$N_A = 6{,}023.10^{23}$ ▪ N_A ▪ N	$n = \frac{N}{N_A}$	**n** **mol**	
g/mol ▪ M g ▪ m	$n = \frac{m}{M}$		
▪ V_g $L/$ ▪ V_M	$n = \frac{V_g}{V_M}$		
mol ▪ n L ▪ V	$c = \frac{n}{V}$	**mol/L** **c**	
g ▪ m L ▪ V	$c_m = \frac{m}{V}$	**g/L** **t** **c_m**	
g ▪ m mL ▪ V	$\rho = \frac{m}{V}$	**g/mL** **ρ**	
▪ ρ_e $\rho_e = 1\ g/ml = 1kg/l$ ▪ ρ	$d = \frac{\rho}{\rho_e}$		**d**
▪ c_1 ▪ c_2 ▪ V_1 ▪ V_2 ▪ $V_e = V_2 - V_1$	$c_1V_1 = c_2V_2$		
▪ c_1 ▪ c_2 ▪ V_1 ▪ V_2	$F = \frac{c_1}{c_2} = \frac{V_2}{V_1}$	**F**	
▪ P ▪ d ▪ M	$C = \frac{10\,.P.d}{M}$		
▪ m ▪ m'	$P = \frac{m}{m'} \times 100$		
▪ $K = \frac{S}{L}$ A ▪ I V ▪ U ▪ σ	$G = \frac{I}{U} = K\sigma$	**S** **G**	
▪ λ_1 mol/m^3 ▪ $[X]$	$\sigma = \lambda_1[X_1] + \lambda_2[X_2] + ..$	**S/m** **σ**	

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$B_{(aq)} + H_2O_{(l)} = BH^+{}_{(aq)} + OH^-{}_{(aq)}$ $[OH^-] < C \quad \tau_f < 1 \quad K < 10^4$ - $[OH^-] = C \quad \tau_f = 1 \quad K > 10^4$ -	$HA_{(aq)} + H_2O_{(l)} = H_3O^+{}_{(aq)} + A^-{}_{(aq)}$ - $[H_3O^+] < C \quad \tau_f < 1 \quad K < 10^4$ - $[H_3O^+] = C \quad \tau_f = 1 \quad K > 10^4$
$[HO^-] = \frac{10^{-14}}{[H_3O^+]} \Longrightarrow [HO^-] = 10^{pH-14}$	$\text{pH} = -\log[H_3O^+] \Longrightarrow [H_3O^+] = 10^{-pH}$
$\tau_f = \frac{x_f}{x_{max}} = \frac{[HO^-]}{C} = \frac{10^{pH-14}}{C}$ -	$\tau_f = \frac{x_f}{x_{max}} = \frac{[H_3O^+]}{C} = \frac{10^{-pH}}{C}$ - -

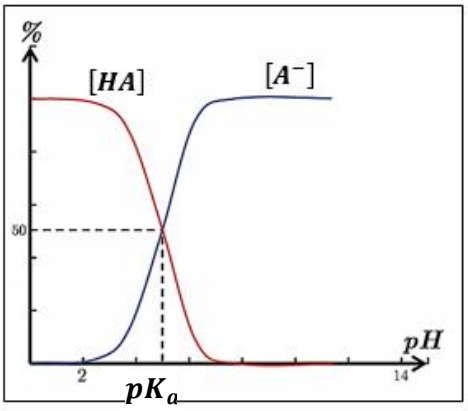
$Ke = [H_3O^+] \times [HO^-] = 10^{-14}$ -

$aA + bB = cC + dD$ K Q_r -

$Q_r = \frac{[C]^c \times [D]^d}{[A]^a \times [B]^b}$, $K = Q_{rf} = \frac{[C]^c{}_f \times [D]^d{}_f}{[A]^a{}_f \times [B]^b{}_f}$

$[H_2O] = 1$ - - -

$K = \frac{[BH^+]_f \times [OH^-]_f}{[B]_f}$ $K = \frac{[BH^+]_f \times [OH^-]_f \times [\boldsymbol{H_3O^+}]}{[B]_f \times [\boldsymbol{H_3O^+}]} \Longrightarrow K = \frac{Ke}{K_a}$	$K_a = \frac{[A^-]_f \times [H_3O^+]_f}{[HA]_f}$ $pK_a = -\log K_a \Longrightarrow K_a = 10^{-pK_a}$ $\text{pH} = pK_a + \log\frac{[A^-]_f}{[HA]_f}$



