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Gas laws calculations worksheet

Name:

You should try to answer questions without referring to your textbook. If it blocks you, try asking another group for help. Of the three main states of matter (gas, liquid, solid), gases exhibit behavior that is more easily linked to molecular movement. Observed gas behavior, embodied in empirical gas laws, leads to a number of equations that can be summarized by a single equation of state, called the ideal equation of gas law. This shows the relationship between the pressure of a gas (P), the temperature (T), the volume (V) and the quantity in moles (n). Connecting these variables together is a fundamental constant in the universe, called the gaseous constant (R). Learning objectives Understanding the nature of the parameters that define the behavior of gases Know the names and relationships represented by the various empirical laws on gas Understand the meaning of the ideal gas law Know how to extract the relevant relationship from the ideal gas law to predict gas parameter values when sample conditions are changed Know the standard temperature and pressure (STP) Success criteria Be able to calculate the pressure from Fundamental equations of physics Be able to determine the pressure from barometer and pressure gauge Readings Be able to make various empirical calculations of gas law Be able to apply the ideal gas law Be able to use STP in gas-law calculations, when appropriate A gas sample is characterized by specifying its quantity, its temperature , its volume and pressure. Most of us have a clear idea of the first three parameters, but our understanding of pressure may be less precise. In physics, pressure is defined as force applied per unit area, force is defined as the product of mass time acceleration, . [P . Using SI units of kilograms, meters, and seconds with these fundamental equations, determine the combination of units that define the following: The newton (N), the fundamental unit of force Pascal (Pa), the fundamental unit of pressure Historically, air pressure was measured by observing the height of the column in a mercury barometer. When the downward pressure of the mercury in the closed column is exactly equal to the air pressure on the surface of the mercury pool where the open end of the tube is submerged, a level is obtained whose height can be used as an indication of air pressure. In these terms we define a standard atmosphere (1 atm) as the pressure necessary to support a height of 760 mm of mercury, written 760 mm Hg. The Hg mm unit is also called torr, so 1 atm - 760 torr. The pressure of a column of liquid is given by (P - gdh), where g is× the acceleration of gravity (9,807 m×s–2), d is the density and h is the height. the height. mercury density is 13.6 g/cm3. What is the pressure exerted in Pa by a 760 mm mercury column? In the United States we mention barometric pressure in inches of mercury (in. Hg). What is a standard pressure atmosphere in these units? (1 in. or 2.54 cm) In Europe barometric pressure is mentioned in ectopascals (hPa), where hecto means one hundred. What is a standard atmosphere in hPa? A typical 10W-40 engine oil has a density of 0.875 g/cm3. If you were to build a barometer using 10W-40 engine oil, how high would the column be when the pressure is an atmosphere? Sample gas pressures are measured using the height difference in the U-tube of a pressure gauge. The gauges are closed or open-end in design. A closed pressure gauge (above, left) provides an absolute measure of the pressure in torr; the open pressure gauge (above, on the right) gives the pressure relative to the atmospheric pressure on the open end. To use an open pressure gauge, you also need to know the barometric pressure at the time of reading. Refer to images of closed and open pressure gauges above. In the left gauge, the left side reads 108 mm and the right side 32 mm. What is the pressure of the sample gas in torr? In the gauge on the right, the left (outer) side reads 98.3 mm, while the right (inner) side reads 32.1 mm. The pressure in the laboratory is 756.2 mm Hg. What is the pressure of the sample gas in torr? In the gauge on the right, if the heights of the two sides were reversed (32.1 mm to the left and 98.3 mm to the right), what would be the pressure of the sample gas in torr? Boyle's law says that for a gas sample at constant temperature the volume is inversely proportional to pressure. Perform the following steps to derive equations for Boyle's Law. Express Boyle's Law in proportion to the two, and the C's. A proportionality can be transformed into an equation by adding a proportionality constant. For example, if you can use a constant, (c) to write the equation. Do this for the proportionality of Boyle's law that you just wrote, making b be the constant. Under what conditions is b a constant? Consider a gas sample at constant temperature with an initial volume V1 and an initial pressure P1. Write an equation that shows how the characters (V_1) and (P_1 are related to the new volume and pressure conditions, if the V_2 and (P_2) conditions change. [Tip: Look at the equation you wrote in part ii.] A gas sample of 144 mL in a piston chamber has a pressure of 2.25 atm. If the piston