Ideal gas law practice worksheet with answers

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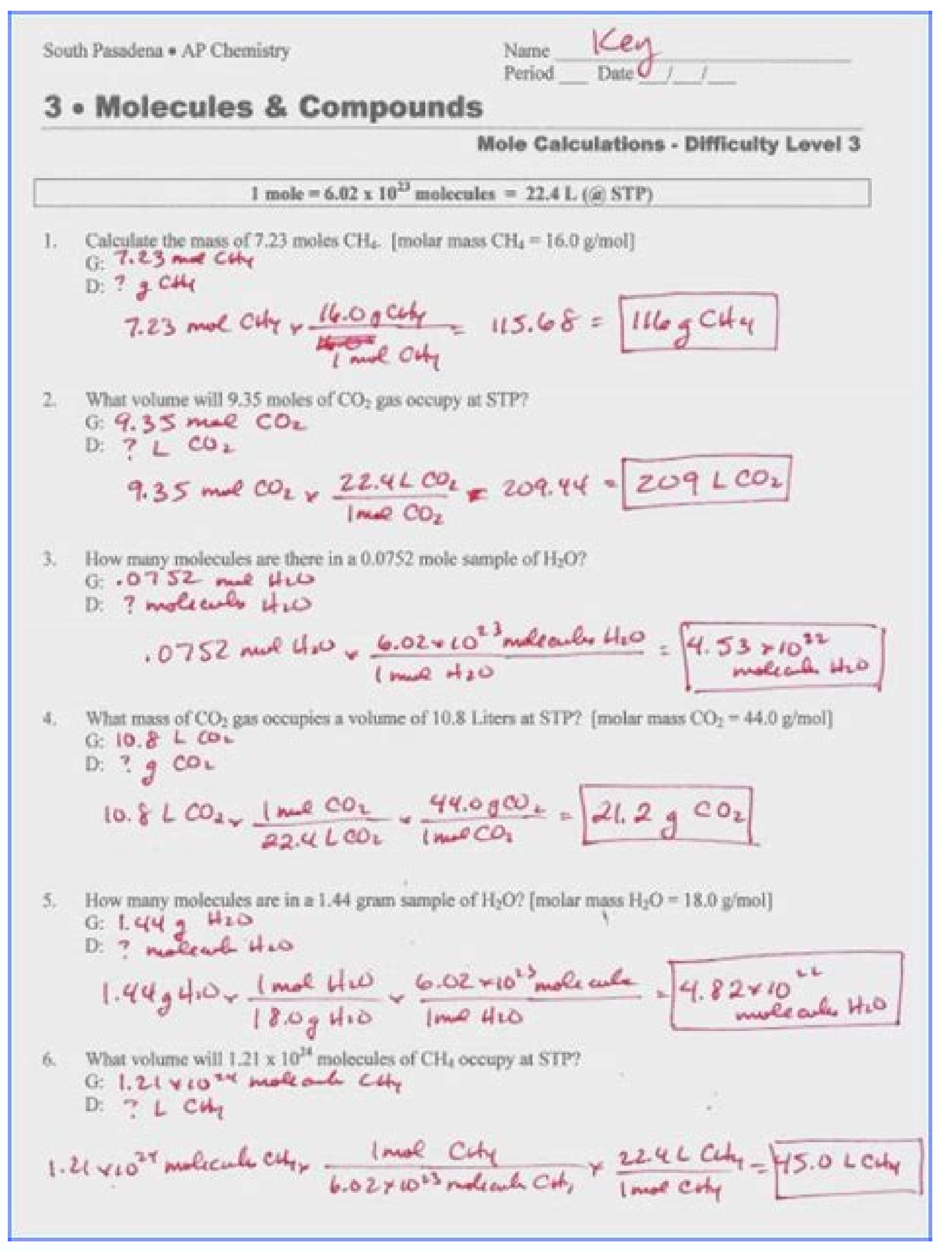


