Question: What is the molar mass of a gas that has a density of 6.70 g/L at STP?.

A. 0.298 g/mol
B. 3.35 g/mol
C. 73 g/mol
D. 150 g/mol
E. 496 g/mol

HINT: What does STP mean?

Concepts: To answer this question we need to understand what density is and how we can obtain it using the ideal gas law.

Connections: *What is given?* We are given the density of a sample of gas as well as the state of the gas sample (STP).

What do I want to know? We want to know the molecular weight of the gas under these conditions. We have to use the density to figure this out.

What else do I need to know? STP is an abbreviation for **S**tandard **T**emperature and **P**ressure. For as, STP corresponds to P = 1 atm and T = 0 °C or 273.2 K

Density is defined as mass per unit volume (m/V). For gases the most common unit is g/L because the densities tend to be low. If we know the number of moles of gas (n) that we have, we can use the molar mass in g (M) to get the mass = (nM). Typically we can use the ideal gas law to get n (n = PV/(RT), however we do not know the volume.

We can however calculate the ratio of the moles to the volume: n/V = P/(RT). If we simply multiply both sides of this equation by the molar mass (M), the ratio nM/V is the density = d

nM/V = d = PM(RT)

From this equation, we see that the density of a gas depends only on its identity (molecular weight), temperature and pressure so we should be able to determine the identity of a gas from its density.

M = dRT/P

As with the idea gas law, proper units is imperative. Since we are given P in atm and T in K, we will use the gas constant: R = 0.0821 L-atm/mol-K. If we use M in g/mol, then the resulting density will have units of g/L.

Be sure you understand everything above before moving on to the solution below.

Solution:

Start by summarizing all your information:

$d = 6.70$ g/L

STP means standard temperature and pressure:

$P = 1.0$ atm

$T = 0°C$

Next, we need to determine which R value to use. Since we're using pressure units we need to use $R = 0.0821$ L-atm/mol-K

Now we see that Kelvin is the temperature scale needed so we convert our temperature to Kelvin:

$T = 0°C + 273.15 = 273.15$ K

We now have all of the information needed to complete the calculation:

$M = dRT/P$ E12-4-4

$M = (6.70 \text{ g/L})(0.0821 \text{ L-atm/mol-K})(273.15 \text{ K})/1.0 \text{ atm}$

$M = 150$ g/mol or answer choice D