BOYLE'S LAW

760 mm Hg = 1 atm = 760 torr

Name Jonathan ______ Block 4

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:

Make sure to show all of your work.

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

Solve the following problems (assuming constant temperature).

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?

   740 · 250 = 800V 231.25 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?

   3.5 · 125 = 2P 218.75 kPa

3. A 2.0 liter container of nitrogen had a pressure of 3.2 atm. What volume would be necessary to decrease the pressure to 1.0 atm?

   6.4 = 6.4 L

4. Ammonia gas occupies a volume of 450. mL at a pressure of 720. mm Hg. What volume will it occupy at standard pressure?

   450 · 720 = 760V 426.3 mL

5. A 175 mL sample of neon had its pressure changed from 75 kPa to 150 kPa. What is its new volume?

   175 · 75 = 150V 87.5 mL

6. A sample of hydrogen at 1.5 atm had its pressure decreased to 0.50 atm producing a new volume of 750 mL. What was its original volume?

   1.5V = 750 · .5 250 mL

7. Chlorine gas occupies a volume of 1.2 liters at 720 torr pressure. What volume will it occupy at 1 atm pressure?

   1.2 · 720 = 760V ✓ 1.1 L

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?

   900V = 1140 · 250 316 2/3 mL

CHARLES' LAW

Name ____________________

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

when working with temperature, everything must be in Kelvin

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

$$K = °C + 273$$

Must be in Kelvins

in these problems you still multiply

Solve the following problems assuming a constant pressure.

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

   $\frac{250}{298} = \frac{x}{368}$ — 308.71 mL

2. Oxygen gas is at a temperature of 40° C when it occupies a volume of 2.3 liters. To what temperature should it be raised to occupy a volume of 6.5 liters?

   $\frac{2.3}{313} = \frac{6.5}{x}$ — 884 K

3. Hydrogen gas was cooled from 15̄0° C to 5̄0° C. Its new volume is 75 mL. What was its original volume?

   $\frac{75}{423} = \frac{x}{323}$ — 57.3 mL

4. Chlorine gas occupies a volume of 25 mL at 3̄00 K. What volume will it occupy at 600 K?

   $\frac{25}{600} = \frac{x}{300}$ — 12.5 mL

5. A sample of neon gas at 5̄0° C and a volume of 2.5 liters is cooled to 25° C. What is the new volume?

   $\frac{2.5}{323} = \frac{x}{298}$ — 2.3 L

6. Fluorine gas at 30̄0 K occupies a volume of 50̄0 mL. To what temperature should it be lowered to bring the volume to 30̄0 mL?

   $\frac{500}{300} = \frac{300}{x}$ — 180 K

7. Helium occupies a volume of 3.8 liters at -45° C. What volume will it occupy at 45° C?

   $\frac{3.8}{228} = \frac{x}{318}$ — 5.3 L

8. A sample of argon gas is cooled and its volume went from 38̄0 mL to 25̄0 mL. If its final temperature was -55° C, what was its original temperature?

   $\frac{380}{x} = \frac{250}{218}$ — 331.4 K

COMBINED GAS LAW

Name ____________________

In practical terms, it is often difficult to hold any of the variables constant. When there is a change in pressure, volume and temperature, the combined gas law is used.

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2} \quad \text{or} \quad P_1V_1T_2 = P_2V_2T_1$$

you have 5 parts of the problem known, you can solve for the unknown

Complete the following chart.

	P_1	V_1	T_1	P_2	V_2	T_2
1	1.5 atm	3.0 L	20° C	2.5 atm	1.5·3/293 = 2.5V/303 1.9 L	30° C
2	720 torr	256 mL	25° C	720·256/298 = 250P/323 799.1 torr	250 mL	50° C
3	600 mmHg	2.5 L	22° C	760 mmHg	1.8 L	600·2.5/295 = 760·1.8/X 269 K
4	P = 1.2 atm 750P/273 = 1000/298	750 mL	0.0° C	2.0 atm	500 mL	25° C
5	95 kPa	4.0 L	95·4/X = 101·6/471 295.3	101 kPa	6.0 L	471 K or 198° C
6	650. torr	650P/373 = 900·225/423 274.7 mL	100° C	900. torr	225 mL	150° C
7	850 mmHg	1.5 L	15° C	850·1.5/288 = 2.5P/303 536.6	2.5 L	30° C
8	125 kPa	125 mL	125·125/X = 100·100/348 543.8 K	100 kPa	100 mL	75° C

