South Pasadena • Chemistry

Name Key
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# 12 • The Gas Laws

## BOYLE'S LAW

Boyle's Law states that the volume of a gas varies inversely with its pressure if temperature is held constant. (If one goes up, the other goes down.) We use the formula:

$$P_1 \times V_1 = P_2 \times V_2$$

***Solve the following problems (assuming constant temperature). Assume all number are 3 significant figures.***

1. A sample of oxygen gas occupies a volume of 250 mL at 740 torr pressure. What volume will it occupy at 800 torr pressure?

$P_1V_1 = P_2V_2$ 250 740/760

$\frac{250 \times 740}{800} = \frac{800 V_2}{800}$

231 mL

2. A sample of carbon dioxide occupies a volume of 3.50 Liters at 125 kPa pressure. What pressure would the gas exert if the volume was decreased to 2.00 liters?

$\frac{3.5L \times 125 kPa}{2.00} = 2.00 P_2$ 219 kPa

3. A 2.00-Liter container of nitrogen had a pressure of 3.20 atm. What volume would be necessary to decrease the pressure to 1.00 atm?

$\frac{2(3.20)}{1} = 1atm\ V_2$ 6.4L

4. Ammonia gas occupies a volume of 450 mL as a pressure of 720 mmHg. What volume will it occupy at standard pressure (760 mmHg)?

$\frac{450 \times 720}{760} =$ 426mL

5. A 175 mL sample of neon had its pressure changed from 75.0 kPa to 150 kPa. What is its new volume?

$\frac{175 \times 75}{150} = 150\ V_2$ $V_2 =$ 87.5mL

6. A sample of hydrogen at 1.50 atm had its pressure decreased to 0.50 atm producing a new volume of 750 mL. What was the sample's original volume?

$1.50\ V_1 = \frac{.50(750)}{1.50}$ 250mL

7. Chlorine gas occupies a volume of 1.20 liters at 720 torr pressure. What volume will it occupy at 1 atm pressure?

$\frac{1.20 \times 720}{760} = \frac{760 V_2}{760} =$ 1.14L

8. Fluorine gas exerts a pressure of 900 torr. When the pressure is changed to 1.50 atm, its volume is 250 mL. What was the original volume?

$V_1 \cdot 900 = \frac{1.5 \cdot 250}{900}$ .42 atm

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## CHARLES'S LAW

Charles' Law states the volume of a gas varies directly with the Kelvin temperature, assuming the pressure is constant. We use the following formulas:

V = Liters T = Kelvin

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad \text{or} \quad V_1 \times T_2 = V_2 \times T_1$$

cross multiplication

always convert

$$K = °C + 273$$

***Solve the following problems assuming a constant pressure. Assume all numbers are 3 significant figures.***

1. A sample of nitrogen occupies a volume of 250 mL at 25 °C. What volume will it occupy at 95 °C?

$\frac{.250L}{25+273K} = \frac{.250L}{298} = \frac{}{368}$ **.31 L**

2. Oxygen gas is at a temperature of 40 °C when it occupies a volume of 2.30 Liters. To what temperature should it be raised to occupy a volume of 6.50 Liters?

$6.5L/313K = 2.3L/T_2$ **111K**

3. Hydrogen gas was cooled from 150 °C to 50 °C. Its new volume is 75.0 mL. What was its original volume?

$V_1/423K = .075/323K$ **.098L or 98mL**

4. Chlorine gas occupies a volume of 25.0 mL at 300 K. What volume will it occupy at 600 K?

$.025L/300K = V_2/600K$ **.05L or 50m**

5. A sample of neon gas at 50 °C and a volume of 2.50 Liters is cooled to 25 °C. What is the new volume?

$2.5L/323K = V_2/298K$ **2.3L**

6. Fluorine gas at 300 K occupies a volume of 500 mL. To what temperature should it be lowered to bring the volume to 300 mL?

$.5L/300K = .3L/T_2$ **180K**

7. Helium occupies a volume of 3.80 Liters at –45 °C. What volume will it occupy at 45 °C?

$3.8/228K = V_2/318K$ **5.3L**

8. A sample of argon gas is cooled and its volume went from 380 mL to 250 mL. If its final temperature was –55 °C, what was its original temperature?

