# 國立中央大學101學年度碩士班考試入學試題卷

所別:<u>環境工程研究所碩士班 甲組(一般生)</u> 科目:<u>環境化學及環境微生物學 共 2 頁 第 1 頁</u>本科考試禁用計算器 <u>\*讀在試卷答案卷(卡)</u>內作答

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

- 1. Please define or explain the followings:
  - a. Alkalinity (3 points)
  - b. Hardness (3 points)
  - c. Chemical oxygen demand (3 points)
  - d. Syntrophy (3 points)
  - e. Cation-exchange capacity (3 points)
  - f. Methanogenesis (3 points)
  - g. Fecal indicator bacteria (3 points)
  - h. Polymerase chain reaction (3 points)
- 2. Lakes in temperate regions are often thermally stratified during summer. When this stratification occurs, the lower layer of the lake is called the *hypolimnion*, and the upper layer is called the *epilimnion*, which is well-mixed. Water from the hypolimnion of a lake has a pH of 8, and the total concentration of the carbonate species, i.e., C<sub>T</sub> (sum of the concentration of CO<sub>2(aq)</sub>, HCO<sub>3</sub><sup>-</sup> and CO<sub>3</sub><sup>2-</sup>), is 3 mM. The partial pressure of CO<sub>2</sub> is approximately 10<sup>-3.5</sup> atm, and the dissolved oxygen concentration is zero.
  - a. Would this water lose or gain CO<sub>2</sub> if it were brought into contact with the atmosphere? (12 points)
  - b. If 1 mM of  $NO_3^-$  is added to the lake, as part of an unusual treatment intended to oxidize large accumulations of organic matter (designated as  $CH_2O$ ) in the lake, how much will this alter  $C_T$ , after denitrification (to nitrogen gas) is complete? (8 points)
- 3. A flask sealed with an airtight stopper at 25°C contains 250 mL of water, 200 mL of octanol, and 50 mL of air. An unknown amount of o-xylene is added to the flask and allowed to partition among the phases. After equilibrium has been established, 5 mg of o-xylene is measured in the water. What is the total mass of o-xylene present in the flask? (12 points)
- Suppose you wanted to grow bacteria in a simple freshwater medium (pH 7.6, C<sub>T</sub> is 10<sup>-3</sup> M, [Ca<sup>2+</sup>]<sub>T</sub> is 10<sup>-4</sup> M, [SO<sub>4</sub><sup>2-</sup>]<sub>T</sub> is 10<sup>-4</sup> M, and insignificant concentrations of other major ions) at a constant free cadmium ion 10<sup>-9</sup> M.
  - a. If you added no organic ligands to your medium, how much total cadmium, i.e., [Cd<sup>2+</sup>]<sub>τ</sub>, would you have to add to get a [Cd<sup>2+</sup>] of 10<sup>-9</sup>? (12 points)
  - b. If your medium contained [NTA]<sub>T</sub> =  $10^{-5}$  M, how much [Cd<sup>2+</sup>]<sub>T</sub> would you need now to get a  $-\log[Cd^{2+}]$  of 9? NTA is nitrilotriacetic acid. (12 points)

注:背面有試題

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- 5. You are in charge of a simple completely-mixed, continuous culture reactor in which bacteria are feeding upon a toxic organic chemical to remove it from a waste stream before discharge. You are able to change the volume of the reactor (V), the flow rate (Q), and the concentration of substrate in the sterile influent [S].
  - a. Show the mass balance and Monod kinetics equation for a chemostat at steady state. (4 points)
  - b. Assuming you are not at maximum growth, how growth rate  $\mu$  (day 1) is affected when you vary Q, holding all else constant. Is there a limit to how much you can vary Q? Why? (4 points)
  - c. Again, assuming you are not at maximum growth, show how growth rate  $\mu$  (day 1) is affected when you vary V, holding all else constant. Is there a limit to how much you can vary V? Why? (4 points)
  - d. How does growth rate  $\mu$  (day<sup>-1</sup>) change when you vary the influent substrate concentration? Assume that the substrate concentration is within a factor of two of the half-saturation constant,  $K_s$ . (4 points)
  - e. How would you answer to "the question d" change if the influent substrate concentration was much greater than the half-saturation constant? (4 points)

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#### **Equations and Constants:**

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CO<sub>2</sub> + H<sub>2</sub>O \stackrel{\  \  \, }{} H<sub>2</sub>CO<sub>3</sub>*; K_H = 10^{-1.5} \, \text{mol/(atm\cdot liter)}

H<sub>2</sub>CO<sub>3</sub>* \stackrel{\  \  \, }{} HCO<sub>3</sub>* + H<sup>+</sup>; K_{\sigma z} = 10^{-6} \, \text{mol/liter}

HCO<sub>3</sub>* \stackrel{\  \  \, }{} CO<sub>3</sub><sup>2-</sup> + H<sup>+</sup>; K_{\sigma z} = 10^{-10} \, \text{mol/liter}
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### o-Xylene's

- (1) molecular weight = 106;
- (2)  $\log K_{ow} = 3$ ;
- (3)  $K_H$  (dimensionless, ratio of concentration in air to concentration in water) = 0.22

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Cd^{2+} + OH^{-} \rightarrow CdOH^{+};
                                                                  \beta_l = 7.94 \times 10^3
Cd^{2+} + 2OH^{-} \rightarrow Cd(OH)_2;
                                                                  \beta_2 = 3.98 \times 10^7
Cd^{2+} + SO_4^{2-} \rightarrow CdSO_4;
                                                                  \beta_l = 2 \times 10^2
Cd^{2+} + 2SO_4^{2-} \rightarrow Cd(SO_4)_2^{2-};
                                                                  \beta_2 = 1.58 \times 10^3
Cd^{2+} + 3SO_4^{2-} \rightarrow Cd(SO_4)_3^{4-};
                                                                  \beta_3 = 5 \times 10^2
Cd^{2+} + NTA \rightarrow Cd(NTA);
                                                                  \beta_l = 1.26 \times 10^{11}
Cd^{2+} + 2NTA \rightarrow Cd(NTA)_2;
                                                                  \beta_2 = 1.26 \times 10^{15}
Cd^{2+} + NTA + OH^{-} \rightarrow Cd(NTA)OH;
                                                                 \beta_{l} = 2.51 \times 10^{13}
Ca^{2+} + NTA \rightarrow Ca(NTA);
                                                                  \beta_l = 3.98 \times 10^7
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