Key

Gas Laws Review

1. A 1.00 L sample of a gas has a mass of 1.25 g at STP. What is the mass of 1 mole of this gas? $PV = nRT$ $n = \frac{PV}{RT} = \frac{1\,atm(1L)}{(0.0821)(273)} = 0.0446$

$\frac{1.25g}{0.0446\,mol} = 28g/1mol$

2. Calculate the approximate volume of a 0.6000 mol sample of gas at 15.0°C and a pressure of 1.10 atm. $PV = nRT$ $V = \frac{nRT}{P} = \frac{(0.6)(0.0821)(288)}{1.10}$

$= 12.9\,L$

3. Calculate the approximate temperature of a 0.500 mol sample of gas at 750 mm Hg and a volume of 12.0 L. $PV = nRT$ $T = \frac{PV}{nR} = \frac{(0.9868)(12)}{(0.5)(0.0821)}$

$750\,mmHg \times \frac{1\,atm}{760\,mmHg} = 0.9868$

$= 288\,K = 290K$

4. What is the pressure exerted by 1.20 mol of a gas with a temperature of 20.0°C and a volume of 9.50 L? $P = \frac{nRT}{V} = \frac{1.20(0.0821)(293)}{9.50} = 3.04\,atm$

5. The volume of a gas is 400.0 mL when the pressure is 1.00 atm. At the same temperature, what is the pressure at which the volume of the gas is 2.00L?

$P_1V_1 = P_2V_2$ $400.0\,mL = 0.4000\,L$

$(0.4)(1.00) = P_2(2)$

$P_2 = 0.200\,atm$

6. At 710.0 mm Hg, a sample of nitrogen gas occupies 625 mL. What volume does the gas occupy if the temperature remains constant and the pressure increases to 760.0 mm Hg?

$(710.0)(625) = 760(V_2)$

584 mL

7. At 7.00°C, the volume of a gas is 49.0 mL. At the same pressure, its volume is 74.0 mL at what Celsius temperature?

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\frac{49.0 mL}{280} = \frac{74.0 mL}{T_2}$

$49.0 T_2 = 20720$

$T_2 = 423 K$

or 149.9°C

150.°C

8. On a cold winter morning when the temperature is -13°C, the air pressure in an automobile tire is 1.5 atm. If the volume does not change, what is the pressure after the tire has warmed to 15°C?

$\frac{1.5 atm}{260 K} = \frac{P_2}{288 K}$ $P_2 = 1.7 atm$

9. Convert 562 mmHg to atm.

$562 mmHg \times \frac{1 atm}{760 mmHg} = 0.739 atm$

10. A gas cylinder containing explosive hydrogen gas has a pressure of 50.00 atm at a temperature of 300.0 K. the cylinder can withstand a pressure of 500.0 atm before it bursts causing a building-flattening explosion. What is the maximum temperature the cylinder can withstand before bursting?

$\frac{50}{300} = \frac{500}{T_2}$ $T_2 = 3000 K$

11. A sample of a gas at 47°C and 1.03 atm occupies a volume of 2.20 L. What volume would this gas occupy at 107°C and 0.789 atm?

$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$ $\frac{(1.03)(2.20)}{320} = \frac{(0.789)(V_2)}{380}$ $V_2 = 3.41 L$

$861.08 = 252.48 V_2$

12. A 350 mL air sample collected at 35°C has a pressure of 550 torr. What pressure will the air exert if it is allowed to expand to 425 mL at 57°C?

$\frac{(550)(350)}{308} = \frac{P_2 (425)}{(330)}$ $63525000 = 130900 P_2$

$P_2 = 485 torr$

13. A gas has a volume of 1.75 L at -23°C and 150 kPa. At what temperature would the gas occupy 1.30 L at 210 kPa?

$\frac{150(1.75)}{250} = \frac{210(1.30)}{T_2}$ 260 K

14. A sample of oxygen at 40°C occupies 820 mL. If this sample later occupies 1250 mL at 60°C and 1.40 atm, what was its original pressure?