$[A^-]_f = [HA]_f \quad \text{pH} = pK_a$ -

$[A^-]_f < [HA]_f \quad \text{pH} < pK_a$ -

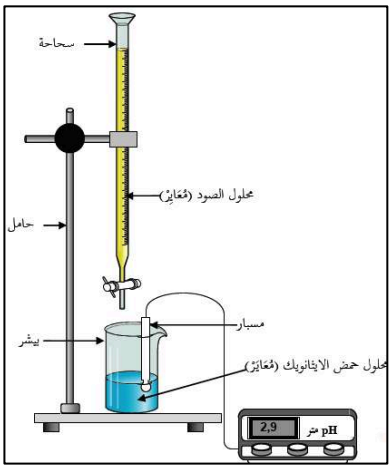
$[A^-]_f > [HA]_f \quad \text{pH} > pK_a$

$\text{pH} = pK_a$ - -

$[HA]_f = \frac{[HA]_f}{[HA]_f + [A^-]_f} \times 100$

; $[A^-]_f = \frac{[A^-]_f}{[HA]_f + [A^-]_f} \times 100$

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- $C_aV_a = C_bV_E$

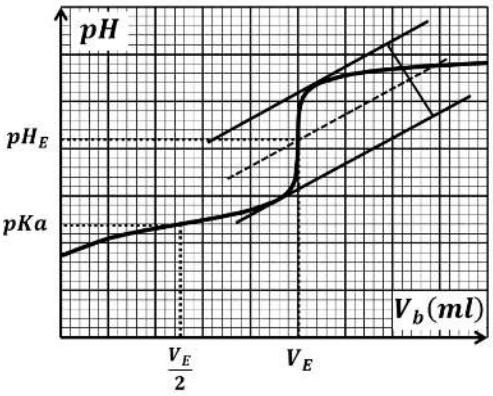
- $[A^-] = [HA] \Longrightarrow V_b = \frac{V_E}{2} \Longrightarrow pH = pKa$

-

$$H_3O^+_{aq} + OH^-_{aq} = 2H_2O$$

$$K = \frac{1}{[OH^-] \times [H_3O^+]} = \frac{1}{Ke}$$

$$\tau_f = \frac{x_f}{x_{max}} = \frac{C_aV_a - [H_3O^+]V_T}{C_bV_b} = \frac{C_aV_a - 10^{-pH}V_T}{C_bV_b} \quad V_b < V_E$$



- $HA_{(aq)} + HO^- = A^-{}_{(aq)} + H_2O_{(l)}$

-

$HA_{(aq)}$ + HO^- =	$A^-{}_{(aq)} + H_2O_{(l)}$		
C_aV_a	C_bV_b	0	
$C_aV_a - x_f$	$C_bV_b - x_f$	x_f	

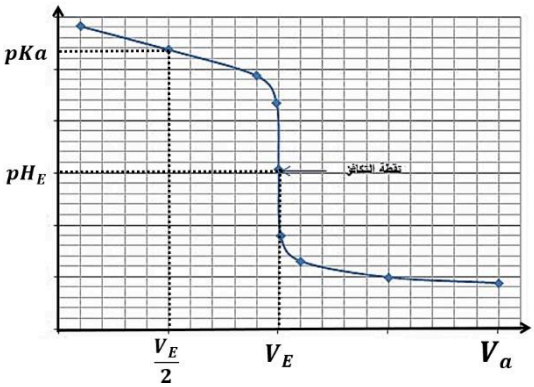
- $\tau_f = \frac{x_f}{x_{max}} \quad V_b < V_E$

$$C_bV_b - x_{max} = 0 \Longrightarrow x_{max} = C_bV_b \qquad HO^-$$

$$[HO^-] = \frac{C_bV_b - x_f}{V_T} \Longrightarrow x_f = C_bV_b - [HO^-]V_T = C_bV_b - 10^{pH-14}V_T$$

$$\tau_f = \frac{x_f}{x_{max}} = \frac{C_bV_b - 10^{pH-14}V_T}{C_bV_b}$$

- $$K = \frac{[A^-]}{[HA] \times [OH^-]} = \frac{[A^-] \times [H_3O^+]}{[HA] \times [OH^-] \times [H_3O^+]} = \frac{Ka}{Ke}$$



- $B_{(aq)} + H_3O^+ = BH^+{}_{(aq)} + H_2O_{(l)}$

$B_{(aq)}$ + H_3O^+ =	$BH^+{}_{(aq)}$ + $H_2O_{(l)}$		
C_bV_b	C_aV_a	0	
$C_bV_b - x_f$	$C_aV_a - x_f$	x_f	