South Pasadena • AP Chemistry

Name Key

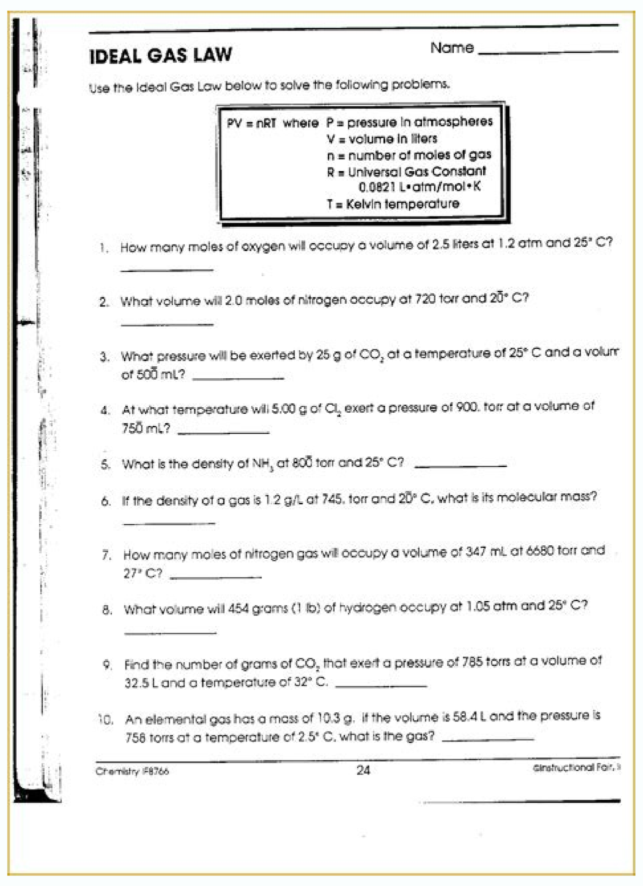
Period ___ Date ___/___/___

3 • Molecules & Compounds

Mole Calculations - Difficulty Level 3

1 mole = 6.02×10^{23} molecules = 22.4 L (@ STP)

1. Calculate the mass of 7.23 moles CH_4. [molar mass CH_4 = 16.0 g/mol]
   G: 7.23 mol CH_4
   D: ? g CH_4
   7.23 mol CH_4 × 16.0 g CH_4 / 1 mol CH_4 = 115.68 = 116 g CH_4
2. What volume will 9.35 moles of CO_2 gas occupy at STP?
   G: 9.35 mol CO_2
   D: ? L CO_2
   9.35 mol CO_2 × 22.4 L CO_2 / 1 mol CO_2 = 209.44 = 209 L CO_2
3. How many molecules are there in a 0.0752 mole sample of H_2O?
   G: .0752 mol H_2O
   D: ? molecules H_2O
   .0752 mol H_2O × 6.02×10^{23} molecules H_2O / 1 mol H_2O = 4.53×10^{22} molecules H_2O
4. What mass of CO_2 gas occupies a volume of 10.8 Liters at STP? [molar mass CO_2 = 44.0 g/mol]
   G: 10.8 L CO_2
   D: ? g CO_2
   10.8 L CO_2 × 1 mol CO_2 / 22.4 L CO_2 × 44.0 g CO_2 / 1 mol CO_2 = 21.2 g CO_2
5. How many molecules are in a 1.44 gram sample of H_2O? [molar mass H_2O = 18.0 g/mol]
   G: 1.44 g H_2O
   D: ? molecules H_2O
   1.44 g H_2O × 1 mol H_2O / 18.0 g H_2O × 6.02×10^{23} molecules / 1 mol H_2O = 4.82×10^{22} molecules H_2O
6. What volume will 1.21×10^{24} molecules of CH_4 occupy at STP?
   G: 1.21×10^{24} molecules CH_4
   D: ? L CH_4
   1.21×10^{24} molecules CH_4 × 1 mol CH_4 / 6.02×10^{23} molecules CH_4 × 22.4 L CH_4 / 1 mol CH_4 = 45.0 L CH_4



IDEAL GAS LAW

Name ____________

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

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. How many moles of oxygen will occupy a volume of 2.5 liters at 1.2 atm and 25° C? ________
2. What volume will 2.0 moles of nitrogen occupy at 720 torr and 20° C? ________
3. What pressure will be exerted by 25 g of CO_2 at a temperature of 25° C and a volume of 500 mL? ________
4. At what temperature will 5.00 g of Cl_2 exert a pressure of 900. torr at a volume of 750 mL? ________
5. What is the density of NH_3 at 800 torr and 25° C? ________
6. If the density of a gas is 1.2 g/L at 745. torr and 20° C, what is its molecular mass? ________
7. How many moles of nitrogen gas will occupy a volume of 347 mL at 6680 torr and 27° C? ________
8. What volume will 454 grams (1 lb) of hydrogen occupy at 1.05 atm and 25° C? ________
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. ________
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? ________

