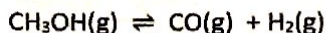


FR Practice #1 (2011B #2, 9 points)

1. An 8.55 mol sample of methanol, CH_3OH , is placed in a 15.0 L evacuated rigid tank and heated to 327°C . At that temperature, all of the methanol is vaporized and some of the methanol decomposes to form carbon monoxide gas and hydrogen gas, as represented in the equation below.



- a. The reaction mixture contains 6.30 mol of $\text{CO}(g)$ at equilibrium at 327°C .
- Calculate the number of moles of $\text{H}_2(g)$ in the tank. (1 point)
 - Calculate the number of grams of $\text{CH}_3\text{OH}(g)$ remaining in the tank. (1 point)
 - Calculate the mole fraction of $\text{H}_2(g)$ in the tank. (2 points)
 - Calculate the total pressure, in atm, in the tank at 327°C . (2 points)
- b. Consider the three gases in the tank at 327°C : $\text{CH}_3\text{OH}(g)$, $\text{CO}(g)$, and $\text{H}_2(g)$.
- How do the average kinetic energies of the molecules of the gases compare? Explain. (1 point)
 - Which gas has the highest average molecular speed? Explain. (1 point)
- c. The tank is cooled to 25°C , which is well below the boiling point of methanol. It is found that small amounts of $\text{H}_2(g)$ and $\text{CO}(g)$ have dissolved in the liquid CH_3OH . Which of the two gases would you expect to be more soluble in methanol at 25°C ? Justify your answer. (1 point)

$$(a)(i) \quad 6.30 \text{ mol CO} \times \frac{2 \text{ mol H}_2}{1 \text{ mol CO}} = \boxed{12.6 \text{ mol H}_2} \quad (1 \text{ pt})$$

$$(ii) \quad 6.30 \text{ mol CO} \times \frac{1 \text{ mol CH}_3\text{OH}}{1 \text{ mol CO}} = 6.30 \text{ mol CH}_3\text{OH reacted}$$

$$8.55 \text{ mol CH}_3\text{OH}_i - 6.30 \text{ mol CH}_3\text{OH}_{\text{reacted}} = 2.25 \text{ mol CH}_3\text{OH} \quad \frac{32.042 \text{ g CH}_3\text{OH}}{1 \text{ mol CH}_3\text{OH}} \\ = \boxed{72.1 \text{ g CH}_3\text{OH}} \quad (1 \text{ pt})$$

$$(2 \text{ pt}) \quad (iii) \quad \frac{12.6 \text{ mol H}_2}{(2.25 \text{ mol CH}_3\text{OH} + 6.30 \text{ mol CO} + 12.6 \text{ mol H}_2)} = \frac{12.6}{21.15} = \boxed{0.596} \quad (1 \text{ pt})$$

$$(2 \text{ pt}) \quad (iv) \quad P = \frac{nRT}{V} = \frac{(21.15 \text{ mol}) \left(0.08206 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}} \right) (600. \text{K})}{15.0 \text{ L}} = \boxed{69.4 \text{ atm}} \quad (1 \text{ pt})$$

(b) (i) The average kinetic energies are the same b/c all three gases are at the same temperature. (1 pt)

(ii) H_2 molecules have the highest average molecular speed, b/c $KE = \frac{1}{2}mv^2$ and thus at the same temperature molecules w/ the lowest mass have the highest average speed. (1 pt)

(c) Non-polar H_2 molecules can only form weak dipole-induced dipole IMFs w/ CH_3OH . In contrast, polar CO molecules can form stronger dipole-dipole attractions w/ CH_3OH . Since CO forms stronger IMFs w/ CH_3OH than H_2 , CO should be more soluble in CH_3OH than H_2 . (1 pt)