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$$\tau_f = \frac{x_f}{x_{max}} \quad V_b < V_E$$

$$C_a V_a - x_{max} = 0 \Longrightarrow x_{max} = C_a V_a \qquad H_3O^+$$

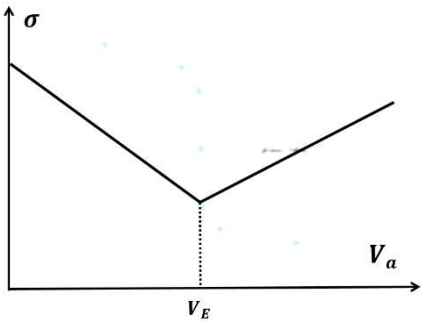
$$[H_3O^+] = \frac{C_a V_a - x_f}{V_T} \Longrightarrow x_f = C_a V_a - [H_3O^+]V_T = C_a V_a - 10^{-pH} V_T$$

$$\tau_f = \frac{x_f}{x_{max}} = \frac{C_a V_a - 10^{-pH} V_T}{C_a V_a}$$

-

$$K = \frac{[BH^+]}{[H] \times [[H_3O^+]]} = \frac{1}{Ka}$$

-



أ-

V_0 -

-

ب- $\boldsymbol{V}$ $\boldsymbol{c}$

$m = c\,VM$ -

-

V -

ج- $\boldsymbol{P}$ $\boldsymbol{V}$ $\boldsymbol{c}$

-

V -

د- $\boldsymbol{V}$ $\boldsymbol{c}$

V_0 -

-

V -

- V_0
- $C = \frac{10\,.P.d}{M}$

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2008 1

İ

$$CH_3COOH_{(aq)} + H_2O_{(\ell)} = CH_3COO^-_{(aq)} + H_3O^+$$

-1

$(acide/base)$ -2

K -3

pH $C = 2.7 \times 10^{-3}\, mol/L$ $V = 100mL$ İİ

3,7 25°C

-1

x_{max} x_f -2

τ_f -3

$[CH_3COOH]_f$ $[CH_3COO^-]_f$ -4

(CH_3COOH/CH_3COO^-) pKa

2011 2

$C_0 = 0.01mol/l$ V_0 CH_3COOH S_0

1

$x_{éq}$ 2

3

$[H_3O^+]_f$ C_0 τ_f

$$Q_{r.éq} = \frac{[H_3O^+]^2_{éq}}{C_0 - [H_3O^+]_{éq}}$$

$[HO^-]_{éq}$ $[H_3O^+]_{éq}$ $\lambda_{CH_3COO^-}$ $\lambda_{H_3O^+}$ $\sigma_{éq}$

4

$\lambda_{CH_3COO^-} = 3.6mS.m^2.mol^{-1}$ $\lambda_{H_3O^+} = 35.9\, mS.m^2.mol^{-1}$

$Q_{r,eq}$	τ_f (%)	$\left[H_3O^+_{(aq)}\right]_{eq}\ (mol.L^{-1})$	$\sigma_{eq}\ (S.m^{-1})$	$c\ (mol.L^{-1})$	المحلول
			0,016	$1,0\times10^{-2}$	S_0
			0,036	$5,0\times10^{-2}$	S_1

$Q_{r.éq}$ τ_f -

3

$C_1 = 10^{-2}\, mol/L$ C_6H_5COOH (S_1) İ

$\sigma = 0{,}86 \times 10^{-2}$S/m 25°C

1

2

(S_1) 3

$\lambda_{C_6H_5-COO^-} = 4\, mS.m^2.mol^{-1}$ $\lambda_{H_3O^+} = 35.0\, mS.m^2.mol^{-1}$

