Pressure and number of moles (n) are constant so the gas law that we need will have only volume and temperature as variables. This law is Charles' Law:

$V_1/T_1 = V_2/T_2$

Next, we need to summarize the information we are given in the problem.

V_1= 4.39 L V_2= 3.78 L

T_1= 44°C T_2=? n and P are constant

We need to use specific units here. This is because the unit conversion from Celsius to Kelvin is not multiplicative it is additive. That means that the conversion does not cancel on both sides of the equation. We need to convert our temperatures to the Kelvin scale and the can use Charles' Law to solve the problem:

T_1= 44°C+273.15 = 317.15 K

$V_1/T_1=V_2/T_2$

$V_1T_2/T_1=V_2$

$V_1T_2=V_2T_1$

$T_2=V_2T_1/V_1$

T_2=(3.78 L)(317.15 K)/(4.39L) = 273.08 K

Our answer choices are in °C so we need to convert this to the problem units. When we do we get 273.08 − 273.15 = −0.07 °C which is essentially answer choice A.