$\frac{P_1(820)}{313} = \frac{1.4(1250)}{(333)}$ $P_1 = 2.01$ atm

15. A gas at 7.75×10^4 Pa and 17°C occupies a volume of 850 cm^3. At what temperature, in degrees Celsius, would the gas occupy 720 cm^3 at 8.10×10^4 Pa?

$\frac{7.75\times10^4(850)}{290} = \frac{8.1\times10^4(720)}{T_2}$ $T_2 = 256.7$ = -16°C

16. A meteorological balloon contains 250 L of He at 22°C and 740 mm Hg. If the volume of the balloon can vary according to external conditions, what volume would it occupy at an altitude at which the temperature is -52°C and the pressure is 0.750 atm?

$0.750 \times \frac{760}{1} = 570$

$\frac{740 \text{ mmHg} (250 \text{ L})}{295} = \frac{570 \; V_2}{221}$ $V_2 = 243$ L

17. The balloon in the previous problem will burst if its volume reaches 400 L. Given the initial conditions specified in that problem, at what temperature, in degrees Celsius, will the balloon burst if its pressure at that bursting point is 0.475 atm?

$0.475 \times 760 = 361$ atm

$\frac{740(250)}{295} = \frac{361(400)}{T_2}$ $T_2 = -43$°C

18. A child receives a balloon filled with 2.30 L of helium from a vendor at an amusement park. The temperature outside is 311 K. What will the volume of the balloon be when the child brings it home to an air-conditioned house at 295 K? Assume that the pressure stays the same.

$\frac{2.30 \text{ L}}{311 \text{ K}} = \frac{V_2}{295 \text{ K}}$ $V_2 = 2.18$ L

19. A sample of argon gas occupies a volume of 295 mL at 36°C. What volume will the gas occupy at 55°C, assuming constant pressure?

$$\frac{295}{309} = \frac{V_2}{328} \qquad V_2 = 313 \text{ mL}$$

20. A sample of carbon dioxide gas occupies 638 mL at 0.893 atm and 12°C. What will the pressure be at a volume of 881 mL and a temperature of 18°C?

$$\frac{0.893(638)}{285} = \frac{P_2(881)}{291} \qquad 0.660 \text{ atm}$$

21. At 84°C, a gas in a container exerts a pressure of 0.503 atm. Assuming the size of the container has not changed, at what Celsius temperature would the pressure be 1.20 atm?

$$\frac{0.503}{357} = \frac{1.20}{T_2} \qquad \begin{array}{r} 273 \\ 84 \\ \hline 357 \end{array} \qquad T_2 = 579°C$$

22. A weather balloon at Earth's surface has a volume of 4.00 L at 304 K and 755 mm Hg. If the balloon is released and the volume reaches 4.08 L at 728 mm Hg, what is the temperature?

$$\frac{755(4)}{304} = \frac{728(4.08)}{T_2} \qquad 299\text{K}$$

23. A gas has a pressure of 4.62 atm when its volume is 2.33 L. What will the pressure be when the volume is changed to 1.03 L, assuming constant temperature? Express the final pressure in torr.

$$4.62(2.33) = P_2(1.03)$$

$$P_2 = 10.5 \text{ atm} \times \frac{760}{1 \text{ atm}} = \begin{array}{c} 7942.8_2 \\ 7940 \text{ torr} \end{array}$$

24. At a deep-sea station 200 m below the surface of the Pacific Ocean, workers live in a highly pressurized environment. How many liters of gas at STP must be compressed on the surface to fill the underwater environment with 2.00 × 10^7 L of gas at 20.0 atm? Assume that temperature remains constant.

$$2\times10^7 \text{L} \ (20.0 \text{atm}) = (1 \text{atm})(V_2)$$

$$4\times10^8 \text{ L}$$

25. If the density of an unknown gas is 3.20 g/L at -18°C and 2.17 atm, what is the molar mass of this gas?

$PV = nRT$ $\quad \frac{P}{RT} = \frac{n}{V}$ $\quad \frac{2.17}{0.0821(255)} = 0.10365\ \frac{mol}{L}$

$\frac{3.20g/L}{0.10365\ mol/L} = 30.9g/mol$

$\frac{3.20g}{L} \times \frac{L}{0.10365\ mol} =$

26. One method of estimating the temperature of the center of the sun is based on the assumption that the center consists of gases that have an average molar mass of 2.00 g/mol. If the density of the center of the sun is 1.40 g/cm^3 at a pressure of 1.30 × 10^9 atm, calculate the temperature in degrees Celsius.

