Solutions

Chemistry 12

2012

acid-base titration calculations

1, a.

$$NH_3 + HCl \longrightarrow NH_4Cl$$

$m(NH_3) = 1.32\,g$

$n(NH_3) = \frac{1.32}{17}$

$= 7.76 \times 10^{-2}$

$n(HCl) = 7.76 \times 10^{-2}$

$c(HCl) = \frac{n}{V} = \underline{0.776\ mol\,L^{-1}}$

b. $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$

$n(NH_4^+) = n(NH_3)$

$= 7.76 \times 10^{-2}\ mol$

$m(NH_4^+) = 7.76 \times 10^{-2} \times 18$

$= 1.398\,g$

$\%(NH_4^+) = \frac{1.398}{5.005} \times 100 = 27.9\%$

c. $Ca(OH)_2 + 2NH_4^+ \rightarrow 2NH_3 + Ca^{2+} + 2H_2O$

$n = 7.76 \times 10^{-2}$

$n = \frac{7.76 \times 10^{-2}}{2}$

$= 3.88 \times 10^{-2}$

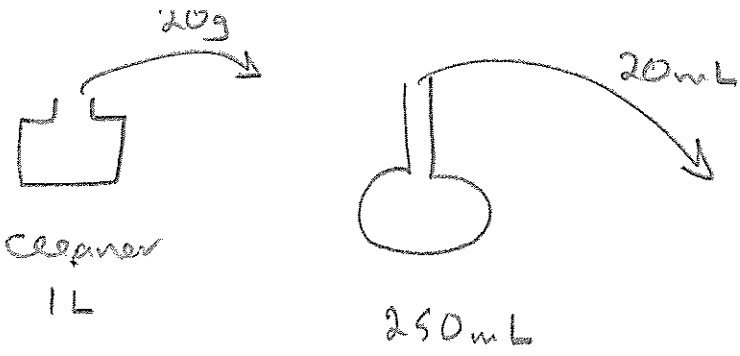
$m = 3.88 \times 10^{-2} \times 74$

$= \underline{2.87\,g}$

d. Red to orange

e. Phosphate
Nitrate
Sulfate

2.



$KHSO_4 + NaOH \rightarrow Na^+ + K^+ + SO_4^{2-} + H_2O$

Titres	~~19.75~~	19.95	19.95	19.95

Average accurate = 19.95 mL

a) $HSO_4^- + OH^- \rightarrow SO_4^{2-} + H_2O$

b)
19.95 mL
0.1105 M

$n = cV$
$= 0.00220$ mol

c) $n(HSO_4^-) = 0.00220$ mol in 20mL

$\therefore n(HSO_4^-) = 0.00220 \times \frac{250}{20}$

$= \underline{0.0276}$ mol in 250mL

& ∴ in 20g of cleaner

d) Conc in mol $L^{-1} = 0.0276 \times 4$
$= 0.110$ mol L^{-1}

Conc in g $L^{-1} = 0.110 \times (M_r\ KHSO_4)$
$= 0.110 \times 136$
$= \underline{15\ g\ L^{-1}}$

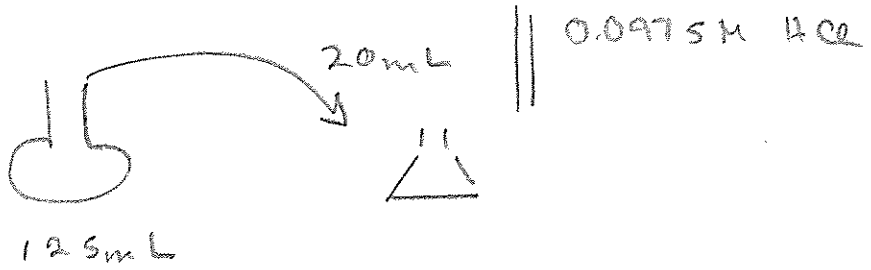
e) Colourless to pink

f) Equivalence point at pH = 7

3.

$Ag(NH_3)_2NO_3 \cdot 4H_2O \rightarrow 2NH_3$

$NH_3 + HCl \rightarrow NH_4Cl$



Titres ~~17.15~~ 16.60 16.65 16.60

Average accurate = 16.62 mL

$NH_3 + HCl \rightarrow NH_4Cl$

20mL 16.62mL

0.0975 M

$n = 1.62 \times 10^{-3}$ mol

$n(NH_3) = 1.62 \times 10^{-3}$ mol in 20 mL

$\therefore n(NH_3) = 1.62 \times 10^{-3} \times \frac{125}{20}$

$= 0.0101$ mol in 125 mL

$Ag(NH_3)_2NO_3 \cdot 4H_2O \rightarrow 2NH_3$

$n = \frac{0.0101}{2}$ $n = 0.0101$

$= 0.00506$ mol

$M = nM = \underline{\quad 1.40 \quad} g$

4.

ester + sodium hydroxide →

20g ointment | 25mL 0.0425M (approx)

