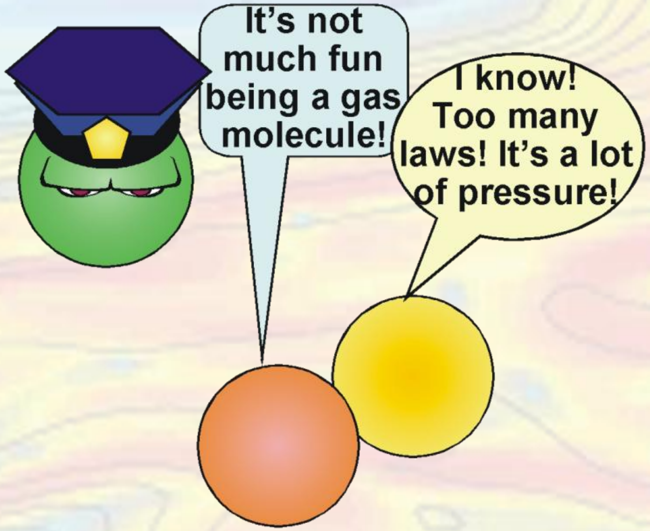
Gas Density and Molar Mass

Gas Law Versatility

- Using the gas constant and the ideal gas law (PV = *n*RT), it is possible to determine the value of any of the four variables knowing the other three.
- Mass can be used as one of the variables since it has a relationship with moles (*n*).
- Consequently the molar mass and density of a gas can be determined from the ideal gas law.



Deriving the Density Equation

- $PV = nRT$
- Let m = mass and M = molar mass

  Then $n = \frac{m}{M}$.
- Substituting, we get $PV = \frac{mRT}{M}$.
- Solving for molar mass, we get $M = \frac{mRT}{PV}$,

  but density is mass per unit volume . . . $D = \frac{m}{V}$.
- Molar mass, $M = \frac{DRT}{P}$.
- Density, $D = \frac{PM}{RT}$.

Problem 1

What is the molar mass of a gas that has a density of 2.16 g/L at 15°C and 3.00 atm?

- $M = \dfrac{DRT}{P}$

$$M = \frac{(2.16\ g/L)(0.0821\ \frac{L \bullet atm}{mol \bullet K})(288\ K)}{(3.00\ atm)} = 17.0\ g/mol$$

Problem 2

What is the density of methane (CH_4) at 100.°C and 2.00 atm?

- $D = \dfrac{PM}{RT}$

$$D = \frac{(2.00\ atm)\ (16.04\ g/mol)}{(0.0821\ \frac{L \bullet atm}{mol \bullet K})(373\ K)} = 1.05\ g/L$$