Basic Chemistry

1. Answer the following questions.

(1) Answer the following questions about hydrogen cyanide (HCN).

a) Give the electronic formula (Lewis structural formula) of HCN.

b) Give the structural formula of HCN.

c) Give how many pairs of shared electron pairs and unshared electron pairs there are in HCN.

d) Calculate the concentration of oxide ions in 1 mM HCN solution. Here, an acidity constant in water, K_a, is 1×10^{-9}.

e) Give the compound formed by the reaction of acetylene with HCN in the presence of a catalyst.

(2) Describe the definition of Brønsted-Lowry acid-base theory. In addition, classify the following ions or molecules as Brønsted acid, Brønsted base or amphoteric substance.

$C_6H_5NH_2$, CN^-, HS^-, H_3O^+, H_2CO_3,
HSO_4^-, NH_3, $(CH_3)_3N$, NH_4^+, HOCN

2. Consider a weak acid, HA, with an acidity constant in water, K_a, of $10^{-5.10}$. The distribution coefficient of HA between hexane (o) and water (a) is

$$K_p = \frac{[HA]_o}{[HA]_a} = 30$$

and the distribution ratio of A is

$$D = \frac{[HA]_a}{[HA]_a + [A^-]_a}.$$

Answer the following questions.

(1) Obtain the respective percentages of A extracted from water at pH=1.0 to hexane when the volume ratios of hexane to water are V_o/V_a=1.0 and V_o/V_a =0.1, assuming that the phases are shaken enough.

(2) Obtain the distribution ratio of A when the volume ratio of hexane to water at pH=5.1 is Vo/Va=1.0, assuming that the phases are shaken enough.

3. Consider a bimolecular reaction as follows:

$$A + B \rightarrow C$$

(1) [A] and [B] mean the concentrations of A and B, respectively. Show the rate equation describing the time-change of [A].

(2) Explain what the apparent order of this reaction is, when [B] >> [A].

(3) The rate constants are 0.01 L/(mol・s) at 400 K, and 0.80 L/(mol・s) at 600 K in temperature, respectively. Find the time (seconds) at which A halves at each temperature under a condition with a large excess of B, i.e., [B] >> [A] as with (2).

(4) Calculate the activation energy, when Arrhenius equation describes the rate constants of (3). Here, gas constant R is 8.314 J/(K・mol).

4. Explain the flowing technical terms.

(1) third law of thermodynamics

(2) chelate effect

(3) synergistic effect on solvent extraction

(4) Beer's law

-End of the questions-