Glutamine (MW = 146.2) is an aminoacid (formal structure H$_2$N-CHR-COOH) whose complex side chain R does not participate in acid/base reactions in aqueous solutions. For the glutamine family, the pK$_a$ values are: pK$_1$ = 2.17 and pK$_2$ = 9.13

a) Construct the detailed pH line for the glutamine family members, including their formulas (as expected to exist when in aqueous solution) and all known numerical values.

\[
\text{(+) } 2.17 \quad (+/-) \quad 5.65 \quad (\text{(-) }) \quad 9.13
\]

\[
\text{Parent:} \quad (+) \quad \text{H}_2\text{N-CHR-COOH} \quad \text{Cl}^-(+) \quad \text{Salt:} \quad \text{Na}^+(+) \quad \text{H}_2\text{N-CHR-COO}^-(-)
\]

b) If 20.0 mL of 0.15M NaCl is mixed into 10.0 mL of 0.50M glutamine solution, determine the final pH and the formula of the solute species most abundant in the final solution. Indicate your reasoning clearly.

\[\text{NaCl has no A/B properties; adding NaCl is the same as a simple dilution. Here it does not change the pH as you are at the Intermediate Salt:}\]

\[
\text{(+) } 2.17 \quad (+/-) \quad 5.65 \quad (\text{(-) }) \quad \text{Int. Salt}
\]

You are here, pH = 5.65 most abund.

c) If 20.0 mL of 0.15M HCl is mixed into 10.0 mL of 0.50M glutamine solution, determine the final pH and the formula of the solute species most abundant in the final solution. Indicate your reasoning clearly.

\[
\text{H}_3\text{O}^+ \quad \text{(+)} \quad 2.17 \quad (+/-) \quad 5.65 \quad (\text{(-) }) \quad \text{H}_3\text{O}^+ \quad \text{(+)} \quad \text{H}_2\text{O} \quad \text{H}_3\text{N-CHR-COO}^- \quad \text{H}_3\text{N-CHR-COOH}
\]

After Rxn: 3mmol 2mmol

\[
\text{pH} = 2.17 + \log \frac{2}{3} = 1.99 \quad \text{parent is most abundant species}
\]
d) If glutamine particles were present free in a normal sample of blood (pH = 7.40), what would be the ratio of the most abundant forms of glutamine present?

\[
\frac{\text{(-)}}{\text{(+/-)}} = \log 7.40 = 9.13 + \log \frac{\text{(-)}}{\text{(+/-)}}
\]

\[\begin{align*}
-1.73 &= \log \frac{\text{(-)}}{\text{(+/-)}} \\
&= \frac{[\text{NH}_2\text{CHR-COO}^-]}{[\text{^+NH}_3\text{CHR-COO}^-]} = 0.0186
\end{align*}\]

e) If glutamine particles were present free in a normal sample of blood (pH = 7.40), what would be the % of uncharged species present?

"From above, \([\text{NH}_2\text{CHR-COO}^-] = 0.0186 \times \text{ENH}_3\text{CHR-COO}^-]\]

\[\begin{align*}
\text{% Zwitherion} &= \frac{[\text{(+/-)}]}{[\text{(+/-)}] + [\text{-}]} \times 100 \\
&= \frac{[\text{(+/-)}]}{[\text{(+/-)}] + 0.0186 \times 0.1} \times 100 = 98.2\%
\end{align*}\]

f) If 0.15 mmol of the sodium salt of glutamine (Na\(^+\)H\(_2\)N-CHR-COO\(^-\)) were dissolved in 10.0mL of water, what would be the expected pH of the final solution?

\[\begin{align*}
\text{Find } pK_b &= 14 - 9.13 = pK_b = 4.87 \\
K_b &= \frac{\text{\(X^2\)}}{\text{\(C\)}} = 10^{-4.87} = \frac{\text{\(X^2\)}}{\left(\frac{0.15}{10}\right)} \\
X &= [\text{OH}^-] = 4.50 \times 10^{-4} \\
pOH &= 3.35 ; \quad pH = 10.65
\end{align*}\]

I have neither given nor received any unacknowledged aid on this quiz.

SIGNED ___________________________