

1. How would the presence of endospores in Louis Pasteur's nutrient solutions have affected his conclusions about spontaneous generation? (5 分)
2. Stress and survival are phenomena that bacterial cells must encounter in the natural environment. (15 分)
 - (a) Given the small size of the individual bacterial cell, how do bacteria manage to have a significant impact on their immediate environment?
 - (b) Under conditions of stress, as for example, lack of sufficient nutrients, bacterial cells may become smaller than typical size. In this instance, why does "smallness" confer an advantage to the cell?
 - (c) What will be the advantage and disadvantage of forming biofilm?
3. Please explain why microbial de-chlorination is more likely to happen under aerobic condition than in anoxic environment. (10 分)
4. How to define a "species" for bacteria? What is the current practicing "role of thumb"? What are species richness and abundance? (10 分)
5. Please explain the mechanism and impact of pipeline corrosion from biofilm in water distribution system. (10 分)
6. (a) Balance the following equation representing biological denitrification process, in which nitrate is reduced by carbohydrate to become nitrogen gas, (b) estimate the change of pH qualitatively and the change of alkalinity for one mole of nitrate reduced.
 $? \text{NO}_3^- + ? \text{CH}_2\text{O} + \dots \rightarrow ? \text{N}_2 + \dots$ (10 分)
7. In a water treatment plant, aluminum sulfate ($\text{Al}_2(\text{SO}_4)_3$) is used as flocculant. If the precipitation of aluminum oxide ($\text{Al}(\text{OH})_3(\text{s})$) is formed, at what pH will aluminum oxide have the lowest solubility and highest amount of flocs formed? What will be the total concentration (mg-Al/L) of soluble aluminum species in the water?

$\text{H}_2\text{O} = \text{H}^+ + \text{OH}^-$	pK = 14.0
$\text{Al}(\text{OH})_3(\text{s}) + 3\text{H}^+ = \text{Al}^{3+} + 3\text{H}_2\text{O}$	pK = -8.5
$\text{AlOH}^{2+} + \text{H}^+ = \text{Al}^{3+} + \text{H}_2\text{O}$	pK = -5.0
$\text{Al}(\text{OH})_2^+ + 2\text{H}^+ = \text{Al}^{3+} + 2\text{H}_2\text{O}$	pK = -9.3
$\text{Al}(\text{OH})_4^- + 4\text{H}^+ = \text{Al}^{3+} + 4\text{H}_2\text{O}$	pK = -23.0
$\text{Al}(\text{OH})_5^0 + 3\text{H}^+ = \text{Al}^{3+} + 3\text{H}_2\text{O}$	pK = -15.0

Note: pK = - logK
 (Atomic weight: O = 16.0, H = 1.0, Al = 27.0) (15 分)
8. Hydraulic fracturing (or "fracking") technique is a method of recovering natural gas from very aquifers by fracturing of rock by a pressurized water (with some chemicals and small particles) through deep well injection and then bringing natural gas back to ground once the hydraulic pressure is removed from the well. There is a fracking operation pumping 10^5 m^3 water into an aquifer at 3000 m below ground surface, letting equilibrated with methane (with Henry's law constant of 647 atm/M at 20 °C) and then drawing back to the ground surface to recover methane.
 - (a) What will be the volume of methane produced from one cycle of fracking operation? Neglect the effect of temperature.
 - (b) What approaches may you take to enhance the solubility of methane in water, that is, to lower the Henry's law constant?

(The density of water is 1.0 g/cm^3 , and mercury is 13.6 g/cm^3 . The atomic weight are: C = 12, H = 1) (10 分)
9. Bisphenol A (4,4'-(propane-2,2-diyl)diphenol, BPA) was accumulated in sludge during the activated sludge wastewater treatment process. The influent total concentration of BPA is 0.1 mg/L and the sludge production rate is 100 g dry weight per cubic meter of wastewater.

- (a) Please estimate the concentration of BPA in the clarified effluent water (per liter) and in the sludge (per kilogram dry weight). The pH of the mixed liquor in the aeration tank is 8, the organic-solid/water partition coefficient, K_d , of BPA is $10^{2.1}$ ((mole/g)/(mole/cm³)), the pK_a of BPA is 10.3.
- (b) What pH in the tank is required to keep the BPA concentration in the produced dry sludge lower than 1 mg/kg?
- (Assume there is no degradation and volatilization of BPA in the aeration tank, and there will no sorption of BPA on the suspended sludge once BPA is dissociated into charged species)

(15 分)

參考資料：指數及對數運算表

運算	數值	運算	數值	運算	數值
$10^{0.1}$	1.26	log 1	0	ln 2	0.69
$10^{0.2}$	1.58	log 2	0.30	ln 3	1.10
$10^{0.3}$	2.00	log 3	0.48	ln 4	1.39
$10^{0.4}$	2.51	log 4	0.60	ln 5	1.61
$10^{0.5}$	3.16	log 5	0.70	ln 6	1.79
$10^{0.6}$	3.98	log 6	0.78	ln 7	1.95
$10^{0.7}$	5.01	log 7	0.85	ln 8	2.08
$10^{0.8}$	6.31	log 8	0.90	ln 9	2.20
$10^{0.9}$	7.94	log 9	0.95	ln 10	2.30

$\ln(a) = \log(a) / \log(e)$, $e = 2.718$, $\log(e) = 0.4343$

試題隨卷繳回