

CH353 – Physical Chemistry I  
Spring 2015, Unique 51170

Quiz 1, 27 January 2015

A weather balloon 15 m in diameter is filled with hydrogen gas and released from a ground-based weather station. It eventually achieves an altitude of 60,000 ft (~18 km), where it records and relays atmospheric conditions. How much hydrogen gas must be added to the balloon to ensure it is fully inflated at its maximum altitude, where the pressure of the atmosphere is approximately 1% as at the surface of the earth and the temperature is  $-60^{\circ}\text{C}$ ? Report your answer both in moles and mass. Assume the balloon is spherical.

Extra credit (not much): When the balloon is filled on the ground, what is its diameter? Again, assume a sphere, and assume ground temperature is approximately room temperature ( $\sim 25^{\circ}\text{C}$ ).

$$P = 0.01 \text{ atm}$$

$$T = -60^{\circ}\text{C} = 213 \text{ K}$$

$$V = \frac{4}{3} \pi r^3, \quad r = 7.5 \text{ m} \quad V = \left(\frac{4}{3}\right) \pi (7.5 \text{ m})^3 = 1767 \text{ m}^3 \left(\frac{10 \text{ dm}}{1 \text{ m}}\right)^3 = 1.767 \times 10^6 \text{ dm}^3 = 1.767 \times 10^6 \text{ L}$$

$$n = ?$$
$$m = ?$$

$$PV = nRT; \quad n = \frac{PV}{RT} = \frac{(0.01 \text{ atm})(1.767 \times 10^6 \text{ L})}{(0.0821 \frac{\text{L atm}}{\text{mol K}})(213 \text{ K})}$$

$$n = 1034 \text{ mol}$$

$$m = (Fw)_n = (2 \text{ g/mol})(1034 \text{ mol})$$

$$m = 2069 \text{ g}$$

EC: @  $P = 1.0 \text{ atm}$  +  $T = 298 \text{ K}$ ,  $V = ?$

$$\frac{V = nRT}{P} = \frac{(1034 \text{ mol})(0.0821 \text{ L atm / mol K})(298 \text{ K})}{1 \text{ atm}}$$

$$V = 24712 \text{ L} \left( \frac{1 \text{ dm}^3}{1 \text{ L}} \right) \left( \frac{1 \text{ m}}{10 \text{ dm}} \right)^3 = 24.7 \text{ m}^3$$

$$V = \left( \frac{4}{3} \right) \pi r^3$$

$$r = \left( \frac{V \left( \frac{3}{4} \right)}{\pi} \right)^{1/3} = \left( \frac{(24.7 \text{ m}^3) \left( \frac{3}{4} \right)}{\pi} \right)^{1/3}$$

$$r = 1.8 \text{ m}$$

$$d = 3.6 \text{ m}$$