SCH 3U – Stoichiometry Test Answers

1. If 13.2 g of zirconium nitrate is reacted, what mass of zirconium phosphate should form?

$$3\,Zr(NO_3)_4 + 4\,K_3PO_4 \longrightarrow Zr_3(PO_4)_4 + 12\,KNO_3$$

$$13.2\text{ g } Zn(NO_3)_3 \text{ x } \frac{1\text{ mol } Zr(NO_3)_4}{339.26\text{ g } Zr(NO_3)_4} \text{ x } \frac{1\text{ mol } Zr_3(PO_4)_2}{3\text{ mol } Zr(NO_3)_4}$$

$$\text{x } \frac{653.54\text{ g } Zr_3(PO_4)_4}{1\text{ mol } Zr_3(PO_4)_4} = 8.48\text{ g } Zr_3(PO_4)_4$$

2. If 50.0 t of propane is distributed and burned, what mass of carbon dioxide is release into the atmosphere? Answer in t. Does it make sense that the mass of carbon dioxide should be greater than the mass of propane? Why?

$$C_3H_8 + 5\,O_2 \longrightarrow 3\,CO_2 + 4\,H_2O$$

$$50.0\text{ t } C_3H_8 \text{ x } \frac{1\,000\,000\text{ g}}{1\text{ t}} \text{ x } \frac{1\text{ mol } C_3H_8}{44.11\text{ g } c_3H_8} \text{ x } \frac{3\text{ mol } CO_2}{1\text{ mol } C_3H_8}$$

$$\text{x } \frac{44.01\text{ g } CO_2}{1\text{ mol } CO_2} \text{ x } \frac{1\text{ t}}{1\,000\,000\text{ g}} = 150\text{ t } CO_2$$

It does make sense that the mass of carbon dioxide should be greater than the mass of propane simply because the mass of oxygen combined per carbon is much greater than the mass of hydrogen combined per carbon.

3. 12.0 g sample of ammonium nitrate is exploded. What is the total volume of gas produced at 745 torr and 527 °C? The reaction is:

$$2\,NH_4NO_3(s) \longrightarrow 4\,H_2O(g) + 2\,N_2(g) + O_2(g)$$

Hint: use the total amount of all three product gases as an easier way to solve this problem - less writing.

$$12.0\text{ g } NH_4NO_3 \text{ x } \frac{1\text{ mol } NH_4NO_3}{80.06\text{ g } NH_4NO_3} \text{ x } \frac{7\text{ mol gas}}{2\text{ mol } NH_4NO_3} = 0.525\text{ mol gas}$$

$$P = 745\text{ torr x } \frac{101.325\text{ kPa}}{760\text{ torr}} = 99.3\text{ kPa}$$
$$V = ?$$
$$n = 0.525\text{ mol}$$
$$R = 8.314\ \frac{\text{kPa} \bullet \text{L}}{\text{K} \bullet \text{mol}}$$
$$T = 527\ ^\circ\text{C} + 273.15 = 800.15\text{ K}$$

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

$$V = \frac{0.525\text{ mol x } 8.314\ \frac{\text{kPa} \bullet \text{L}}{\text{K} \bullet \text{mol}} \text{ x } 800.15\text{ K}}{99.3\text{ kPa}}$$

$$V = 35.2\text{ L}$$

4. For the gas phase reaction:

$$N_2(g) + 3\,H_2(g) \longrightarrow 2\,NH_3(g)$$

25500 L of hydrogen gas at S.T.P. (yes that is right, a great big volume!) is reacted with just sufficient nitrogen gas to complete the reaction. What mass of nitrogen gas is required. Secondly, what volume of ammonia would form at 5.5 atm and 575 °C?

$$25500\ \text{L}\ H_2\ \text{x}\ \frac{1\ \text{mol}\ H_2}{22.414\ \text{L}\ H_2}\ \text{x}\ \frac{1\ \text{mol}\ N_2(g)}{3\ \text{mol}\ H_2(g)}\ \text{x}\ \frac{28.02\ \text{g}\ N_2(g)}{1\ \text{mol}\ N_2(g)} = 10626.2\ \text{g}\ N_2(g)$$

$$25500\ \text{L}\ H_2\ \text{x}\ \frac{1\ \text{mol}\ H_2}{22.414\ \text{L}\ H_2}\ \text{x}\ \frac{2\ \text{mol}\ NH_3(g)}{3\ \text{mol}\ H_2(g)} = 758.5\ \text{mol}\ NH_3(g)$$

$$\begin{aligned}
P &= 5.5\ \text{atm}\ \text{x}\ \frac{101.325\ \text{kPa}}{1\ \text{atm}} = 557.3\ \text{kPa} \\
V &= ? \\
n &= 758.5\ \text{mol}\ NH_3(g) \\
R &= 8.314\ \frac{\text{kPa} \bullet \text{L}}{\text{K} \bullet \text{mol}} \\
T &= 527\ ^\circ\text{C} + 273.15 = 848.15\ \text{K}
\end{aligned}$$

$$\begin{aligned}
V &= \frac{nRT}{P} \\
V &= \frac{758.5\ \text{mol x}\ 8.314\ \frac{\text{kPa} \bullet \text{L}}{\text{K} \bullet \text{mol}}\ \text{x}\ 848.15\ \text{K}}{557.3\ \text{kPa}} \\
V &= 9596.9\ \text{L}
\end{aligned}$$

5. During an experiment in which cobalt(II) chloride hexahydrate is thermally decomposed, you accidentally forget to record the mass of the empty test tube before your start. Your teacher suggests rather that find the % error for your reaction (like the lab we did) that you could instead deduce the mass of the test tube. At some point, a good three line calculation or two might be in order. Given the following incomplete date table, find the mass of the empty test tube. Pay close attention to format. Hint: why does the test tube get lighter?

mass of empty test tube	oops!
mass of test tube plus $CoCl_2 \cdot 6\,H_2O$	23.985 g
mass of test tube plus $CoCl_2$ residue	22.542 g

$$CoCl_2 \cdot 6\,H_2O \longrightarrow CoCl_2 + 6\,H_2O$$

$$\begin{aligned} \text{mass } H_2O &= (\text{mass test tube} + CoCl_2 \cdot 6\,H_2O) - (\text{mass test tube} + CoCl_2) \\ &= 23.985 \text{ g} - 22.542 \text{ g} \\ &= 1.443 \text{ g } H_2O \end{aligned}$$

$$1.443 \text{ g } H_2O \text{ x } \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} \text{ x } \frac{1 \text{ mol } CoCl_2 \cdot 6\,H_2O}{6 \text{ mol } H_2O}$$

$$\text{x } \frac{237.95 \text{ g } CoCl_2 \cdot 6\,H_2O}{1 \text{ mol } CoCl_2 \cdot 6\,H_2O} = 3.176 \text{ g } CoCl_2 \cdot 6\,H_2O$$

$$\begin{aligned} \text{mass test tube} &= (\text{mass test tube} + CoCl_2 \cdot 6\,H_2O) - (\text{mass } CoCl_2 \cdot 6\,H_2O) \\ &= 23.985 \text{ g} - 3.176 \text{ g} \\ &= 20.809 \text{ g} \end{aligned}$$