SOLUTIONS
(5/13/14)

GAS LAWS WORKSHEET

For each problem, state the gas law/equation being illustrated, write the equation and the rearranged equation, and solve the problem.

1. A gas occupies 3.5L at 2.5 mm Hg pressure. What is the volume at 10 mm Hg at the same temperature? (ans. .875 L)

Gas law/equation:

$$P_1 V_1 = \underset{\uparrow}{P_2}\underset{\downarrow}{V_2}$$

equation:

Boyles (P ↑ V ↓)

rearranged equation:

$$V_2 = \frac{P_1 V_1}{P_2}$$

solved problem:

$$V_2 = \frac{(2.5 \cancel{\text{mm Hg}})(3.5\ L)}{(10 \cancel{\text{mm Hg}})}$$

$$\boxed{V_2 = 0.9\ L}$$

$V_1 = 3.5\ L$ $V_2 = ?$

$P_1 = 2.5\ mm\ Hg$ $P_2 = 10\ mm\ Hg$

2. A constant volume of oxygen is heated from $\underbrace{100.0°C \text{ to } 185.0°C}_{\Delta T}$. The $\underbrace{\text{initial pressure}}_{\Delta P}$ is 4.1 atm. What is the final pressure? (ans. 5.0 atm)

V & n constant

Gas law/equation:

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

equation:

Gay Lussac's (T ↑ P ↑)

rearranged equation:

solved problem:

$T_1 = 373\ K$ $T_2 = 458\ K$

$P_1 = 4.1\ atm$ $P_2 = ?$

$$P_2 = \frac{P_1 T_2}{T_1} = \frac{(4.1\ atm)(458\ K)}{(373\ K)} = \boxed{5.0\ atm = P_2}$$

3. A sample of 25.0L of NH_3 gas at 10.0°C is heated at constant pressure until it fills a volume of 50.0L. What is the new temperature in °C? (ans. 293 °C)

P and n constant

Gas law/equation:

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

equation:

Charle's Law (V ↑ T ↑)

rearranged equation:

solved problem:

$V_1 = 25.0\ L$ $V_2 = 50.0\ L$

$T_1 = 283\ K$ $T_2 = ?$

$$T_2 = \frac{V_2 T_1}{V_1} = \frac{(50 \cancel{L})(283\ K)}{(25 \cancel{L})} = 566\ K - 273$$

$$\boxed{T_2 = 293°C}$$

4. A certain quantity of argon gas is under 2.13 kPa pressure at 253K in a 12 L vessel. How many moles of argon are present? (ans. .012 mol)

no Δ in system ∴ use $PV=nRT$

Gas law/equation:

$\cancel{\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}}$ Ideal

equation:

$PV=nRT$

rearranged equation:

$$n = \frac{PV}{RT}$$

solved problem:

$$n = \frac{(2.13\ \cancel{kPa})(12\ \cancel{L})}{(253\ \cancel{K})(8.31\ \frac{\cancel{kPa}\cdot\cancel{L}}{mol\cdot\cancel{K}})} = \boxed{0.012\ mol\ Ar}$$

$P = 2.13\ kPa$

$V = 12\ L$

$T = 253\ K$

$R = 8.31\ \frac{kPa\cdot L}{mol\cdot K}$

5. An unknown gas weighs 34.0g and occupies 6.7L at 2.0 atm and 245K. What is its molecular mass? (ans. 51 g/mol)

Gas law/equation:

no Δ to system ∴

Use Ideal Gas

equation:

1) $PV=nRT$

2) $n \rightarrow$ molar mass $= \frac{\#g}{n}$ (g/mol units)

rearranged equation:

solved problem:

1) $$n = \frac{PV}{RT} = \frac{(2.0\ \cancel{atm})(6.7\ \cancel{L})}{(0.082\ \frac{\cancel{atm}\cdot\cancel{L}}{mol\cdot\cancel{K}})(245\ \cancel{K})} = 0.667\ mol$$

2) $$\text{molar mass} = \frac{\#\ g}{\#\ mol} = \frac{34.0\ g}{0.667\ mol} = 51\ g/mol$$

6. An ideal gas occupies 400.0ml at 270 **mm Hg** and 65°C. If the pressure is changed to 1.4 **atm** and the temperature is increased to 100.0°C, what is the new volume? (ans. 110 ml)

ΔP & ΔV & ΔT

Gas law/equation:

$$\frac{P_1V_1}{\cancel{n_1}T_1} = \frac{P_2V_2}{\cancel{n_2}T_2}$$

equation:

Boyles (P↑ V↓)

rearranged equation:

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

solved problem:

$$V_2 = \frac{(0.355\ \cancel{atm})(400.0\ mL)(373\ \cancel{K})}{(1.4\ \cancel{atm})(338\ \cancel{K})}$$

$$\boxed{V_2 = 110\ mL}$$

$P_1 = 270\ \cancel{mm\ Hg} \left| \frac{1\ atm}{760\ \cancel{mm\ Hg}} \right. = 0.355\ atm$

