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Homework 1 on Boyles' Law

Use Boyles' Law to answer the following questions. Show all work.

1) 1.00 L of a gas at standard temperature (273K) and pressure (1 atm) is compressed to 0.473 L. What is the new pressure of the gas?

Given Information

$P_1 = 1\text{atm}$ $P_2 = ?\text{ atm}$

$V_1 = 1.00\text{L}$ $V_2 = 0.473\text{ L}$

$P_1 V_1 = P_2 V_2$

$$\frac{(1\text{atm})(1.00\text{L})}{(0.473\text{L})} = \frac{P_2(0.473\text{L})}{(0.473\text{L})}$$

$2.11\text{ atm} = P_2$

2) In a thermonuclear device, the pressure of 0.050 liters of gas within the bomb casing reaches 4.0×10^6 atm. When the bomb casing is destroyed by the explosion, the gas is released into the atmosphere where it reaches a pressure of 1.00 atm. What is the volume of the gas after the explosion?

Given:

$P_1 = 4.0 \times 10^6\text{ atm}$ $P_2 = 1.00\text{ atm}$

$V_1 = 0.050\text{L}$ $V_2 = ?\text{ L}$

$P_1 V_1 = P_2 V_2$

$$\frac{(4.0 \times 10^6\text{ atm})(0.050\text{L})}{1.00\text{ atm}} = \frac{(1.00\text{ atm})(V_2)}{1.00\text{ atm}}$$

$200{,}000\text{ L} = V_2$

$2.0 \times 10^5\text{ L} = V_2$

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3) Synthetic diamonds can be manufactured at pressures of 6.00×10^4 atm. If we took 2.00 liters of gas at 1.00 atm and compressed it to a pressure of 6.00×10^4 atm, what would the volume of that gas be?

Given:

$P_1 = 1.00\ atm$ $\quad P_2 = 6.00 \times 10^4\ atm$

$V_1 = 2.00\ L$ $\quad V_2 = ?\ L$

$$P_1 V_1 = P_2 V_2$$

$$\frac{(1.00\ atm)(2.00\ L)}{(6.00 \times 10^4\ atm)} = \frac{(6.00 \times 10^4\ atm)\ V_2}{(6.00 \times 10^4\ atm)}$$

$$3.33 \times 10^{-5}\ L = V_2$$

4) The highest pressure ever produced in a laboratory setting was about 2.0×10^6 atm. If we have a 1.0×10^{-5} liter sample of a gas at that pressure, then release the pressure until it is equal to 0.275 atm, what would the new volume of that gas be?

$P_1 = 2.0 \times 10^6\ atm$ $\quad P_2 = 0.275\ atm$

$V_1 = 1.0 \times 10^{-5}\ L$ $\quad V_2 = ?\ L$

$$P_1 V_1 = P_2 V_2$$

$$\frac{(2.0 \times 10^6\ atm)(1.0 \times 10^{-5}\ L)}{0.275\ atm} = \frac{(0.275\ atm)\ V_2}{0.275\ atm}$$

$$72.73\ L = V_2$$

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Homework 2 on Boyles' Law

Use Boyles' Law to answer the following questions. Show all work.

5) Atmospheric pressure on the peak of Mt. Everest can be as low as 150 mm Hg, which is why climbers need to bring oxygen tanks for the last part of the climb. If the climbers carry 10.0 liter tanks with an internal gas pressure of 3.04×10^4 mm Hg, what will be the volume of the gas when it is released from the tanks?

$P_1 = 3.04 \times 10^4 \text{ mm Hg}$ $P_2 = 150 \text{ mm Hg}$

$V_1 = 10.0 \text{ L}$ $V_2 = ?$

$$P_1V_1 = P_2V_2$$

$$\frac{(3.04 \times 10^4 \text{ mm Hg})(10.0 \text{ L})}{150 \text{ mm Hg}} = \frac{(150 \text{ mm Hg})\, V_2}{150 \text{ mm Hg}}$$

$$V_2 = 2.03 \times 10^3 \text{ L}$$

6) Part of the reason that conventional explosives cause so much damage is that their detonation produces a strong shock wave that can knock things down. While using explosives to knock down a building, the shock wave can be so strong that 12 liters of gas will reach a pressure of 3.8×10^4 mm Hg. When the shock wave passes and the gas returns to a pressure of 760 mm Hg, what will the volume of that gas be?

$P_1 = 3.8 \times 10^4 \text{ mm Hg}$ $P_2 = 760 \text{ mm Hg}$

$V_1 = 12 \text{ L}$ $V_2 = ? \text{ L}$

$$P_1V_1 = P_2V_2$$

$$\frac{(3.8 \times 10^4 \text{ mm Hg})(12 \text{ L})}{(760 \text{ mm Hg})} = \frac{(760 \text{ mm Hg})\, V_2}{(760 \text{ mm Hg})}$$

$$600 \text{ L} = V_2$$

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7) Submarines need to be extremely strong to withstand the extremely high pressure of water pushing down on them. An experimental research submarine with a volume of 15,000 liters has an internal pressure of 1.2 atm. If the pressure of the ocean breaks the submarine forming a bubble with a pressure of 250 atm pushing on it, how big will that bubble be?

