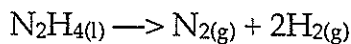


Another way to power a rocket is using a chemical that will decompose to release heat and gases. One very common way to power rockets is the use of hydrazine, N_2H_4 , hydrazine will decompose to nitrogen and hydrogen gas when exposed to a catalyst according to the reaction given below:



The reaction releases large quantities of heat and the reaction chamber will frequently reach $800.^\circ C$ very quickly. Liquid hydrazine has a density of 1.02 g/mL .

1-A) A rocket's combustion chamber has a volume of $10.5L$, during a test of the chamber $15.00mL$ of liquid hydrazine is pumped into the initially empty chamber and decomposes.

i) What would be the pressure of the nitrogen gas in the chamber after the reaction?

$$15.00mL \cdot \frac{1.02g N_2H_4}{1mL} \cdot \frac{1mol N_2H_4}{37.05g N_2H_4} \cdot \frac{1mol N_2}{1mol N_2H_4} = 0.477mol N_2$$

$$P = \frac{0.477mol \cdot 0.0821 \frac{atm \cdot L}{mol \cdot K} \cdot 1073K}{10.5L} = 4.00atm N_2$$

ii) What would be the pressure of the hydrogen gas in the chamber after the reaction?

$$4.00atm N_2 \cdot \frac{2H_2}{1N_2} = 8.00atm H_2$$

iii) What would be the total pressure in the chamber after the reaction?

$$P_T = P_{H_2} + P_{N_2} = 8 + 4 = 12.00atm$$

1-B) The chamber where the hydrazine reacts is connected to another second pressure vessel with a volume of $5.5L$. The second vessel contains oxygen gas at a pressure of 16.0 atm at $800^\circ C$. After the reaction in part A has finished happening the valve connecting the two tanks is opened.

i) What would be the pressure of oxygen gas after the valve has been opened?

$$P_1 V_1 = P_2 V_2 \quad 16.0atm \cdot 5.5L = P_2 \cdot 16.0L \quad P_{O_2} = 5.5atm$$

ii) What would be the pressure of hydrogen gas after the valve has been opened?

$$8.00atm \cdot 10.5L = P_{H_2} \cdot 16.0L \quad P_{H_2} = 5.25atm$$

iii) What would be the pressure of nitrogen gas after the valve has been opened?

$$4.00atm \cdot 10.5L = P_{N_2} \cdot 16.0L \quad P_{N_2} = 2.63atm$$

1-C) At the temperatures in the container the hydrogen and oxygen gas will react to produce water vapor. This reaction releases heat and raises the temperature to 950.°C

i) Write a balanced chemical equation for the reaction.



ii) What is the limiting reactant for the reaction between the hydrogen gas and oxygen gas?

$$5.25 \text{ atm H}_2 \quad 5.5 \text{ atm O}_2$$

$$5.25 \text{ atm H}_2 \cdot \frac{1 \text{ O}_2}{2 \text{ H}_2} = 2.625 \text{ atm O}_2$$

needed to use all the H₂ so H₂ is limiting

iii) What will be the pressure of water vapor after the hydrogen and oxygen have reacted?

$$5.25 \text{ atm H}_2 = 0.954 \text{ mol H}_2$$

$$0.954 \text{ mol H}_2 \cdot \frac{1 \text{ H}_2\text{O}}{1 \text{ H}_2} = 0.954 \text{ mol H}_2\text{O} \quad \text{but temp has changed}$$

$$\frac{5.25 \text{ atm}}{1073} = \frac{P_{\text{H}_2\text{O}}}{1223} \quad \boxed{P_{\text{H}_2\text{O}} = 5.98 \text{ atm}}$$

iv) What will be the new total pressure in the containers after the hydrogen gas and oxygen gas have reacted?

$$P_{\text{Total}} = P_{\text{H}_2\text{O}} + P_{\text{O}_2} + P_{\text{N}_2} = 5.98 \text{ atm} + 3.28 \text{ atm} + 3.00 \text{ atm}$$

$$\boxed{P_{\text{T}} = 12.26 \text{ atm}}$$

$$P_{\text{O}_2} = 5.5 \text{ atm} - 2.625 \text{ atm}$$

$$= 2.875 \text{ atm @ } 800^\circ\text{C}$$

$$\frac{2.63 \text{ atm H}_2}{1073} = \frac{P_{\text{N}_2}}{1223}$$

$$\frac{2.875 \text{ atm}}{1073} = \frac{P_{\text{O}_2}}{1223}$$

$$P_{\text{N}_2} = 3.00 \text{ atm}$$

$$P_{\text{O}_2} = 3.28 \text{ atm}$$