Question#46528 – Chemistry – Inorganic Chemistry

Question:

The Ostwald process is used commercially to produce nitric acid, which is, in turn, used in many modern chemical processes. In the first step of the Ostwald process, ammonia is reacted with oxygen gas to produce nitric oxide and water. What is the maximum mass of H_2O that can be produced by combining 86.4 g of each reactant?

4 $NH_{3(g)}$ +5 $O_{2(g)}$ --> 4 $NO_{(g)}$ + 6 $H_2O_{(g)}$

Answer:

Firstly, the amount of moles of each initial compound can be calculated:

$$n(NH_3) = \frac{m(NH_3)}{M(NH_3)} = \frac{86.4g}{17g/mol} = 5.1mol$$

$$n(O_2) = \frac{m(O_2)}{M(O_2)} = \frac{86.4g}{32g/mol} = 2.7mol$$

From the equation above it is obvious, that the theoretical molar ratio between NH_3 and O_2 is 4:5. In our case there is $n(NH_3)$:$n(O_2)$ = 5.1 : 2.7.

Therefore, the limiting reactant is oxygen gas and ammonia is in excess. And we will continue calculations using amount of moles of O_2.

If 5 moles of O_2 produce 6 moles of water H_2O, than 2.7 moles of O_2 produce x moles of H_2O. Using the following proportion, one can calculate x:

$$\frac{5}{6} = \frac{2.7}{x} \Rightarrow x = \frac{2.7 \times 6}{5} = 3.24mol$$

The mass of water can be calculated considering that mass of one mole of water is 18 g/mol:

$$m(H_2O) = n(H_2O) \times M(H_2O) = 3.24mol \times 18g/mol = 58.32g$$