Set 19: Acid-base titrations 2

1. $n(NaOH)=cV=(1.50\text{x}10^{-4})(0.02000)=3.00\text{x}10^{-6}\ \text{molL}^{-1}$
   $n(H_2Tar)=1/2n(H^+)=1/2n(OH^{1-})=1.50\ \text{x}\ 10^{-6}\ \text{mol}$
   $c(H_2Tar)=n/V=1.50\text{x}10^{-6}/0.1090=1.376\ \text{x}10^{-5}=1.38\text{x}10^{-5}\text{molL}^{-1}$

2. $n(NaOH)=cV=6.06\text{x}10^{-5}\text{x}0.0200=1.212\text{x}10^{-6}\ \text{mol}$
   $n(H^+)=n(OH^-)$
   $n(HX)=n(OH)=1.212\text{x}10^{-6}\ \text{mol}$
   $c(HX)=1.212\text{x}10^{-6}/0.048=2.52\text{x}10^{-5}\ \text{molL}^{-1}$

3. $n(HCl)=cV=3.76\text{x}10^{-6}\text{x}0.0336=1.2634\text{x}10^{-7}$
   $n(HCO_3^-)=n(HCl)$
   $c(HCO_3^-)=n/V=1.26\text{x}10^{-7}/0.020=6.3\text{x}10^{-6}$

4. pH range 7.0→7.6
   HCL $V_{av}=47.23$ mL
   $c=6.72\text{x}10^{-7}$
   $n(HCl)=cV=6.72\text{x}10^{-7}\text{x}0.04723-3.17\text{x}10^{-8}$
   n(pool base)=n(HCl)
   $c(\text{pool})=n/V=3.17\text{x}10^{-8}/0.020=1.59\text{x}10^{-6}\text{mol L}^{-1}$

5. pH fresh milk 6.4 to 6.8
   NaOH V=20mL; $c=3.41\text{x}10^{-5}\text{molL}^{-1}$
   $V_{milk}=34.2\text{mL}$
   $n(NaOH)=cV=3.41\text{x}10^{-}5\text{x}0.020=6.82\text{x}10^{-7}\ \text{mol}$
   $n(\text{lactic acid})=1/2n(NaOH)=6.82\text{x}10^{-7}/2=3.41\text{x}10^{-7}$
   $c(\text{lactic acid})=n/V=3.41\text{x}10^{-7}/0.0342=9.97\text{x}10^{-6}$

6. $n(OH^-) = n(NaOH) = cV = 0.107 \times 0.0200 = 2.14 \times 10^{-3}$ mol

$H^+(aq) + OH^-(aq) \leftrightarrows H_2O(\ell)$
$n(H^+)_{\text{in 20 mL dilute acid}} = n(OH^-) = 2.14 \times 10^{-3}$ mol

$$n(H^+)_{\text{in 5 mL conc acid}} = n(H^+)_{\text{in 1 L dilute acid}} = \frac{1000}{38.2} \times 2.14 \times 10^{-3} = 0.0560 \text{ mol}$$

$$[H^+]_{\text{conc acid}} = \frac{n}{V} = \frac{0.0560}{0.00500} = 11.2 \text{ mol L}^{-1}$$

7. $H^+(aq) + OH^-(aq) \leftrightarrows H_2O(\ell)$
$n(OH^-) = n(NaOH) = cV = 0.00120 \times 0.0215 = 2.58 \times 10^{-5}$ mol

$n(H_3C_6H_5O_7) = ⅓\, n(H^+) = ⅓(2.58 \times 10^{-5}) = 8.60 \times 10^{-6}$ mol
$M(H_3C_6H_5O_7) = 192.124$ g mol^{-1}

$m(H_3C_6H_5O_7) = nM = 8.60 \times 10^{-6} \times 192.124 = 1.65 \times 10^{-3}$ g
$m(\text{juice}) = 50.0 \times 1.05 = 52.5$ g

$$[H_3C_6H_5O_7]_{\text{ppm}} = \frac{m(H_3C_6H_5O_7)_{\text{in mg}}}{m(\text{juice})_{\text{in kg}}} = \frac{1.65 \times 10^{-3} \times 10^{3}}{52.5 \times 10^{-3}} = 31.4 \text{ ppm}$$

8. (a) $NH_3(aq) \leftrightarrows H^+(aq) + NH_4{}^+(aq)$

(b)

Trial	1	2	3	4
$V(HC\ell)_{\text{used}}$	38.37	38.70	38.43	38.40

$$V(HC\ell)_{\text{average}} = \frac{38.37 + 38.43 + 38.40}{3} = 38.40 \text{ mL}$$

$n(NH_3) = cV = 0.000671 \times 0.0200 = 1.34 \times 10^{-5}$ mol
$n(H^+)_{\text{in 38.40 mL of dilute gastric fluid}} = n(NH_3) = 1.34 \times 10^{-5}$ mol
$n(H^+)_{\text{in 10.0 mL of undilute gastric fluid}} = n(H^+)_{\text{in 250 mL of dilute gastric fluid}}$

