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Chem Ch. 4 Problems

**4.90** $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

also: $HCl + NaOH \rightarrow NaCl + H_2O$

total mol HCl − excess mol HCl = mol HCl reacted

mol $CaCO_3$ = mol HCl / 2 because of balanced chem. eq.

g $CaCO_3$ = mol $CaCO_3$ × molar mass (×100 for percent by mass)

$$\frac{1.035 \text{ mol HCl}}{1 \text{ L soln}} \Big| .03 \text{ L} = .031050 \text{ mol HCl total}$$

$$\frac{1.010 \text{ mol NaOH}}{1 \text{ L soln}} \Big| .011564 \text{ L} = .011676 \text{ mol HCl excess}$$

.031050 total − .011676 excess = .019374 mol HCl reacted

$$.019374 \text{ mol HCl} \Big| \frac{1 \text{ mol } CaCO_3}{2 \text{ mol HCl}} \Big| \frac{100.09 \text{ g } CaCO_3}{1 \text{ mol } CaCO_3} = .96959 \text{ g } CaCO_3$$

$$\text{mass \% } CaCO_3 = \frac{\text{g } CaCO_3}{\text{g rock}} \times 100 = \frac{.96959}{1.245} \times 100 = \boxed{77.69\% \ CaCO_3}$$

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4.89

Give mass impure $Mg(OH)_2$ ; M and vol excess HCl; M and vol NaOH

Find mass % $Mg(OH)_2$ in sample.

$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$

$HCl + NaOH \rightarrow NaCl + H_2O$

Calculate total moles of HCl = M HCl × L HCl

$$\frac{.2050 \text{ mol HCl}}{1 \text{ L soln}} \Big| .100 \text{ L} = .02050 \text{ mol HCl total}$$

mol excess HCl = mol NaOH used = M NaOH × L NaOH

$$\frac{.1020 \text{ mol NaOH}}{1 \text{ L soln}} \times .01985 \text{ L} = .0020247 = .002025 \text{ mol NaOH}$$

mol HCl reacted w/ $Mg(OH)_2$ = total mol HCl − excess mol HCl

.02050 mol total − .0020247 mol excess = .0184753 = .01848 mol HCl reacted

Use mol ratio to get mol $Mg(OH)_2$ in sample, then molar mass of $Mg(OH)_2$ to get g pure $Mg(OH)_2$

$$.0184753 \text{ mol HCl} \Big| \frac{1 \text{ mol } Mg(OH)_2}{2 \text{ mol HCl}} \Big| \frac{58.32 \text{ g } Mg(OH)_2}{1 \text{ mol } Mg(OH)_2} = .5387 \text{ g } Mg(OH)_2$$

$$\frac{.5387 \text{ g } Mg(OH)_2}{.5895 \text{ g sample}} \times 100 = 91.40\% \text{ } Mg(OH)_2$$

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**4.113**

a) $As^{+5}$

b) $Ag_3PO_4$ is silver phosphate, so $Ag_3AsO_4$ is silver arsenate

c)

$$.250\,L\ soln \left| \frac{.102\,mol\ Ag^+}{1\,L\ soln} \right| \frac{1\,mol\ Ag_3AsO_4}{3\,mol\ Ag^+} \left| \frac{1\,mol\ As}{1\,mol\ Ag_3AsO_4} \right| \frac{74.92\,g\ As}{1\,mol\ As} = .06367\,g\ As$$

$$\frac{.06367\,g\ As}{1.22\,g\ sample} \times 100 = 5.22\%\ As$$

**4.115**

a) mol initial HCl − mol $NH_3$ from air = mol HCl remaining (also mol NaOH required for titration)

$$mol\ NaOH = .0588\ M \times .0131\ L = 7.703\times10^{-4}\ mol\ NaOH$$
$$= 7.70\times10^{-4}\ mol\ HCl\ remain$$

mol initial − mol HCl remaining = mol $NH_3$ from air

$$(.0105\ M\ HCl \times .100\ L) - 7.703\times10^{-4}\ mol\ HCl = 2.80\times10^{-4}\ mol\ NH_3$$

$$\frac{2.8\times10^{-4}\ mol\ NH_3}{1} \left| \frac{17.03\,g\ NH_3}{1\,mol\ NH_3} \right. = 4.77\times10^{-3}\,g\ NH_3 = 4.8\times10^{-3}\,g\ NH_3$$

b) Calculate molecules $NH_3$ from mol $NH_3$ $\quad 2.80\times10^{-4}\ mol\ NH_3 \left| \frac{6.022\times10^{23}\ molecules\ NH_3}{1\,mol\ NH_3} \right. = 1.686\times10^{20}$

Calculate total volume of air processed, then g of air using density, then molecules of air using molar mass.

$$= 1.7\times10^{20}\ molecules$$

$$\frac{10\,L}{1\,min} \times 10\,min \times \frac{1.20\,g\ air}{1\,L\ air} \times \frac{1\,mol\ air}{29\,g\ air} \times \frac{6.022\times10^{23}\ molecules}{1\,mol} = 2.5\times10^{24}\ air\ molecules.$$

task list:

c) 68 ppm > 50 ppm. The manufacturer is not in compliance