SOLUTIONS

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Combining the Gas Laws (pg. 463)

equation: more laws = more fun

Laboratory experiments are almost always made at temperatures and pressures other than standard. It is sometimes necessary to correct the laboratory volumes of gases for temperature and pressure. This correction is made by multiplying the original volume by two ratios, one for temperature and the other for pressure.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$ *** temperature must be in Kelvin

Example: 10.0 mL of a gas is collected and measured at 75.6 kPa pressure and 60°C. What volume would this gas occupy at STP?

reasoning: If the pressure is increased the volume will decrease, thus divide by the larger pressure. If the temperature is decreased the volume will decrease, thus divide by the larger Kelvin temperature.

$$10.0\text{ mL} \times \frac{75.6\text{ kPa}}{101.3\text{ kPa}} \times \frac{273\text{ K}}{333\text{ K}} = 6.12\text{ mL at STP}$$

Gas Density: The density of a gas (expressed as g/L) is greatly effected by changes in temperature and pressure. Since density indicates how tightly packed the particles are, any increase in pressure would pack the particles more tightly, thus increasing the density. A decrease in temperature would slow down the gas particles allowing them to come closer together and thereby increasing the density as well.

Problems : For each problem, write the original equation, rewritten equation, and then plug in your numbers.

1. 7.51 m^3 of a gas is collected and measured at 59.5 kPa pressure and 5°C. What volume would this gas occupy at STP? (ans. 4.33 m^3)

$$\frac{P_1V_1}{\cancel{n_1}T_1} = \frac{P_2 \boxed{V_2}}{\cancel{n_2}T_2}$$

amount of gas constant ∴ can cross of n

$$\frac{P_1V_1T_2}{T_1P_2} = V_2$$

$P_1 = 59.5\text{kPa}$

$V_1 = 7.51\text{ m}^3$

$T_1 = 5+273 = 278\text{ K}$

$P_2 = 101.3\text{ kPa}$

$V_2 = ?$

$T_2 = 0+273 = 273\text{ K}$

$$\frac{(59.5\,\cancel{\text{kPa}})(7.51\text{ m}^3)(273\,\cancel{\text{K}})}{(278\,\cancel{\text{K}})(101.3\,\cancel{\text{kPa}})} = \boxed{V_2 = 4.3\text{ m}}$$

V_1 T_1 P_1 T_2

2. A 738 ml sample of a gas at 0°C and 760 mm Hg is cooled to -200°C and compressed to 75.0 atm. What will be the new volume of this gas sample? (ans. 2.6 mL)

P_2

$$\frac{P_1V_1T_2}{T_1P_2} = V_2$$

$V_1 = 738\text{ mL}$

$T_1 = 0+273 = 273\text{ K}$

$P_1 = 760\text{ mmHg}$

$V_2 = ?$

$T_2 = -200+273 = 73\text{ K}$

$P_2 = 75.0\,\cancel{\text{atm}} \left| \frac{760\text{ mmHg}}{1\,\cancel{\text{atm}}} \right. = 57{,}000\text{ mmHg}$

$$V_2 = \frac{(760\,\cancel{\text{mmHg}})(738\text{ mL})(73\,\cancel{\text{K}})}{(273\,\cancel{\text{K}})(57{,}000\,\cancel{\text{mmHg}})} = \boxed{2.6\text{ mL}}$$

3. A given mass of gas occupies a volume of 435 ml at 25°C and 740 mm Hg. What will be the new volume at STP? (ans. 388 mL)

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$V_1 = 435\ mL$ $V_2 = ?$

$P_1 = 740\ mm\ Hg$ $P_2 = 760\ mm\ Hg$

$T_1 = 25 + 273 = 298\ K$ $T_2 = 273\ K$

$$V_2 = \frac{P_1V_1T_2}{T_1P_2}$$

$$= \frac{(740\ \cancel{mm\ Hg})(435\ mL)(273\ \cancel{K})}{(760\ \cancel{mm\ Hg})(298\ \cancel{K})}$$

$$\boxed{V_2 = 388\ mL}$$

4. Find the volume of a dry gas at STP if it measures 928 cm^3 at 27°C and 106.0 kPa. (883 cm^3)

$V_1 = 928\ cm^3$

$T_1 = 27 + 273 = 300\ K$

$P_1 = 106.0\ kPa$

$V_2 = ?$

$T_2 = 0 + 273 = 273\ K$

$P_2 = 101.3\ kPa$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$V_2 = \frac{P_1V_1T_2}{P_2T_1}$$

$$= \frac{(106.0\ \cancel{kPa})(928\ cm^3)(273\ \cancel{K})}{(101.3\ \cancel{kPa})(300\ \cancel{K})}$$

$$\boxed{V_2 = 884\ cm^3}$$