Exam III Key

① $HNO_2 \rightleftharpoons H^+ + NO_2^-$

	HNO_2	H^+	NO_2^-
I	.120	~0	0
C	$-x$	$+x$	$+x$
E	$.120-x$	x	x

$$K_a = \frac{A_{H^+} \cdot A_{NO_2^-}}{A_{HNO_2}} = \frac{\gamma_{H^+}[H^+]\gamma_{NO_2^-}[NO_2^-]}{\gamma_{HNO_2}[HNO_2]}$$

($\gamma_{HNO_2} \rightarrow 1$)

$$1.03 \times 10^{-3} = \frac{.8252(x)(.7583(x)}{.120-x}$$

$x = .0133$

$$pH = -\log A_{H^+} = -\log[.8252 \cdot .0133] = 1.96$$

$\alpha = .100$

$$\log \gamma_{H^+} = \frac{-.51(+1)^2\sqrt{.100}}{1+(900\sqrt{.100}/305)} = -.0834$$

$\gamma_{H^+} = .8252$

$$\log \gamma_{NO_2^-} = \frac{-.51(+1)\sqrt{.100}}{1+(300\sqrt{.100}/305)} = -.123$$

$\gamma_{NO_2^-} = .7533$

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② See text & notes

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③ CB: $[H^+] + [Na^+] = [OH^-] + [ClO^-]$

MB: $[HClO] + [ClO^-] = 0.150\ M$

(also: $[Na^+] = 0.100\ M$)

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④ First, consider the reaction that occurs:

$Pb^{2+}_{(aq)} + 2\ Cl^-_{(aq)} \longrightarrow PbCl_{2(s)}$

mol = MV: $= .100(.050) = .005$ mol

mol = MV: $= (.100)(.100) = .01$ mol

$\longrightarrow$ .005 mol $PbCl_{2(s)}$ formed

stoichiometrically equivalent amts (no excess)

④ (cont.)

What is left over? .010 mol NO_3^- & .010 mol Na^+

$$[Na^+] = [NO_3^-] = \frac{.010\ mol}{.150\ L} = .0667\ M$$

$$\log \gamma_{Pb^{2+}} = \frac{-.51(+2)^2\sqrt{.0667}}{1 + \left(\frac{450\sqrt{.0667}}{305}\right)} = -.3815 \Rightarrow \gamma_{Pb^{2+}} = 0.415$$

$$\log \gamma_{Cl^-} = \frac{-.51(-1)^2\sqrt{.0667}}{1 + \left(\frac{300\sqrt{.0667}}{305}\right)} = -.105 \Rightarrow \gamma_{Cl^-} = 0.785$$

$$PbCl_2(s) \rightleftharpoons Pb^{2+}(aq) + 2Cl^-(aq)$$
$$\quad - \qquad\quad x \qquad\quad 2x$$

$$K_{sp} = A_{Pb^{2+}} \cdot A_{Cl^-}^2$$

$$1.7\times10^{-5} = (.415)(x)(.785)^2(2x)^2 = (x^3)(.415)(.785)^2(4)$$

$$x = .0255 \Rightarrow [Cl^-] = 2x = .0510\ M$$

$$pCl = -\log A_{Cl^-} = -\log(\gamma_{Cl^-}[Cl^-]) = -\log(.785 \cdot .0510) = \boxed{1.40}$$

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⑤ $L = 15.0\ cm$; $t_m = 31\ s$; $t_{r,A} = 119\ s$; $t_{r,B} = 123\ s$

a) $k' = \frac{t_r - t_m}{t_m}$ $\quad k'_A = \frac{119-31}{31} = \boxed{2.84}$; $\quad k'_B = \frac{123-31}{31} = \boxed{2.97}$

b) $N = 2000$

$$N = 16\left(\frac{t_r}{w}\right)^2 \qquad 2000 = 16\left(\frac{119}{w_A}\right)^2 = 16\left(\frac{123}{w_B}\right)^2$$

$\boxed{w_A = 10.64\ s}$ $\quad$ $\boxed{w_B = 11.00\ s}$

c) $R_s = \frac{\Delta t_r}{w_{ave}} = \frac{123-119}{\left(\frac{10.64+11.00}{2}\right)} = \boxed{0.37}$

d) $R \propto \sqrt{N}$

$$\Rightarrow \frac{R_1}{R_2} = \frac{\sqrt{N_1}}{\sqrt{N_2}} \qquad \frac{.37}{1.50} = \frac{\sqrt{2000}}{\sqrt{N_2}} \Rightarrow N_2 = 32871\ \text{plates}$$

$L \propto N \Rightarrow \frac{L_1}{L_2} = \frac{N_1}{N_2} \qquad \frac{15}{L_2} = \frac{2000}{32871} \Rightarrow L_2 = \boxed{247\ cm}$

e) $t_r \propto L$

A: $\frac{t_{r1}}{t_{r2}} = \frac{L_1}{L_2} \qquad \frac{119}{t_{r2}} = \frac{15}{247}$ $\quad$ B: $\frac{123}{t_{r2}} = \frac{15}{247}$

$\boxed{t_{r,A} = 1960\ s}$ $\quad$ $\boxed{t_{r,B} = 2025\ s}$