is pushed so that the gas has a volume of 36.0 mL, what is the new pressure? Suppose the temperature remains constant. Charles' Law says that at constant pressure the volume from a certain amount of gas is directly proportional to its absolute temperature. Perform the following steps to derive equations for Charles' law. Carlo. proportionality between the two values (V) and (T) expressing Charles' Law. Using the proportionality constant c, write an equation for the relationship between (V) and (T). Under what conditions is there a constant? What does absolute temperature mean? Why do we have to use absolute temperature in the equation for Charles' Law? Write an equation for the relationship between the initial temperature and volume, the T_1 values, and the values of (V_1) and the final temperature and volume(T_2) and (V_2), when one of them is changed under constant pressure conditions. A gas sample of 5.00-L in a piston chamber at 25 degrees centigrade is heated to 100 degrees centigrade, while the pressure is maintained at 1.00 atm. What is the volume of gas after heating? Boyle's law and Charles' law can be combined into a single equation expressing volume, temperature, and pressure relationships for a fixed amount of gas. Perform the following steps to derive equations for the combined gas law. Combine your two expressions of proportionality for Boyle's Law and Charles' Law into a single expression that shows how volume depends on both pressure and temperature. Using the proportionality constant k, write an equation for this combined gas law. Write an equation for the relationship between the initial conditions (V_1) and P_1 the final conditions (T_1 V_2) and the final conditions (V_2) and (P_2 and (T_2), when two of these are modified for a gas sample. At 29 and 756 torr, a gas occupies 2.50 L. What is the volume if the temperature is changed to 159 degrees centigrade and the pressure is changed to 1550 torr? For any gas sample under ideal conditions, the relationship between the amount of gas in moles (n) and its temperature, pressure and volume is given by the relation [PV - nRT] in which R is the gas constant, with a value of 0.08206 L×atm/K×mol. When using this value of R, the volume must be in liters, the temperature must be in degrees kelvin, and the amount of gas must be in moles. If other drives are provided, convert them to these drives. When other units are used, the value of R is different. [Later, we will see another use of R, where its value and units are 8,314 J/K×mol.] A sample of He(g) occupies 15.0 L with a pressure of 856 torr when the temperature is 52 oC. How many grams of He(g) does the sample contain? [at. wt. He : 4.00 u] We have seen equations for Boyle's law, Charles' law and the Combined Gas Act. You don't really need to remember these equations if you know PV - nRT, because these and some other relationships that we haven't seen yet are contained in the Ideal Gas Act. For example, Boyle's Law is the volume and pressure when quantity and temperature are constant. If we take the variable n and T in PV nRT as constants, then everything to the right is a constant. The product of any number of constants is a constant, so you can write . The result PV - b, is our previous equation for Boyle's law. Derive the equation for Charles' law by reorganizing PV nRT to put all constants on one side of the equation. Thus, redefining the product of constants to be the constant c. Amonton's Law expresses the ratio of temperature to pressure for a gas sample in constant volume. Derive the expression for Amonton's Law, using a as a constant. Then write the relationship between the initial conditions T1 and P1 and the final conditions T2 and P2, when the quantity and volume are constant. Avogadro's law is based on the ratio of the amount of gas to its volume under constant temperature and pressure conditions. Derive an equation for Avogadro's Law from PV nRT to show the relationship between the initial conditions n1 and V1 and the final conditions n2 and V2. Avogadro's Law was an extension of an earlier gay-lussac observation. Gay-Lussac law says that in reactions between gas at constant temperature and pressure, the volumes that react are in the ratios of small integers. Nitrogen gas and hydrogen gas combine directly to form ammonia gas. Write the balanced equation for this reaction. If 250 mL of nitrogen gas at 5.00 atm and 750 K reacts with hydrogen gas at the same pressure and temperature, what volume of hydrogen gas is needed? What is the theoretical yield in ammonia gas milliliters under these conditions? Due to nRT PV, we can calculate the volume occupied by a gas mole under specific temperature and pressure conditions. For convenience, we define the standard temperature and pressure (abbreviated STP) as 0 degrees centigrade (273 K) and 1 atm. Using these values in PV - nRT, we can calculate the volume of the STP molar for an ideal gas: 1 mol gas - 22.4 L Realize that this relationship is valid only when the gas sample is in STP conditions. What volume in STP occupies a sample of 76.0 g of N2 (m.w. - 28.0 u)? A gas sample with a mass of 57.2 g at STP occupies 80.0 L. Which of the following gases could be: N2, CO2, CH4? CH4?

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