τ_{1f} 4

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k_1 5

$25°C$ $pH = 3,2$ $C_2 = C_1$ HA (S_2) İİ

τ_{2f} 1

τ_{2f} τ_{1f} 2

2012 4

pH $C_1 = 10^{-2}\,mol/l$ C_6H_5COOH $V = 200ml$ S_1

$pH_1 = 3.1$

-1

-2

τ_{1_f} -3

$C_6H_5COOH/C_6H_5OO^-$ K_{a_1} -4

$K_{a_1} = C_1\frac{{\tau_{1_f}}^2}{1-\tau_{1_f}}$ K_{a_1} -5

C'_1 S_1' S_1 $20ml$ -6

$pH'_1 = 3.6$ pH

$C'_1 = 1 \times 10^{-3}\,mol/l$ -

τ_{2_f} -

2016 5

C_0 HA S_0

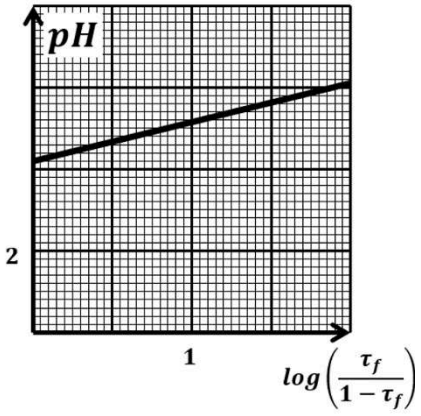
HA -1

C_0 pH τ_f

$pH = pKa + \log\left(\frac{\tau_f}{1-\tau_f}\right)$ S_0 pH

C_0 -2

$pH = f\left(log\left(\frac{\tau_f}{1-\tau_f}\right)\right)$ pH S_0



-

(HA/A^-) Ka -

$\tau_f = 0.4$ HA -

$pH = 4.2$ 160 -

C_0

(HA/A^-) pKa -

HA

HA/A^-	CH_3COOH/CH_3COO^-	$HCOOH/HCOO^-$	$C_6H_6COOH/C_6H_5COO^-$
pKa	4.8	3.8	4.2

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2010 6

500 ml 1,2 L NH_3 (S_1)

$V_M = 24\ L/mol$ (S_1) C_1 1

11,1 25°C (S_1) pH 2

τ_{1f}

$V = 50\ ml$ (S_2) 3

(S_1) $C_b = 2 \times 10^{-2} mol/l$

(S_2)

τ_{2f} 10,8 (S_2) pH

$(NH_4^+(aq)/NH_3(aq))$ ka 4

7

$V = 100ml$ $C = 0.02\ mol/l$ NH_3 (S_1) -

$\sigma = 15.3 mS.m^{-1}$

-1

-2

τ_f -3

(NH_4^+/NH_3) pka k -4

20 (S_1) $V_2 = 200ml$ (S_2) -

(S_2) C_2 -1

$pH = 10.08$ $\tau_{2f} = \frac{1}{1+10^{pH-pKa}}$ τ_{2f} -2

-3

$Ke = 10^{-14}$ $\lambda_{NH_4^+} = 7.34\ mS.m^2/mol$ $\lambda_{OH^-} = 19.9\ mS.m^2/mol$

2016 8

$M(C_6H_5COOH) = 122 g/mol$ 25°C

C_6H_5COOH -1

$C_1 = 0.01\ mol/L$ $V_1 = 50mL$ (S_1) $C_6H_5OO^-$

$C_0 = 0.025\ mol/L$

V_0 -

(S_1) -

$(50mL\ ,\ 100mL\ ,\ 500mL)$ -

$(5mL\ ,\ 10mL\ ,\ 20mL)$ -

1

3.12 (S_1) pH -2

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-

Q_{rf} -

(S_1) $10mL$ -3

pH

$V_{H_2O}(mL)$	0	10	40
$C(mol/L)$			
pH	3.12	3.28	3.49
τ_f			

-

τ_f c

2013 9

$m = 0.72g$ CH_3COOH S_1 -1

3.3 pH 25°C $800ml$

S_1 C_1 أ-

ب-

ج-

S_1 V V pH x_{eq} د-

4.76 $CH_3COOH(aq)/CH_3COO^-(aq)$ pKa ه-

n_0 V_2 n_0 S_1 V_1 -2

NH_3 CH_3COOH أ-

K ب-

$\tau_{eq} = \frac{\sqrt{K}}{1+\sqrt{K}}$ τ_{eq} ج-

τ_{eq} د-

$M(C) = 12\,g/mol$ ، $M(H) = 1\,g/mol$ ، $M(O) = 16\,g/mol$ ، $pKa(NH_4^+/NH_3) = 9.2$

10

11,3 pH $V = 100\,ml$ $C = 0.01\,mol/l$ CH_3NH_2 (S_0)

( ) -1

-2

τ_f -3

$pka = 10.6$ $CH_3NH_3^+/CH_3NH_2$ pKa -4

$(Na^+ + HCO_3^-)$ CH_3NH_2 -5

$n = CV$

$$CH_3NH_{2(aq)} + HCO_3^-{}_{(aq)} = CH_3NH_3^+{}_{(aq)} + CO_3^{2-}{}_{(aq)}$$

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-

-

$pka(HCO_3^-/CO_3^{2-}) = 10.3$ k

x_f $k = \frac{(x_f)^2}{(cV-x_f)^2}$

$\tau`_f$

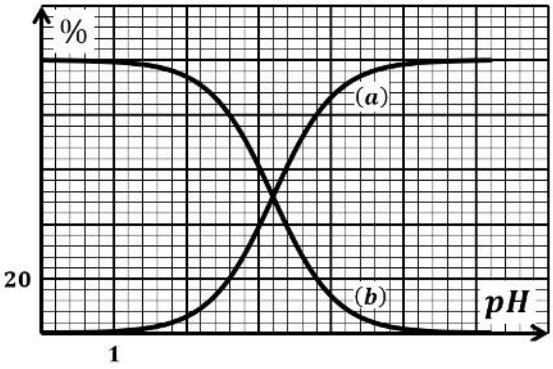
pH

HNO_2

$C_0 = 0.625mol/L$ (S_0)

