Chemistry 20 - Unit 4 - Gravimetric Stoichiometry

Name: _____

1) If 56.0 grams of iron (III) chloride reacts with 38.8 grams of solid vanadium, what mass of vanadium (V) chloride is theoretically produced? If the percent yield of this reaction is 25.0 %, what is the actual yield of vanadium (V) chloride?

$5\,FeCl_{3(aq)} + 3\,V_{(s)} \rightarrow 3\,VCl_{5(aq)} + 5\,Fe_{(s)}$

$n = \frac{m}{M}$ — 56.0 g / 162.20 g/mol = 0.345 mol (3/5) → 0.207 mol (Limiting, use this value)

38.8 g / 50.94 g/mol = 0.762 mol (ignore, too much / Excess) (228.19 g/mol)

$n_{VCl_5} = 0.345\,mol \times \frac{3}{5} = 0.207\,mol$

$m_{VCl_5} = 0.207\,mol \times \frac{228.19\,g}{mol} = 47.3\,g$ (predicted)

$\%Y = \frac{actual}{predicted} \times 100\%$

actual = 0.250 × predicted = **11.8 g**

2) If 18.0 mL of 2.50 mol/L cesium sulfide reacts with 42.9 grams of nickel (III) nitride, what mass of cesium nitride is theoretically produced? What is the actual mass of cesium nitride if the percent yield is 45.0 %?

$3\,Cs_2S + 2\,Ni_3N \rightarrow Ni_2S_3 + 2\,Cs_3N$

Cs_2S: 0.045 mol

Ni_3N: 42.9 g / 72.70 g/mol — Excess

Cs_3N: m = ??, M = 412.74 g/mol

$n_{Cs_2S} = \frac{2.50\,mol}{L} \times 0.0180\,L = 0.045\,mol$ (Limiting) → ×2/3

$n_{Ni_3N} = 42.9\,g \times \frac{1\,mol}{72.70\,g} = 0.590\,mol$ (Excess) — 0.03 mol needed

$m_{Cs_3N(s)} = 0.045\,mol \times \frac{2}{3} \times \frac{412.74\,g}{mol} = 12.4\,g$ (predicted)

actual = 0.450 × predicted = **5.57 g**

3) The invention of trinitrotoluene, otherwise known as TNT, revolutionized the mining industry. When TNT detonates, it does so according to the following unbalanced chemical equation:

$2\,C_7H_5N_3O_{6(s)} \rightarrow 3\,N_{2(g)} + 5\,H_2O_{(g)} + 7\,CO_{(g)} + 7\,C_{(s)}$

$C_7H_5N_3O_6$: 0.10000 kg, 1.0000×10^{-4} g, 227.15 g/mol

$C_{(s)}$: m = ??, 12.01 g/mol

If 1.0000×10^{-1} kilograms of TNT detonates, what mass of solid carbon is theoretically produced? If the percent yield of this reaction is 60.0%, what is the actual yield of solid carbon?

$n_{TNT} = 1.0000 \times 10^{-4}\,g \times \frac{1\,mol}{227.15\,g} = 4.4024 \times 10^{-7}\,mol$

$n_{C(s)} = 4.4024 \times 10^{-7}\,mol \times \frac{7}{2} = 0.00000154\,mol$

$m_{C(s)} = 0.00000154\,mol \times 12.01\,g/mol = 1.8505 \times 10^{-5}\,g$ (predicted)

actual = $1.8505 \times 10^{-5}\,g \times 0.600$ = **1.1103×10^{-5} g**

4) Nitrocellulose, otherwise known as guncotton, is a highly reactive and explosive gunpowder substitute that can be prepared via the nitration of cellulose. This reaction takes place according to the following unbalanced chemical equation:

$$3\ HNO_{3(aq)} + C_6H_{10}O_{5(s)} \rightarrow C_6H_7(NO_2)_3O_{5(s)} + 3\ H_2O_{(l)}$$

3.0L, 0.100 mol/L, 0.30 mol (Limiting), 1/3 → 0.1 mol; ~~162.16 g~~ Excess, ~~162.16 g/mol~~, 1.0000 mol; m = ??, 297.16 g/mol

3.0 L of 0.100 mol/L nitric acid is mixed with 162.16 g of cellulose, $C_6H_{10}O_{5(s)}$. What is the theoretical yield of nitrocellulose? What is the percent yield of the reaction if the actual yield of nitrocellulose is 5.0 grams?

$$n_{Ncell} = 0.30\,mol \times \frac{1}{3} = 0.10\,mol$$

$$m_{Ncell} = 0.10\,mol \times \frac{297.16\,g}{mol} = 30\,g\ (predicted)$$

$$\%\,Yield = \frac{5.0\,g}{30\,g} \times 100\% = \boxed{17\%}$$

5) Balance each of the following chemical equations using lowest whole numbers.

a) $5\ NaBr_{(aq)} + NaBrO_{3(aq)} + 3\ H_2SO_{4(aq)} \rightarrow 3\ Br_{2(l)} + 3\ Na_2SO_{4(aq)} + 3\ H_2O_{(l)}$

b) $4\ FeS_{2(s)} + 11\ O_{2(g)} \rightarrow 2\ Fe_2O_{3(s)} + 8\ SO_{2(g)}$

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c) $I_{2(s)} + 4\ HNO_{3(aq)} \rightarrow 2\ HIO_{3(aq)} + 4\ NO_{(g)} + 2\ H_2O_{(l)}$

d) $Sc_2O_{3(s)} + 5\ Cl_{2(g)} + S_2Cl_{2(s)} \rightarrow 2\ ScCl_{3(s)} + 2\ SOCl_{2(s)}$