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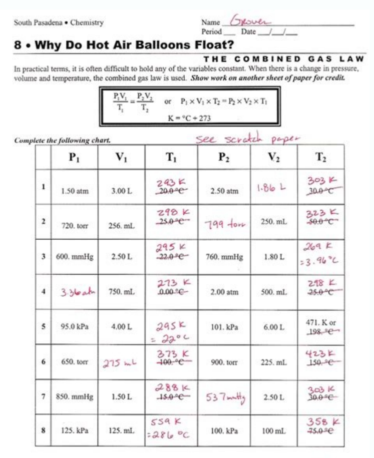


South Pasadena • Chemistry

Name Grover

Period ___ Date ___/___/___

8 • Why Do Hot Air Balloons Float?

THE COMBINED GAS LAW

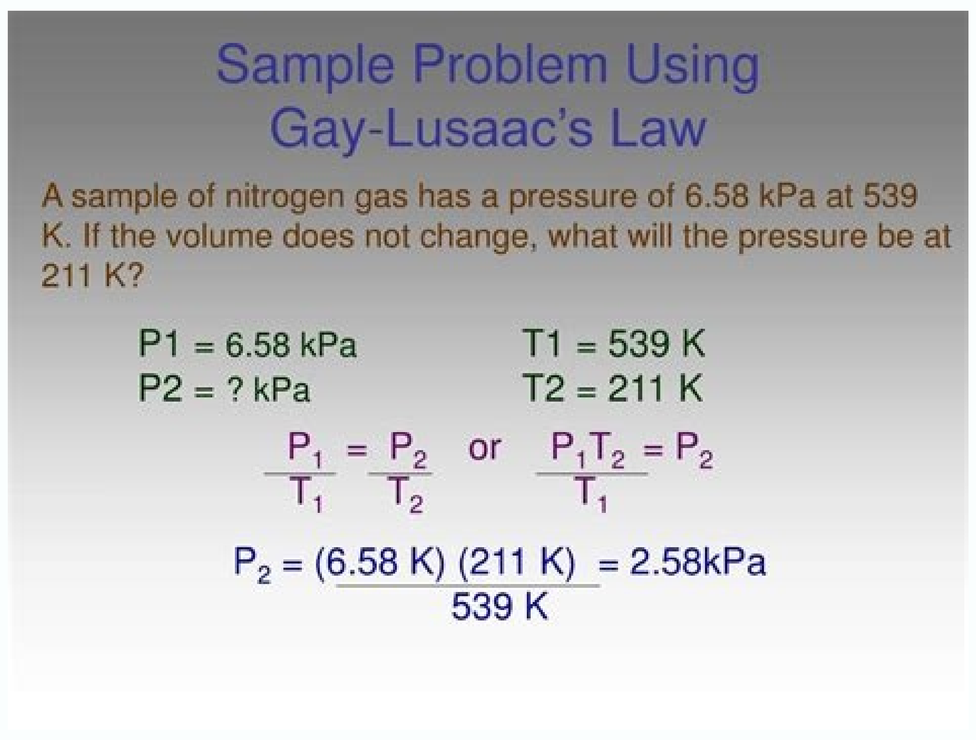
In practical terms, it is often difficult to hold any of the variables constant. When there is a change in pressure, volume and temperature, the combined gas law is used. ***Show work on another sheet of paper for credit.***