In x's

X's

$NaOH + HCl \rightarrow NaCl + H_2O$

25mL | 0.500M

18.65mL

$n = cV$

$= 0.009325$ mol → 0.009325 mol

Separate titration

$NaOH + HCl \rightarrow NaCl + H_2O$

50mL | 42.25mL 0.5M

$n = cV$

$= 0.02113$ mol ← 0.02113 mol

$c(NaOH) = \frac{0.02113}{0.05}$

$= 0.4225$ mol L^{-1}

Original titration

ester + OH^- $\rightarrow$

$n(NaOH)$ added $= cV$

$= 0.4225 \times 0.025$

$= 0.0106$ mol

$n(X's) = 0.009325$ mol

a) $n(NaOH)$ reacted with ester

$= 0.0106 - 0.009325$

$= \underline{0.001274 \text{ mol}}$

b) ester + OH^-

1 : 1 ratio

$n(\text{ester}) = 0.001274$ mol in 2g

$m = nM_r = \underline{0.1881 \text{ g}}$

c) mass of ester in 100g $= 0.1881 \times \frac{100}{20}$

$= \underline{0.9405 \text{ g}}$

d) Label states 1g present

acceptable range $= 0.95 - 1.05$ g

$\therefore$ Outside the range

5.

$Cu(NH_3)_x SO_4 \cdot y H_2O$

a) $Cu(NH_3)_x SO_4 \cdot y H_2O \xrightarrow{\text{heated}} CuSO_4$

1.0087 g → 0.652 g

$n(CuSO_4) = \frac{m}{M} = \frac{0.652}{159.61} = 0.0040855 \text{ mol}$

$n(\text{complex}) = n(CuSO_4)$

$= 0.0040855$

$M_r(\text{complex}) = \frac{m}{n} = \frac{1.0087}{0.0040855}$

$= 247$

b) 1.4009 g complex → NH_3 (250 mL sol'n) —20 mL→ + HCl (0.0988 M, 18.33 mL)

$HCl + NH_3 \rightarrow NH_4Cl$

$n = cV$

$= 1.81 \times 10^{-3} \text{ mol}$

$n(NH_3) \text{ in } 250 \text{ mL} = \frac{1.81 \times 10^{-3}}{20} \times 250$

$= 0.02266 \text{ mol}$

c) $n(\text{complex}) = \frac{1.4009}{246.9} = 5.674 \times 10^{-3}$ mol

Ratio complex : ammonia

$5.674 \times 10^{-3} : 0.0226$

$1 : 4$

$x = 4$

d)

M_r (complex) = 246.9

M_r (NH_3) in complex = 17×4

$= 68.14$

M_r ($CuSO_4$) in complex = 159.61

$\therefore$ M_r (H_2O) in complex =

$247 - (68 + 159.61) = 19.15$

$y = 1$

$Cu(NH_3)_4SO_4 \cdot H_2O$

6. Titres ~~37.06~~ 35.96 35.98 35.94

Ave acc = 35.96 mL

$NaOH + HCl \rightarrow NaCl + H_2O$

20 mL 35.96 mL

0.0813 M

a) $n(NaOH) = n(HCl) = cV = 2.92 \times 10^{-3}$ mol

$c(NaOH) = \frac{n}{V} = \frac{2.92 \times 10^{-3}}{0.02} = \underline{0.146}$ mol L^{-1}

b) $\therefore$ n (NaOH) in 1L = 0.146 mol

$NaOH + HCl \rightarrow NaCl + H_2O$

20 mL 0.0813 M

ave acc = 35.64 mL

$n(NaOH) = n(HCl) = cV = 0.00289$ mol

$c(NaOH) = \frac{n}{V} = \frac{0.00289}{0.02} = 0.1449$ mol

$\therefore$ n (NaOH) in 1L = 0.1449 mol

$\therefore$ n (NaOH) reacted with $Mg^{2+} = 0.146 - 0.145$

$= 0.001$ mol

$Mg^{2+} + 2OH^- \rightarrow Mg(OH)_2$

$n(Mg^{2+}) = \frac{n(OH^-)}{2} = 0.0005$ mol

$m(Mg^{2+}) = nM = 0.0122$ g

$\therefore$ Conc = $\underline{0.0122}$ g L^{-1}

7. a)

$2.56\,g \longrightarrow 4.422\,L$ @ $10\,kPa$ & $773\,K$

$$n = \frac{PV}{RT} = \frac{4.422 \times 10}{8.314 \times 773} = 6.88 \times 10^{-3}$$

$$M_r = \frac{M}{n} = \frac{2.56}{6.88 \times 10^{-3}} = \underline{372}$$

b) $CH_3COO^- + H^+ \rightarrow CH_3COOH$

$(14.55\,g)$ $117.3\,mL$ $1\,M$

$$n(H^+) = cV$$
$$= 0.1173 \times 1$$
$$= 0.1173\,mol$$

$n = 0.1173\,mol$ ←

$$n(\text{Compound}) = \frac{m}{M} = \frac{14.55}{372} = 3.911 \times 10^{-2}$$

Ratio Compound : acetate

3.911×10^{-2} : 0.1173

1 : 3

$$\underline{X = 3}$$

$Pr\ (CH_3COO)_3 \cdot Y H_2O$

$M_r = 372$

$Pr\ (CH_3COO)_3$

$M_r = 140.9 + 72 + 9 + 96$

$= 317.9$

$\therefore$ M_r of $Y H_2O$

$= 372 - 317.9$

$= 54$

$n(H_2O) = \frac{54}{18} = \underline{3}$

c) Basic

$Pr(CH_3COO)_3 \cdot 3H_2O \longrightarrow$

$Pr^{3+} + 3\ CH_3COO^- + 3H_2O$

$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$

$\therefore$ basic