參考用

All the equations and constants that you may need are provided on Page 2.

1. Please define or explain the followings:
   a. Fluorescence *in situ* hybridization (FISH) **(4 points)**
   b. Denaturing gradient gel electrophoresis (DGGE) **(4 points)**
   c. Minimum inhibitory concentration (MIC) **(4 points)**
   d. Enzyme-linked immunosorbent assay (ELISA) **(4 points)**
   e. The electrical double layer **(4 points)**
   f. Desalination **(4 points)**
   g. Beer-Lambert Law **(4 points)**
   h. Fugacity **(4 points)**

2. During a rainstorm, a reduced pond containing negligible organic matter doubles its volume and reaches complete acid-base and redox equilibrium – **it does NOT equilibrate with the atmosphere**. Given the initial conditions of the pond as follows (before the rainstorm), and assuming rainwater to be slightly polluted (**Alk = -10^{-4} M**) and saturated with atmospheric CO_2 and O_2 (**$[H_2CO_3^*] = 10^{-5}$ M** and **$[O_{2\,(aq)}] = 3 \times 10^{-4}$** M), what is the final alkalinity (Alk) and pH of the pond after mixing? Please note that for the redox portion of the problem, the main reaction to consider is the oxidation of sulfide species (H_2S or HS^-) to sulfate (SO_4^{2-}) with oxygen.

   pH = 8.0
   Alk = 10^{-3} M (carbonate system present but not at equilibrium with the atmosphere)
   $[SO_4^{2-}] = 4 \times 10^{-3}$ M
   $[H_2S] = 4 \times 10^{-4}$ M

   Note: as long as the solving process is clearly shown, you will get full credit even though the final answer is not obtained. (22 points)

3. An adsorption experiment using activated carbon (AC) to treat wastewater has been carried out, and the data are shown in the following table, which are confirmed to fit well into the Langmuir isotherm model. Please use these data to construct this Langmuir equation? **(12 points)**

Jar #	AC weight (mg)	Final volume (mL)	Final COD (mg/L)
1	804	200	4.7
2	668	200	7.0
3	512	200	9.3
4	393	200	16.6
5	313	200	32.5
6	238	200	62.9
7	0	200	250.0

4. Polyphosphate-accumulating organisms (PAOs) have been enriched and employed for the process of *enhanced biological phosphorus removal* (EBPR), which is currently the most common bio-treatment method used to remove phosphorus in wastewater. On the basis of an activated sludge process, please draw a simple prototype that contains essential components for EBPR, and indicate how PAOs and polyphosphate get involved in this phosphorus removal system. **(14 points)**

注意：背面有試題

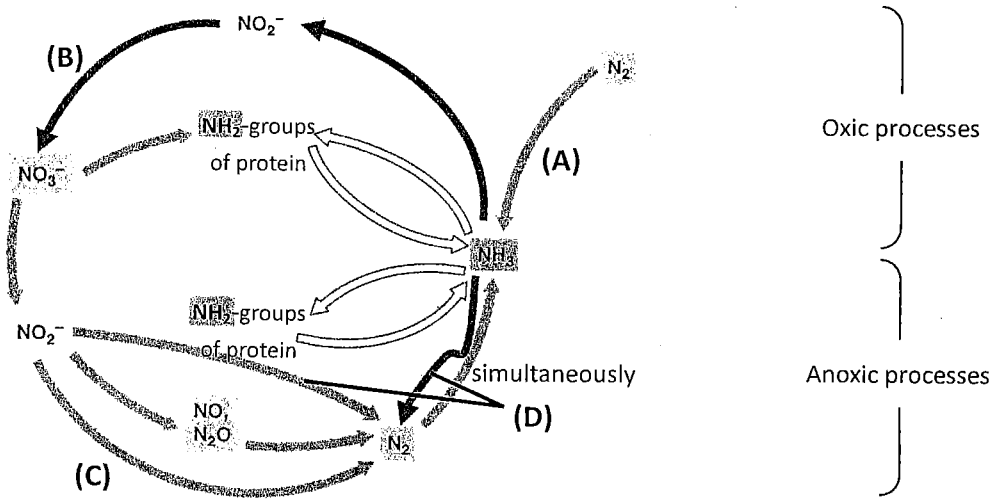
參考用

5. You have been hired by the town of Lakeville as an environmental consultant regarding two lakes in the town. The lakes are of similar size and shape, with one located in a wooden area (Wasabi Lake) and the other surrounded by farmland and suburbs (Sashimi Lake). During the spring of 2012, lake stratification sets up at the same time in both lakes. By June of that same year, reduced iron (Fe) and arsenic (As) are observed accumulating in the bottom of Wasabi Lake only.

   During your research, you note that the residents and farmers have been very concerned about eutrophication of their lake, and have completely banned high phosphorus fertilizers (since phosphorus is often the limiting nutrient in freshwater) and been using a low-phosphorus, high-nitrate alternative. Indeed, it appears that primary productivity is the same in the surface waters of both lakes, even though the concentration of nitrate is higher in Sashimi Lake.

   Please describe the microbial processes occurring in the lakes that may be responsible for the observations, and explain to your client the reason for the different chemistries in the two lakes. (Hint: ferric iron minerals are good absorbents for many pollutants, including As-species, in aquatic environments). **(12 points)**

6. What are these microbial processes A to D? **(8 points)**



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Chemical equations and constants:

$CO_2 + H_2O \leftrightarrows H_2CO_3$*;	$K_H = 10^{-1.5}$ mol/(atm· liter)
H_2CO_3* $\leftrightarrows HCO_3^- + H^+$;	$K_{a1} = 5\times10^{-7}$ mol/liter
$HCO_3^- \leftrightarrows CO_3^{2-} + H^+$;	$K_{a2} = 5\times10^{-11}$ mol/liter
$H_2S \leftrightarrows HS^- + H^+$;	$K_{a1} = 10^{-7}$ mol/liter
$HS^- \leftrightarrows S^{2-} + H^+$;	$K_{a2} = 10^{-14}$ mol/liter

The Langmuir isotherm: $x/m = (aKC_e) / (1+KC_e)$

where x = mass of solute adsorbed
m = mass of adsorbent
C_e = equilibrium concentration of solute
a = mass of adsorbed solute required to saturate completely a unit mass of adsorbent
K = experimental constant

注意:背面有試題