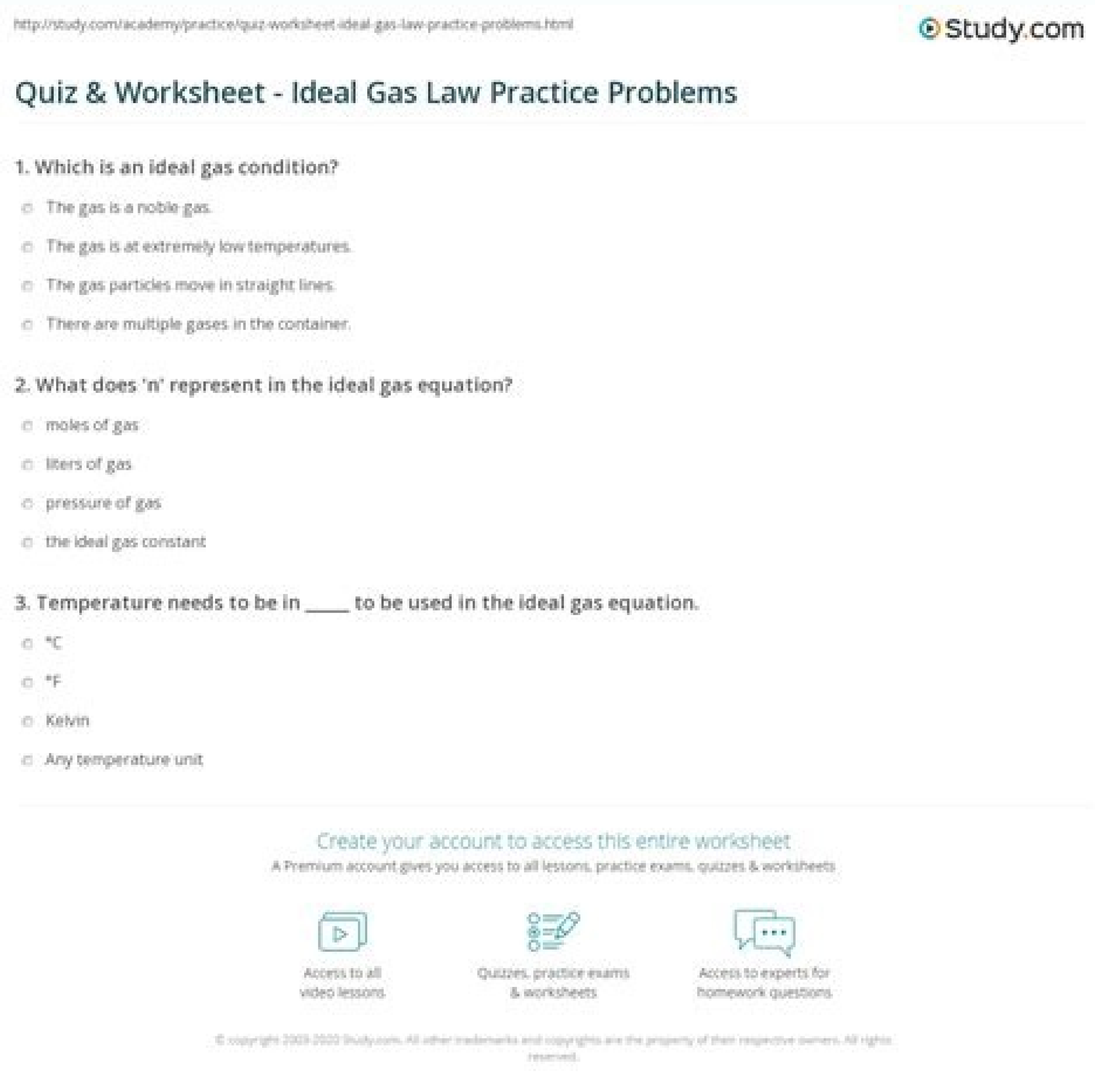
$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ or $P_1 \times V_1 \times T_2 = P_2 \times V_2 \times T_1$

K = °C + 273

Complete the following chart. see scratch paper

	P_1	V_1	T_1	P_2	V_2	T_2
1	1.50 atm	3.00 L	293 K 20.0 °C	2.50 atm	1.86 L	303 K 30.0 °C
2	720. torr	256. mL	298 K 25.0 °C	799 torr	250. mL	323 K 50.0 °C
3	600. mmHg	2.50 L	295 K 22.0 °C	760. mmHg	1.80 L	269 K = 3.96 °C
4	3.36 atm	750. mL	273 K 0.00 °C	2.00 atm	500. mL	298 K 25.0 °C
5	95.0 kPa	4.00 L	295 K = 22 °C	101. kPa	6.00 L	471. K or 198. °C
6	650. torr	275 mL	373 K 100. °C	900. torr	225. mL	423 K 150. °C
7	850. mmHg	1.50 L	288 K 15.0 °C	537 mmHg	2.50 L	303 K 30.0 °C
8	125. kPa	125. mL	559 K = 286 °C	100. kPa	100 mL	358 K 75.0 °C





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Quiz & Worksheet - Ideal Gas Law Practice Problems

1. Which is an ideal gas condition?

- The gas is a noble gas.
- The gas is at extremely low temperatures.
- The gas particles move in straight lines.
- There are multiple gases in the container.

