Unit I.

Online test (typical questions)

1. The solubility of gaseous compounds in water, L(gas) / L(H_2O), depends on:
   a) volume of gas b) pressure of gas c) volume of water d) mass of water
2. The mass fraction of a compound X in a solution, ω(X), can be expressed in:
   a) mg% b) mg/mL c) mol d) mol/kg
3. The molar concentration of compound X in a solution can be calculated using the formula:
   a) m(X) / $V_{(sol)}$ b) m(X) / M(X) c) m(X) / $m_{(sol)}$ d) m(X) / [M(X) × $V_{sol)}$]
4. The mass of sulfuric acid that should be dissolved in 440 g of water to prepare a solution with $\omega(H_2SO_4)$ = 12% is:
   a) 52.8 g b) 60 g c) 45 g d) 80 g
5. The molar concentration of a sodium hydroxide solution containing 0.25 mol of NaOH in 500 mL of the solution is:
   a) 0.25 mol/L b) 0.05 mol/L c) 0.5 mol/L d) 0.025 mol/L
6. The mass of potassium bromide (M = 119 g/mol) that should be dissolved in 400 g of water to prepare a KBr solution with b(KBr) = 0.25 mol/kg is:
   a) 29.75 g b) 1.19 g c) 11.9 g d) 297.5 g
7. Are the following statements true or false?
   1) osmosis is the diffusion of solvent molecules through a semipermeable membrane from a solution with a lower concentration of dissolved particles into a solution with a higher concentration;
   2) osmolarity is the sum of molar concentrations of all particles in the solution except the particles of the solvent;
   3) an increase in temperature decreases the osmotic pressure of a solution;
   4) the lower the degree of a dispersion, the greater the osmotic pressure of the dispersion, given that the mass concentration of the dispersed phase is the same.
   a) true b) false
8. The osmolarity (mol/L) of a 0.4 M sucrose ($C_{12}H_{22}O_{11}$) solution is:
   a) 0.1 b) 0.4 c) 0.2 d) 1.2
9. The osmolarity (mol/L) of a solution containing 0.05 mol/L NaCl and 0.15 mol/L KNO_3 is:
   a) 0.4 b) 0.3 c) 0.2 d) 0.15
10. Match the isotonic solutions if 1 liter of each solution contains the given number of moles of solutes at the same temperature:

0.15 mol of NaCl	0.1 mol of K_2SO_4
0.2 mol of Na_2CO_3	0.1 mol of KNO_3 and 0.4 mol of $C_6H_{12}O_6$
0.4 mol of NaCl	0.2 mol of $CaCl_2$ and 0.1 mol of NaCl
0.24 mol of NaCl	0.11 mol of Na_2SO_4 and 0.05 mol of $Mg(NO_3)_2$

11. Which solutions are hypotonic with respect to blood plasma (osmolarity of blood plasma is 0.3 mol/L):

a) 0.3 M NaCl b) 0.1 M $CaBr_2$ c) 0.1 M KNO_3 d) 0.3 M $C_6H_{12}O_6$

12. The osmotic pressure at 25 °C in the series of solutions 0.1 M K_2SO_4, 0.1 M KBr, 0.1 M $C_6H_{12}O_6$:
    a) increases b) decreases
    c) does not change d) has no definite pattern
13. Match the values of osmotic pressure (kPa) of the solutions with equal molar concentrations of solutes at same temperature with the formula of the solute:
    1) NaCl 2) HCOOH 3) $CaCl_2$ 4) $CO(NH_2)_2$
    a) 750 b) 250 c) 280 d) 500
14. Equal volumes of solutions contain the equal masses of the following compounds: a) Li_2SO_4, b) K_2SO_4, c) Na_2SO_4, d) Rb_2SO_4. Arrange the solutions in order of decreasing molar concentration.
15. An endothermic reaction is defined by the inequality:
    a) $\Delta H > 0$; b) $\Delta H < 0$; c) $\Delta G < 0$; d) $\Delta G > 0$.
16. A process with $\Delta H > 0$ and $\Delta S > 0$ is possible in the closed system:
    a) at any temperature; c) only at high temperature;
    b) only at low temperature; d) never.
17. Without calculations, identify the processes with a positive ΔS value:
    a) $CaO_{(s)} + CO_{2(g)} \rightarrow CaCO_{3(s)}$; c) $2CH_{4(g)} \rightarrow C_2H_{2(g)} + 3\,H_{2(g)}$;
    b) $N_{2(g)} + 3\,H_{2(g)} \rightarrow 2\,NH_{3(g)}$; d) $NH_{3(g)} + HCl_{(g)} \rightarrow NH_4Cl_{(s)}$.
18. For which of the following reactions the enthalpy change is equal to $\Delta H°_f(C_2H_{2(g)})$:
    a) $C_2H_{2(g)} + H_2O_{(l)} \rightarrow CH_3COH_{(l)}$; c) $2\,CH_{4(g)} \rightarrow C_2H_{2(g)} + 3\,H_{2(g)}$;
    b) $2\,C_{(s)} + H_{2(g)} \rightarrow C_2H_{2(g)}$; d)
    $CaC_{2(s)} + 2\,H_2O_{(l)} \rightarrow C_2H_{2(g)} + Ca(OH)_{2(aq)}$.
19. Choose the correct statements:
    a) the standard enthalpy change of a neutralisation reaction is positive;
    b) exothermic reactions are always spontaneous;
    c) the molar entropy of a compound in the solid state is lower than that in the gaseous state;
    d) the molar entropy of a compound in the gaseous state is lower than that in the liquid state.
20. For which of the following reaction the enthalpy change is equal to $\Delta H°_c$?
    a) $2S_{(s)} + 3\,O_{2(g)} \rightarrow 2\,SO_{3(g)}$; c) $S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$;
    b) $SO_{2(g)} + 0.5O_{2(g)} \rightarrow SO_{3(g)}$; d) $2\,SO_{2(g)} + O_{2(g)} \rightarrow 2\,SO_{3(g)}$.
21. During the reaction $2H_2O_{(l)} = 2H_{2(g)} + O_{2(g)}$ the entropy of the system:
    a) increases; c) remains approximately the same;
    b) first increases, then decreases; d) decreases.
22. The value of standard molar entropy for the series of compounds
    methane → cyclopropane → butane → propane:
    a) increases; c) remains constant;
    b) shows no definite pattern; d) decreases.

