Answer on Question #63274 - Chemistry - General Chemistry

Question:

Carbon dioxide, which is recognized as the major contributor to global warming as a "greenhouse gas," is formed when fossil fuels are combusted, as in electrical power plants fueled by coal, oil, or natural gas. One potential way to reduce the amount of CO2 added to the atmosphere is to store it as a compressed gas in underground formations. Consider a 1000-megawatt coal-fired power plant that produces about 7×106 tons of CO2 per year.

1)Assuming ideal gas behavior, 1.00 atm, and 17 ∘C, calculate the volume of CO2 produced by this power plant.

2) If the CO2 is stored underground as a liquid at 10 ∘C and 120 atm and a density of 1.2 g/cm3, what volume does it possess?

3) If it is stored underground as a gas at 33 ∘C and 90 atm , what volume does it occupy?

Solution:

1) The relation between pressure, volume, temperature and amount of ideal gas is expressed by the ideal gas equation:

$$P * V = (m / M) * R * T, \text{ where}$$

P – the pressure of gas (Pa),
V – volume of gas (m^3),
m – mass of gas (g),
M – molar mass of gas (g/mol)
R – universal gas constant = 8.314 m^3 Pa K^{-1} mol^{-1}
T – absolute temperature (K).

Let's express volume from the equation above:

$$V = (m / M) * R * T / P$$

and bring to the standard units:
$m = 7*10^6$ tons $= 7*10^{12}$ grams;
$M (CO_2) = 12+16*2 = 44$ g/mol;
$T = 17$ ∘C $= (17+273)$ K $= 290$ K;
$P = 1.00$ atm $= 101325$ Pa.

Do the calculation:
$V = (7*10^{12}\ g / 44\ g/mol) * 8.314\ m^3\ Pa\ K^{-1}\ mol^{-1} * 290\ K / 101325\ Pa = 3.79*10^9\ m^3$.

2) Density is mass / volume. Therefore volume = mass / density.
Do the calculation:
$V = 7*10^{12}\ g / 1.2\ g/cm^3 = 5.83*10^{12}\ cm^3 = 5.83*10^6\ m^3$.

3) Use the equation from part 1), but with another pressure and temperature:
   $P = 90\ atm = (90 * 101325)\ Pa = 9.1*10^6\ Pa$;
   $T = 33\ ^\circ C = (33+273)\ K = 306\ K$.

   Do the calculation:

$V = (7*10^{12}\ g / 44\ g/mol) * 8.314\ m^3\ Pa\ K^{-1}\ mol^{-1} * 306\ K / 9.1*10^6\ Pa = 4.45*10^7\ m^3$.

Answer:

1) $3.79*10^9\ m^3$.
2) $5.83*10^6\ m^3$.
3) $4.45*10^7\ m^3$.