$P_1 = 1.2\ atm$ $\quad P_2 = 250\ atm$

$V_1 = 15000\ L$ $\quad V_2 = ?\ L$

$P_1V_1 = P_2V_2$

$$\frac{(1.2\ atm)(15000\ L)}{(250\ atm)} = \frac{(250\ atm)V_2}{(250\ atm)}$$

$72\ L = V_2$

8) Divers get "the bends" if they come up too fast because gas in their blood expands, forming bubbles in their blood. If a diver has 0.05 L of gas in his blood under a pressure of 250 atm, then rises instantaneously to a depth where his blood has a pressure of 50.0 atm, what will the volume of gas in his blood be? Do you think this will harm the diver?

$P_1 = 250\ atm$ $\quad P_2 = 50.0\ atm$

$V_1 = 0.05\ L$ $\quad V_2 = ?\ L$

$P_1V_1 = P_2V_2$

$$\frac{(250\ atm)(0.05\ L)}{50.0\ atm} = \frac{(50.0\ atm)V_2}{50.0\ atm}$$

$0.25\ L = V_2$

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Charles' Law Practice Problems

Use Charles' Law to answer the following questions. Show all work. Any questions not completed in your groups are homework.

1) The temperature inside my refrigerator is about 4^0 Celsius. If I place a balloon in my fridge that initially has a temperature of 22^0 C and a volume of 0.5 liters, what will be the volume of the balloon when it is fully cooled by my refrigerator? Don't forget to convert temperatures into Kelvin.

$V_1 = ?\ L$ $\quad V_2 = 0.5\ L$

$T_1 = 4°C + 273 = 277\ K$ $\quad T_2 = 22°C + 273 = 295\ K$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{V_1}{277\ K} = \frac{0.5\ L}{295\ K}$$

$$277\ K\left(\frac{V_1}{277\ K}\right) = \left(\frac{0.5\ L}{295\ K}\right)(277\ K)$$

$$V_1 = 0.47\ L$$

2) A man heats a balloon in the oven. If the balloon initially has a volume of 0.4 liters and a temperature of 20 ^{0}C, what will the volume of the balloon be after he heats it to a temperature of 250 ^{0}C?

$V_1 = 0.4\ L$ $\quad V_2 = ?\ L$

$T_1 = 20°C + 273 = 293\ K$ $\quad T_2 = 250°C + 273 = 523\ K$

$$T_2\left(\frac{V_1}{T_1}\right) = \left(\frac{V_2}{T_2}\right)T_2$$

$$\frac{T_2 V_1}{T_1} = V_2$$

$$V_2 = \frac{(523\ K)(0.4\ L)}{293\ K}$$

$$V_2 = 0.71\ L$$

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3) On hot days, you may have noticed that potato chip bags seem to "inflate", even though they have not been opened. If I have a 250 mL bag at a temperature of 19 ^{0}C, and I leave it in my car which has a temperature of 60^0 C, what will the new volume of the bag be?

$T_1 = 19°C + 273 = 292K$ $T_2 = 60°C + 273 = 333\ K$

$V_1 = 250\ mL$ $V_2 = ?\ mL$

$$V_2 = \frac{T_2 V_1}{T_1} = \frac{(333\ K)(250\ mL)}{292\ K}$$

$V_2 = 285\ mL$

4) A soda bottle is flexible enough that the volume of the bottle can change even without opening it. If you have an empty soda bottle (volume of 2 L) at room temperature (25 ^{0}C), what will the new volume be if you put it in your freezer (-4 ^{0}C)?

$T_1 = 25°C + 273 = 298\ K$ $T_2 = -4°C + 273 = 269\ K$

$V_1 = 2L$ $V_2 = ?$

$$V_2 = \frac{T_2 V_1}{T_1} = \frac{(269\ K)(2L)}{(298K)} = 1.80\ L$$

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5) Some students believe that teachers are full of hot air. If I inhale 2.2 liters of gas at a temperature of 18° C and it heats to a temperature of 38° C in my lungs, what is the new volume of the gas?

$T_1 = 18°C + 273 = 291\,K \quad T_2 = 38°C + 273 = 311\,K$

$V_1 = 2.2\,L \qquad V_2 = ?$

$$V_2 = \frac{T_2 V_1}{T_1} = \frac{(311\,K)(2.2\,L)}{(291\,K)} = 2.35\,L$$

6) How hot will a 2.3 L balloon have to get to expand to a volume of 400 L? Assume that the initial temperature of the balloon is 25 °C.

$T_1 = 25°C + 273 = 298\,K \quad T_2 = ?$

$V_1 = 2.3\,L \qquad V_2 = 400\,L$

$$T_1\left(V_2 = \frac{T_2 V_1}{T_1}\right) \qquad \frac{V_2 T_1}{V_1} = \frac{T_2 V_1}{V_1} \Rightarrow \qquad T_2 = \frac{V_2 T_1}{V_1}$$

$$T_2 = \frac{(400\,L)(298\,K)}{2.3\,L} = 5.18 \times 10^4\,K = 5,1826\,K$$

Both are correct answers

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7) I have made a thermometer which measures temperature by the compressing and expanding of gas in a piston. I have measured that at 100° C the volume of the piston is 20 L. What is the temperature outside if the piston has a volume of 15 L? What would be appropriate clothing for the weather?

$V_1 = 20L$ $\quad V_2 = 15L$

$T_1 = 100°C + 273 = 373K$ $\quad T_2 = ?$

From Previous example:

$$T_2 = \frac{V_2 T_1}{V_1} = \frac{(15L)(373K)}{20L} = 279.7\ K$$

To convert back to °C:

$279.7K - 273 = 6.7°C$

Since the question doesn't specify, either 279.7 K or 6.7°C would be acceptable answers.

Since $279.7K = 2.797 \times 10^2 K$ when written in Scientific Notation. This would also be a correct answer.