2. What does 'n' represent in the ideal gas equation?

- moles of gas
- liters of gas
- pressure of gas
- the ideal gas constant

3. Temperature needs to be in ____ to be used in the ideal gas equation.

- °C
- °F
- Kelvin
- Any temperature unit

Gas laws review worksheet. Ideal gas law practice answer key.

PROBLEM \(\PageIndex{1}\) What is the density of laughing gas, dinitrogen monoxide, N2O, at a temperature of 325 K and a pressure of 113.0 kPa? Answer 1.84 g/L PROBLEM \(\PageIndex{2}\) Calculate the density of Freon 12, CF2Cl2, at 30.0 °C and 0.954 atm. Answer 4.64 g/L Click here to see a video of the solution PROBLEM \(\PageIndex{3}\) Which is denser at the same temperature and pressure, dry air or air saturated with water vapor? Explain. Answer air saturated with water vapor - it has a higher molar mass PROBLEM \(\PageIndex{4}\) A cylinder of O2(g) used in breathing by emphysema patients has a volume of 3.00 L at a pressure of 10.0 atm. If the temperature of the cylinder is 28.0 °C, what mass of oxygen is in the cylinder? Answer 38.8 g Click here to see a video of the solution PROBLEM \(\PageIndex{5}\) What is the molar mass of a gas if 0.0494 g of the gas occupies a volume of 0.100 L at a temperature 26 °C and a pressure of 307 torr? Answer 30.0 g/mol PROBLEM \(\PageIndex{6}\) What is the molar mass of a gas if 0.281 g of the gas occupies a volume of 125 mL at a temperature 126 °C and a pressure of 777 torr? Answer 72.0 g/mol Click here to see a video of the solution PROBLEM \(\PageIndex{7}\) The density of a certain gaseous fluoride of phosphorus is 3.93 g/L at STP. Calculate the molar mass of this fluoride and determine its molecular formula. Answer 88.1 g mol−1; PF3 PROBLEM \\(\PageIndex{8}\) What is the molecular formula of a compound that contains 39% C, 45% N, and 16% H if 0.157 g of the compound occupies 125 mL with a pressure of 99.5 kPa at 22 °C? Answer H5CN Click here to see a video of the solution PROBLEM \\(\PageIndex{9}\) A sample of gas isolated from unrefined petroleum contains 90.0% CH4, 8.9% C2H6, and 1.1% C3H8 at a total pressure of 307.2 kPa. What is the partial pressure of each component of this gas? (The percentages given indicate the percent of the total pressure that is due to each component.) Answer CH4: 276 kPa; C2H6: 27 kPa; C3H8: 3.4 kPa PROBLEM \(\PageIndex{10}\) Automobile air bags are inflated with nitrogen gas, which is formed by the decomposition of solid sodium azide (NaN3). The other product is sodium metal. Calculate the volume of nitrogen gas at 27 °C and 756 torr formed by the decomposition of 125 g of sodium azide. Answer 71.26 L Click here to see a video of the solution PROBLEM \\(\PageIndex{11}\) A sample of a compound of xenon and fluorine was confined in a bulb with a pressure of 18 torr. Hydrogen was added to the bulb until the pressure was 72 torr. Passage of an electric spark through the mixture produced Xe and HF. After the HF was removed by reaction with solid KOH, the final pressure of xenon and unreacted hydrogen in the bulb was 36 torr. What is the empirical formula of the xenon fluoride in the original sample? (Note: Xenon fluorides contain only one xenon atom per molecule.) Answer XeF2 Contributors If you're seeing this message, it means we're having trouble loading external resources on our website. If you're behind a web filter, please make sure that the domains *.kastatic.org and *.kasandbox.org are unblocked. Fifteen Examples Problems #11-25 Examples and Problems only Return to KMT & Gas Laws Menu Problem #1: Determine the volume of occupied by 2.34 grams of carbon dioxide gas at STP. Solution: 1) Rearrange PV = nRT to this: V = nRT / P 2) Substitute: V = [(2.34 g / 44.0 g mol¯1) (0.08206 L atm mol¯1 K¯1) (273.0 K)] / 1.00 atm V = 1.19 L (to three