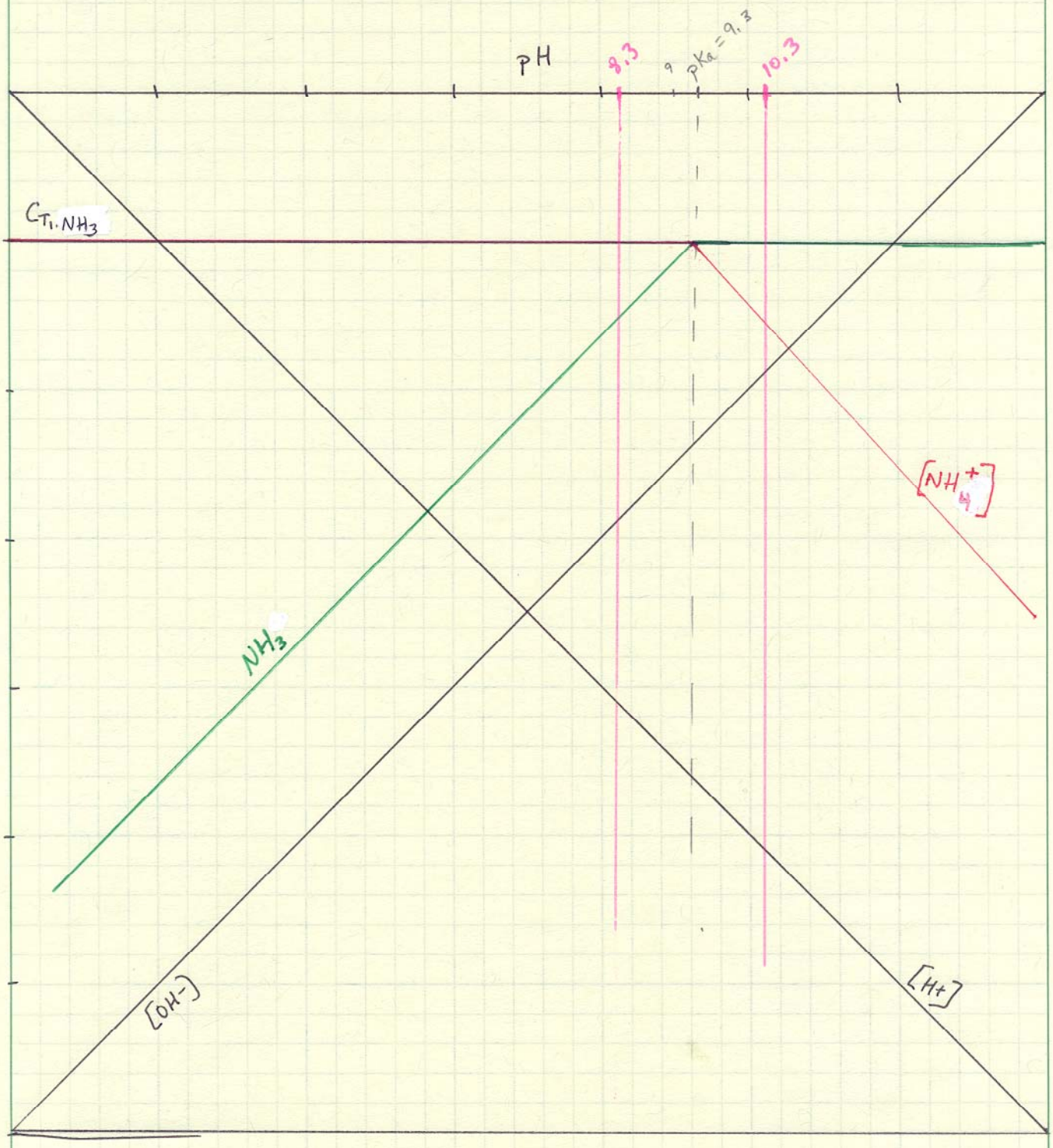
HW #9 Solutions EUE 410

#1. Which pH for discharge? $pK_a = 9.3$

Assume a 10^{-2} M solution of NH_3^+



There is less NH_3 at pH = 8.3, so I would rather discharge at this pH. At pH = 10.3, almost all the NH_3 in solution is in the more toxic form, NH_3.

