1. Please indicate the relationship of the following terms and the meanings in environmental applications. (20%)

   [A] Ionic strength and Adsorption.

   [B] Henderson-Hasselbalch equation and Buffer intensity.

   [C] Terpene and Photochemical smog.

   [D] Soft metal and Complexation.

   [E] Humic acid and Dechlorination.

2. Phenol is a priority environmental contaminant and can be removed by advanced oxidation processes (AOPs). An oxidant (e.g. ozone) is now used to decompose phenol at 25 °C and found that the reaction rate is functions of oxidant (ozone) and phenol concentrations. After conducting an experiment by adding excess amounts of ozone in solution, the following results were obtained.
   (a) Please derive the reaction rate equation of phenol and determine the apparent rate constant. (10%)
   (b) The apparent rate constant increase 4 times when the reaction temperature increases to 60 °C. Please use Arrhenius equation to calculate the apparent constant at 37°C. (5%)

Time (min)	0	10	20	40	60	80	100	120	150
Phenol (mg/L)	50	21.2	13.2	7.62	5.25	4.13	3.35	2.84	2.21

Note: oxidant is in excess concentration.

Arrhenius equation: $\dfrac{d \ln K}{dT} = \dfrac{\Delta E_a}{RT^2}$

3. In the metal plating industry, cyanide is frequently eliminated from wastewater discharges by treatment with chlorine species (Cl_2, OCl^-) at high pH values. Two steps at different pH values are usually involved: (1) the oxidation of cyanide to cyanate (CNO^-), and (2) oxidation of CNO^- to N_2 and CO_2.
   (a) Write the balanced reaction and the required pH values for each of the two steps given that OCl^- is the oxidizing chlorine species and that chloride ion is formed as the reduced chlorine species in each step. (10%)
   (b) How much OCl^-, in mg/L as Cl_2, is required in each step for the removal of 10 mg/L of CN^-? (5%)

4. The sorption of organic compounds onto soil is highly dependent on the organic content of soil (f_{oc}) and the partition coefficient (K_p) of organic compound, which can be calculated from the equilibrium between the sorbed amounts onto soil (mg/g) and the equilibrated aqueous solution (mg/L). Now a factory accidentally emits 150 kg of carbon tetrachloride (CT) (log K_{ow} = 2.83) into the soil which contains 2 % of organic carbons. Laboratory experiment also found that the CT can be anaerobically decomposed to chloroform (CF) via first-order kinetics. The first-order rate constant is 0.0015 day^{-1}. Please use the following relationship to estimate the remaining mass of CT in soil environments after 6 months. (10 %)

$$\log K_{oc} = 0.63 \log K_{ow}$$

$$K_p = f_{oc} \times K_{oc}$$

where K_{ow} is the octanol-water partition coefficient, and K_{oc} is the ratio of the amount of a chemical adsorbed per unit weight of organic carbon in the soil.

5. Greenhouse effect is one of the worldwide environmental issues which can cause the increase in global air temperature.
   (a) Please explain the formation mechanism of greenhouse effect. (7 %)
   (b) Indicate those gases that can cause greenhouse effect, their possible global warming potential (GWP) values, and their contribution to the increase in global temperature. (8 %)

6. Fifty mL of a natural water sample is titrated with 0.02 N sulfuric acid. The titrant volume required to titrate to pH 8.3 is 6 mL, and an additional 8 mL is required to titrate to pH 4.3
   (a) What is the caustic, carbonate, and total alkalinity in mg-$CaCO_3$/L. (5%)
   (b) What is pH_{CO2} and pH_{CO3}^{2-} (5%)

7. Photochemical smog is the major air pollution issue in urban areas, which produced as a result of the light-induced reaction of pollutants containing nitrogen oxide gases and volatile organic compounds.
   (a) Please write down the main reactions of photochemical smog and sketch the concentration profiles of reactants and products in photochemical smog. (8%)
   (b) The photochemical reaction starts from the photoreaction of nitrogen dioxide (NO_2). However, NO is the original species of the reaction of nitrogen and oxygen in air at high temperature. Usually NO should be oxidized to NO_2 before the trigger of photochemical smog. Explain the mechanism for the conversion of NO to NO_2 in air. (7%)