Unit test No. 2

Online unit test contains 30 questions randomly chosen from previous tests.

Written and oral examination

This part contains four questions on topics 1–4.

Topic 5. Strong and weak electrolytes, protolytic equilibria and pH

Example 1:

For 0.0015 M aqueous solutions of H_3PO_4 and $(C_2H_5)_2NH$ (or any other pairs of different electrolytes, such as strong or weak acids, strong or weak bases, normal or acid salts):

a) Determine the type of each electrolyte, write protolytic equations in their aqueous solutions, identify acid–base conjugate pairs and estimate the pH (> 7, = 7, < 7).

b) Write the equilibrium constant expressions for these electrolytes.

c) Write the formulae and calculate the pH in their solutions (pK_a, pK_B or pK_{BH+} values will be given).

Topic 6. Buffer solutions

Example 1:

A hydrogencarbonate buffer was prepared from 40 mL of 0.1 M Na_2CO_3 and 20 mL of 0.1 M $NaHCO_3$. For the given buffer solution:

a) Calculate the pH value (for H_2CO_3 $pK_{a1} = 6.36$, $pK_{a2} = 10.33$).

b) 10 mL of 0.1 M HCl solution was added to the buffer. Calculate the pH of the final solution.

c) Write a net ionic equation showing the mechanism of buffer action with respect to a strong acid.

d) Calculate the B_a value.

Example 2:

1 L of a buffer contains 0.02 mol of Na_3PO_4 and 0.02 mol of Na_2HPO_4. For the given buffer solution:

a) Calculate the pH value (for H_3PO_4 $pK_{a1} = 2.12$, $pK_{a2} = 7.2$, $pK_{a3} = 12.44$).

b) 0.005 mol of NaOH was added to the buffer. Calculate the pH of the final solution.

c) Write a net ionic equation illustrating the mechanism of buffer action with respect to a strong base.

d) Calculate the B_B value.

Example 3:

For a hydrogencarbonate buffer:

a) Draw the formulae of buffer components and calculate their ratio at pH = 7 (for H_2CO_3 $pK_{a1} = 6.36$, $pK_{a2} = 10.33$).

b) Calculate the amount of an alkali that can be consumed by this buffer to increase the pH to 7.2 if its buffer capacity with respect to a base is 5 mmol/L.

c) Write a net ionic equation showing the mechanism of buffer action with respect to a strong base.

Example 4:

Problems similar to 1–3 for amino acid buffer system.

Topic 7. Electrode, redox and membrane potentials. Direction of the redox process

Example 1:

For the reaction $CH_3C(O)COO^- + H^+ + NADH \rightarrow CH_3CH(OH)COO^- + NAD^+$

pyruvate lactate

$E°'_{310}(NAD^+/NADH) = -0.328$ V; $E°'_{310}$(pyruvate/lactate) = –0.203 V

a) Calculate the E_{mf} and $\Delta G°'_{310}$ values for the reaction and determine whether it is spontaneous or not under standard biological conditions.

b) Which system is an oxidant in the given reaction? Write the Nernst–Peters equation for this system.

c) How will the potential of this system change if pH decreases (or increases)?

Example 2:

For the system $CH_3COOH + 2H^+ + 2\bar{e} \rightleftharpoons CH_3C(O)H + H_2O$

$E°_{298}(CH_3COOH/CH_3C(O)H) = -0.119$ V

a) Write the Nernst–Peters equation for this system.

b) Calculate its reduction potential at 298 K, pH = 3 and molar concentrations of CH_3COOH and $CH_3C(O)H$ 0.01 and 0.5 mol/L, respectively.

c) How will the potential change upon the addition of a base (or acid) to the system?

Topic 8. Heterogeneous equilibria solid phase–solution. Equilibria in solutions of coordination compounds

Example 1:

For the complex compound $[Ag(NH_3)_2]NO_3$ $K_{st} = 1.12 \cdot 10^7$:

a) State the outer and inner spheres, the central ion, the coordination number, the ligands and their denticity. Write the dissociation reactions for the inner and outer coordination spheres.

b) Write the stability constant expression.

c) 0.1 mol of ammonia was added to 1 L of 0.1 M solution of this complex. Calculate the concentration of the free central ion in the resulting solution.

d) How will the concentration of Ag^+ and the value of K_{st} change if 1) $NaNO_3$; 2) HNO_3; 3) NH_3 is added to the solution of $[Ag(NH_3)_2]NO_3$?

Example 2:

For the sparingly soluble electrolyte $BaCrO_4$ $K_{sp} = 1 \cdot 10^{-10}$:

a) Write the equation of the heterogeneous equilibrium in its aqueous solution and the K_{sp} expression.

b) Calculate the solubility (in mol/L) of this salt in water.

c) How will the addition of water (or sodium phosphate, or barium chloride, etc.) affect the position of the heterogeneous equilibrium, solubility and K_{sp} value?

Sample examination paper

1. For aqueous solutions of Na_3PO_4 and HCOOH:

a) Determine the type of each electrolyte, write the protolytic equations in their aqueous solutions, identify acid–base conjugate pairs.

b) For each solution estimate the pH (> 7, = 7, < 7) and suggest a formula for pH calculation.

c) Calculate the pH of a 0.015 M solution of Na_3PO_4 (for H_3PO_4 $pK_{a1} = 2.12$; $pK_{a2} = 7.2$; $pK_{a3} = 12.44$).

3. 1 L of a buffer solution contains 0.02 mol of Na_3PO_4 and 0.02 mol of Na_2HPO_4 (for H_3PO_4 $pK_{a1} = 2.12$; $pK_{a2} = 7.2$; $pK_{a3} = 12.44$).

a) Calculate the pH of this buffer.

b) 0.005 mol of NaOH were added to the buffer. Calculate the pH of the resulting solution.

c) For the given buffer write the equation showing the mechanism of its buffer action with respect to a strong base.

4. For the sparingly soluble electrolyte $ZnCO_3$ $K_{sp} = 1 \cdot 10^{-10}$:

a) Write an equation of the heterogeneous equilibrium in its aqueous solution and the K_{sp} expression.

b) Calculate the solubility (in mol/L) of this salt in water.

c) How will the addition of 1) water and 2) zinc chloride affect the state of heterogeneous equilibrium, the solubility of the salt and the K_{sp} value? Explain your answer.

or

For the complex ion $[Cd(NH_3)_4]^{2+}$ $K_{st} = 1.3 \cdot 10^7$.

a) This complex ion forms when excess ammonia is added to a solution of $Cu(NO_3)_2$. Write the reaction (in molecular and ionic form), indicate the outer and inner spheres of the complex compound, the central ion, the coordination number, the ligands and their denticities.

b) Write the stability constant expression.

c) How many times the concentration of Cd^{2+} ions will decrease when 0.14 mol of gaseous NH_3 is added to 1 L of a 0.01 M solution of $Cd(NO_3)_2$ (ignore the change in the volume of the solution)?