DALTON'S LAW OF PARTIAL PRESSURES

Name ____________

Dalton's Law says that the sum of the individual pressures of all the gases that make up a mixture is equal to the total pressure or : $P_T = P_1 + P_2 + P_3 + \ldots$ The partial pressure of each gas is equal to the mole fraction of each gas x total pressure.

$$P_T = P_1 + P_2 + P_3 + \ldots \quad \text{or} \quad \frac{\text{moles gas}_x}{\text{total moles}} \times P_T = P_x$$

Solve the following problems.

1. A 250. mL sample of oxygen is collected over water at 25° C and 760.0 torr pressure. What is the pressure of the dry gas alone? (Vapor pressure of water at 25° C = 23.8 torr)

again make sure to show all work

740 torr

2. A 32.0 mL sample of hydrogen is collected over water at 20̄° C and 750.0 torr pressure. What is the volume of the dry gas at STP? (Vapor pressure of water at 20̄° C = 17.5 torr)

$32 \cdot \frac{732.5}{293} \cdot \frac{273}{760}$

29 mL

3. A 54.0 mL sample of oxygen is collected over water at 23° C and 770.0 torr pressure. What is the volume of the dry gas at STP? (Vapor pressure of water at 23° C = 21.1 torr)

$54 \cdot \frac{770}{296} \cdot \frac{273}{760}$

50 torr

4. A mixture of 2.00 moles of H_2, 3.00 moles of NH_3, 4.00 moles of CO_2 and 5.00 moles of N_2 exerts a total pressure of 800̄ torr. What is the partial pressure of each gas?

14

NH_3 171 torr H_2 : 114 t

CO_2 229 torr

N_2 : 286 torr

5. The partial pressure of F_2 in a mixture of gases where the total pressure is 1.00 atm is 300. torr. What is the mole fraction of F_2?

300 torr = 760 torr · x

.394

IDEAL GAS LAW

Name ______________

Use the Ideal Gas Law below to solve the following problems.

The key is always helpful to use. >

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

1 atm / 760 = ? / 720

1. How many moles of oxygen will occupy a volume of 2.5 liters at 1.2 atm and 25° C? .123 moles

2.5 • 1.2 = 298 • R • N

2. What volume will 2.0 moles of nitrogen occupy at 720 torr and 20° C? 50.8 L

.947 • V = 293 • R • 2

3. What pressure will be exerted by 25 g of CO_2 at a temperature of 25° C (298 K) and a volume of 500 mL? 2.77 atm

25 / (12•32) = .568 g   P • .5 = .568 • 298 • R

4. At what temperature will 5.00 g of Cl_2 exert a pressure of 900. torr (1.2 atm) at a volume of 750 mL (.75 L)? 10.8 K

.143

.143 • 7.5 = 1.2 • R • V

5. What is the density of NH_3 at 800 torr and 25° C? .730 g/L

1.05 atm • .0821 atm•L / mol•K • 1 / 298 K

6. If the density of a gas is 1.2 g/L at 745. torr and 20° C, what is its molecular mass? 29 g/mol

.98 atm / (.0821 L atm / mol k • 293 K) = .04075 / L   1.2 g / .04075

7. How many moles of nitrogen gas will occupy a volume of 347 mL at 6680 torr and 27° C? .124 mol.

8. What volume will 454 grams (1 lb) of hydrogen occupy at 1.05 atm and 25° C? 5240. L

9. Find the number of grams of CO_2 that exert a pressure of 785 torrs at a volume of 32.5 L and a temperature of 32° C. 55.8 g

(1.03 atm)(32.5) = n(.0821 L atm / mol K)(305 K)

10. An elemental gas has a mass of 10.3 g. If the volume is 58.4 L and the pressure is 758 torrs at a temperature of 2.5° C, what is the gas? Helium

(.9974 atm)(58.4L) = n(.0821 L atm / mol K)(275.5 K)   10.3 g / 2.575

n = 2.575 mol   4.0 g/mol

Name ______________________ Date ____________ Class ____________

13–4 Practice Problems

1. What volume would be occupied by 100. g of oxygen gas at a pressure of 1.50 atm and a temperature of 25°C?

3.13 mol · 0.0821 · (25+273 K) / 1.5 atm

l = 51 L

2. An air-filled balloon has a volume of 225 L at 0.94 atm and 25°C. Soon after, the pressure changes to 0.99 atm and the temperature changes to 0°C. What is the new volume of the balloon?

