Unit II.

Online test (typical questions)

1. Decide whether the statement is true or false:
   1) the stronger the acid, the stronger the conjugate base
   2) the strength of a weak acid is characterised by its acid dissociation constant K_a
   3) a Brønsted base is a species (molecule or ion) capable of accepting a proton (H^+)
   4) the hydrolysis of a salt is not a protolytic equilibrium
2. Match species 1–4 with species a–d to form conjugate acid–base pairs:
   1) H_2O a) OH^-
   2) $C_6H_5NH_2$ b) $C_6H_5NH_3^+$
   3) H_3O^+ c) NH_4^+
   4) NH_3 d) H_2O
3. Match electrolytes 1–4 with the pH values of their solutions of equal molarities:
   1) HNO_3 a) 7.0
   2) CsOH b) 2.6
   3) HNO_2 c) 2.0
   4) $Ca(NO_3)_2$ d) 12.0
4. Match each salt with the type of its hydrolysis:
   1) ammonium carbonate a) anion hydrolysis
   2) sodium chloride b) does not undergo hydrolysis
   3) chromium(III) nitrate c) anion and cation hydrolysis
   4) sodium sulfide d) cation hydrolysis
5. How does the acid strength in the series $HNO_2 \rightarrow C_3H_7COOH \rightarrow HCN$ change if $pK_a(HNO_2) = 3.14$, $pK_a(C_3H_7COOH) = 4.82$ and $pK_a(HCN) = 9.2$?
   a) decreases b) increases c) has no definite pattern
6. Which of the following equations are protolytic equilibria?
   a) $H_2S + H_2O \rightarrow HS^- + H_3O^+$ b) $H_2S \rightarrow 2H^+ + S^{2-}$
   c) $Na_2S \rightarrow 2Na^+ + S^{2-}$ d) $S^{2-} + H_2O \rightarrow HS^- + OH^-$
7. Decide whether the statement is true or false:
   1) a protolytic buffer system contains at least two components
   2) in blood buffer systems the HCO_3^- and HPO_4^{2-} ions are conjugate bases
   3) the decrease in $c(H^+)$ and increase in alkaline blood reserve is called alkalosis
   4) The buffer range is the pH range where a buffer effectively neutralizes added acids and bases while maintaining a relatively constant pH
8. Choose the pH range where the buffer system consisting of cationic and bipolar forms of valine exists (for valine, $pK_{a1} = 2.27$, $pK_{a2} = 9.52$)
   a) 1.27–3.27 b) 2.27–9.52 c) 8.52–10.52 d) 3.27–5.27
9. Which role can Na_2HPO_4 play in a buffer solution?
   a) acid b) either acid or base c) base d) oxidising agent
10. What is the ratio of the components in the buffer that contains $(C_2H_5)_2NH$ and $[(C_2H_5)_2NH_2]Cl$ at pH = 10.2? For $(C_2H_5)_2NH$, $pK_{BH+} = 10.8$.

a) $c([(C_2H_5)_2NH_2]Cl) > c((C_2H_5)_2NH)$
b) $c((C_2H_5)_2NH) > c([(C_2H_5)_2NH_2]Cl)$
c) $c([(C_2H_5)_2NH_2]Cl) = c((C_2H_5)_2NH)$

11. What are the components of a glycine buffer solution at pH = 4 if pI = 6.0?
a) cationic and bipolar forms b) anionic and bipolar forms
c) cationic and anionic forms d) bipolar form only

12. Which of the following systems maintain the blood pH?
a) $CO_2 \bullet H_2O / HCO_3^-$ c) Hb^-, $Hb^- \bullet O_2$ / HHb, $HHb \bullet O_2$
b) $NH_3 \bullet H_2O / NH_4^+$ d) $HCOO^-$ / HCOOH

