11.10: Gases in Chemical Reactions- Stoichiometry Revisited

Earlier in the course we performed stoichiometric calculations with chemical reactions using quantities of moles and mass (typically in grams). These same principles can be applied to chemical reactions involving gases except that we first have to convert volumes of gases into moles.

Example

Hydrogen gas reacts with oxygen gas to produce water vapor via the following balanced chemical equation:
$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(g)}$
If the temperature is 320 K and pressure is 1.34 atm, what volume of oxygen is required to produce 65.0 g of water?
Strategy: Since we are given the temperature and pressure, to find the volume of oxygen using the ideal gas law we need to first calculate the moles of oxygen. To find the moles of oxygen required, we can first calculate the moles of water in 65.0g.

$$n_{water} = \frac{m_{water}}{mm_{water}} = \frac{65.0\text{ g}}{18.0\text{g/mol}} = 3.61\text{ mol of water} \tag{11.10.1}$$

From the balanced chemical equation, we can see that 1 equivalent of oxygen produces 2 equivalents of water. We can therefore write the following ratio:
1 mol O_2 : 2 mol H_2O
We can now solve for the amount of oxygen:

$$(3.61\text{ mol } H_2O) \times (\frac{1\text{ mol } O_2}{2\text{ mol } H_2O}) = 1.81\text{ mol } O_2 \tag{11.10.2}$$

Finally, now that we know how many moles of oxygen are required, we can calculate the volume of the oxygen using the ideal gas law and the temperature&pressure provided in question:

$$PV = nRT \tag{11.10.3}$$

$$V = \frac{nRT}{P} \tag{11.10.4}$$

$$V = \frac{1.81\text{mol } \cdot 0.08206\frac{\text{Latm}}{\text{molK}} \cdot 320\text{K}}{1.34\text{atm}} \tag{11.10.5}$$

$$V = 35.5\text{L} \tag{11.10.6}$$