1.26 atm · 1.25 L / .06230 atm · .0821

l = 308 °K

3. A gas confined in a 515-cm^3 container exerts a pressure of 107.4 kPa at 38.6°C. At what Celsius temperature will it exert a pressure of 635.7 kPa if it is placed into a 644-cm^3 container? ($1 cm^3$ = 1 mL)

107.4 · 515 / 311.8 = 635.7 · 644 / x

2307.82 − 273 = 2034.82 °C

4. A balloon is inflated with 0.2494 g of helium to a pressure of 1.26 atm. If the desired volume of the balloon is 1.250 L, what must the temperature be in °C?

1.26 atm · 1.25 L / .0623 mol · .0821

308 K

5. A welder's acetylene tank has a volume of 75.0 L. It is stored at a temperature of 23.24°C and has a pressure of 7667 kPa. How many moles of acetylene are in the tank?

(75.696)(75) / (.0821)(296.24) = n

7667 KPa / 101.3 KPa

≈ 233 moles

6. How many grams of argon would it take to fill a light bulb with a volume of 0.475 L at STP?

.0212 mol · 39.95 g

≈ .847 g

7. Dry ice is carbon dioxide in the solid state. 1.28 grams of dry ice are placed into a 5.00 L evacuated chamber that is maintained at 35.1°C. What is the pressure in the chamber in kPa after all the dry ice has sublimed into CO_2 gas?

(1atm)(.25L) / (.0821)(273)

≈ .011 mol

8. A sample of Br_2 gas is loaded into an evacuated demonstration bottle at STP. The volume of the bottle is 0.25 L. How many moles of Br_2 gas will be contained in the bottle?

1 atm · .25 L / .0821 · 273 K

≈ .011 mol Br_2

9. A sample of gas occupies 0.308 m^3 at a temperature of 325 K and a pressure of 149 kPa. Calculate the number of moles of the gas that are present. Note: $1 m^3$ = 1000L

308 L

(1.47)(308) / (.0821)(325)

≈ 149 KPa / 101.3 KPa ≈ 1.47 atm

10. What pressure is exerted by 0.625 mole of a gas in a 45.4 L container at −24.0°C?

(.625)(.0821)(249) / 45.4

P ≈ .281 atm

the practice problems are on Boyle's law and Charles' law

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Name ______________________ Date ____________ Class ____________

13–2 Practice Problems

1. The air pressure for a certain tire is 109 kPa. What is this pressure in atmospheres? 1.08 atm

   109 kPa / 101.325 kPa

2. The air pressure inside a submarine is 0.62 atm. What would be the height of a column of mercury balanced by this pressure? 470 mm Hg

   .62 atm / 760 mm Hg

3. The weather news gives the atmospheric pressure as 1.07 atm. What is this atmospheric pressure in mm Hg? 813 mm Hg

   1.07 atm · 760 mm Hg

4. An experiment at Sandia National Labs in New Mexico is performed at an atmospheric pressure of 758.7 mm Hg. What is this pressure in atm? .9983 atm

   758.7 mm Hg / 760 mm Hg

5. A bag of potato chips is sealed in a factory near sea level. The atmospheric pressure at the factory is 761.3 mm Hg. The pressure inside the bag is the same. What is the pressure inside the bag of potato chips in Pa? 101,500 Pa

   761.3 mm Hg / 760 mm Hg · 101,325 Pa

6. The same bag of potato chips from Problem 5 is shipped to a town in Colorado, where the atmospheric pressure is 99.82 kPa. What is the difference (in Pa) between the pressure in the bag and the atmospheric pressure of the town? 1768 Pa

