1. Why chlorine/hypochlorite is still the most common disinfectant for water and wastewater (compare to other disinfectants such as ozone, UV, phenolic compounds, formaldehydes, hydrogen peroxides etc.)? (15 pts)
2. What is antibiotic/antimicrobial resistance? What will be the impacts to our environment? (15 pts)
3. In a nature environment, bacteria may encounter feast/famine conditions frequently. Therefore, stress coping and survival skills are very important for their "bacterial life". Please explain the following:
   A. What are the advantages of being small in size? (10 pts)
   B. How does microorganism cope with starvation? (10 pts)
4. Please define what is "Photochemical Reaction"? Does Chlorofluorocarbons (CFCs) cause photochemical reaction? If so, please describe the chain reaction. (10 pts)
5. The chemical constituents of humic acid and fulvic acid are shown in the following table. Please compare the adsorption capacity for heavy metals and organics. (10 pts)

Element Analysis	*Humic Acid (wt%)*	*Fulvic Acid(wt%)*
Carbon	50~60	40~50
Hydrogen	4~6	4~6
Oxygen	30~35	44~50
Nitrogen	2~4	1~3
Sulfur	1~2	0~2

6. Using biological treatment to decompose wastewater which contain sugar (CH_2O), the sugars will be fermented to generate methane (CH_4). An appropriate amount of nitrogen (NH_4^+) is added to the reaction as a nitrogen source to generate biomass ($C_5H_7O_2N$). The relevant half-reaction equations are shown as follows.
   a. Cell synthesis reaction (R_c):
   $$4CO_{2(g)} + HCO_3^- + NH_4^+ + 20H^+ + 20e^- \rightarrow C_5H_7O_2N + 9H_2O$$
   b. Electronic acceptor reaction (R_a):
   $$CO_{2(g)} + 8H^+ + 8e^- \rightarrow CH_{4(g)} + 2H_2O$$
   c. Electronic donor reaction (R_d):
   $$CO_{2(g)} + 4H^+ + 4e^- \rightarrow CH_2O + H_2O$$
   In this reaction, R_d loses one electron, while R_c and R_a gain 0.28e and 0.72e, respectively.
   (1) How many kilograms of microorganisms will be produced by 2,000 kilograms of sugars completely fermented? (10 pts)
   (2) If the generated methane is directly discharged into the atmosphere, how much greenhouse gas will be emitted by the whole reaction? (Hint: CH_4 GWP=25) (10 pts)
7. What is the difference between O_2^* and $^{\cdot}O_2^-$? Please describe the formation mechanism. (10 pts)

試題隨卷繳回