.I

pH C (S) (S_0)



$pH = 2.8$

pH pH -1

-2

-3

-4

(HNO_2/NO_2^-) pKa -5

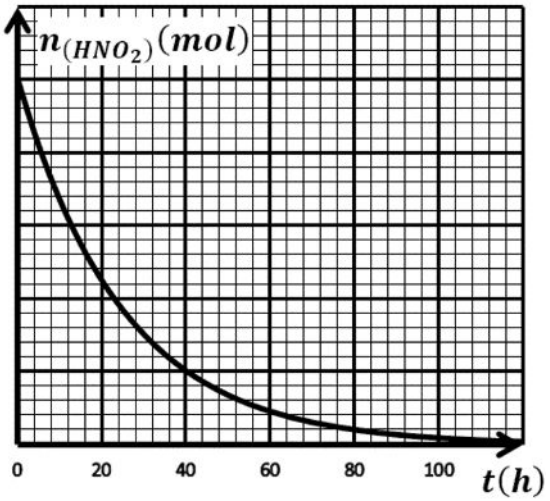
(S) C -6

τ_f -7

.II

$$3HNO_{2(aq)} = 2NO_{(g)} + H_3O^+_{(aq)} + {NO_3}^-_{(aq)}$$

(S_0) $V = 800mL$



-1

-2

-3

$v = -\frac{1}{3V} \times \frac{dn_{(HNO_2)}}{dt}$ -4

$t = 60h$ $t = 20h$

-

$[HNO_2] = [NO_3^-]$ -5

n_0 $x = \frac{n_0}{4}$

$[HNO_2] = [NO_3^-]$ -

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2010 12

$100\,ml$ m CH_3COOH (S)

3,4 25°C pH (S) pH

1

x_f 2

m $C = 0.01\,mol/L$ $\tau_f = 0.039$

(S)

Q_{rf} Q_{ri} 3

$V_a = 10mL$ (S) C 4

$V_{bE} = 25mL$ $C_b = 4 \times 10^{-3}mol/l$ $(Na^+ + HO^-)$

(S) C

12,5 ml pH

$M(H) = 1g/mol$ $M(C) = 12g/mol$ $M(O) = 16g/mol$ $pKa(CH_3COOH/CH_3COO^-) = 4,8$

2016 13

25°C

$(P\%)$ HA HSO_3NH_2

$V = 100mL$ C_A (S_A) -1

$m = 0.9g$

-

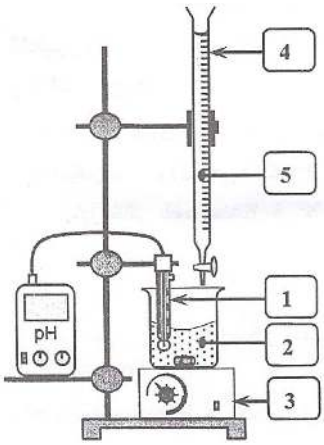
(S_A) -

$80mL$ $V_A = 20mL$ (S_A) -2

$(Na^+ + HO^-)$

$V_{bE} = 15.3mL$ $C_b = 0.1\,mol/L$

$pH_E = 7$



-

-

HA m_A (S_A) C_A -

$(P\%)$ -

$M = 97g/mol$ HA

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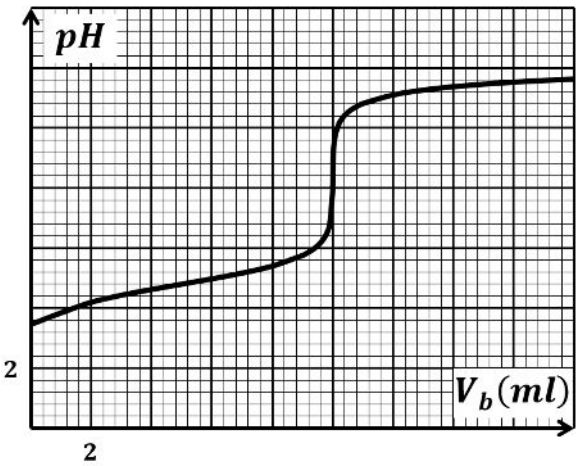
2016 14