$PV = nRT$ $\quad T = \frac{PV}{nR}$

$\frac{V}{n} =$ $\frac{2.00g}{1 mol} \times \frac{cm^3}{1.40g} \times \frac{1L}{1000cm^3} = 0.001429$

$T = \frac{(1.3\times10^9)(0.001429)}{0.0821}$

$T = 2.26\times10^7\ K = 2.26\times10^7\ °C$

27. A container holds 265 mL of chlorine gas, Cl_2. Assuming that the gas sample is at STP, what is its mass?

$PV = nRT$ $\quad n = \frac{PV}{RT} = \frac{1atm(0.265L)}{(0.0821)(273)}$

$n = 0.011823\ mol$

35 × 2 = 70

$0.011823\ mol \times \frac{70g}{1 mol} = 0.828\ g$

28. A gas sample that has a mass of 0.993 g occupies 0.570 L. Given that the temperature is 281 K and the pressure is 1.44 atm, what is the molar mass of the gas?

$PV = nRT$ $\quad n = \frac{PV}{RT} = \frac{(1.44)(0.570)}{(0.0821)(281)} = 0.03558\ mol$

$\frac{0.993g}{0.03558\ mol} = 27.9g/mol$

29. The normal respiratory rate for a human being is 15.0 breaths per minute. The average volume of air for each breath is 505 cm^3 at 20°C and 9.95 × 10^4 Pa. What is the volume of air at STP that an individual breathes in one day? Give your answer in cubic meters.

$\frac{462 cm^3}{1 breath} \times \frac{15 breaths}{1 min} \times \frac{60 min}{1 hr} \times \frac{24 hr}{1 day} = 9979200\ cm^3 \times \frac{(1m)^3}{(100cm)^3} = 9.98 m^3$

1000000

(1) $\frac{(9.95\times10^4\ Pa)(505 mL)}{(293K)} = \frac{(101300Pa)(V_2)}{(273K)}$

$1 atm = 101.3\ kPa \times \frac{1000Pa}{1 kPa} = 101300$

$V_2 = 462\ cm^3$

barometer - atmospheric pressure

manometer - pressure in general /

compares pressures of gases

PV=nRT

another way to get n of H_2O: $n = \frac{(1 atm)(0.75 L)}{(0.0821)(273 K)} = 0.0335$ mol H_2O

30. Solid iron (III) hydroxide decomposes to produce iron (III) oxide and water vapor. If 0.75 L of water vapor are produced at STP,

a. How many grams of iron (III) hydroxide were used?

b. How many grams of iron (III) oxide were produced?

55.85 + 48 + 3.03 = 106.88

@ STP 1mol = 22.4L

$$2\,Fe(OH)_{3(s)} \rightarrow Fe_2O_{3(s)} + 3H_2O_{(g)}$$

0.75L @ STP

55.85 + 55.85 = 111.7; + 48 = 159.7

a.) $0.75 L \times \frac{1 mol H_2O}{22.4 L} \times \frac{2 mol Fe(OH)_3}{3 mol H_2O} \times \frac{106.88 g Fe(OH)_3}{1 mol} = $ **2.4g $Fe(OH)_3$**

b.) $2.386 g Fe(OH)_3 \times \frac{1 mol Fe(OH)_3}{106.88 g Fe(OH)_3} \times \frac{1 mol Fe_2O_3}{2 mol Fe(OH)_3} \times \frac{159.7 g Fe_2O_3}{1 mol} = $ **1.8 g Fe_2O_3**

31. Solid iron reacts with sulfuric acid (H_2SO_4) to produce iron (II) sulfate and hydrogen gas. If 650 mL of hydrogen gas are collected at STP, how many grams of iron (II) sulfate are also produced?

$$Fe_{(s)} + H_2SO_{4(aq)} \rightarrow FeSO_{4(aq)} + H_{2(g)}$$

650 mL @ STP

$650 mL \times \frac{1 L}{1000 mL} \times \frac{1 mol H_2}{22.4 L} \times \frac{1 mol FeSO_4}{1 mol H_2} \times \frac{151.92 g}{1 mol FeSO_4} = 4.4 g FeSO_4$

32. If air is 20.9% oxygen by volume,

a. How many liters of air are needed to complete the combustion of 25.0 L of octane vapor (C_8H_{18}) at STP?

b. What volume of each product is produced?

