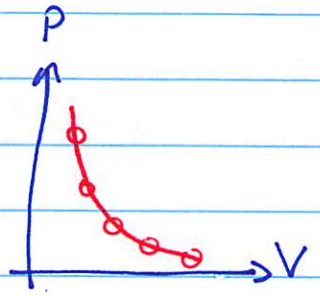
10/14/2019

Boyle's law

$p \propto 1/V$ (cont T, n)



$pV = \text{constant}$, or $\boxed{P_1 V_1 = P_2 V_2}$

ex: balloon w/ vol. of $3.0\,L$ (V_1) @ $760\,mmHg$ (P_1)
+ squeeze until vol. becomes $1.4\,L$ (V_2)

Q: What's new P_2? ($mmHg$, atm)

$$P_1 V_1 = P_2 V_2$$

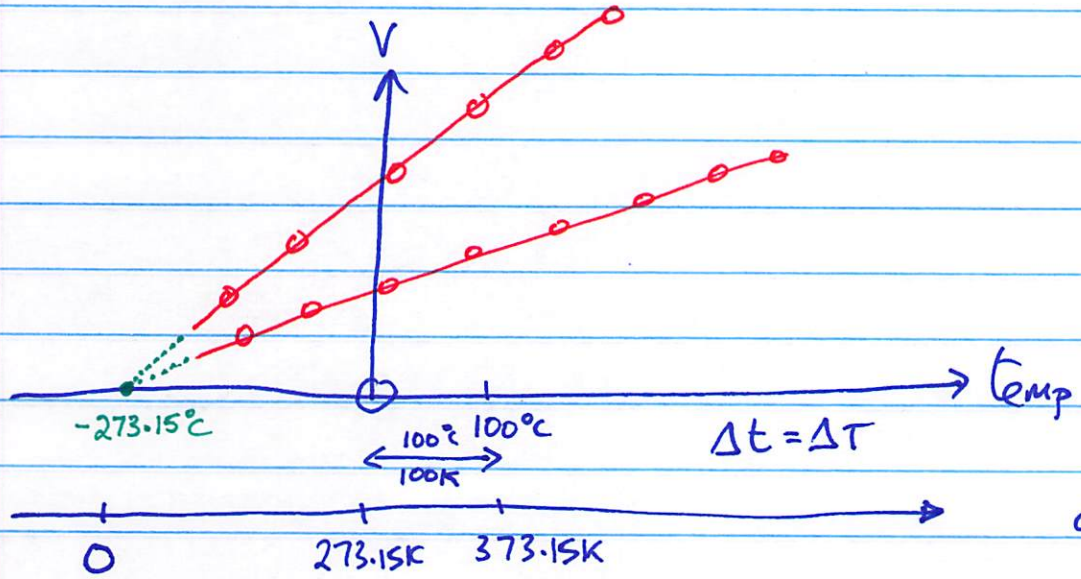
$$\Rightarrow P_2 = \frac{P_1 V_1}{V_2} = \frac{760\,mmHg \times 3.0\,L}{1.4\,L}$$

$$= 1600\,mmHg$$

in atm? $P_2 = 1600\,mmHg \times \frac{1\,atm}{760\,mmHg} = 2.1\,atm.$

Charles's law

$V \propto T$ (const n, P)



°F
°C
K

Kelvin scale

$T/K = t/°C + 273.15$ $\quad T(K)$

Mathematically, can write:

$$\frac{V}{T} = \text{const.}, \qquad \boxed{\frac{V_1}{T_1} = \frac{V_2}{T_2}}$$ Charles's law

ex: 25.0 mL (V_1) of nitrogen gas @ 37°C (t_1, $T_1 = 37 + 273.15 = 310\,K$) is cooled down until its vol is 8.40 mL (V_2).

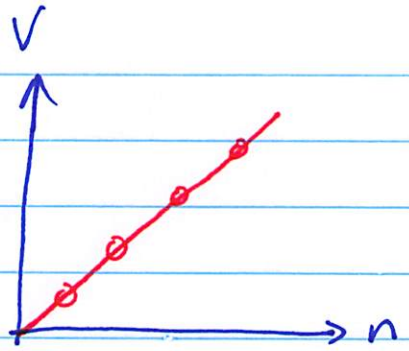
Q: What's its new temp? in K and °C.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow \frac{V_1 \cdot T_2}{V_1} = \frac{T_1 \cdot V_2}{V_1} \Rightarrow T_2 = \frac{T_1 \cdot V_2}{V_1} = \frac{310.K \times 8.40\,mL}{25.0\,mL}$$

$= 104\,K$ or $-169°C$

Avogadro's law

$V \propto n$ (const T, p)



Math: $\frac{V}{n} = \text{constant}$

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

ex: 1.00 mol (n_1) gas occupies 22.4 L (V_1) @ 1 atm, 0°C

Standard temp + pressure: STP

Q: How many mol (n_2?) gas are in 2.8 L (V_2) @ STP?

$$\frac{V_1}{n_1} = \frac{V_2}{n_2?}$$

$$n_2 = \frac{n_1 \cdot V_2}{V_1} = \frac{1.00\,\text{mol} \times 2.8\,\text{L}}{22.4\,\text{L}}$$

$$= 0.13\,\text{mol}$$

Ideal Gas Law

$$pV = nRT$$

R = Ideal gas constant $= 0.08206 \frac{atm \cdot L}{mol \cdot K}$

$$R = \frac{pV}{nT}$$

$$\boxed{\frac{P_1 V_1}{n_1 T_1} = \frac{P_2 V_2}{n_2 T_2}}$$

- can calculate, say, p given other info!

ex: What's p of 32.0g nitrogen gas ($N_2(g)$) @ 27°C w/ volume of 185mL.

$$\frac{pV}{V} = \frac{nRT}{V} \qquad p = \frac{nRT}{V}$$

N_2: $2 \times N = 2 \times 14.01$ g/mol $= 28.02$ g/mol

$$32.0\text{g } N_2 \times \frac{1\text{ mol } N_2}{28.02\text{g } N_2} = 1.142\text{ mol } N_2$$

$$27°C + 273.15 \rightarrow 300.\text{K} \quad (0\text{ d.p.})$$

$$185\text{mL} \rightarrow 0.185\text{L}$$

$$p = \frac{nRT}{V} = \frac{1.142\text{mol} \times 0.08206 \frac{atm \cdot L}{mol \cdot K} \times 300\text{K}}{0.185\text{L}}$$

$$= 152\text{ atm}$$