#2a. 10^{-3} M Na_2B

Proton condition

$[H^+] + [HB^-] + 2[H_2B] = [OH^-]$

pH ≅ 9.1

2b. 10^{-3} M NaHB

Proton condition

$[H^+] + [H_2B] = [OH^-] + [B^{2-}]$

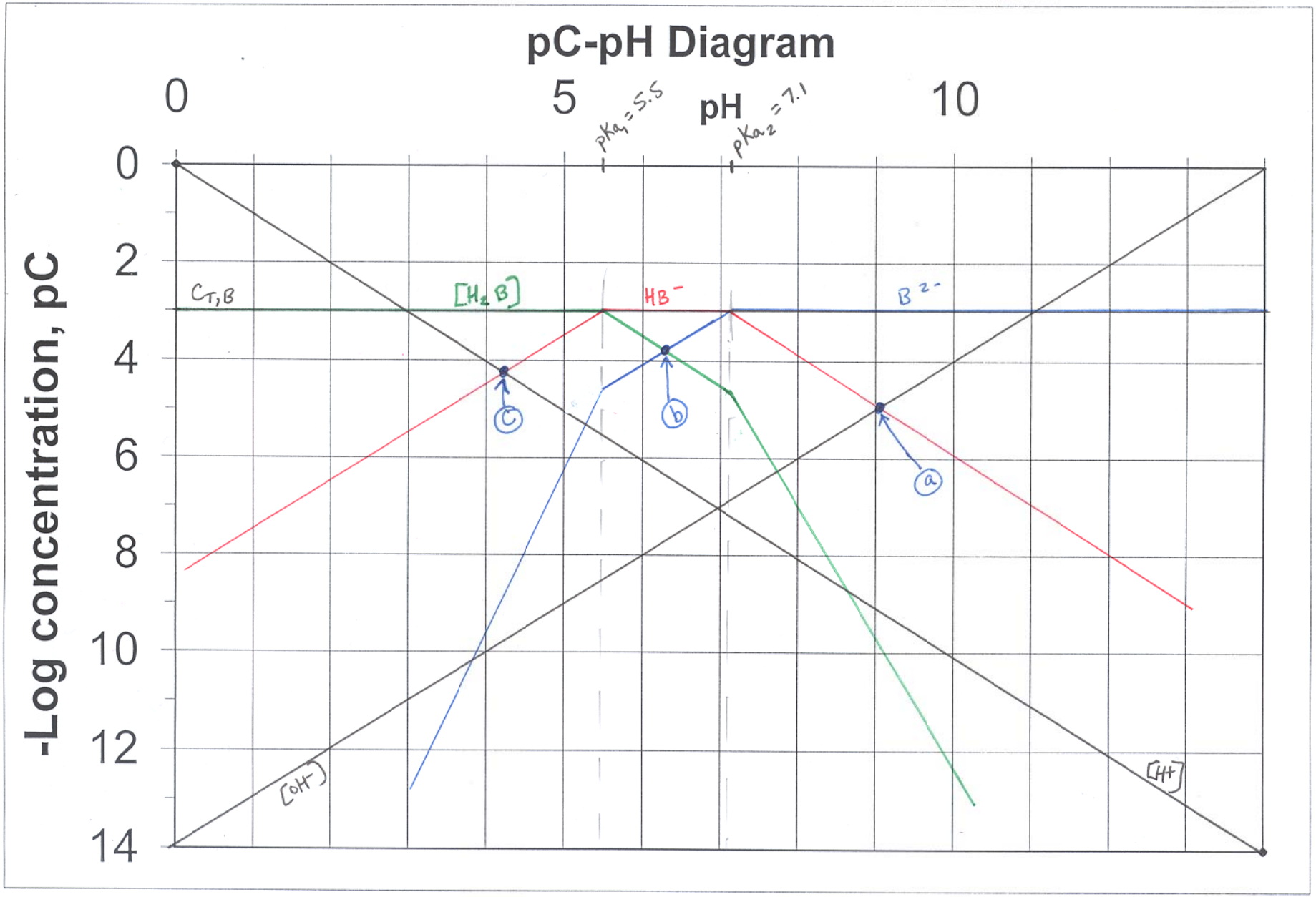
pH ≈ 6.3

2c. 10^{-3} M H_2B

Proton condition

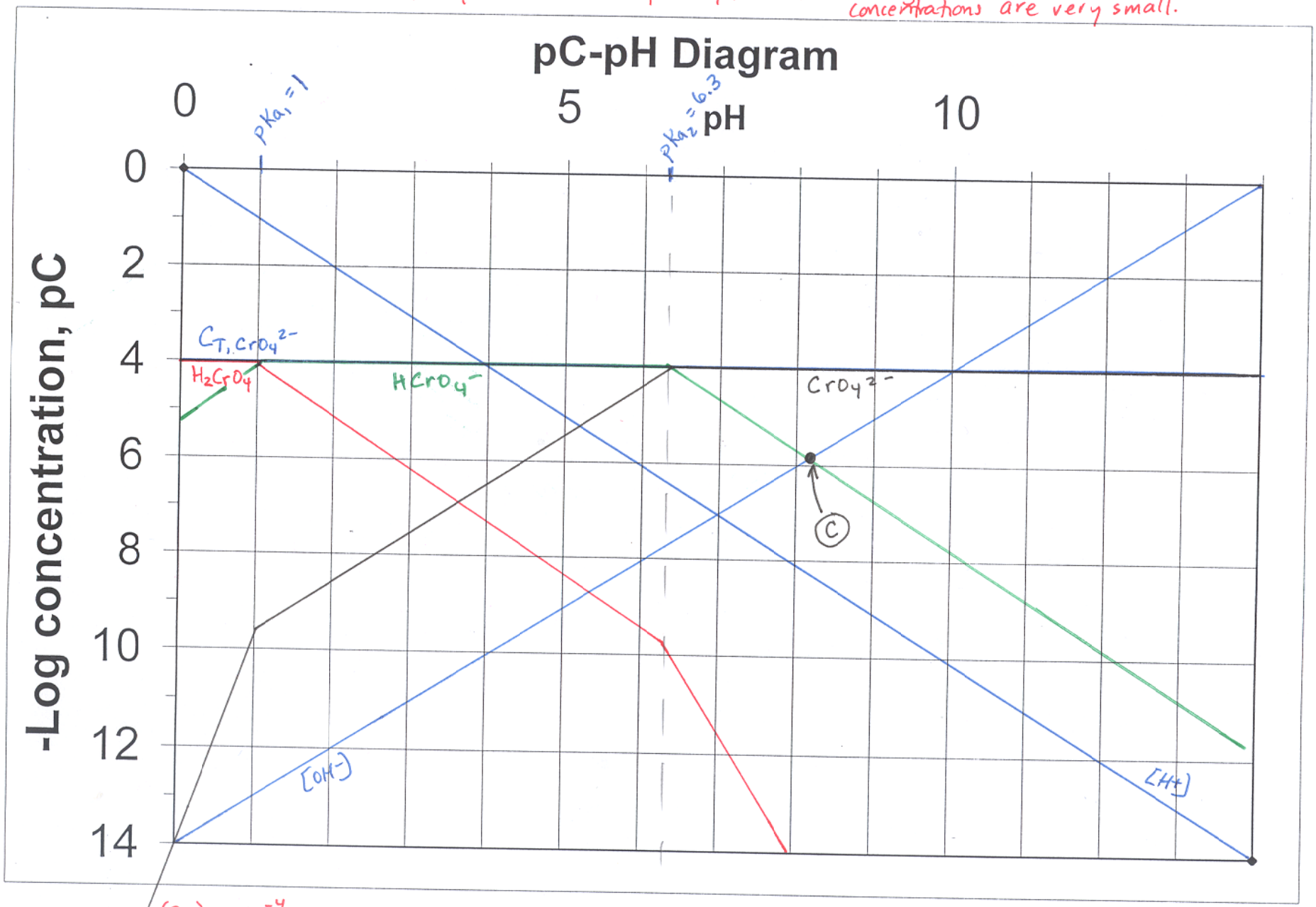
$[H^+] = [OH^-] + [HB^-] + 2[B^{2-}]$

pH ≈ 4.2



(3a) diagram

3(b) At increasing pH values, the concern of H_2CrO_4 in the ground water decreases.
For groundwater with pH > 6, there is no worry as concentrations are very small.



(3c) 10^{-4} M Na_2CrO_4

proton condition $[H^+] + [HCrO_4^-] + 2[H_2CrO_4] = [OH^-]$

$pH \approx 8.2$

(4) write proton conditions

(a) $NH_4Cl \rightleftharpoons NH_4^+ + Cl^-$

$NH_4^+ \rightleftharpoons H^+ + NH_3$

$Cl^- + H_2O \rightleftharpoons HCl + OH^-$

$$[H^+] + [HCl] = [OH^-] + [NH_3]$$

(b) $Na_2S \rightleftharpoons 2Na + S^{2-}$

$H_2O + S^{2-} \rightleftharpoons HS + OH^-$

$HS^- + H_2O \rightleftharpoons H_2S + OH^-$

$$[H^+] + [HS^-] + 2[H_2S] = [OH^-]$$

