Solutions to: Gas Law Problem Set

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I have a special, ideal balloon. This balloon does not exert any pressure on the gas inside it. I start by taking the balloon and inflating it to 4 L in Wilmington DE last night. The weather channel said that the temperature was 45.0 °F, and the pressure was 30.27 inches of Hg.

These problems may be solved using a variety of different equations. I will solve each one using the ideal gas law. So first I need to look at the information given above. I know the volume, temperature and pressure when the balloon is filled. From this I can determine the number of moles of gas inside the balloon.

First convert to SI Units:

$V_{initial} := 4 \cdot liter$ $\quad 1 \cdot liter = 0.001 \cdot m^3$ $\quad V_{initial} = 0.004 \cdot m^3$

$T_{initial} := \left[\frac{5}{9} \cdot (45 - 32) + 273.15\right] \cdot K$ $\quad T_{initial} = 280.372 \cdot K$

$P_{initial} := 30.27 \cdot in\_Hg$ $\quad 1 \cdot in\_Hg = 25.4 \cdot torr$ $\quad P_{initial} = 1.025 \cdot 10^5 \cdot Pa$

$1 \cdot torr = 133.322 \cdot Pa$

The Ideal Gas Constant and the Equation

$$R := 8.314510 \cdot \frac{joule}{mole \cdot K}$$

$$P \cdot V = n \cdot R \cdot T$$

$$n := \frac{P_{initial} \cdot V_{initial}}{R \cdot T_{initial}} \qquad n = 0.176 \cdot mole$$

1.First I take this balloon scuba diving and go down to a depth of 100 ft where the pressure is 7 atm. and the temperature is 54.2 °F. What is the volume of the balloon?

Conversions:

$P := 7 \cdot atm$ $\quad 1 \cdot atm = 1.013 \cdot 10^5 \cdot Pa$ $\quad P = 7.093 \cdot 10^5 \cdot Pa$

$T := \left[\frac{5}{9} \cdot (54.2 - 32) + 273.15\right] \cdot K$ $\quad T = 285.483 \cdot K$

Ideal Gas Equation:

$$V := \frac{n \cdot R \cdot T}{P}$$

$V = 5.886 \cdot 10^{-4} \cdot m^3$ $\quad V = 0.589 \cdot liter$

2.Next I take the ballon out to Colorado. In Denver when I arrive at the airport the temperature is 68.4 °F and the barometric pressure is 640 mmHg. Now what size is the balloon?

Conversions:

$P := 640 \cdot torr$ (1 torr = 1 mmHg) $torr = 133.322 \cdot Pa$ $P = 8.533 \cdot 10^4 \cdot Pa$

$T := \left[\frac{5}{9} \cdot (68.4 - 32) + 273.15 \right] \cdot K$ $T = 293.372 \cdot K$

Ideal Gas Equation:

$V := \frac{n \cdot R \cdot T}{P}$

$V = 0.005 \cdot m^3$ $V = 5.028 \cdot liter$

3.Next on my trip is a hike up to the top of Longs Peak (14,256 ft) where the pressure is 470 torr and the temperature is -20°C. Now what size is the balloon?

Conversions:

$P := 470 \cdot torr$ $torr = 133.322 \cdot Pa$ $P = 6.266 \cdot 10^4 \cdot Pa$

$T := (-20 + 273.15) \cdot K$ $T = 253.15 \cdot K$

Ideal Gas Equation:

$V := \frac{n \cdot R \cdot T}{P}$

$V = 0.006 \cdot m^3$ $V = 5.908 \cdot liter$

4.Finally I take the balloon on the airplane for the trip home and let it out the window. The 747 is flying at 40,000 ft where the pressure is about 80.0 torr and the temperature is -60.0 °C. What is the volume of the balloon here?

Conversions:

$P := 80.0 \cdot torr$ $\quad torr = 133.322 \cdot Pa$ $\quad P = 1.067 \cdot 10^4 \cdot Pa$

$T := (-60 + 273.15) \cdot K$ $\quad T = 213.15 \cdot K$

Ideal Gas Equation:

$$V := \frac{n \cdot R \cdot T}{P}$$

$V = 0.029 \cdot m^3$ $\quad V = 29.226 \cdot liter$

5.And last of all the balloon soars up into the stratosphere where the pressure has dropped to 0.8 torr and the temperature is 0°C, what size is it just before it pops?

Conversions:

$P := 0.8 \cdot torr$ $\quad torr = 133.322 \cdot Pa$ $\quad P = 106.658 \cdot Pa$

$T := (0 + 273.15) \cdot K$ $\quad T = 273.15 \cdot K$

Ideal Gas Equation:

$$V := \frac{n \cdot R \cdot T}{P}$$

$V = 3.745 \cdot m^3$ $\quad V = 3.745 \cdot 10^3 \cdot liter$