$K_e = 10^{-14}$ 25°C

$V_a = 20mL$ HA C_a

pH $C_b = 0.02\,mol/L$ $(K^+ + HO^-)$

V_b $pH = f(V_b)$



-1

C_a -2

(HA/A^-) pKa -3

(HA/A^-)	pKa
CH_3COOH/CH_3COO^-	4,8
$HCOOH/HCOO^-$	3,8
$C_6H_6COOH/C_6H_5COO^-$	4,2

HA -4

-5

	6.2 7.6
	8.2 10.0
	4.2 6.2

K

τ_f $V_b = 5mL$

-6

2017 15

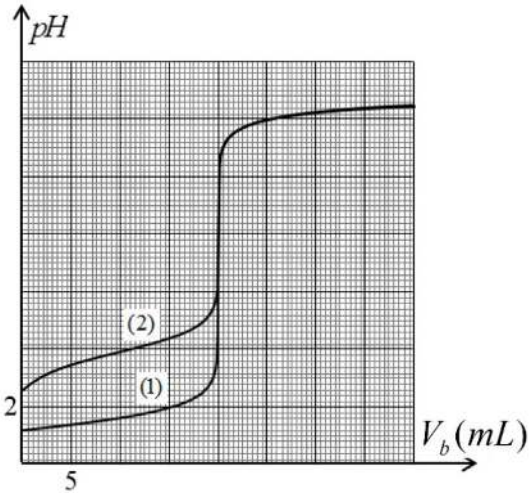
$Ke = 10^{-14}$ 25°C

$V_2 = 20mL$ C_1 $V_1 = 30mL$

$(Na^+ + HO^-)$ C_2 $HCOOH$

V_b pH pH $C_b = 0.1\,mol/l$

(2) (1)



(1

(2

(3

C_2 C_1 (4

$(HCOOH/HCOO^-)$ pKa (5

K (6

(7

الكاشف الملون	مجال التغير اللوني
الهليانتين	3,1 - 4,4
ازرق البروموتيمول	6,2 - 7,6
فينول فتاليين	8,0 - 10,0

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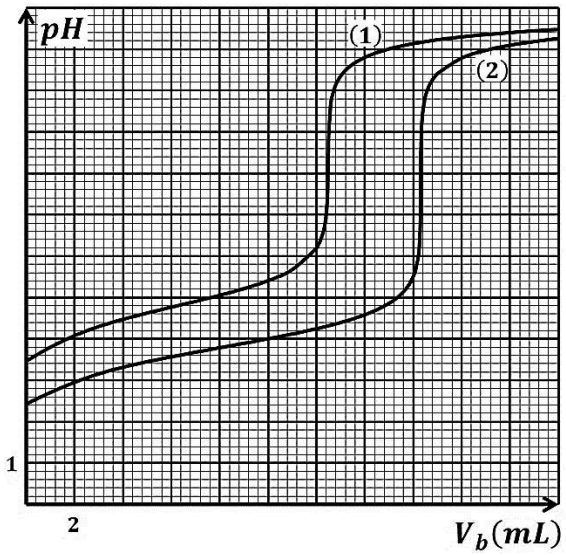
25°C R' R $R'COOH$ $RCOOH$

$m = 0.6g$

$V =$ $R'COOH$ (S_2) $RCOOH$ (S_1)

$800mL$

$(Na^+ + HO^-)$ $V_1 = 10mL$ (S_1)



(S_2) $C_b = 10^{-2}\,mol/l$

pH

(S_2) (S_1)