13. Decide whether the statement is true or false:
1) K_{sp} is temperature independent
2) The precipitate of a sparingly soluble strong electrolyte forms when $Q_c > K_{sp}$
3) Solubility product constant is the equilibrium constant (K_{sp}) defined for the equilibrium between a solid phase of a sparingly soluble compound and its respective ions in the saturated solution of that compound
4) Chelating ligand is a bidentate or polydentate ligand that is attached by two or more donor atoms to the same central atom forming a ring structure

14. Which definition(s) of the term "coordinating atoms" are correct?
a) molecules or ions containing one or more atoms that act as donors of electron pairs
b) the atom within a ligand that is bonded directly to the central atom
c) molecules or ions containing one or more atoms that act as donors of electron orbitals
d) species that are able to form ionic bonds

15. A small amount of a NaCl solution is added to a saturated solution of calcium carbonate. The solubility of $CaCO_3$:
a) decreases b) increases c) does not change

16. Estimate the molar solubility (mol/L) of CuS if $K_{sp}(CuS) = 6.3 \bullet 10^{-36}$.
a) $2.5 \bullet 10^{-18}$ b) $6.3 \bullet 10^{-36}$ c) $2.5 \bullet 10^{-26}$

17. What salts can be used for precipitating Cd^{2+} from a saturated solution of CdS?
a) Na_2S b) $Cd(NO_3)_2$ c) $K[Cd(CN)_4]$ d) $NaNO_3$

18. Arrange the cations in order of sequential precipitation when Na_2CO_3 is added to their solution if $K_{sp}(BaCO_3) = 3.9 \bullet 10^{-10}$; $K_{sp}(PbCO_3) = 7.5 \bullet 10^{-14}$; $K_{sp}(CdCO_3) = 1.0 \bullet 10^{-12}$:
a) Pb^{2+} b) Cd^{2+} c) Ba^{2+}

19. Determine the charge of the complex ion and the number of ligands in $[Cr(OH)_2(H_2O)_4]Cl$:
a) 1+ and 6; b) 2+ and 4; c) 1– and 6; d) 3+ and 6

20. Arrange the complex ions in order of increasing concentrations of free metal cations in 0.01 M solutions if: $K_{inst}[Hg(CN)_4]^{2-} = 4.0 \bullet 10^{-42}$; $K_{inst}[Co(CN)_4]^{2-} = 1.4 \bullet 10^{-19}$; $K_{inst}[Cu(NH_3)_4]^{2+} = 2.14 \bullet 10^{-13}$