   101,325 − 99,820

7. The pressure gauge on a compressed air tank reads 43.2 lb/in². What is the pressure in atm? 2.94 atm

   43.2 lb/in² / 14.7 lb/in²

8. The pressure in the tire of an automobile is 34.8 lb/in². What is the pressure in kPa? 240. kPa

   34.8 lb/in² · 101.325 kPa / 14.7 lb/in²

9. A gas container is fitted with a manometer. The level of the mercury is 15 mm lower on the open side. Using a laboratory barometer, you find that atmospheric pressure is 750 mm Hg. What is the pressure, in atmospheres, of the gas in the container? 0.97 atm

   750 − 15 = 735

   735 mm Hg / 760 mm Hg = .967 atm

10. A soccer ball is attached to an open-ended manometer. The mercury level in the manometer is 10 mm higher on the side attached to the ball than on the side open to the atmosphere. Atmospheric pressure has already been determined to be 770 mm Hg. What is the gas pressure in the ball? 760 mm Hg

    770 − 10

11. One end of an open-ended manometer is connected to a canister filled with a gas at a pressure of 771.0 mm Hg. The mercury level on the side open to the atmosphere is 11.2 mm higher than on the side connected to the canister. What is the atmospheric pressure in mm Hg? 759.8 mm Hg

12. Suppose you are measuring the pressure inside a sealed cabinet using an open-ended manometer. The atmospheric pressure is 762.4 mm Hg. If the mercury level on the side open to the atmosphere is 3.6 mm higher than on the side attached to the cabinet, what is the pressure inside the cabinet in units of kPa? 102.1 kPa

13. The U-tube of a manometer is 26.4 cm tall. With both ends open, it is filled until the mercury level in each tube is 13.2 cm from the top. What is the largest difference in pressure this manometer can measure in units of mm Hg? 264 mm Hg

14. A manometer contains a sample of nitrogen gas at a pressure of 88.3 kPa. The level of mercury in the U-tube is 12.8 mm lower on the end open to the atmosphere. What is the atmospheric pressure in kPa? 90.0 kPa

15. One end of an open-ended manometer is connected to a canister of unknown gas. The atmospheric pressure is 1.03 atm. The mercury level is 18.6 mm higher in the U-tube on the side open to the atmosphere than on the side attached to the canister. What is the pressure of the gas in mm Hg? 801.4 mm Hg

good job with doing all the problems

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these help understand Dalton's law and combined gas laws

Name

Date Class

13–3 Practice Problems

1. A gas occupies a volume of 458 mL at a pressure of 1.01 kPa and temperature of 295 K. When the pressure is changed, the volume becomes 477 mL. If there has been no change in temperature, what is the new pressure? (1.01 kPa)(458 mL) = 477x

= .970 kPa

2. A gas occupies a volume of 2.45 L at a pressure of 1.03 atm and a temperature of 293 K. What volume will the gas occupy if the pressure changes to 0.980 atm and the temperature remains unchanged?

(1.01)(2.45) = .98x

2.58 L

3. The cylinder of a car's engine has a volume of 0.6250 L when the piston is at the bottom of the cylinder. When the piston is at the top of the cylinder the volume is 0.0600 L. If the cylinder is filled with air at an atmospheric pressure of 765.1 mm Hg when the piston is at the bottom, what is the pressure in units of kPa when the piston is at the top of the cylinder? (765.1)(.625 L) = .600x

(7970)(101.325)/760 = 1063 kPa

4. A discarded spray paint can contains only a small volume of the propellant gas at a pressure of 34,470 Pa. The volume of the can is 473.18 mL. If the can is run over by the garbage truck and flattened to a volume of 13.16 mL, what is the pressure in Pa assuming the can doesn't leak?

(34470)(473.18) = 13.16x

= $1.239 \cdot 10^6$ kPa

5. A sample of 10.0 L of argon gas is stored in a cylinder at a room temperature of 23.8°C and a pressure of 78.6 lb/in². The sample is transferred completely to another 2.8 L cylinder. Several hours after the transfer, the second cylinder has also attained room temperature. What is the pressure in the second cylinder in units of kPa?

