# Chapter 14
## Gas Laws Study Guide Answers

Definitions

Describe Boyle's Law. Give an example.
Pressure and volume of a gas at constant temperature are inversely proportional. ($P_1V_1 = P_2V_2$)

Describe Charles' Law. Give an example.
Temperature and volume of a gas at constant pressure are directly proportional. ($T_1V_2 = T_2V_1$)

Describe Gay-Lussac's Law. Give an example.
Temperature and pressure of a gas at constant volume are directly proportional. ($T_1P_2 = T_2P_1$)

Describe the combined gas laws. Why is the combined gas laws formula convenient to have?
A combination of Boyle's Law and Charles' Law that allows you to account for two changing conditions of a gas simultaneously in one calculation.

Describe an ideal gas. List the 5 properties.

Properties of an ideal gas.

1. Gases are composed of tiny particles in constant rapid, ("random" or "straight–lined"?) motion.
2. Gases are separated by relatively huge distances. The volume of the particles is essentially zero.
3. The collisions between molecules are completely elastic. (No energy is converted to heat or other forms of energy.)
4. The molecules of a gas display no attraction or repulsion.
5. The molecules of a gas have different velocities at any given moment. Since the molecules have different velocities, they have different amounts of kinetic energy. The amount of kinetic energy of the molecules is directly proportional to the Kelvin temperature.

Describe a manometer.

a device used to measure the pressure of a gas relative to another (or to the open atmosphere)

- may be a tube filled with water, or mercury

Questions

Answer the following.

1. What are the four variables that are used to describe a gas?
   P – pressure
   V – volume
   n – number of moles
   T – temperature (Kelvins)

2. What law describes the pressure of multiple gases in a shared container?
   Dalton's Law of Partial Pressures

3. Define the term mole. How many particles of any kind does one mole represent?
   The number of particles present in 12 grams of Carbon-12. $6.022 \times 10^{23}$

4. Describe how a gas moves from one end of a room to another.
   Diffusion – movement of particles from areas of high concentration to areas of low concentration.

5. What are the values of STP (in mmHg, kPa, atm)
   Standard Temperature = 273K. Standard Pressure = 760mmHg = 101.325kPa = 1atm.

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6. Under what conditions do gases deviate from ideal behavior?
   Under extremely high pressure or extremely low temperature.

7. Name the correct gas law for each of the following:
   a) the total pressure of a mixture of gas = the sum of the individual pressures of each gas
   Dalton's Law of Partial Pressures
   b) the air in a scuba diver's lungs moves rapidly into their blood stream when they surface too quickly
   Boyle's Law
   c) a soda can explodes in a hot car
   Gay-Lussac

<u>Convert the following</u>

1. 700mmHg to atm.

$$\frac{700\text{mmHg}}{} \times \frac{1\text{ atm}}{760\text{ mmHg}} = 0.92\text{ atm}$$

2. 470K to $^{o}$C

$$470\text{K} - 273 = 197^{o}\text{C}$$

3. 45$^{o}$C to K

$$45^{o}\text{C} + 273 = 318\text{K}$$

4. 3.2atm to mmHg

$$\frac{3.2\text{ atm}}{} \times \frac{760\text{ mmHg}}{1\text{ atm}} = 2432\text{ mmHg}$$

<u>Calculations</u>

Solve the following problems:

1. A quantity of gas has a volume of 321L at 23$^{o}$C and 700mmHg of pressure. If the conditions are changed to STP, what will the new volume be? (Combined Gas Law)

$P_1 = 700$ mmHg
$V_1 = 321$ L
$T_1 = 23^{o}$C (296 K)
$P_2 = 760$ mmHg
$V_2 = ?$
$T_2 = 273$ K

$V_2 = V_1 \times P_1/P_2 \times T_2/T_1$

$V_2 = 321\text{ L} \times (700\text{ mmHg}/760\text{ mmHg}) \times (273\text{ K}/296\text{ K}) =$ **273 L**

2. A quantity of gas has a volume of 250L at 40$^{o}$C . If the gas is heated to 120$^{o}$C, what will the new volume be? Which law describes this change?

$V_1 = 250$ L
$T_1 = 40^{o}$C (313 K)
$V_2 = ?$
$T_2 = 120^{o}$C (393 K)

$V_2 = V_1 \times T_2/T_1$

$V_2 = 250\text{ L} \times 393\text{ K}/313\text{ K} =$ **314 L**

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3. If a sample of gas at constant temperature has its pressure doubled, what will happen to its volume?
   According to Boyle's Law, doubling the pressure of a sample of gas will reduce it's volume by ½.

