1. Please explain the following terms and indicate their meanings in environmental applications. (20%)
   (A) Winkler method.
   (B) Aerosol.
   (C) Zeta potential.
   (D) Conditional solubility.
   (E) Partition coefficient.

2. A buffer is made by combining monosodium oxalate (NaC_2O_4H) and disodium oxalate ($Na_2C_2O_4$) to give concentrations of 0.01 M for NaC_2O_4H and 0.02 M for $Na_2C_2O_4$. The pK_{a1} and pK_{a2} of the buffer are 1.25 and 4.28, respectively. (10%)
   (A) Please calculate the initial pH and buffer capacity of this buffer.
   (B) What is the pH of this buffer after the addition of 0.001 M NaOH?

3. The pH of a stabilization pond effluent is measured in the field and found to be 7.8 at 25 °C. A sample of the effluent is taken back to a laboratory. Due to the improper pretreatment and conveying process, the sample pH was found to be 10.2 upon arrival at the laboratory.
   (A) Please explain the reason and the possible reactions of the increase in sample pH. (5%)
   (B) After the measuring the atmosphere above the sample, the oxygen percentage was found to be 40 % and some nitrate and sulfate were found in the solution. The temperature was still at 25 °C. Please calculate the change in redox potential of the sample (in pε) and the impact on further redox reaction (10%).

$4e^- + 4H^+ + O_{2(g)} \leftrightarrow 2\ H_2O$	$E^0 = +\ 1.23$ V
$4e^- + 4\ H^+ + O_{2(aq)} \leftrightarrow 2\ H_2O$	$E^0 = +\ 1.27$ V
$2NO_3^- + 12\ H^+ + 10\ e^- \leftrightarrow N_{2(g)} + 6\ H_2O$	$E^0 = +\ 1.24$ V
$SO_4^{2-} + 10\ H^+ + 8e^- \leftrightarrow H_2S_{(g)} + 4\ H_2O$	$E^0 = +\ 0.34$ V

4. A power plant combusts 100 tons coal per day as the heating source to generate electrical power. The coal contains 0.5 % S and the flow rate of flue gas is 80 m^3/s at STP. Assume that the power plant operates 24 h per day. Please calculate the concentration of SO_2 (in $\mu g/m^3$) in flue gas at 80 °C. If the wet limestone process is used to control the emission of SO_2 from flue gas. Please calculate the required limestone (in kg/day) to remove SO_2. (10%)

5. Ozone layer depletion is one of the major globally environmental issues. In 1985, scientists discovered that stratospheric ozone over Antarctica is reduced by about 50 % for several months each year, and the decrease in ozone concentration in Spring is more serious than in Autumn. Please describe the main reactions for ozone layer depletion and the reasons why the ozone hole occurs mostly in Spring. (10%)

6. Humic substances have recently received much attention in Environmental Chemistry. They can be used as complexing agents to sorb heavy metals and organics. They also can serve as electron mediators to enhance the degradation rate of environmental pollutants and the reductive dissolution of ferric oxides in soil and sediments. The possible reason is the versatile functional groups in their structures. Please answer the following questions:
   (A) The possible formation mechanisms of humic substances. (5%)
   (B) Usually humic substances can be divided into humic acid, fulvic acid and humin according to the solubility in acid and base. Please compare the general properties of humic acid and fulvic acid (e.g. molecular weights, functional groups, elemental composition). (5%)
   (C) Briefly describe the principles of electron shuttling effect of humic substances. (5%)

7. Environmental nanotechnology is one of the growing techniques in Environmental Science and Technology due to its special physicochemical properties and large specific surface area. Carbon nanotube (CNT) is one of the most often used nanomaterials for pollutant treatment. CNT is made of carbon atoms which is similar to graphite and diamond. In addition, CNTs have several unusual properties, such as hardness, elastic, magnetic and electrical properties. (10%)
   (A) Which pollutants can be treated by CNTs? Propose the possible reactions and mechanisms of your answer.
   (B) Predict the possible environmental fate of CNTs when released to the natural environments.

8. Chlorination of organic compounds can occur during disinfection of drinking water. The chlorination of phenol (C_6H_5OH) occurs by direct reaction of hypochlororous acid (HOCl) on the phenolate anion ($C_6H_5O^-$) with the second-order rate constant, k, and follows the second-order rate law: (10%)

$$C_6H_5OH + HOCl \rightarrow ClC_6H_4O^- + H_2O$$

$$-d[C_6H_5O^-]/dt = k[C_6H_5O^-]\,[HOCl]$$

   (a) Deduce an expression for the rate of disappearance of phenol in terms of total phenol and total HOCl.

$$-d[C_6H_5O^-]/dt = k^*[C_6H_5OH]_T\,[HOCl]_T$$

   where

$$[C_6H_5OH]_T = [C_6H_5OH] + [C_6H_5O^-]$$

$$[HOCl]_T = [HOCl] + [OCl^-]$$

   (b) The pKa of HOCl is 7.5 and pKa of phenol is 10. In what pH range would the fastest rate of chlorination be expected: (1) pH < 7.5, (2) 7.5 < pH < 10, and (3) pH > 10?