Sample: Inorganic Chemistry - Calculation of Solution Concentrations
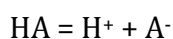
Element 1.

Task A.

Solution	Species present in order of decreasing concentration
HNO_3	H^+, NO_3^-
NH_3	NH_4^+
$MgCl_2$	Cl^-, Mg^{2+}
HF	H^+, F^-
CH_3COONa	CH_3COO^-, Na^+

Task B.
1. The pH of a 0,100 mol L^{-1} methanoic acid solution HCOOH is 2,37. Calculate the $\underline{K_a}$ of methanoic acid.

$HA = H^+ + A^-$

$K_a = [H^+] * [A^-] / [HA]$

$[H^+] = [A^-] \rightarrow [H^+] * [A^-] = [H^+]^2$ $\qquad\qquad$ (1)

$pH = - lg [H^+] \rightarrow [H^+] = 10^{-pH}$ $\qquad\qquad$ (2)

(2) $\rightarrow$ (1): $K_a = 10^{-pH} / [HCOOH]$

$\underline{K_a = 10^{-2,37} / [0,100] = 1,82 * 10^{-4}}$

2. A solution of bleach contains 0,0571 mol L^{-1} of hypochlorous acid, HClO. Calculate the $\underline{pH}$ of this solution if $pK_a(HClO) = 7,53$.

$pH = \frac{1}{2} pK_a (HClO) – 1/2 lg [HClO]$

$\underline{pH = \frac{1}{2} * 7,53 – \frac{1}{2} * lg\, 0,0571 = 4,387}$

3. Calculate the $\underline{pK_a}$ value of a 0,01 mol L^{-1} solution of benzoic acid which has a pH of 3,1.

$pH = \frac{1}{2} pK_a – \frac{1}{2} lg [C_6H_5COOH] \rightarrow pK_a = 2pH + lg [C_6H_5COOH]$

$\underline{pK_a = 2*3,1 + lg\, 0,01 = 4,2}$

4. Calculate the $\underline{pH}$ of a 0,250 mol L^{-1} solution of CH_3COONa given that K_a $(CH_3COONa) = 1,8*10^{-5}$

$h = \sqrt{K_a (CH_3COONa)/ [CH_3COONa]}$

$[OH^-] = h* [CH_3COONa]$

$h = \sqrt{1,8*10^{-5}}/0,250 = 8,5*10^{-3}$

$[OH^-] = 8,5*10^{-3} * 0,250 = 2,125*10^{-3}$
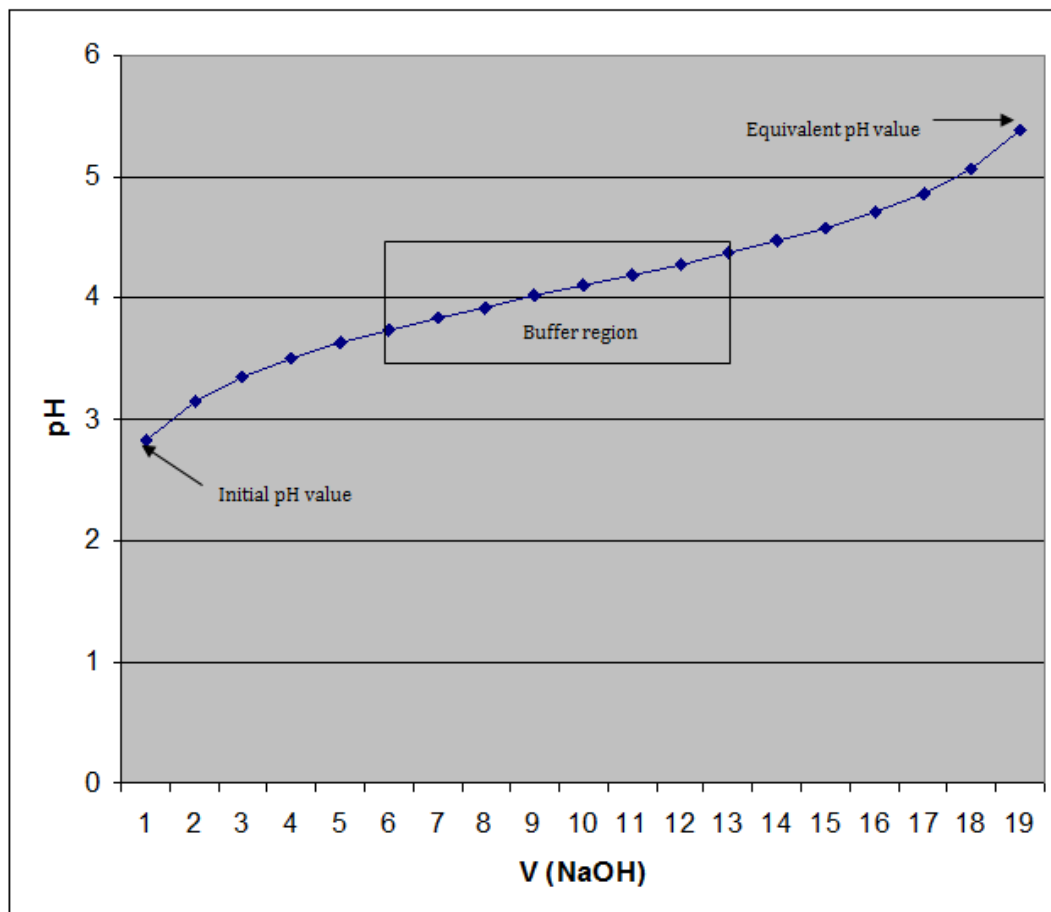
$pOH = - lg[OH^-]$

