

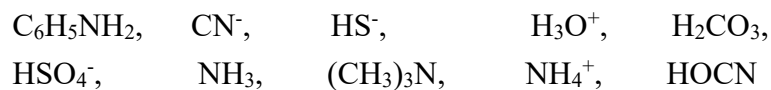
## Basic Chemistry

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  $1 \times 10^{-9}$ .
- 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.



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  $V_o/V_a=1.0$ , assuming that the phases are shaken enough.

3. Consider a bimolecular reaction as follows:



- (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  $[B] \gg [A]$ .
- (3) The rate constants are  $0.01 \text{ L}/(\text{mol}\cdot\text{s})$  at 400 K, and  $0.80 \text{ L}/(\text{mol}\cdot\text{s})$  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.,  $[B] \gg [A]$  as with (2).
- (4) Calculate the activation energy, when Arrhenius equation describes the rate constants of (3). Here, gas constant  $R$  is  $8.314 \text{ J}/(\text{K}\cdot\text{mol})$ .

4. Explain the following technical terms.

- (1) third law of thermodynamics
- (2) chelate effect
- (3) synergistic effect on solvent extraction
- (4) Beer's law

-End of the questions-