32 + 18 = 50

$$2C_8H_{18} + 25O_2 \rightarrow 18H_2O + 16CO_2$$

$25.0 L \times \frac{1 mol C_8H_{18}}{22.4 L} \times \frac{25 mol O_2}{2 mol C_8H_{18}} \times \frac{22.4 L}{1 mol} = 312.5 L\ O_2$

$\frac{312.5 L\ O_2}{x} = \frac{20.9}{100}$

x = **1495L air**

$25.0 L C_8H_{18} \times \frac{18 mol H_2O}{2 mol C_8H_{18}} = $ **225L H_2O**

$25.0 L C_8H_{18} \times \frac{16 mol CO_2}{2 mol C_8H_{18}} = $ **200L CO_2**

25. If the density of an unknown gas is 3.20 g/L at -18°C and 2.17 atm, what is the molar mass of this gas?

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$PV=nRT$ $V=\frac{nRT}{P}$ $\frac{(713.776 mol)(0.0821 \frac{L \cdot atm}{mol \cdot K})(823 K)}{25 atm}$ $= 1929.15 L$

1900L

33. Fritz Haber, a German chemist, discovered a way to synthesize ammonia gas (NH_3) by combining hydrogen and nitrogen gases at extremely high temperatures and pressures.

a. Write the balanced equation for this reaction.

b. If 10.00 kg of nitrogen combines with excess hydrogen at 550°C and 25 atm, what volume of ammonia gas is produced?

$3H_{2(g)} + N_{2(g)} \rightarrow 2NH_{3(g)}$

excess; 10.00 kg, 550°C, 25 atm; ? L

$10.00 kg \times \frac{1000 g N_2}{1 kg} \times \frac{1 mol N_2}{28.02 g N_2} \times \frac{2 mol NH_3}{1 mol N_2} = 713.776 mol NH_3$

40.08
24.02
64.10

34. A 3.25 gram sample of solid calcium carbide (CaC_2) reacts with water to produce acetylene gas (C_2H_2) and aqueous calcium hydroxide. If the acetylene was collected over water at 17°C and 740.0 mm Hg, how many milliliters of acetylene were produced?

$CaC_{2(s)} + 2H_2O_{(l)} \rightarrow C_2H_{2(g)} + Ca(OH)_{2(aq)}$

3.25 g; 17°C; 740.0 mm Hg

$3.25 g \times \frac{1 mol CaC_2}{64.10 g CaC_2} \times \frac{1 mol C_2H_2}{1 mol CaC_2} =$ $0.0507 mol C_2H_2$ ①

$PV=nRT$

$(0.9546 atm)V = (0.0507 mol)(0.0821)(290 K)$ ③

$V = 1.265 L \times \frac{1000 mL}{1 L} = $ 1270L

$740 mmHg = 14.5 + P_{C_2H_2}$

725.5 mm Hg ②

$725.5 mmHg \times \frac{1 atm}{760} = 0.9546$

35. Suppose you have a sample of gas A, with a molar mass of 75 g/mol, and another sample of gas B, with a molar mass of 150 g/mol. How many more times faster will gas A diffuse than gas B?

$\frac{r_A}{r_B} = \sqrt{\frac{M_B}{M_A}}$ $\frac{r_A}{r_B} = \sqrt{\frac{150 g/mol}{75 g/mol}}$

$r_A = 1.41 r_B$ or 1.4x faster

36. If hydrogen is diffusing at 10 m/s what is the velocity of helium under the same conditions?

$\frac{10 m/s}{r_2} = \sqrt{\frac{4.00}{2.02}}$ $r_2 = 7.1 m/s$

7 m/s

37. What is the molar volume of air at –180°C, just above the boiling point of liquid air (at a pressure of 1 atm and 1 mole of gas)?