-1

-2

(S_2) C_2 (S_1) C_1 -3

$C_nH_{2n+1}COOH$ -4

pKa -5

$RCOOH$ -6

(S_1) pH

τ_f

$H = 1\,g/mol$ $O = 16\,g/mol$ $C = 12\,g/mol$

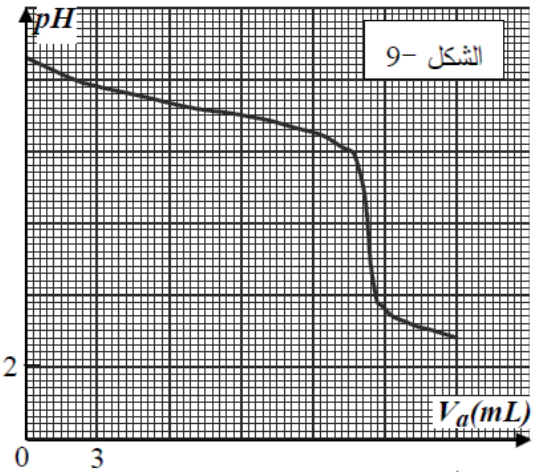
2014 17

pH NH_3 (S) C_b

$C_a = 0.015mol/L$ $(H_3O^+ + Cl^-)$ (S) $V_b = 20mL$

1

09 25°C 2



-

C_b -

NH_4^+/NH_3 pKa

K 3

$V_a = 9mL$ 4

$\frac{[NH_3]_f}{[NH_4^+]_f}$ -

x_f V_b C_b -

τ_f

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2011 18

$d = 1,3$ 27% S_0

$C_0 = 8,8\ mol/l$ 1

$V_0 = 10\ ml$ $C_a = 0,1\ mol/l$

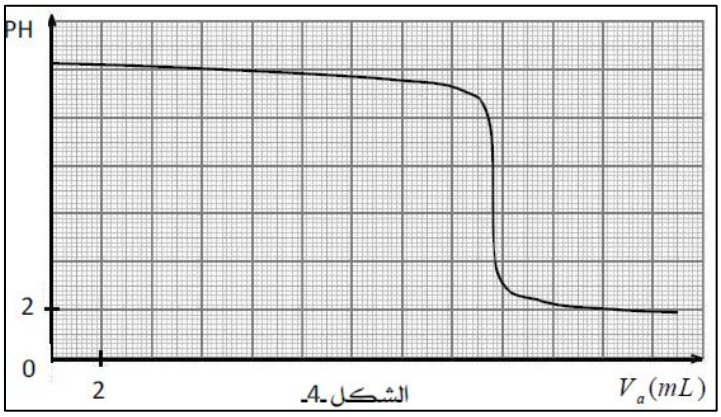
S $500\ ml$ 50 S 2

pH S $V_b = 10\ ml$ 3

pH

pH

pH



الشكل-4

E $(V_{aE}\ ; PH_E)$

S

$H = 1g/mol$ $Na = 23g/mol$ $O = 16g/mol$

2013 19

$C = 10^{-2}\ mol/l$ V CH_3COOH S

$\sigma = 16ms.m^{-1}$ 25°C S σ

-1

λ $\lambda_{H_3O^+}$ $\lambda_{CH_3COO^-}$ σ S $[H_3O^+]$ -2

3.4 pH -3

$(K^+_{aq} + OH^-_{aq})$ S V_a -4

$\frac{[CH_3COO^-(aq)]}{[CH_3COOH(aq)]} = 41.43 \times 10^{-3}$ $C_b = 2 \times 10^{-3}\ mol/l$

$\frac{[CH_3COO^-(aq)]}{[CH_3COOH(aq)]} = 1$ $V_b = 10ml$

$CH_3COOH(aq)/CH_3COO^-(aq)$ K_A -

V_a -

$\lambda_{CH_3COO^-} = 4.1\ mS.m^2.mol^{-1}$ $\lambda_{H_3O^+} = 35.0\ mS.m^2.mol^{-1}$

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$800ml$ $m = 0.48g$ $C_nH_{2n+1}COOH$ S_1 -1

$pH = 3.39$ pH 25°C

-

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-

C_a $pKa_1 = 4.76$ $C_nH_{2n+1}COOH/C_nH_{2n+1}COO^-$ pKa_1 -

$(Na^+ +$ S_1 $V_a = 20mL$ C_a -2

pH $V_b = 8ml$ $C_b = 2 \times 10^{-2}\, mol/l$ $HO^-)$

$pH = 5.36$

-

K -

V_{bE} $V_{bE} = V_b(1 + 10^{pKa-pH})$ V_b -

C_a -

$H = 1\, g/mol$ $O = 16\, g/mol$ $C = 12\, g/mol$

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NH_4NO_3

25°C 33%

$C_1 = 0.15\, mol/l$ NH_4^+ $V_1 = 20ml$ $t = 0$

pH $C_2 = 0.15\, mol/l$ $(Na^+ + HO^-)$ $V_2 = 10ml$

pH = 9.2

$$NH_4^+{}_{(aq)} + HO^-{}_{(aq)} = NH_{3(aq)} + H_2O_{(l)}$$

-1

x_{max}

$x_{eq} = 1.5 \times 10^{-3}\ mol$

τ_f

$m = 6g$ -2

(S_a) $V_a = 10ml$ $250ml$ (S_a)

$V_{bE} = 14ml$ $C_b = 0.2\, mol/l$

(S_a) C_a -

-

-

$M(H) = 1\, g/mol\ , M(N) = 14\, g/mol\, , M(O) = 16\, g/mol$ $PKa(NH_4^+/NH_3) = 9.2$

