# Gases and Gas Laws

1. What are the 4 variables used to describe a gas? Give their symbol and units.

Temp - T - (K)
Volume - V - (mL or L)
Pressure - P - (atm, mm Hg, psi, torr, kPa)
moles - n - (mol)

2. What is meant by the pressure of the atmosphere? What causes this pressure?

weight of all air, gravity

3. Define pressure in terms of gas particles.

when a gas particle collides with wall of container

4. Convert the following pressures into the appropriate units:

a. 105.2 kPa → atm  b. 752 mm Hg → atm  c. 44 psi → atm

$105.2\ kPa \times \frac{1\ atm}{101.3\ kPa} =$ ____ atm  $752\ mm\ Hg \times \frac{1\ atm}{760\ mm\ Hg} =$ ____ atm  $44\ psi \times \frac{1\ atm}{14.7\ psi} =$ ____ atm

d. 745 torr → mm Hg  e. 98.7 kPa → mm Hg  f. 112.5 Pa → psi

$745\ torr \times \frac{760\ mm\ Hg}{760\ torr} = 745\ mm\ Hg$  $98.7\ kPa \times \frac{760\ mm\ Hg}{101.3\ kPa} =$ ____ mm Hg  $112.5\ Pa \times \frac{14.7\ psi}{101,300\ Pa} =$ ____ psi

5. Explain how each of the following variables affect the pressure of a gas:

Volume = size of container

less collisions

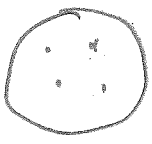
more collisions

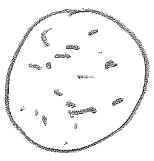
Temperature = speed of particles

high T - more collisions

Low T - less collisions

Moles = # of particles





more particles
more collisions

6. A balloon occupies 53.2 mL ($V_1$) at 785 mm Hg ($P_1$). If the pressure is increased to 870. mm Hg ($P_2$), will the volume increase or decrease? Explain. Calculate the new volume.

Given ($V_2$)

$V_1 = 53.2\text{ mL}$

$P_1 = 785\text{ mm Hg}$

$P_2 = 870.\text{ mm Hg}$

Looking for

$V_2 = ?\text{ mL}$

Type- Boyle's

HDYK?- only P + V's

Formula - $P_1V_1 = P_2V_2$

$$V_2 = \frac{P_1V_1}{P_2} = \frac{(785\text{ mm Hg})(53.2\text{ mL})}{(870\text{ mm Hg})} = 48.0\text{ mL}$$

7. A flexible container has a volume of 2.25 L ($V_1$) at 1.67 atm ($P_1$). If the volume is decreased to 2.00 L ($V_2$), will the pressure increase or decrease? Explain. Calculate the new pressure. ($P_2$)

Given

$V_1 = 2.25\text{ L}$

$P_1 = 1.67\text{ atm}$

$V_2 = 2.00\text{ L}$

Looking for

$P_2 = ?\text{ atm}$

Type- Boyles

HDYK?- only P's + V's

Formula - $P_1V_1 = P_2V_2$

$$P_2 = \frac{P_1V_1}{V_2} = \frac{(1.67\text{ atm})(2.25\text{ L})}{(2.00\text{ L})} = 1.88\text{ atm}$$

8. If the pressure exerted on the gas in a weather balloon decreases from 1.20 atm to 0.60 atm as it rises, by what factor will the volume of the gas in the balloon increase as it rises?

P ½ so V × 2

9. A balloon has a volume of 2.71 L ($V_1$) at 101.4 kPa ($P_1$). If the volume increases 1.5 times ($V_2$), will the pressure increase or decrease? Explain. Calculate the new pressure in mm Hg.

Given

$V_1 = 2.71\text{ L}$

$P_1 = 101.4\text{ kPa}$

$V_2 = (1.5)(2.71\text{ L})$

Looking for

$P_2$

Type- Boyles

HDYK?- P + V's

Formula - $P_1V_1 = P_2V_2$

$$P_2 = \frac{P_1V_1}{V_2} = \frac{(101.4\text{ kPa})(2.71\text{ L})}{(1.5)(2.71\text{ L})} = 67.6\text{ kPa}$$

10. What is meant by absolute zero?

T at which all particles stop moving

11. If a 45.0 mL sample of a gas at 26.5 °C is heated to 55.2 °C, will the volume of the sample increase or decrease? Explain. Calculate the new volume.

Given

$V_1 = 45.0\ mL$

$T_1 = 26.5°C + 273.2 = 299.7\ K$

$T_2 = 55.2°C + 273.2 = 328.4\ K$

Looking for

$V_2 = ?\ mL$

Type- Charles's

HDYK?- V + T's

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

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{(45.0\ mL)(328.4\ K)}{299.7\ K} = 49.3\ mL$$

12. A balloon has a volume of 750 mL at 20.0 °C. The balloon's volume is increased to 1.25 L? Will the temperature have increased or decreased? Explain. Calculate the answer.