$PV=nRT$

$V = 7.6 L$ $V = \frac{(1 mol)(0.0821)(93)}{1 atm}$

38. A sample of oxygen gas occupies 560.0 ml when the pressure is 800.00 mm Hg. At a constant temperature, what volume does it occupy when the pressure decreases to 700.0 mm Hg?

$P_1V_1 = P_2V_2$

$(560 mL)(800.00) = (700.0)(V_2)$

640.0 mL

39. A gas sample with a mass of 12.8 g exerts a pressure of 1.2 atm at 15°C and a volume of 3.94 L. What is the molar mass of the gas?

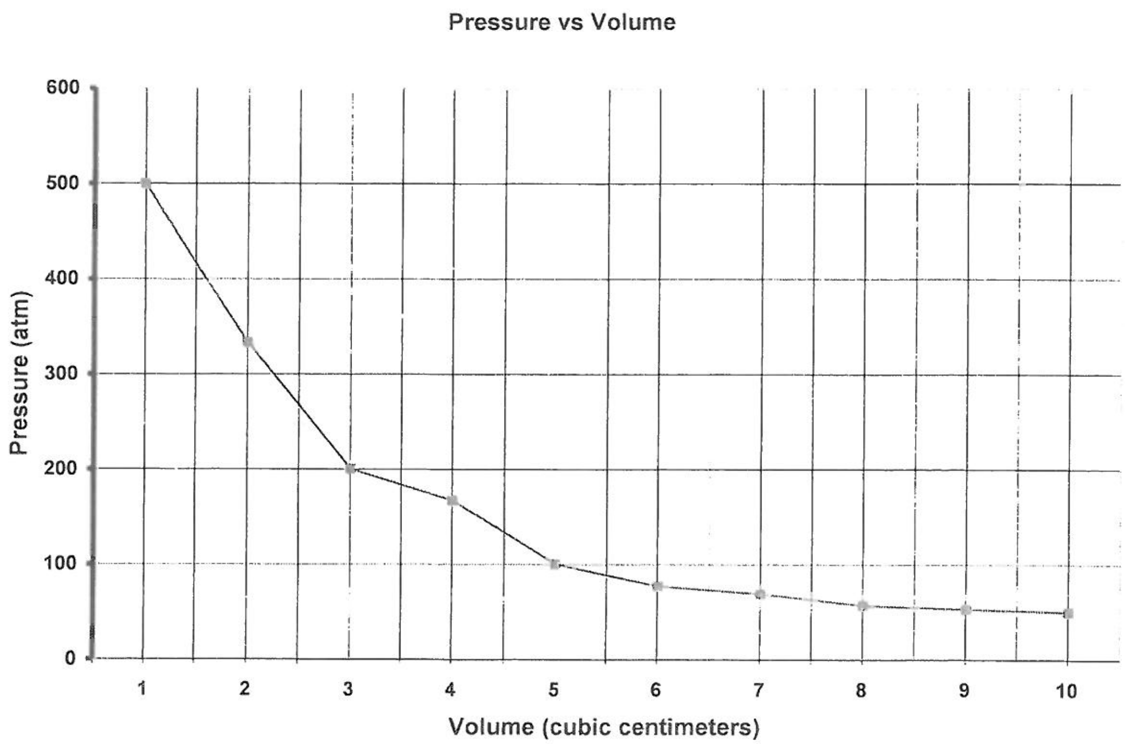
PV = nRT

1.2atm (3.94L) = n (0.0821)(288 K)

n = 0.19996 mol

$\frac{12.8g}{0.19996mol}$ = 64.01 g/mol

40. Refer to the graph below when answering the remaining questions



a. Which gas law does this graph illustrate? Boyle's (P&V)

b. What is the pressure if the volume of the gas is 1.5 cm^3?

~267 atm

c. If you assume that the maximum volume of the gas is 15.0 cm^3 at STP, how much gas is present? Give your answer in moles, and show your work!

moles of gas present: 6.70×10^{-4} mol

$15.0\ mL \times \frac{1L}{1000mL} \times \frac{1mol}{22.4L} =$

d. By looking at the graphs, what type of relationship exists between pressure and volume? In other words, is the relationship proportional or inversely proportional?

inversely proportional