$pOH = -lg\ 2,125*10^{-3} = 2,673$

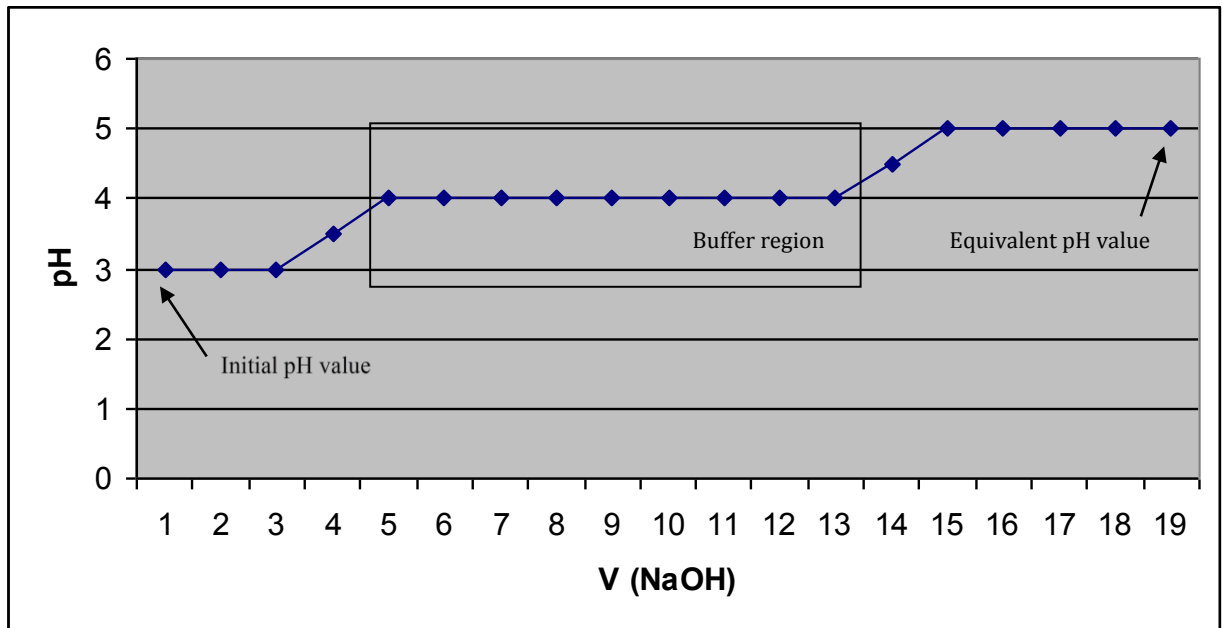$\underline{pH = 14 – 2,673 = 11,237}$

Element 2.