Given

$V_1 = 750\ mL \times \frac{1\ L}{1000\ mL} = .750\ L$

$T_1 = 20.0°C + 273.2 = 293.2\ K$

$V_2 = 1.25\ L$

Looking for

$T_2 = ?\ K$

Type- Charles's

HDYK?- V + T

Formula - $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\quad T_2 V_1 = V_2 T_1$

$$T_2 = \frac{V_2 T_1}{V_1} = \frac{(1.25\ L)(293.2\ K)}{.750\ L} = 489\ K$$

13. If 0.214 mol of argon gas occupies a volume of 652 mL at a particular temperature and pressure, what volume would 0.375 mol of argon occupy under the same conditions? Would the volume increase or decrease? Explain. Calculate the answer.

Given

$n_1 = .214\ mol$

$V_1 = 652\ mL$

$n_2 = .375\ mol$

Looking for

$V_2 = ?\ mL$

Type- Avogadro's

HDYK?- n + V's

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

$$V_2 = \frac{V_1 n_2}{n_1} = \frac{(652\ mL)(.375\ mol)}{(.214\ mol)} = 1140\ mL$$

14. A sample of neon gas occupies 266 mL at 25.2 °C and 1.23 atm. At what temperature would the volume of the neon gas be 133 mL at 1.23 atm? ← constant

Given

$V_1 = 266\ mL$

$T_1 = 25.2°C + 273.2 = 298.4\ K$

$V_2 = 133\ mL$

Looking for

$T_2 = ?\ K$

Type- Charles's

HDYK?- V + T's

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

$$T_2 = \frac{V_2 T_1}{V_1} = \frac{(133\ mL)(298.4\ K)}{(266\ mL)} = 149.2\ K$$

15. Show how Boyle's law can be derived from the ideal gas law.

$P_1V_1 = n_1R_1T_1$ $\quad P_2V_2 = n_2R_2T_2$

$P_1V_1 = nRT$ $\quad \boxed{n_1 = n_2 = n,\ R_1 = R_2 = R,\ T_1 = T_2 = T}$ constant $\quad P_2V_2 = nRT$

$P_1V_1 = nRT = P_2V_2$

$\boxed{P_1V_1 = P_2V_2}$

16. Given each of the following sets of data, calculate the unknown quantity

a. P = 782 mm Hg, n = 0.210 mol, T = 27 °C, V = ? L

Given

$P = 782\ mmHg \times \frac{1\ atm}{760\ mmHg} = 1.03\ atm$

$n = .210\ mol$

$T = 27°C + 273 = 300.\ K$

Looking for $V = ?$

Type- Ideal

HDYK?- all 4

Formula - $PV = nRT$

$V = \frac{nRT}{P} = \frac{(.210\ mol)\left(.0821\ \frac{atm \cdot L}{mol \cdot K}\right)(300.\ K)}{1.03\ atm} = \boxed{5.02\ L}$

b. V = 644 mL, n = 0.0921 mol, T = 30. °C, P = ? atm

Given

$V = 644\ mL \times \frac{1\ L}{1000\ mL} = .644\ L$

$n = .0921\ mol$

$T = 30°C + 273 = 303\ K$

Looking for $P = ?$

Type- Ideal

HDYK?- All 4

Formula - $PV = nRT$

$P = \frac{nRT}{V} = \frac{(.0921\ mol)\left(.0821\ \frac{atm \cdot L}{mol \cdot K}\right)(303\ K)}{.644\ L} = \boxed{3.56\ atm}$

c. P = 97.3 kPa, V = 11.2 L, n = 16.0 g $O_2$, T = ?°C

Given

$P = 97.3\ kPa \times \frac{1\ atm}{101.3\ kPa} = .961\ atm$

$V = 11.2\ L$

$n = 16.0\ g\ O_2 \times \frac{1\ mol\ O_2}{32.00\ g\ O_2} = .500\ mol$

Looking for $T$

Type- Ideal

HDYK?- all 4

Formula - $PV = nRT$

$T = \frac{PV}{nR} = \frac{(.961\ atm)(11.2\ L)}{(.500\ mol)\left(.0821\ \frac{atm \cdot L}{mol \cdot K}\right)} = 262\ K - 273 = \boxed{-11°C}$

17. What will the be the new volume if 125 mL (1) of He gas at 100.°C (1) and 0.981 atm (1) is cooled to 25°C (2) and the pressure is increased to 1.15 atm? (2) Hint: use the ideal gas law to come up with a gas law that contains pressure, volume, and temperature. What variable remains constant? (n)

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ $\quad V_2 = \frac{P_1V_1}{T_1} \cdot \frac{T_2}{P_2} = \frac{(.981\ atm)(125\ mL)(298\ K)}{(373\ K)(1.15\ atm)} = \boxed{85.2\ mL}$

$T_1 = 100 + 273 = 373\ K$

$T_2 = 25 + 273 = 298\ K$