significant figures) Problem #2: A sample of argon gas at STP occupies 56.2 liters. Determine the number of moles of argon and the mass of argon in the sample. Solution: 1) Rearrange PV = nRT to this: n = PV / RT 2) Substitute: n = [(1.00 atm) (56.2 L)] / [(0.08206 L atm mol¯1 K¯1) (273.0 K)] n = 2.50866 mol (I'll keep a few guard digits) 3) Multiply the moles by the atomic weight of Ar to get the grams: 2.50866 mol times 39.948 g/mol = 100. g (to three sig figs) Problem #3: At what temperature will 0.654 moles of neon gas occupy 12.30 liters at 1.95 atmospheres? Solution: 1) Rearrange PV = nRT to this: T = PV / nR 2) Substitute: T = [(1.95 atm) (12.30 L)] / [(0.654 mol) (0.08206 L atm mol¯1 K¯1)] T = 447 K Problem #4: A 30.6 g sample of gas occupies 22.414 L at STP. What is the molecular weight of this gas? Solution: Since one mole of gas occupies 22.414 L at STP, the molecular weight of the gas is 30.6 g mol¯1 Problem #5: A 40.0 g gas sample occupies 11.2 L at STP. Find the molecular weight of this gas. Solution: 11.2 L at STP is one-half molar volume, so there is 0.500 mol of gas present. Therefore, the molecular weight is 80.0 g mol¯1 Problem #6: A 12.0 g sample of gas occupies 19.2 L at STP. What is the molecular weight of this gas? Solution: This problem, as well as the two just above can be solved with PV = nRT. You would solve for n, the number of moles. Then you would divide the grams given by the mole calculated. 1) Use PV = nRT: (1.00 atm) (19.2 L) = (n) (0.08206) (273 K) n = 0.8570518 mol (I'll keep a few guard digits) 2) Determine the molecular weight: 12.0 g / 0.8570518 mol = 14.0 g/mol 3) Since it is at STP, we can also use molar volume: (19.2 L / 12.0 g) = (22.414 L / x) 19.2x = 268.968 x = 14.0 g/mol Warning: you can only use molar volume when you are at STP. Problem #7: 96.0 g. of a gas occupies 48.0 L at 700.0 mm Hg and 20.0 °C. What is its molecular weight? Solution: 1) Solve for the moles using PV = nRT: n = PV / RT n = [(700.0 mmHg / 760.0 mmHg atm¯1) (48.0 L)] / [(0.08206 L atm mol¯1 K¯1) (293.0 K)] n = 1.8388 mol 2) Divide the grams given (96.0) by the moles just calculated above: 96.0 g / 1.8388 mol = 52.2 g/mol Problem #8: 20.83 g of a gas occupies 4.167 L at 79.97 kPa at 30.0 °C. What is its molecular weight? Solution: 1) Solve for the moles using PV = nRT: n = PV / RT n = [(79.97 kPa / 101.325 kPa atm¯1) (4.167 L)] / [(0.08206 L atm mol¯1 K¯1) (303.0 K)] n = 0.13227 mol 2) Divide the grams given (20.83) by the moles just calculated above: 20.83 g / 0.13227 mol = 157.5 g/mol Notice that, in the two problems just above, the I converted the pressure unit given in the problem to atmospheres. I did this to use the value for R that I have memorized. There are many different ways to express R, it's just that L-atm/mol-K is the unit I prefer to use, whenever possible. Also, you cannot use molar volume since the two problems just above are not at STP. Problem #9a: What is the value of and units on R? What is R called ("A letter" is not the correct answer!)? R is called the gas constant. It was first discovered, as part of the discovery in the mid-1830's by Emil Clapeyron of what is now called the Ideal Gas Law. Sometimes it is called the universal constant because it shows up in many non-gas-related situations. However, it is mostly called the gas constant or, sometimes, the universal gas constant. Depending on the units selected, the "value" for R can take on many different forms. Here is a list. Keep in mind these different "values" represent the same thing. Problem #9b: What is often called the Ideal Gas Constant is 0.0820574 L atm mol¯1 K¯1. What is often called the Universal Gas Constant is 8.31451 J mol¯1 K¯1. Convert the Ideal Gas Constant into the Universal Gas Constant and vice versa. Solution: 