Task C.
1. Addition of 0,100 mol L^{-1} NaOH to 20 ml of 0,100 mol L^{-1} ascorbic acid (Vitaman C) pK_a (ascorbic acid) = 4,10
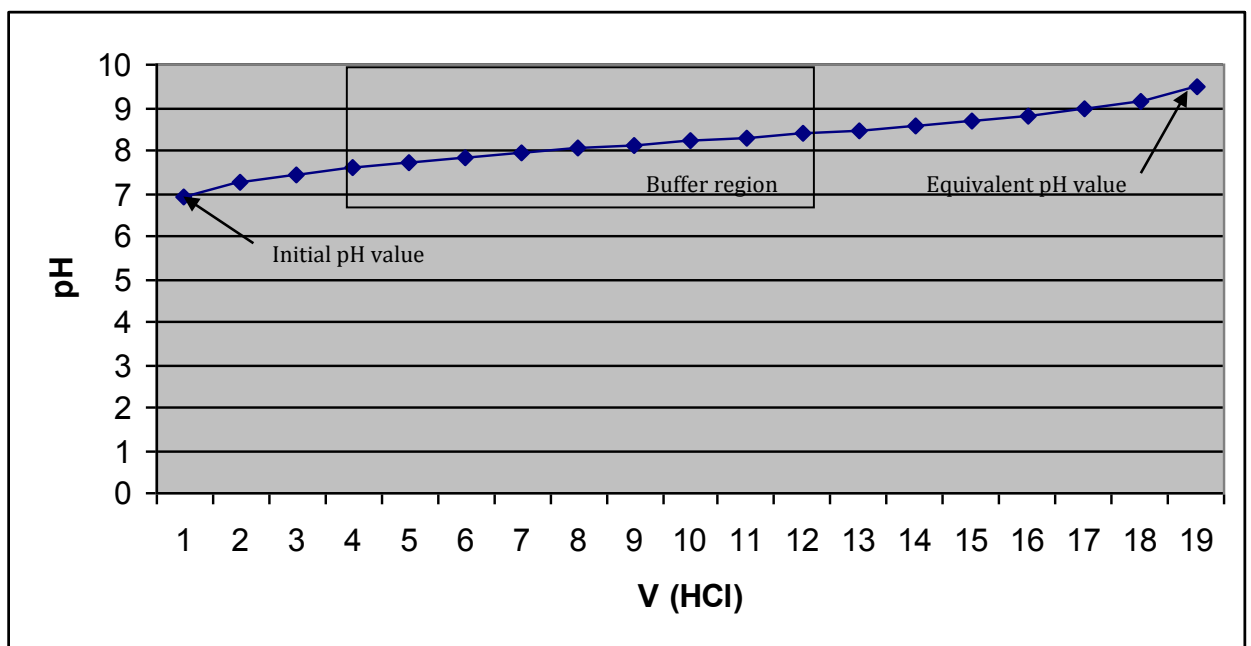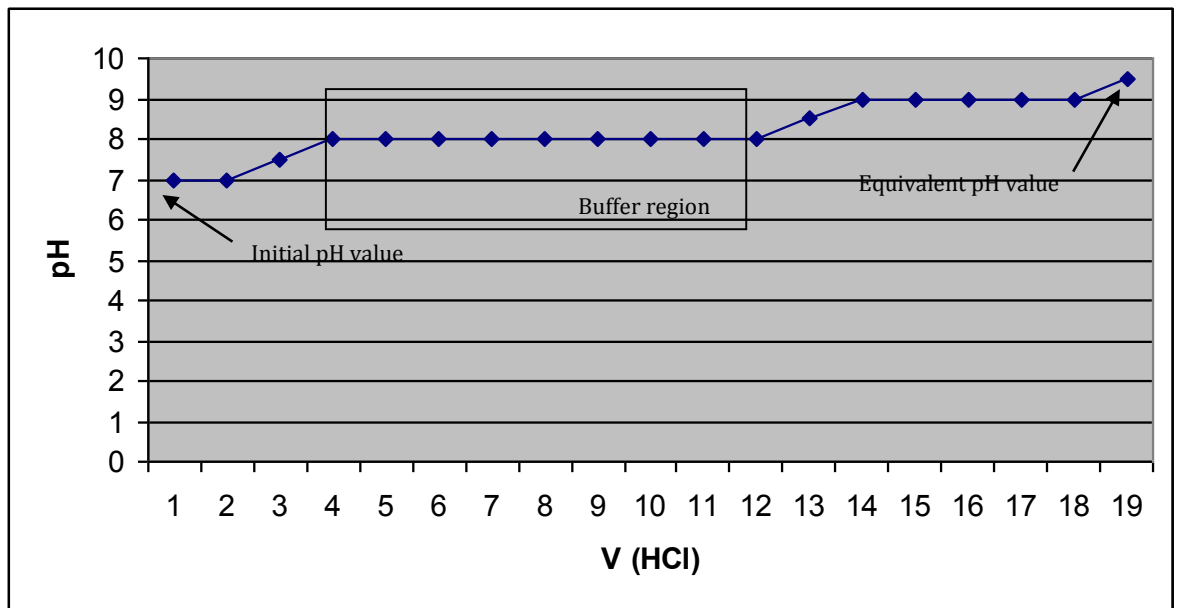
Precise calculations

Approximated calculations

2. Addition of 0.1 Mole L^{-1} solution of weak base morphine. The pK_a of the conjugate acid of morphine = 8,21.

Precise calculations

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Approximated calculations

Task D.

From the following list of indicators, select the indicator which is most likely to change color at the equivalent point for each of the above titrations.

Thymol blue $pK_a = 1{,}7$
Methyl red $pK_a = 5{,}0$
Phenophthalein $pK_a = 9{,}6$

Titration	Indicator
NaOH and ascorbic acid (equivalent point = 5,4)	Methyl red $pK_a = 5{,}0$
HCl and morphine (equivalent point = 9,5)	Phenophthalein $pK_a = 9{,}6$

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