$.38L/T_1 = .25/218K$

**331K**

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## THE IDEAL GAS LAW

C° + 273 = K

$\frac{g}{V} = D = \frac{PM}{RT}$

**PV = nRT where**
**P = pressure in atmosphere**
**V = volume in liters**
**n = number of moles of gas**
**R = Universal Gas Constant = 0.0821 L·atm/mol·K**
**T = Kelvin temperature**

760 torr = 1
760 mmHg = 1
101.3 kpa = 1 atm

1. How many moles of oxygen will occupy a volume of 2.50 liters at 1.20 atm and 25 °C?
n = .12 moles $O_2$
V - 2.5
P - 1.20 atm
T - 298K
$\frac{2.5(1.2)}{(0.0821 \cdot 298)} = \frac{n(0.0821)(298)}{(0.0821)(298)}$

2. What volume will 2.00 moles of nitrogen occupy at 720. torr and 20.°C?
V = 51 L
n - 2
P - 720torr/760 = .947
T = 20+273 = 293K
$\frac{.947(V)}{.947} = \frac{2(.0821)(293)}{.947}$

3. What ~~pressure~~ will be exerted by 25.0 g of $CO_2$ at temperature of 25 °C and a volume of 500. mL?
P = 2.8 atm
25+273 = 298
$\frac{25g}{.500L} = \frac{P(44)}{(.0821 \cdot 298)}$
44 g/mol (Periodic Table)
$\frac{1223.29}{44}$

4. At what temperature will 5.00 g of $Cl_2$ exert a pressure of 900. torr at a volume of 750. mL?
157 K
900/760 = 1.18
$\frac{5}{.750}$
$\frac{5}{70}$ 760 (1.18) = .07 (0.0821) T
157K

5. What is the density of $NH_3$ at 800. torr and 25 °C?
800/760 = 1.1
$\frac{17(1.1)}{(.0821)298} = .76$
.769 g/L

6. If the ~~density of~~ a gas is 1.2 g/L at 745 torr and 20.°C, what is its molar mass?
29.5 g/mol
P - 745/760 =
$1.2 = \frac{.98M}{(.0821 \cdot 293)}$
$\frac{(1.2 \times .0821 \times 293)}{.98} =$ 29.5 g/mol

7. How many moles of nitrogen gas will occupy a volume of 347 mL at 6680 torr and 27 °C?
n = .12 moles $N_2$
V = .347L
P = 6680/760 = 8.79
T = 27 + 273 = 300K
$\frac{8.79(.347)}{(.0821 \cdot 300K)} = \frac{n(0.0821)(300K)}{(.0821 \cdot 300K)}$

8. What volume will 454 grams (1 lb) of hydrogen occupy at 1.05 atm and 25 °C?
5,289 L
25 + 273 = 298K
$\frac{454}{V} = \left[\frac{1.05(2)}{(.0821 \cdot 298K)}\right]$ 2 - $H_2$ - P.T. $\frac{454g}{(.0858)} = V$

9. Find the number of grams of $CO_2$ that exert a pressure of 785 torr at a volume of 32.5 L and a temperature of 32 °C.
59 g
785/760 = 1.03 atm 32.5
32°C + 273 = 305K
$\frac{g}{32.5L} = \left[\frac{1.03atm\ (44g/mol(CO_2))}{(0.0821 \cdot 305K)}\right] \cdot 32.5L$

10. An elemental gas has a mass of 10.3 g. If the volume is 58.4 L and the pressure is 758 torr at a temperature of 2.5 °C, what is the gas?
4.35g → P.T. → HELIUM
758/760
2.5+273
$\left[\frac{10.3g}{58.4L}\right] = \frac{.997(M)}{(0.0821 \cdot 293.5K)} \cdot (.0821 \cdot 293.5K)$
$\frac{.18(.0821 \cdot 293.5K)}{.997} = \frac{.997(M)}{.997}$