Advanced Biomolecular Architecture
Assignment-11
Amino acids and Ionic Equilibria

(NB. Set A is a practice assignment. You need to submit the other questions by October 16, 2k17)

Set A

Q1. Study the resources uploaded, to familiarize yourself with
a. Structures and names of the 20 amino acids
b. The concept of isoelectric point for amino acids
c. Relationship of isoelectric point K_I with K_1, K_2 and K_R (where applicable) for any amino acid.

Q2. What should be the Kw of water at 40°C? Is it less than, greater than or equal to 10^{-14}? Does neutral water on heating still remain neutral or does it become acidic or basic? Some metals such as sodium reacts with cold water to give hydrogen while some others, unreactive to cold water, react at higher temperatures. Can you explain why?

Q3. The pH of a 0.1 M monobasic acid solution is 3. What would be the acid concentration when it is diluted 100 times? What would be its pH when it is diluted 100 times? Is the acid a strong or a weak acid? Calculate its degree of dissociation in a 0.01 M solution.

Q4. You have five aqueous solutions containing:

Ammonium Chloride
Sodium Citrate
Sodium Chloride
Ferric Chloride
Equal moles of acetic acid and sodium acetate

Mark them as having pH greater than, less than or equal to 7 and give brief explanation

Q5. For a 0.1 M aqueous solution of Ammonium Acetate: a) write down:
i) The equations showing all the equilibrium reactions
ii) Charge balance equation and iii) Mass balance equation
b) Calculate the pH given that PKa (Acetic acid) = 5, pKa' (Ammonia) = 9

Q6. Write the formula for

a. Conjugate acids of

i. NH_2NH_2

ii. HPO_4^{2-}

iii. HNO_3

b. Conjugate bases of

i. OH^-

ii. HCO_3^-

Q7. Calculate the molar concentrations of

a. H_3O^+, OH^- and NO_3^- in a 0.003 molar HNO_3 solution

b. H_3O^+, OH^-, NH_3 and K^+ in a 6.0×10^{-5} M KNH_2 (aq) solution

Q8. Use charge and mass balance concepts to derive expressions for the pH and the degree of ionization a, for a solution of an amino acid with ionization constants K_1 and K_2, and with no ionizable group in its side chain.

Q9.a. Draw Fischer projections of all the 20 amino acids and give their Full names along with their three letter and one letter abbreviations respectively

b. Using mass balance and charge balance protocols derive the relation for the pH of the aqueous solution of an amino acid in terms of its pK1 and pK2

Set B

Q9. For the above amino acid, show that

a. Isoelectric point $K_I = (K_1 + K_2)/2$

b. In a buffer solution of a given pH

i. $[H_2A^+]/[HA] = 10^{pK1 - pH}$

ii. $[A^-]/[HA] = 10^{pH - pK2}$

c. The concentration ratios, given in (i) and (ii) above, become equal at $pH = pK_I$

Q10. Calculate the pH of 25 mL of 0.15 M NaOH and of the resulting solutions after adding the following volumes of 0.1 M HCl respectively:
i. 5.00 mL ii. 10.00 mL iii. 37.5 mL iv. 42.5 mL v. 47.5 mL

Q11. Calculate the pH and percentage ionization of:

a. 0.1 M aqueous Acetic acid ($K_a = 1.8 \times 10^{-5}$)

b. 0.02 M aqueous Methylamine ($K_b = 8.4 \times 10^{-4}$)

Q12. a. The pH of 0.030 M Nicotinic acid is 3.19. Calculate its Ka and a.
b. The pH of 0.010 M Codeine is 10.10. Calculate its Kb.

Q13. Classify the aqueous solutions of the following ions as acidic, basic or neutral:
$C_6H_5NH_3^+$, Cl^-, Fe^{3+}, Mg^{2+}, HSO_4^-, NO_3^-, NH_4^+, Al^{3+}, $C_5H_5NH^+$, $H_2PO_4^-$, $CH_3CO_2^-$, Cu^{2+}, Na^+, Ag^+, ClO_4^-, PO_4^{3-}, CN^-, SH^-, Ba^{2+}

Q14. Calculate the pH of a solution that is 0.15 M NaCN (aq)
(Ka of HCN 4.3×10^{-4})

Q15. Calculate the pH of a solution of 25 mL of 0.1 M aqueous Formic acid after the addition of 5 mL of 0.15 M aqueous NaOH. The Ka of Formic acid is 1.8×10^{-4}.

Q16. Calculate the pH at the stoichiometric point of the titration of 25.0 mL of aqueous 0.10M hypochlorous acid with 0.20 M KOH (aq). (Ka HOCl 3×10^{-8})