1) To find the conversions, divide one by the other: 8.31451 J mol¯1 K¯1 / 0.0820574 L atm mol¯1 K¯1 = 101.3255 J L¯1 atm¯1 This means that 1 L atm = 101.3255 J 2) The other division: 0.0820574/8.31451 = 0.00986918 (try putting the units in as was done just above) This means that 1 J = 0.00986918 L atm You could have also done this: 1 / 101.3255 = 0.00986918 3) Here are the conversions: (0.0820574 atm L/mol K) (101.3255 J/L atm) = 8.31451 J/mol K and (8.31451 J/mol K) (0.00986918 L atm / J) = 0.0820574 L atm / mol K Problem #10: 5.600 g of solid CO2 is put in an empty sealed 4.00 L container at a temperature of 300 K. When all the solid CO2 becomes gas, what will be the pressure in the container? Solution: 1) Determine moles of CO2: 5.600 g / 44.009 g/mol = 0.1272467 mol 2) Use PV = nRT (P) (4.00 L) = (0.1272467 mol) (0.08206 L atm mol¯1 K¯1) (300 K) P = 0.7831 atm (to four sig figs) Bonus Problem #1: 2.035 g H2 produces a pressure of 1.015 atm in a 5.00 L container at -211.76 °C. What will the temperature (in °C) have to be if an additional 2.099 g H2 are added to the container and the pressure increases to 3.015 atm. Solution: 1) What gas law should be used to solve this problem? Notice that we have pressure, volume and temperature explicitly mentioned. In addition, mass and molecular weight will give us moles. It appears that the ideal gas law is called for. However, there is a problem. We are being asked to change the conditions to a new amount of moles and pressure. So, it seems like the ideal gas law needs to be used twice. 2) Let's set up two ideal gas law equations: P1V1 = n1RT1 This equation will use the 2.035 g amount of H2 as well as the 1.015 atm, 5.00 L, and the -211.76 °C (converted to Kelvin, which I will do in a moment). P2V2 = n2RT2 This second equation will use the data in the second sentence and T2 will be the unknown. What I need to do is set the two equations equal to each other. First, I rearrange a bit. 3) Like this: P1V1 = n1RT1 leads to: and P2V2 = n2RT2 leads to: 4) I will use the fact that R is the same value in each equation: R = R, therefore: P1V1 P2V2 ––––– = ––––– n1T1 n2T2 5) I'm going to isolate T2 on one side of the equals sign: Since the volume never changes, we can eliminate it from the equation: P1 P2 ––––– = ––––– n1T1 n2T2 Now, cross-multiply: P1n2T2 = P2n1T1 Isolate T2: Another way to write it is this: T2 = P2n1T1 / P1n2 6) One more comment: it's about the moles: Each of the mole amounts would be arrived at by dividing the grams by the molar mass (in this case, H2). However, notice the molar masses will cancel, being the same numerical value and one in the nominator and one in the denominator. After cancelling, this is what we wind up with: P2mass1T1 T2 = ––––––––– P1mass2 7) We are now ready to solve: (3.015 atm) (2.035 g) (61.24 K) T2 = ––––––––––––––––––––––––– (1.015 atm) (4.134 g) T2 = 89.546867 K Converting to Celsius and using four sig figs gives 362.5 °C for the answer. Bonus Problem #2: 1.00 mole of gas occupies 22.414 L at STP. Calculate the temperature and pressure conditions needed to fit 2.00 moles of a gas into a volume of 22.414 L. Solution: 1) Notice that the problem asks for two conditions: one of temperature and one of pressure. The answer we arrive at will not be a value of T and one of P, but a ratio between the two. Start here: PV = nRT 2) Insert our known values: (P) (22.414 L) = (2.00 mol) (0.08206 L atm / mol K) (T) 3) Since the question mentions T first, let's determine a T/P ratio: T/P = 22.414 L / [(2.00 mol) (0.08206 L atm / mol K)] T/P = 136.57 K/atm Any T/P combination that gives 136.57 will be an answer. 4) If you wanted a P/T ratio, it would be 0.007322. Fifteen Examples Problems #11-25 Examples and Problems only Return to KMT & Gas Laws Menu

