Periodic table with some essential data is given at the end of the test!

1. Which of the following species can act as both proton-donor and a proton-acceptor?
   (A) Cl_2
   (B) Ni
   (C) NH_3
   (D) O^{2-}

2. The compound HA is a strong acid. According to this, A^- must be:
   (A) its conjugate base and regarding the strength is weak.
   (B) its conjugate acid and regarding the strength is weak.
   (C) its conjugate base and regarding the strength is strong.
   (D) its conjugate acid and regarding the strength is strong.

3. In the case of water autoprotolysis:
   (A) the water species are both weak proton-donor and weak proton-acceptor.
   (B) water does not show any tendency to accept or give-away protons.
   (C) the water species are both strong proton-donor and strong proton-acceptor.
   (D) the water species are both oxidizing and reducing agent.

4. The value of pH of pure water at 37 ºC is 6,8. According to this:
   (A) water at this temperature is slightly acidic.
   (B) water at this temperature is slightly basic.
   (C) water at this temperature remains neutral.
   (D) there isn't sufficient data given to answer this question.

5. An iron rod, exposed to air for a long time slowly forms a surface oxide layer with a brown color. This reaction:

   (A) is an example of oxidation of iron, but with no reduction of other species.
   (B) is an example of oxidation of iron while reducing some other agents such as H_2O and O_2 from the environment.
   (C) is an example of reduction of iron, but with no oxidation of other species.
   (D) is an example of reduction of iron while oxidizing some other agents such as H_2O and O_2 from the environment.

6. An oxidation process cannot be:
   (A) electron-releasing process.
   (B) process leading to higher oxidation state.
   (C) process of receiving protons, but without any change of the oxidation state of the species being oxidized.
   (D) process of release of protons while changing the oxidation state of the species being oxidized.

7. The value of the equilibrium constant, K_c:
   (A) increases with increasing temperature.
   (B) decreases with increasing temperature.
   (C) depends on the initial amounts of the species so it can adopt any value for a particular reaction.
   (D) can have different values at a constant temperature if the reaction is balanced using other set of correct coefficients.

8. Autoprotolysis reaction cannot be:
   (A) $2HPO_4^- \rightleftharpoons H_2PO_4^- + PO_4^{3-}$
   (B) $2H_3PO_4 \rightleftharpoons H_4P_2O_7 + H_2O$
   (C) $2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$
   (D) $2OH^- \rightleftharpoons H_2O + O^{2-}$

9. What is the reason behind the statement that sodium is almost impossible to be an oxidizing agent?
   (A) Because sodium does not show any tendency to gain an electron.

(B) Because sodium does not show any tendency to release an electron.

(C) Because sodium does not show any tendency to gain a proton.

(D) Because sodium does not show any tendency to release a proton.

10. Acidic is the aqueous solution of:
    (A) KCN
    (B) $NaNO_2$
    (C) K_2S
    (D) NH_4NO_3

11. The pH value of a solution is doubled by introducing some base. After this:
    (A) the concentration of hydronium ions in the solution is doubled.
    (B) the concentration of hydroxide ions in the solution is doubled.
    (C) the concentration of hydroxide ions is always increased ten times.
    (D) none of the responses above is correct.

12. Which of the following species can act as both oxidizing and reducing agent?
    (A) $H_2PO_4^-$
    (B) OH^-
    (C) Cu^+
    (D) Cu^{2+}

13. Which of the species, Fe, Fe^{2+} и Fe^{3+}, is the strongest oxidizing agent?

(A) Fe
(B) Fe^{2+}
(C) Fe^{3+}
(D) one cannot give an exact answer since the oxidation capability depends on the other reactants in a particular reaction.

14. Consider the following reaction:
    $N_2 + 3H_2 \rightleftharpoons 2NH_3$.
    One of the ways to increase the yield of ammonia is to increase the overall pressure of the reaction mixture. Why?
    (A) Because the value of the equilibrium constant is increased at higher pressure.
    (B) Because the value of the equilibrium constant is decreased at higher pressure
    (C) Because ammonia is not stable at ambient conditions, so the pressure has to be increased.
    (D) None of the responses is a correct explanation of the question.

15. The conjugate base of hydrogenarsenate ion is:
    (A) dihydrogenarsenate ion.
    (B) arsenate ion.
    (C) arsenic (elemental).
    (D) arsine.

Written tasks/problems:

A periodic table with some essential data is given at the end of the test!

1. One particular reaction $A(g) \rightleftharpoons B(g)$ is said to be impossible if the value of $K_c < 10^{-10}$.

(A) Write down the expression of K_c using the equilibrium concentrations of A and B. **(1)**

See the Macedonian version for the correct answers.

(B) Write down the expression of K_c using the equilibrium amounts of A and B. **(2)**

See the Macedonian version for the correct answers.

(C) If $n_0(A)$ moles of A were initially introduced in a reaction vessel, write down the expression of K_c using the initially introduced amount of A and the amount of reacted A, $n_{rea}(A)$. Note that at the beginning of the reaction only A was present in the reaction vessel. **(2)**

See the Macedonian version for the correct answers.

(D) Using the expression obtained in (C), derive an expression to show what amount of A will react after the equilibrium state is reached. **(3)**

See the Macedonian version for the correct answers.

(E) What part/percentage of the initially present amount of A has reacted? **(3)**

See the Macedonian version for the correct answers.

2. White powder with the chemical formula $Ba(OH)_2 \cdot xH_2O$ is analysed to depict the number of water molecules present in one formula unit. A sample is introduces into a TGA apparatus and

heated to 800 °C. During this process, the gaseous products of the pyrolysis reactions are released which lead to decrease in mass of the sample. Two decreases in mass are registered, one at 130 °C and another one at 780 °C.

(A) Regarding the heat transfer, are these two processes endothermic or exothermic? **(1)**

Endothermic

(Б) Which gas is released at 130 °C, and which one at 780 °C? **(2)**

Water vapor in both cases.

(В) Write down the equations for reactions occurring at 130 and 780 °C. **(1,5 + 1,5)**

See the Macedonian version for the correct answers.

(Γ) After heating the sample at 130 °C for sufficient time the measured mass loss was 45,7 %. Identify the compound. **(5)**

See the Macedonian version for the correct answers.

3. It is almost impossible to measure the heat effects of the reaction ½I$_2$(s) + ½Cl$_2$(g) → ICl(g). However, the entalpies of the following reactions are well know. **(8)**

$Cl_2(g) \rightarrow 2Cl(g)$ $\quad \Delta_r H^{\ominus} = 242{,}3$ kJ/mol
$ICl(g) \rightarrow I(g) + Cl(g)$ $\quad \Delta_r H^{\ominus} = 211{,}3$ kJ/mol
$I_2(g) \rightarrow 2I(g)$ $\quad \Delta_r H^{\ominus} = 151{,}0$ kJ/mol
$I_2(s) \rightarrow I_2(g)$ $\quad \Delta_r H^{\ominus} = 62{,}80$ kJ/mol

Use these equations to determine the enthalpy of the reaction.

See the Macedonian version for the correct answers.