Name______________________________Pd________

Gas Laws: The Equations of State and Flux

1. How many molecules of gasoline vapor are there in one car engine cylinder, assuming the following: a) gasoline vapor is an ideal gas, b) the cylinder is 4 cm in diameter and 10 cm in height, c) the temperature of the vapor in the cylinder is 644 K, and the pressure before the engine's stroke is 1.7 atm?

   Normalizing units: $r = 0.02$ m and $h = 0.1$ m and $P = 1.7 \cdot 10^5$ Pa

   Small calculation: $V = \pi r^2 h = (3.14)(.02)^2(.1) = 1.256 \cdot 10^{-4}$ m^3

   We'll use: $PV=nRT \rightarrow n=PV/RT = (1.7 \cdot 10^5)(1.256 \cdot 10^{-4})/(8.314)(644) = 0.00399$ mol $= 2.4 \cdot 10^{21}$ molecules

2. A 4.6 liter balloon (0.0046 m^3) at 9°C is released by a skin diver from deep in the ocean. When it reaches the surface, its volume is 5.8 liters, the pressure of the gas at the surface is $1.01 \cdot 10^5$ Pa, and the temperature is 23.9°C. What is the initial pressure of the gas when the balloon is underwater? How many moles of gas are in the balloon?

   Normalizing units: $T_{ocean}=282$ K and $T_{surface}=296.9$ K and $V_{surface}=0.0058$ m^3

   First, we'll use $P_1V_1/T_1 = P_2V_2/T_2 \rightarrow P_1 = P_2V_2T_1/V_1T_2 = (1.01 \cdot 10^5)(.0058)(282)/(.0046)(296.9) = 1.21 \cdot 10^5$ Pa

   We'll use: $PV=nRT \rightarrow n=PV/RT = (1.01 \cdot 10^5)(.0058)/(8.314)(296.9) = .237$ mol

3. A driver measures the pressure in her tires before a long trip. The pressure gauge reads $2.81 \cdot 10^5$ Pa at the beginning of the trip, and $3.01 \cdot 10^5$ Pa afterwards. The beginning temperature is 284 K. Assuming the change in the tire's volume is negligible, what is the temperature of the air in the tires at the trip's end?

   We'll use $P_1V_1/T_1 = P_2V_2/T_2 \rightarrow T_2 = P_2T_1/P_1 = (3.01 \cdot 10^5)(284)/(2.81 \cdot 10^5) = 304$ K

4. Oxygen for hospital patients is kept in special tanks at a pressure of 65 atm, and a temperature of 288 K. The oxygen is pumped from a separate room into the patient's room, which is kept at a more comfortable 297 K and standard pressure. What volume would 1 m^3 of gas in the tanks occupy in the patient's room?

   Normalizing units: Although good practice, isn't needed here, since temps are already in Kelvins

   We'll use $P_1V_1/T_1 = P_2V_2/T_2 \rightarrow V_2 = P_1V_1T_2/T_1P_2 = (65)(1)(297)/(288)(1) = 67.03$ m^3

5. Find the volume occupied by one mole of an ideal gas at STP, in liters. (1 liter = 10^{-3} m^3)

   Remembering: STP is defined as 1 atm and 0°C (10^5 Pa and 273 K)

   We'll use $PV=nRT \rightarrow V=nRT/P = (1)(8.314)(273)/(10^5) = 0.0227$ m^3 which is equal to 22.7 L

   (Not the 22.4 you might know from Chemistry because of rounding…like usual.)

6. The space shuttle's rocket boosters change the liquid fuel within into a gas in order to blast off. The gas inside the 4000 m^3 engines is initially at a temperature of 5750 K and a pressure of 4 atm that is released as exhaust at a pressure of 1 atm. If the exhaust cloud billows to a size of 16000 m^3 upon exiting the booster, what is the temperature of the exhaust gases?

   [We're making a lot of bad assumptions with this problem…Just live with them!!!!]

   Normalizing units: Although good practice, isn't needed here again; notice my little shorthand trick, too…

   We'll use $P_1V_1/T_1 = P_2V_2/T_2 \rightarrow T_2 = P_2V_2T_1/P_1V_1 = (1)(16k)(5750)/(4)(4k) = 5750$ K

   You could've saved time if you'd noticed the pressure decreases by 4X and the volume increases by 4x--this would make an excellent AP MC question!

7. A copper box is constructed so that it has dimensions of 20 cm x 30 cm x 1 m when at a temperature of 30°C. It is filled with an ideal gas at a pressure of 5 MPa at this temperature. The box is then heated to 393 K so that its new volume is 60.275 liters. a) How many moles of gas were in the container to start with? b) How many molecules of gas were in the container after heating it? c) What's the final volume of the box in m^3? and d) What's the pressure of the gas in the box after heating?

   Normalizing units: L·W·H are (.2)(.3)(1) so $V_1 = .06$ m^3 and $T_1=303$ K and $V_2=.060275$ m^3

   First, we'll use: $PV=nRT \rightarrow n=PV/RT = (5 \cdot 10^6)(.06)/(8.314)(303) = 119.1$ mol $= 7.2 \cdot 10^{25}$ molecules (# of molecules stays constant)

   Third, we'll use $P_1V_1/T_1 = P_2V_2/T_2 \rightarrow P_2 = P_1V_1T_2/T_1V_2 = (5 \cdot 10^6)(.06)(393)/(303)(.060275) = 6.46 \cdot 10^6$ Pa (or 6.46 MPa)