molecular formula. Answer 88.1 g mol−1; PF3 PROBLEM \\(\PageIndex{8}\) What is the molecular formula of a compound that contains 39% C, 45% N, and 16% H if 0.157 g of the compound occupies 125 mL with a pressure of 99.5 kPa at 22 °C? Answer H5CN Click here to see a video of the solution PROBLEM \\(\PageIndex{9}\) A sample of gas isolated from unrefined petroleum contains 90.0% CH4, 8.9% C2H6, and 1.1% C3H8 at a total pressure of 307.2 kPa. What is the partial pressure of each component of this gas? (The percentages given indicate the percent of the total pressure that is due to each component.) Answer CH4: 276 kPa; C2H6: 27 kPa; C3H8: 3.4 kPa PROBLEM \(\PageIndex{10}\) Automobile air bags are inflated with nitrogen gas, which is formed by the decomposition of solid sodium azide (NaN3). The other product is sodium metal. Calculate the volume of nitrogen gas at 27 °C and 756 torr formed by the decomposition of 125 g of sodium azide. 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Solution: 1) To find the conversions, divide one by the other: 8.31451 J mol¯1 K¯1 / 0.0820574 L atm mol¯1 K¯1 = 101.3255 J L¯1 atm¯1 This means that 1 L atm = 101.3255 J 2) The other division: 0.0820574/8.31451 = 0.00986918 (try putting the units in as was done just above) This means that 1 J = 0.00986918 L atm You could have also done this: 1 / 101.3255 = 0.00986918 3) Here are the conversions: (0.0820574 atm L/mol K) (101.3255 J/L atm) = 8.31451 J/mol K and (8.31451 J/mol K) (0.00986918 L atm / J) = 0.0820574 L atm / mol K Problem #10: 5.600 g of solid CO2 is put in an empty sealed 4.00 L container at a temperature of 300 K. When all the solid CO2 becomes gas, what will be the pressure in the container? Solution: 1) Determine moles of CO2: 5.600 g / 44.009 g/mol = 0.1272467 mol 2) Use PV = nRT (P) (4.00 L) = (0.1272467 mol) (0.08206 L atm mol¯1 K¯1) (300 K) P = 0.7831 atm (to four sig figs) Bonus Problem #1: 2.035 g H2 produces a pressure of 1.015 atm in a 5.00 L container at -211.76 °C. What will the temperature (in °C) have to be if an additional 2.099 g H2 are added to the container and the pressure increases to 3.015 atm. Solution: 1) What gas law should be used to solve this problem? Notice that we have pressure, volume and temperature explicitly mentioned. In addition, mass and molecular weight will give us moles. It appears that the ideal gas law is called for. However, there is a problem. We are being asked to change the conditions to a new amount of moles and pressure. So, it seems like the ideal gas law needs to be used twice. 2) Let's set up two ideal gas law equations: P1V1 = n1RT1 This equation will use the 2.035 g amount of H2 as well as the 1.015 atm, 5.00 L, and the -211.76 °C (converted to Kelvin, which I will do in a moment). P2V2 = n2RT2 This second equation will use the data in the second sentence and T2 will be the unknown. What I need to do is set the two equations equal to each other. First, I rearrange a bit. 3) Like this: P1V1 = n1RT1 leads to: and P2V2 = n2RT2 leads to: 4) I will use the fact that R is the same value in each equation: R = R, therefore: P1V1 P2V2 ––––– = ––––– n1T1 n2T2 5) I'm going to isolate T2 on one side of the equals sign: Since the volume never changes, we can eliminate it from the equation: P1 P2 ––––– = ––––– n1T1 n2T2 Now, cross-multiply: P1n2T2 = P2n1T1 Isolate T2: Another way to write it is this: T2 = P2n1T1 / P1n2 6) One more comment: it's about the moles: Each of the mole amounts would be arrived at by dividing the grams by the molar mass (in this case, H2). However, notice the molar masses will cancel, being the same numerical value and one in the nominator and one in the denominator. After cancelling, this is what we wind up with: P2mass1T1 T2 = ––––––––– P1mass2 7) We are now ready to solve: (3.015 atm) (2.035 g) (61.24 K) T2 = ––––––––––––––––––––––––– (1.015 atm) (4.134 g) T2 = 89.546867 K Converting to Celsius and using four sig figs gives 362.5 °C for the answer. Bonus Problem #2: 1.00 mole of gas occupies 22.414 L at STP. Calculate the temperature and pressure conditions needed to fit 2.00 moles of a gas into a volume of 22.414 L. Solution: 1) Notice that the problem asks for two conditions: one of temperature and one of pressure. The answer we arrive at will not be a value of T and one of P, but a ratio between the two. Start here: PV = nRT 2) Insert our known values: (P) (22.414 L) = (2.00 mol) (0.08206 L atm / mol K) (T) 3) Since the question mentions T first, let's determine a T/P ratio: T/P = 22.414 L / [(2.00 mol) (0.08206 L atm / mol K)] T/P = 136.57 K/atm Any T/P combination that gives 136.57 will be an answer. 4) If you wanted a P/T ratio, it would be 0.007322. Fifteen Examples Problems #11-25 Examples and Problems only Return to KMT & Gas Laws Menu

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