23. The standard enthalpy change of formation ($\Delta H°_{298}$) for H_2S is –20 kJ/mol. $M(H_2S)$ = 34 g/mol. Which mass of H_2S was formed if 4.0 kJ of heat was released?
    a) 6.8 g; b) 3.4 g; c) 34 g; d) 17 g.
24. The equilibrium constant of a reaction decreases when temperature increases. According to Le Chatelier's principle, the reaction is:
    a) endothermic; b) exothermic; c) endergonic; d) exergonic.
25. An increase in pressure shifts the equilibrium to the left in:
    a) $CO_{2(g)} + H_{2(g)} \rightleftharpoons CO_{(g)} + H_2O_{(g)}$;
    b) $C_4H_{10(g)} \rightleftharpoons C_4H_{8(g)} + H_{2(g)}$;
    c) $H_2S_{(g)} \rightleftharpoons H_{2(g)} + S_{(s)}$;
    d) $PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)}$.
26. The value of the equilibrium constant for the reaction $Fe_{(s)} + CO_{2(g)} \rightleftharpoons FeO_{(s)} + CO_{(g)}$ is 0.005. Which statement is true for the position of equilibrium?:
    a) $[CO] / [CO_2] = 0.005$; b) $[CO] = [CO_2] / 0.005$;
    c) $[CO] \times [FeO] = [CO_2] / [Fe]$; d) $[CO] \times 0.005 = [CO_2] + [H_2]$.
27. Choose the correct statement:
    a) an increase in temperature does not affect the position of equilibrium;
    b) a catalyst increases the rate of forward and reverse reactions and changes the value of equilibrium constant;
    c) the value of equilibrium constant depends on temperature;
    d) an increase in concentration of products increases the equilibrium constant.
28. For the reaction: $SO_{2(g)} + NO_{2(g)} \rightleftharpoons SO_{3(g)} + NO_{(g)}$ at 400 K the value of equilibrium constant (K_c) is 1. Determine the direction of the spontaneous process at 400 K if the initial concentrations of SO_2, NO_2, SO_3 and NO are 0.2; 0.4; 0.2 and 0.2 mol/L respectively.
    a) can not be determined; b) to the left;
    c) to the right; d) the system is already at equilibrium.
29. The reaction 2A + B → C proceeds in a solution. The rate law expression for this reaction is $\nu = k \cdot cA \cdot cB$ and $\gamma = 2$. What will happen to the reaction rate if:
    1) c(A) increases 2 times; 2) c(B) decreases 2 times;
    3) pressure increases; 4) temperature increases by 20 °C?
    a) decreases 2 times; b) increases 2 times; c) increases 4 times; d) no change.
30. The half-life of a radioactive isotope is 5 years. How long will it take the isotope activity to fall to 25% of its original level?
    a) 10 years; b) 15 years; c) 20 years; d) 40 years.

Paper test (typical questions)

1. 500 mL of a solution contains 0.05 mol of glucose ($C_6H_{12}O_6$) and 0.02 mol of KCl.
   a) Calculate the osmolarity of the solution.
   b) Calculate the osmotic pressure of the solution at 25°C.
   c) What will happen to erytrocytes in this solution? (the osmotic pressure of blood plasma is 740–780 kPa).
2. The standard enthalpy of combustion (ΔH^0(combustion) 298) for butane is –2880 kJ/mol.
   a) Write the thermochemical equation of the reaction with this enthalpy change
   b) Calculate the standard enthalpy change of formation for butane if $\Delta H^0_{f\,298}$ ($CO_{2\ (gas)}$) = –393.5 kJ/mol, $\Delta H^0_{f\,298}$ ($H_2O_{\ (liquid)}$) = –286 kJ/mol
   c) Calculate the volume of butane (STP) burned if 144 kJ of heat was released in the reaction
3. For the reaction $CaCO_{3(solid)} \rightarrow CaO_{(solid)} + CO_{2(gas)}$
   a) Write the equilibrium constant expression (K_c)
   b) Calculate ΔG^0_{298} for the reaction if ΔG^0_f for $CaCO_3$, CaO and CO_2 are: –1131.8;
   –600 and –395 kJ/mol, respectively
   c) Calculate the K_c value for the reaction under standard conditions
4. The initial reaction rate of the reaction $2\,A \rightarrow B + C$ is $5 \cdot 10^{-3}$ mol/L•s if the initial concentration of A is 0.02 mol/L.
   a) Write the rate law expression for this reaction assuming that it is a zero order process
   b) Calculate the reaction rate constant for the reaction
   c) How the reaction rate will change if temperature increases by 20°C given that the temperature coefficient is 2?