(c) $KH_2PO_4 \rightleftharpoons K^+ + H_2PO_4^-$

$H_2PO_4^- + H_2O \rightleftharpoons H_3PO_4 + OH^-$

$H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+$

$HPO_4^{2-} \rightleftharpoons PO_4^{3-} + H^+$

$$[H^+] + [H_3PO_4] = [OH^-] + [HPO_4^{2-}] + 2[PO_4^{3-}]$$

(d) $(NH_4)_2CO_3 \rightleftharpoons 2NH_4^+ + CO_3^{2-}$

$NH_4^+ \rightleftharpoons NH_3 + H^+$

$CO_3^{2-} + H_2O \rightleftharpoons HCO_3^- + OH^-$

$HCO_3^- + H_2O \rightleftharpoons H_2CO_3 + OH^-$

$$[H^+] + [HCO_3^-] + 2[H_2CO_3] = [OH^-] + [NH_3]$$

(5) $NH_4Cl \rightleftharpoons NH_4^+ + Cl^-$

proton condition $[H^+] + [HCl] = [OH^-] + [NH_3]$

charge balance $[NH_4^+] + [H^+] = [OH^-] + [Cl^-]$

mass balance

$$C_T = [NH_3] + [NH_4^+]$$

$$C_T = [Cl^-] + [HCl]$$

so $[NH_3] + [NH_4^+] = [Cl^-] + [HCl]$

solving for $[NH_4^+]$

$$[NH_4^+] = \{Cl^-] + [HCl] - [NH_3]$$

substitute into charge balance

$$\cancel{[Cl^-]} + [HCl] - [NH_3] + [H^+] = [OH^-] + \cancel{[Cl^-]}$$

$$\boxed{[HCl] + [H^+] = [OH^-] + [NH_3]}$$

This solution is equal to the proton condition!