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$C_{13}H_{18}O_2$

$200mg$

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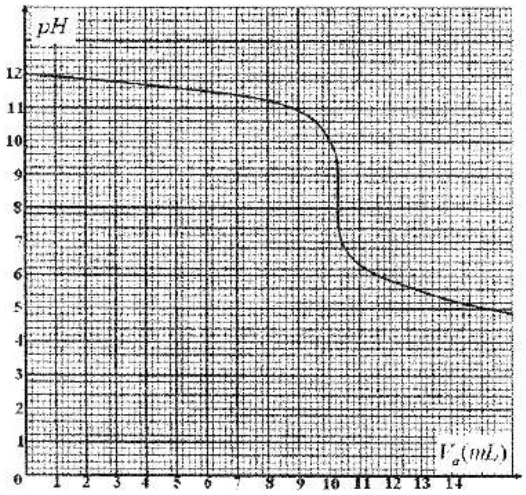
$M(RCOOH) = 206\,g/mol$ $RCOO^-$ $RCOOH$

25°C

S_b $V_b = 100ml$

S $C_b = 2 \times 10^{-2}\,mol/l$ $(Na^+{}_{aq} + OH^-{}_{aq})$

$C_a = 0.02\,mol/l$ S $20ml$ V_b



$H_3O^+{}_{aq} + OH^-{}_{aq} = 2H_2O$

-1

E -2

$OH^-{}_{aq}$ -3

$OH^-{}_{aq}$ -4

$RCOOH$

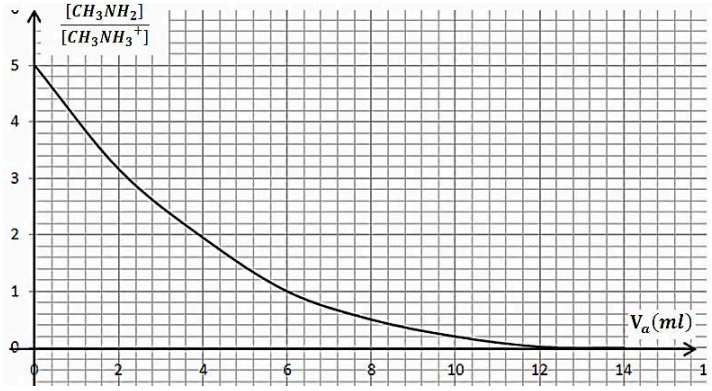
m

23

$CH_3NH_3{}^+{}_{(aq)}$ $CH_3NH_{2(aq)}$

(S)

$V_b = 20\,ml$ 10 (S_1)



$C_a = 0.02\,mol/l$

-1

-2

-3

C_b -4

$V_a = 2.8ml$ -5

pH -

τ_f -

(S_1) -6

-أ

PH K_e C_b $\tau`_f$ -ب

$\tau`_f$ -

e $^{-14}$ 3 $_3{}^+$ $CH_3NH_2) = 10.6$

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5g 100g 5%

$d = 1.02$ CH_3COOH

$$CH_3COOH_{(aq)} + H_2O_{(l)} = CH_3COO^-{}_{(aq)} + H_3O^+{}_{(aq)}$$

$200\ mL$ $100\ mL$ $50\ mL$ -

$20\ mL$ $10\ mL$ $5\ mL$ -

pH -

$C_b = 0.05\ mol/L$ $(Na^+ + OH^-)$ -

.I $V_1 = 100\ mL$ 20 (S_1)

(S_1) -1

(S_1) C_1 $C_0 = 0{,}85\ mol/L$ -2

3,07 (S_1) pH -3

-

τ_f -

(CH_3COOH/CH_3COO^-) $pka = 4{,}76$ -

.II $V_a = 20ml$

$C_b = 0.05\ mol/L$ (S_1)

$V_b(ml)$	1	2	4	6	8	9	10	12	14
pH	3.55	3.88	4.24	4.49	4.7	4.81	4.91	5.14	5.42
$\frac{[CH_3COO^-]}{[CH_3COOH]}$									

$$CH_3COOH_{(aq)} + OH^-{}_{(aq)} = CH_3COO^-{}_{(aq)} + H_2O_{(l)}$$

-1

$\frac{[CH_3COO^-]}{[CH_3COOH]} = 10^{pH-pKa}$ V_b -2

$\frac{[CH_3COO^-]}{[CH_3COOH]} = f(V_b)$ -

(S_1) -3

-4

pH -5

$V_b = 14mL$ -6

$M_O = 16\ g/mol$ $M_H = 1\ g/mol$ $M_C = 12\ g/mol$

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