4. A 10L gas container is designed to hold gases with a pressure of up to 5000mmHg. If a gas sample that has a pressure of 600mmHg at -20°C is placed in the container, at what temperature will the container burst? (Gay-Lussac's Law)

   $P_1$ = 600 mmHg
   $V_1$ = 10 L (volume remains constant)
   $T_1$ = -20°C (253 K)
   $P_2$ = 5000 mmHg
   $V_2$ = 10 L (volume remains constant)
   $T_2$ = ? K

   $T_2 = T_1 \times P_2 / P_1$

   $T_2$ = 253 K x 5000 mmHg/600 mmHg = 2108 K

5. If a sample of gas at constant volume has its pressure reduced by ½, what happens to its temperature?

   According to the Gay-Lussac Law, the temperature and pressure of a sample of gas are directly proportional, therefore the temperature will also drop by ½.

6. If the mercury level in the manometer arm attached to the gas sample is 45mm lower than the level open to the atmosphere, what is the pressure of the gas sample if the atmospheric pressure is 0.95 atm?

   Since the mercury level is lower in the manometer arm, the gas sample has a greater pressure (by 45 mmHg) than the outside air.

   $$\frac{0.95 \text{ atm}}{} \times \frac{760 \text{ mmHg}}{1 \text{ atm}} = 722 \text{ mmHg}$$

   The pressure of the outside air in 722 mmHg, therefore the pressure of the gas sample is 767 mmHg.

7. Derive the value of R (Universal Gas Law Constant) using psi as your unit of pressure.

   P = 14.7 psi (standard pressure in psi)
   V = 22.4 L (per Avogadro's Law)
   n = 1 mol (per Avogadro's Law)
   R = ?
   T = 273 K (per Avogadro's Law)

   PV = nRT

   R = PV/nT

   R = (14.7 psi x 22.4 L) / (1 mol x 273 K ) = 1.206 psi●L/mol●K

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8. A gas whose behavior closely resembles that of an ideal gas has a volume of 3.00L at a temperature of 25°C and a pressure of 800mm Hg. (Ideal Gas Law)
   a) How many moles are in the sample?

P = 800 mmHg
V = 3.00 L
n = ?
R = 62.359 mmHg●L/mol●K
T = 25°C (298 K)

PV = nRT

n = PV/RT

n = (800 mmHg x 3.00 L) / (62.359 mmHg●L/mol●K x 298 K ) = 0.129 mol

9. A gas whose behavior closely resembles that of an ideal gas has a volume of 4.00L at a temperature of -15°C and a pressure of 730mm Hg. (Ideal Gas Law)
   a) How many moles are in the sample?

P = 730 mmHg
V = 4.00 L
n = ?
R = 62.359 mmHg●L/mol●K
T = -15°C (258 K)

PV = nRT

n = PV/RT

n = (730 mmHg x 4.00 L) / (62.359 mmHg●L/mol●K x 258 K ) = 0.181 mol

   b) How many molecules are in the sample?

$$\frac{0.181 \text{ mol}}{} \times \frac{6.02 \times 10^{23} \text{ molecules}}{1 \text{ mol}} = 1.09 \times 10^{23} \text{ molecules}$$

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10. Suppose you have a 4L container of oxygen gas at 2 atmospheres pressure and a 1L container of nitrogen gas at 2 atmosphere pressure. If you transfer the oxygen to the container holding the nitrogen,
a) what pressure would the oxygen exert?

When the oxygen is moved from the 4L container to the 1L container, its volume is being reduced by a factor of 4, so its pressure would increase by a factor of 4 for a new pressure of 8atm.

$V_1$ = 4 L
$P_1$ = 2 atm.
$V_2$ = 1 L
$P_2$ = ? atm.

$V_2 = V_1 \times P_1/P_2$

$V_2$ = 4 L x 2 atm. / 1 L = 8 atm

b) what would be the total pressure exerted by the mixture? (Dalton's Law of Partial Pressure)

Dalton's Law says that the Total Pressure of a gas is equal to the sum of the partial pressures of the gases in a container. ($P_t = P_1 + P_2 + P_3 \ldots$)

The Pressure of oxygen in its new tank would be 8 atm.. The Pressure of the nitrogen would remain 2 atmospheres.

$P_t$ = 8 atm. + 2 atm. = 10 atm.