# Back-Titration Problems: solutions.

1) $1.3820g \times \frac{1 mol\ K_2CO_3}{138.20g} \times \frac{25mL}{250mL} \times \frac{2HCl}{1K_2CO_3} \times \frac{1mol}{0.1L}$

$= 0.02L = \boxed{20\ mL}$

2) In Erlenmeyer flask:

$691.0mg \times \frac{20mL}{200mL} = 69.10\ mg\ K_2CO_3$

$69.10mg\ K_2CO_3 \times \frac{1\ mole}{138.2mg} = 0.5\ mmol\ K_2CO_3$

$20.00mL \times 0.2\frac{moles}{L}HCl = 4\ mmol\ HCl$

excess HCl $= 4\ mmol\ HCl - 0.5\ mmol\ K_2CO_3 \times \frac{2HCl}{1K_2CO_3}$

$= 3\ mmol\ HCl$

NaOH used: $3\ mmol\ HCl \times \frac{1\ NaOH}{1HCl} \times \frac{1L}{0.15mol} = \boxed{20\ mL}$

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3) In volumetric flask:

$$400.4\,\text{mg}\,CaCO_3 \times \frac{1\,\text{mol}}{100.1\,\text{g}} = 4\,\text{mmol}\,CaCO_3$$

$$15\,\text{mL} \times \frac{2\,\text{moles}\,HCl}{\text{L}} = 30\,\text{mmol}\,HCl$$

HCl in excess: $30\,\text{mmol}\,HCl - 4\,\text{mmol}\,CaCO_3 \times \frac{2HCl}{CaCO_3}$

$$= 22\,\text{mmol}\,HCl$$

Into ~~an~~ Erlenmeyer flask:

$$22\,\text{mmol}\,HCl \times \frac{10}{200} = 1.1\,\text{mmol}\,HCl$$

NaOH used: $1.1\,\text{mmol}\,HCl \times \frac{1\,NaOH}{1\,HCl} \times \frac{1\,\text{L}}{0.11\,\text{moles}}$

$$\boxed{= 10\,\text{mL}}$$

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4) Into Erlenmeyer flask:

$$738.9\text{ mg } M_2CO_3 \times \frac{10}{100} = 73.89\text{ mg } M_2CO_3$$

$$25\text{ mL} \times 0.2\frac{\text{moles HCl}}{\text{L}} = 5\text{ mmol HCl}$$

$$20\text{ mL} \times \frac{0.15\text{ moles}}{\text{L}}\text{ NaOH} = 3\text{ mmol NaOH}$$

HCl reacted w/ $M_2CO_3$:

$$5\text{ mmol HCl} - 3\text{ mmol NaOH} \times \frac{1\text{ HCl}}{1\text{ NaOH}} = 2\text{ mmol HCl}$$

moles $M_2CO_3$: $2\text{ mmol HCl} \times \frac{1\,M_2CO_3}{2\text{ HCl}} = 1\text{ mmol } M_2CO_3$

molar mass $M_2CO_3 = \frac{73.89\text{ mg}}{1\text{ mmol}} = 73.89\frac{\text{g}}{\text{mol}}$

So $2M + 12.011 + 3 \times 15.999 = 73.89$

$\Rightarrow M = 6.941\frac{\text{g}}{\text{mol}}$, which is $\boxed{\text{Li}}$

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5) In Erlenmeyer Flask:

$$20\text{ mL} \times 0.175 \frac{\text{moles NaOH}}{\text{L}} = 3.5\text{ mmol NaOH}$$

∴ 3.5 mmol HCl were in the 10 mL aliquot delivered to the Erlenmeyer flask.

$$\underset{\uparrow \text{ volumetric flask}}{\frac{X\text{ mmol}}{100\text{ mL}}} = \underset{\nwarrow \text{ into Erlenmeyer Flask}}{\frac{3.5\text{ mmol}}{10\text{ mL}}}$$

⇒ x = 35 mmol of HCl were in excess after the reaction in the volumetric flask.

Total moles HCl in volumetric Flask:

$$25\text{ mL} \times 3 \frac{\text{moles}}{\text{L}}\text{ HCl} = 75\text{ mmol HCl}$$

$$\therefore \text{HCl reacted w/}M(OH)_2 = 75 - 35 = 40\text{ mmol}$$

$$\therefore \text{mmol } M(OH)_2 = 40\text{ mmol HCl} \times \frac{1\,M(OH)_2}{2\,HCl}$$

$$= 20\text{ mmol}$$

$$M(OH)_2 = \frac{1166.4\text{ mg}}{20\text{ mmol}} = 58.32 \frac{\text{g}}{\text{mol}}$$

$$M + 2\times15.999 + 2\times1.0079 = 58.32 \Rightarrow M = 24.3 \frac{\text{g}}{\text{mol}} \quad \boxed{\text{Mg}}$$

# Back-Titration Problems: Solutions

6) Into volumetric Flask:

$20\,mL \times 2\,\frac{moles}{L} = 40\,mmol\ HCl$

$1.0687\,g\ Fe(OH)_n$

Into Erlenmeyer flask:

$20\,mL \times 0.05\,\frac{moles}{L}\,KOH = 1\,mmol\ KOH$

Therefore 1 mmol HCl must have been in the 20 mL aliquot.

$$\therefore \quad \frac{X\,mmol}{\underset{\substack{\uparrow \\ \text{vol. flask}}}{200\,mL}} = \frac{1\,mmol}{\underset{\substack{\uparrow \\ \text{aliquot taken}}}{20\,mL}} \Rightarrow X = 10\,mmol.$$

So there were 10 mmol HCl in excess after it reacted w/ $Fe(OH)_n$

$\therefore$ HCl reacted w/ $Fe(OH)_n = 40\,mmol - 10\,mmol = 30\,mmol$

The HCl only reacts with the $OH^-$ in the $Fe(OH)_n$, so there must have been 30 mmol $OH^-$ in the $Fe(OH)_n$ sample.

$(HCl + OH^- \longrightarrow Cl^- + H_2O)$

# Back-Titration Problems: Solutions

6) (cont'd)

The mass of Fe in $Fe(OH)_n$ must therefore be:

$$1068.7\ mg = \text{mass Fe} + 30\ mmol\ OH^- \times 17.007\ \frac{g}{mol}$$

$$= \text{mass Fe} + 510.2\ mg$$

$\therefore$ mass Fe = 558.493 mg

$\therefore$ mmoles Fe = $558.493\ mg \times \frac{1\ mol}{55.845\ g} \simeq 10\ mmol$

$\therefore$ 10 mmol Fe for every 30 mmol $OH^-$, or

$Fe_{10}(OH)_{30} \longrightarrow Fe(OH)_3$, so $\boxed{n=3}$