$V_1 = 400.0\ mL$

$T_1 = 65+273 = 338\ K$

$P_2 = 1.4\ atm$

$T_2 = 373\ K$

$V_2 = ?$

7. What is the volume of 23.0g of neon gas at 1.0°C and a pressure of 2.0 atm? (ans. 13 L)

Gas law/equation:

$PV = nRT$

↑

equation:

1) determine n using stoichiometry

2) $V = \frac{nRT}{P}$

rearranged equation:

solved problem:

1) $\frac{23.0\cancel{g\,Ne}}{} \left| \frac{1\,mol\,Ne}{20.18\cancel{g\,Ne}} \right. = 1.14\,mol\,Ne$

2) $V = \frac{(1.14\cancel{mol})(0.082\frac{\cancel{atm}\,L}{\cancel{mol}\,\cancel{K}})(1+273\,\cancel{K})}{(2.0\,\cancel{atm})} = 12.8\,L$

$\boxed{V = 13\,L}$ (2 sig figs)

8. If 11.0 moles of HCl gas occupies 15.0L at 300.0°C, what is the pressure in mm Hg? (ans. 26,200 mm Hg)

Gas law/equation:

$PV = nRT$

equation:

1) $P = \frac{nRT}{V}$ 2) $P_{(atm)} \rightarrow P_{(mmHg)}$

rearranged equation:

solved problem:

1) $P = \frac{(11.0\,\cancel{mol\,HCl})(0.082\frac{atm\,\cancel{L}}{\cancel{mol}\,\cancel{K}})(300+273\,\cancel{K})}{(15.0\,\cancel{L})} = 34.5\,atm$

2) $P_{(mmHg)} = \frac{34.5\,\cancel{atm}}{} \left| \frac{760\,mm\,Hg}{1\,\cancel{atm}} \right. = \boxed{26{,}200\,mm\,Hg}$

(3 sig fig)

9. 2.3 moles of Br_2 gas occupies 9.3 L pressure at 6.5 atm,. What is the temperature in °C? (ans. 47°C)

Gas law/equation:

Ideal Gas law $PV = nRT$

equation:

1) $T = \frac{PV}{nR}$

2) $T_{(K)} \rightarrow T_{(°C)}$

rearranged equation:

solved problem:

1) $T = \frac{(6.5\,\cancel{atm})(9.3\,\cancel{L})}{(2.3\,\cancel{mol})(0.082\frac{\cancel{atm}\,\cancel{L}}{\cancel{mol}\,K})} = 320.5\,K$

2) $T_{(°C)} = 320.5\,K - 273.15$

$\boxed{T_{(°C)} = 47°C}$

(2 sig fig)

Δ in system occuring?

10. A 600.0mL balloon is filled with helium at 700.0mm Hg barometric pressure. The balloon is released and climbs to an altitude where the barometric pressure is 400.0mm Hg. What will the volume of the balloon be if, during the ascent, the temperature drops from 24.0 to 5.0°C? (ans. 980 ml)

$\Delta P, \Delta T, \Delta V$

Gas law/equation:

$$\frac{P_1V_1}{\cancel{n_1}T_1} = \frac{P_2V_2}{\cancel{n_2}T_2} \checkmark$$

equation:

Combined gas law

rearranged equation:

$V_1 = 600$ mL
$P_1 = 700$ mmHg
$T_1 = 24 + 273$ K

$V_2 = ?$
$P_2 = 400$ mm Hg
$T_2 = 5 + 273$ K

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

solved problem:

$$V_2 = \frac{(700 \cancel{\text{mm Hg}})(600 \text{ mL})(278 \cancel{\text{K}})}{(400 \cancel{\text{mm Hg}})(297 \cancel{\text{K}})}$$

$$\boxed{V_2 = 980 \text{ mL}}$$

(2 sig figs)

11. An unknown gas has a volume of 200.0L at 5.0 atm and -140.0°C. What is its volume at STP?
(ans. 2050 L)

Δ in system

Gas law/equation:

Combined Gas law

equation:

$$\frac{P_1V_1}{\cancel{n_1}T_1} = \frac{P_2V_2}{\cancel{n_2}T_2} \checkmark$$

rearranged equation:

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

solved problem:

$$V_2 = \frac{(5 \cancel{\text{atm}})(200 \text{ L})(273 \cancel{\text{K}})}{(133 \cancel{\text{K}})(1 \cancel{\text{atm}})}$$

$V_2 = 2056$ L → $\boxed{V_2 = 2100 \text{ L}}$

(2 sig fig)

$V_1 = 200$ L
$P_1 = 5.0$ atm
$T_1 = 273 - 140 = 133$ K

$V_2 = ?$
$P_2 = 1$ atm
$T_2 = 0$°C $= 273$ K