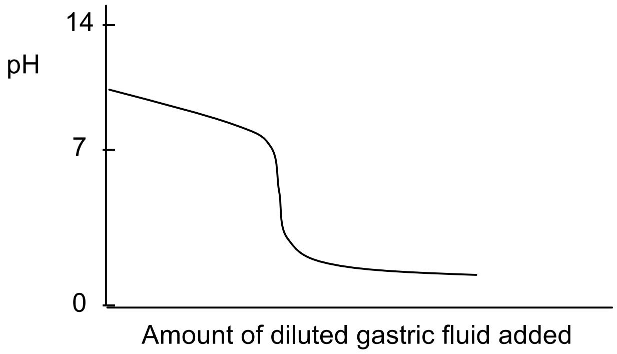
$$n(H^+)_{\text{in 10.0 mL of undilute gastric fluid}} = n(H^+)_{\text{in 250 mL of dilute gastric fluid}} = \frac{250}{38.40} \times 1.342 \times 10^{-5} = 8.737 \times 10^{-5} \text{ mol}$$

$$[H^+]_{\text{in 10.0 mL of undilute gastric fluid}} = \frac{n}{V} = \frac{8.737 \times 10^{-5}}{0.0100} = 8.737 \times 10^{-3} \text{ mol L}^{-1}$$

$pH = -\log_{10}[H^+] = -\log_{10}(8.737 \times 10^{-3}) = 2.06$

8. (c)

(i)



(ii) methyl orange, methyl red or bromothymol blue.

(iii) The end point (the point where the colour changes) must occur at the equivalence point. As the equivalence point is acidic an indicator that changes colour at a pH between about 3 and 7 is required. Methyl orange (3.1 – 4.4), methyl red (4.4 – 6.2) and bromothymol blue (3.0 – 4.6) all change colour within this range.

9. $H^+_{(aq)} + OH^-_{(aq)} \leftrightarrows H_2O_{(\ell)}$ and $Fe^{3+}_{(aq)} + 3OH^-_{(aq)} \leftrightarrows Fe(OH)_{3(s)}$

$n(OH^-)_{\text{added to bore water}} = n(NaOH)_{\text{added to bore water}} = cV = 0.103 \times 0.0100 = 1.03 \times 10^{-3}$ mol
$n(H^+)_{\text{for neutralisation}} = n(HC\ell)_{\text{for neutralisation}} = cV = 0.0277 \times 0.02734 = 7.57 \times 10^{-4}$ mol
$n(OH^-)_{\text{left}} = n(HC\ell)_{\text{for neutralisation}} = 7.57 \times 10^{-4}$ mol
$n(OH^-)_{\text{used to ppt Fe}} = n(OH^-)_{\text{added to bore water}} - n(OH^-)_{\text{left}} = 1.03 \times 10^{-3} - 7.57 \times 10^{-4} = 2.73 \times 10^{-4}$ mol

$n(Fe) = n(Fe^{2+}) = ⅓\, n(OH^-)_{\text{used to ppt Fe}} = ⅓ \times 2.73 \times 10^{-4} = 9.10 \times 10^{-5}$ mol
$m(Fe) = nM = 9.10 \times 10^{-5} \times 55.58 = 5.08 \times 10^{-3}$ g
m(Bore water) = V × density = 250 × 1.01 = 252.5 g

$$[Fe]_{\text{ppm}} = \frac{m(Fe)_{\text{in mg}}}{m(\text{borewater})_{\text{in kg}}} = \frac{5.08\times10^{-3}\times10^{3}}{252.5\times10^{-3}} = 20.1\text{ ppm}$$

10. $H^+_{(aq)} + OH^-_{(aq)} \leftrightarrows H_2O_{(\ell)}$ and $Pb(CO_3)_{(s)} + 2H^+_{(aq)} \rightarrow CO_{2(g)} + H_2O_{(\ell)} + Pb^{2+}_{(aq)}$
$n(H^+)_{\text{added to sample}} = n(HNO_3)_{\text{added to sample}} = cV = 2.00 \times 0.0500 = 0.100$ mol
$n(OH^-)_{\text{used to neutralise 20 mL acid left}} = cV = 0.156 \times 0.03576 = 5.58 \times 10^{-3}$ mol

$$n(OH^-)_{\text{used to neutralise 50 mL acid left}} = \frac{50}{20}\times5.58\times10^{-3} = 0.0139\text{ mol}$$

$n(H^+)_{\text{left}} = n(OH^-)_{\text{used to neutralise 50 mL acid left}} = 0.0139$ mol
$n(H^+)_{\text{reacted with cerussite}} = n(H^+)_{\text{added to sample}} - n(H^+)_{\text{left}} = 0.100 - 0.0139 = 0.0861$ mol

$n(Pb) = n(Pb(CO_3)) = ½\, n(H^+)_{\text{reacted with cerussite}} = ½ \times 0.0861 = 0.0431$ mol
m(Pb) = nM = 0.0431 × 207.2 = 8.92 g

$$\%Pb = \frac{m(Pb)}{m(\text{sample})}\times100 = \frac{8.92}{9.87}\times100 = 90.4\%$$