Key

Gas Laws - Ch 11

NOTE: SOLVE ALL PROBLEMS ON SEPARATE PAPER. SHOW ALL WORK

$P_1V_1 = P_2V_2$

I. Boyle's Law (11.3)

Describe Boyle's Law: related pressure to volume

Is this a direct or an indirect relationship? indirect, meaning as P↑ V↓ ; P↓ V↑

Write the formula for Boyle's Law: $P_1V_1 = P_2V_2$

List acceptable units for each variable in Boyle's Law. P: atm, KPa, torr, mmHg, psi

V: mL, L, cm^3

Solve:

a. Calculate the final pressure in the cylinder of a car engine if the original volume was 450 ml at a pressure of 101.3 kPa and the final volume is 120 ml. Assume no change in the number of molecules or temperature.

$P_2 = \frac{(101.3\text{ kPa})(450\text{ mL})}{120\text{ mL}}$; $P_2 = 380$ kPa

b. The volume of a gas is 250 ml at 3.5 atm pressure. What will the volume be when the pressure is reduced to 0.75 atm?

$V_2 = \frac{(3.5\text{ atm})(250\text{ mL})}{0.75\text{ atm}} =$ 1167 mL or 1.2 L

c. CQ # 36, 65 SKIP

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$

II. Charles's Law (11.4 & 11.5)

Describe Charles's Law: relates volume & temperature

Is this a direct or an indirect relationship? direct, meaning as T↑ V↑ ; T↓ V↓

Write the formula for Charles' Law: $V_1/T_1 = V_2/T_2$

List acceptable units for each variable in Charles' Law. V: mL, L, cm^3

T: °C, K

Solve:

a. A helium balloon inflated in an air-conditioned store at 27°C has a volume of 4.0 liters. When the balloon is taken outside, the temperature is 40°C. What is the new volume?

$V_2 = \frac{(4\text{ L})(313\text{ K})}{300\text{ K}}$; $V_2 = 4.2$ L

b. The gas inside a piston was heated until the volume of gas had increased from 125 ml to 850 ml. If the temperature inside the piston was originally 15°C, calculate the new temperature. The amount of gas and the pressure do not change.

$T_2 = \frac{V_2T_1}{V_1} = \frac{(850\text{ mL})(288\text{ K})}{125\text{ mL}} =$ 1958 K

c. CQ # 7, pg 299 SKIP

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$

III. Gay-Lussac's Law (the pressure-temperature relationship): (11.4 & 11.6)

Describe Gay-Lussac's Law: relates pressure & temperature

Is this a direct or an indirect relationship? direct, meaning as T↑ P↑ ; T↓ P↓

Write the formula for Gay-Lussac's Law: $P_1/T_1 = P_2/T_2$

List acceptable units for each variable in Gay-Lussac's Law. P: atm, KPa, torr, mmHg, psi

T: °C, K

Solve:

a. The propellant gas left in an "empty" aerosol can is at atmospheric pressure (101.3kPa) and room temperature (23°C). If the can is thrown into a fire where the temperature of the gas reaches 927°C, what is the pressure in the can?

$P_2 = \frac{(101.3\text{ kPa})(1200\text{ K})}{296\text{ K}}$; $P_2 = 411$ kPa

b. A certain gas is held in a storage tank at a pressure of 50 atm and a temperature of 23°C. There is a small metal safety plug, designed to melt at high temperatures in order to relieve dangerously high pressure. If the pressure inside the tank reaches 75 atm, the plug will melt. What is the temperature at this pressure?

$T_2 = \frac{P_2T_1}{P_1} = \frac{(75\text{ atm})(296\text{ K})}{50\text{ atm}} =$ 444 K

c. CQ # 39, 40

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

IV. Combined Gas Law (11.7)

What is meant by the "Combined" Gas Law? relates each of the above laws

Write the formula for the Combined Gas Law. $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

Solve:

a. At sea level the volume of a hot air balloon is 1 x 10^5 liters. The pressure is 760 mm of Hg and the temperature is 25°C. At an altitude of 6 km, the pressure is 350 mm of Hg, and the temperature is -23°C. What is the volume of the balloon at this altitude?

$V_1 = 1\times10^5$ L ; $P_1 = 760$ mmHg ; $T_1 = 298$ K ; $P_2 = 350$ mmHg ; $T_2 = -23°C$ 250 K ; $V_2 = ?$

$V_2 = \frac{P_1V_1T_2}{T_1P_2} = 1.8\times10^5$ L

b. Determine the temperature required to change 10 liters of helium at -100°C and 0.1 atm to 20 liters at 1.7 atm. Rewrite the final answer in celsius units.

$V_1 = 10$ L ; $T_1 = 173$ K ; $P_1 = 0.1$ atm ; $V_2 = 20$ L ; $T_2 = ?$; $P_2 = 1.7$ atm

$T_2 = \frac{P_2V_2T_1}{P_1V_1} =$ 5882 K ; 5609 °C

c. CQ # 12, pg. 303

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$R = 8.31 \frac{L \cdot kPa}{K \cdot mol}$

V. The Ideal Gas Law: (11.8)

What variables are included in the Ideal Gas Law? $PV = nRT$

The Ideal Gas Law is a modification of the Combined Gas Law. Describe the modification relating every thing to moles (# part) $\frac{PV}{Tn}$ = constant for all ideal gases

If P, V, n, and T are considered to represent exactly 1 mole of gas at STP, calculate the value of PV/nT. Be sure to include the appropriate units. $8.314 \frac{L \cdot kPa}{K \cdot mol}$ or $0.0821 \frac{L \cdot atm}{K \cdot mol}$

1 mol = 22.4L

STP = 0°C, 273K, 101.3 KPa, 1atm

Write the mathematical form of the ideal gas law: $PV = nRT$

Solve:

a. When a rigid hollow sphere containing 680 L of helium gas is heated 600 K, the Pressure of the gas increases to 1800 kPa. How many moles of helium are present?

b. CQ # 45, 60, 63

$PV = nRT$

$n = \frac{PV}{RT} = \frac{(1800\,kPa)(680\,L)}{(8.314 \frac{L \cdot kPa}{K \cdot mol})(600\,K)}$

$n = 245.4$ mol

VI. Dalton's Law of Partial Pressures (11.9)

Define "partial pressure". contribution of each gas in a mixture... all = total pressure

Write the mathematical form of Dalton's Law of partial pressures. $P_{TOT} = P_1 + P_2 + \ldots P_n$

Solve:

CQ # 17, 18 (both on pg. 308); 49

VII. Avogadro's Hypothesis (11.10)

Recall earlier references to STP, moles, number of molecules, and volume. What is the molar volume of oxygen gas at STP? 1 mol = 22.4L. How many molecules would be present? 6.02×10^{23} molec What would the mass of the gas be at these conditions? 32g

$\frac{1\,mol\,O_2}{1} \times \frac{32g}{1\,mol}$ $\frac{22.4L}{1} \times$

Solve:

CQ # 21, 22, 23 (on pg. 311)

VIII. Real vs Ideal gases (11.12)

We live in a world of ______ (real? ideal?) gases. Under conditions of (low? high?) pressures and (low? high?) temperatures gases will condense to liquids. In addition, real gas molecules (have? have no?) volume of their own. This is contrary to the concept of an ideal gas, which follows the gas laws at all conditions of temperature and pressure, and assumes that gas molecules occupy no space of their own. However, under most conditions of temperature and pressure, real gases do behave like an ideal gas.

Try; CQ #29 on pg. 315. Hint: "Intermolecular forces" play a large part in determining the exact molar volume of a gas.