(78.6)(10) = 2.8x

$\frac{280.7 \cdot 101.325}{14.7}$ = 1.9 · 10^4 kPa

6. What will be the volume of a gas sample at 309 K if its volume at 215 K is 3.42 L? Assume that pressure is constant.

$\frac{3.42}{215} = \frac{x}{309}$

x = 4.92 L

7. A gas sample at 83°C occupies a volume of 1400 m³. At what temperature will it occupy 1200 m³?

$x = \frac{1200 \cdot 356}{1400}$ 305 K

8. A tank of compressed CO_2 has a temperature of 23.6°C and a volume of 31.4 L. The CO_2 is completely transferred into a smaller tank that has a volume of 25.0 L. Assuming none of the CO_2 escapes during the transfer, what is the temperature of the CO_2 in the smaller tank if the temperature is lowered to achieve the same pressure as in the larger tank?

$\frac{25 \cdot 296.6}{31.4 L}$ 236 K = -36.9 C

9. A tube of mercury at a room temperature of 22.4°C has a volume of 10.6 mL between the sealed end of the tube and the mercury. The sun rises and shines through a window on the tube and warms it to 27.8°C. If the atmospheric pressure remains constant, what is the new volume between the sealed end of the tube and the mercury?

$\frac{10.6}{295.4} = \frac{x}{300.8 k}$ = 10.8 mL

10. A gas occupies 0.105 dm³ at 100. K. At what Celsius temperature will its volume be 0.140 dm³? Assume that pressure remains constant.

$\frac{.105}{100}$ = .140 dm³ / T_2

133.3 - 273

= -140 °C

It is good that you put the Kelvins back to Celsius.

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these problems are to help with ideal gas laws

13-3 Practice Problems (continued)

11. At 75°C, a gas has a volume of 3.22 dm^3. What volume will it occupy at 75 K?

$\frac{3.22}{348} = \frac{x}{75}$ | .069 dm^3 |

12. A gas at 300. K occupies 6.50 dm^3. What will its volume be at 250. K?

$\frac{6.5}{300} = \frac{x}{250}$

| x = 5.42 dm^3 |

13. What is the pressure of a mixture of helium, nitrogen, and oxygen if their partial pressures are 600. mm Hg, 150. mm Hg, and 102 mm Hg?

600 + 150 + 102

| = 852 mm Hg |

14. A flask contains a mixture of hydrogen and oxygen. The pressure being exerted by these gases is 785 mm Hg, as determined by a manometer. If the partial pressure of the hydrogen in the mixture is 395 mm Hg, what is the partial pressure of the oxygen?

785 mm − 395 mm Hg

| = 390 mm Hg |

15. An environmental testing lab uses a pump and cylinder to collect a sample of air near a leaking natural gas line. The lab finds the total pressure in their sample cylinder is 776.134 mm Hg. Analyzing the sample, they find it contains oxygen, nitrogen, and methane. What is the partial pressure of the methane in units of Pascal if the partial pressure of oxygen is 253.948 mm Hg and the partial pressure of nitrogen is 515.390 mm Hg?

$6.976 \cdot \frac{101.325}{760} \cdot \frac{1000P}{1\,kP}$

| = 906.059 Pa |

16. The barometer shows the atmospheric pressure to be 762 mm Hg. What is the partial pressure of nitrogen if nitrogen makes up 78 percent of the air?

762 · .78

| = 590 mm Hg |

17. What partial pressure of oxygen is a scuba diver breathing if the total pressure is 6.3 atm, and 20. percent of the air is oxygen?

6.3 · .2

| = 1 atm |

18. What is the atmospheric pressure if the partial pressures of nitrogen, oxygen, and argon are 77.75 kPa, 19.94 kPa, and 1.99 kPa, respectively?

77.75 + 19.94 + 1.99

| = 79.68 KPa |

19. The gases carbon dioxide, oxygen, and argon are mixed in a container. All gases have the same partial pressure, and the total pressure of the container is 32,680 Pa. What is the partial pressure of argon?

$\frac{32680}{3}$ = | 10890 KPa |

20. The partial pressure of water vapor in a greenhouse is 139.0 mm Hg, which is 18 percent of the total pressure. What is the total pressure in the greenhouse?

$\frac{.139}{.18}$ | 770 mm Hg |

Way to finish, woo!
too perf.

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