21. Will the system quinone–hydroquinone ($E°_{298}$ = +0.699 V) be the oxidant or reductant with respect to the following processes at 298 K?
    a) $H_2O_2 + 2H^+ + 2\bar{e} \rightarrow 2H_2O$ E = + 1.77 V
    b) $O_2 + 2H^+ + 2\bar{e} \rightarrow H_2O_2$ E = + 0.68 V
    c) $MnO_4^- + 8H^+ + 5\bar{e} \rightarrow Mn^{2+} + 4H_2O$ E = + 1.51 V
    d) $Fe^{3+} + \bar{e} \rightarrow Fe^{2+}$ E = + 0.77 V
22. Choose the redox systems with pH–dependent reduction potentials:
    a) $2BrO^{3-} + 12H^+ + 10\bar{e} \rightarrow Br_2 + 6H_2O$
    b) $SO_4^{2-} + 4H^+ + 2\bar{e} \rightarrow H_2SO_3 + H_2O$
    c) $Cu^{2+} + 2\bar{e} \rightarrow Cu$
    d) $Br_{2(aq)} + 2\bar{e} \rightarrow 2Br^-$
23. The standard biological potential is measured at:
    a) pH = 0 b) pH = 1 c) pH = 7 d) pH = 14
24. The standard biological reduction potentials $E°'$(pyruvate, $2H^+$/lactate) and $E°'$($NADP^+$, H^+/NADPH) are –0.185 V and –0.322 V respectively. Is the following reaction spontaneous at pH = 7 and T = 310 K?
    $CH_3C(O)COO^- + NADPH + H^+ \rightarrow CH_3CH(OH)COO^- + NADP^+$
    a) yes; b) no; c) impossible to say.
25. The E_{mf} for a certain reaction at 298 K is positive. What is the sign of the Gibbs energy change ($\Delta G°_{298}$) for this reaction?
    a) $\Delta G°_{298} > 0$ b) $\Delta G°_{298} = 0$ c) $\Delta G°_{298} < 0$
26. How does the electrode potential change when temperature increases?
    a) increases b) decreases
    c) does not change d) can either increase or decrease
27. Compare the value of a redox potential with the value of the standard potential if the oxidized and reduced forms in the redox pair have equal concentrations:
    a) $E > E°$ b) $E = E°$ c) $E < E°$ d) impossible to compare
28. Compare the values of the standard reduction potential and the standard biological reduction potential for the system $NAD^+ + H^+ + 2\bar{e} \rightarrow NADH$:
    a) $E° = E°'$ b) $E° > E°'$ c) $E° < E°'$
29. Are these statements true or false?
    a) A membrane potential can arise if the membrane ion permeability is selective
    b) Diffusion potential occurs for a short time when the cell membrane is damaged
    c) EMF of a chemical reaction can have a negative value
    d).The standard biological reduction potential is measured at concentrations (activities) of oxidized and reduced forms of 1 mol/L, pH = 1 and T = 310 K
30. Match the particles: Ag; Cl_2; Cu^{2+}; He
    to their REDOX properties
    a) reducing properties only b) both oxidizing and reducing properties
    c) oxidizing properties only d) neither properties oxidizing nor reducing properties

Paper test (typical questions)

1. For 0.01M solutions of: a) $Ba(OH)_2$, b) $[C_6H_5NH_3]Cl$:
   a) Determine the type of each of the electrolytes, write the equations that affect the pH value in each solution. Indicate acid-base conjugated pairs in protolytic equilibria. Estimate (without calculation) the pH value in each solution.
   b) Write the appropriate protolytic equations and the K_{eq} expressions for all equilibria.
   c) Calculate the pH value of each solution if $pK_{BH+}(C_6H_5NH_2) = 4.60$.
2. A buffer solution was prepared from 40 mL of 0.1M NH_3 and 10 mL of 0.1M HCl.
   a) Calculate the pH value of buffer formed if $pK_{BH+}(NH_3) = 9.25$
   b) Calculate the buffer capacity of this solution with respect to KOH (in mmol/L), if the addition of 5 mL of 0.1M KOH solution to the buffer increased the pH value to 10.
   c) Write the equations that explain the buffer action mechanism of this buffer with respect to HCl and KOH.
3. For the coordinated compound $K_4[Fe(CN)_6]$ with $K_{inst} = 1.0 \cdot 10^{-24}$:
   a) State the central atom, its coordination number, ligands, their denticities and charges, counterions, the primary coordination sphere and its charge.
   b) Write the dissociation schemes for this compound and the stability constant expression
   c) What will happen with the concentration of the central ion (will decrease, increaes or stay the same) after the addition solid KCN into a solution of this complex compound? Calculate the concentration of the central ion after the addition of 0.01 mol of solid KCN to 1 L of 0.01M solution of this complex compound.
4. For the system $NAD^+ + H^+ + 2e^- \rightarrow NADH$ the value of $E^0(NAD^+, H^+/NADH)$ is –0.113 V.
   a) Write the Nernst-Peters equation for the system. How will the potential of this system change with an increase in the concentration of NADH?
   b) Calculate the potential of this system at 310 K, pH = 7, and molar concentrations of NAD^+ and NADH equal to 1 mol/L. Which name is used for potentials measured under these conditions?
   c) Determine whether the forward reaction
   quinone + NADH + H^+ → hydroquinone + NAD^+
   is spontaneous or not under standard biological conditions if $E^{0\prime}$(quinone, H^+/hydroquinone) = +0.286 V. Confirm your answer b