

1. Please define or explain the followings:

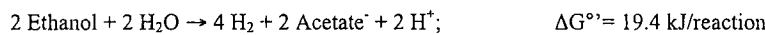
- (a) Total Kjeldahl nitrogen (3 points)
- (b) Zeta potential (3 points)
- (c) Bioconcentration factor (3 points)
- (d) Endocrine disruptors (3 points)
- (e) Eutrophication (3 points)
- (f) Fecal indicator bacteria (3 points)
- (g) Polymerase chain reaction (3 points)
- (h) Differences between assimilative and dissimilative metabolism (3 points)

2. Please identify three (or four, if you want to be more precisely) major categories of bacteria that are involved in successful anaerobic digestion, and list them in an order of their appearance during the process. (6 points)

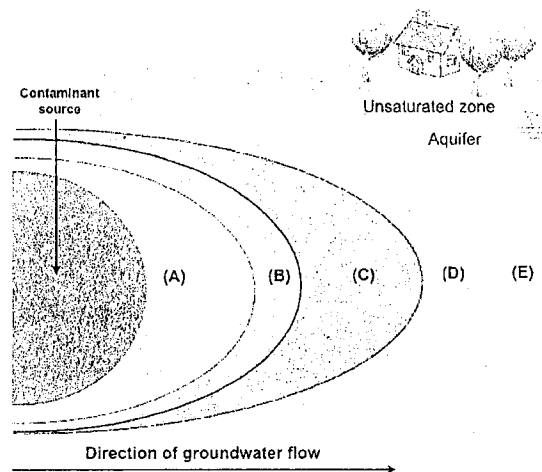
3. *Pseudomonas* sp. Su-Huan-Jen (S-H-J) is a denitrifying bacterium with the capacity to accumulate polyphosphate intracellularly without the need for aerobic and anaerobic switches. Please answer the following questions:

- (a) The result from the Gram stain shows that the cell color of the strain S-H-J is pink – what would it be, G(+) or G(-)? Also, please list the reagents, in experimental order, used in the Gram stain procedure. (10 points)
- (b) Based on its metabolic characteristics stated above, what kind of role(s) this strain would possibly play in wastewater treatment processes? (4 points)

4. According to the equation given below, would *Syntrophomonas* sp. One-Page-Book (O-P-B) be potentially able to ferment ethanol? If not, what kind of bacteria can be added into the system to make both strains (the strain O-P-B and the newly introduced strain) grow simultaneously? Please explain why. (6 points)



5. In subsurface environments polluted with oxidizable organic contaminants (e.g., petroleum) or leached materials from landfills, generally there are distinct zones in which different degradative processes predominate (see the figure below). Please identify and link the following bacterial groups: sulfate-reducers, denitrifiers, iron-reducers, methanogens, aerobes, to the designations of (A) to (E) on the figure. Also, please explain your choices for the answers. (12 points)



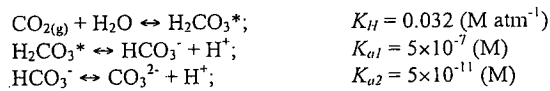
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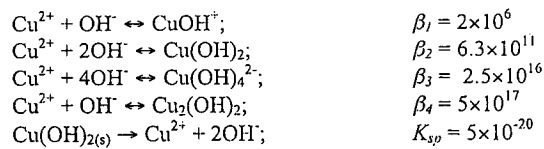
6. Please calculate the hardness (expressed in "mg/L as CaCO₃") of a solution with the following analysis. The standard atomic weights (g/mol) that you may need are: C = 12; Na = 23; Ca = 40; Mg = 24; Sr = 87.6; Cl = 35.5; S = 32; O = 16; N = 14. (10 points)

| Cation | Concentration (mg/L) | Anion | Concentration (mg/L) |
|------------------|----------------------|-------------------------------|----------------------|
| Na ⁺ | 20 | Cl ⁻ | 40 |
| Ca ²⁺ | 15 | SO ₄ ²⁻ | 16 |
| Mg ²⁺ | 10 | NO ₃ ⁻ | 5 |
| Sr ²⁺ | 2 | Alkalinity | 50 |

7. It is noted that the chemistry of a reservoir is mediated by carbonate system with 3.2×10^{-4} atm of CO₂. Please use the reactions listed below to calculate the alkalinity (in terms of mole/L) of this waterbody at equilibrium with atmospheric CO₂ and a pH of 8. (12 points)



8. Cooking with fancy copper pots is in fashion these days, but how safe are these pots? After several uses, the pots develop a coating of oxidized copper, Cu(OH)_{2(s)}. How much total copper ends up in cooking water (assume buffered at pH 7) and tomato sauce (assumed buffered at pH 4.0) at equilibrium with Cu(OH)_{2(s)}? If the Recommended Daily Allowance (RDA) of copper is 2.0 mg per day (the molecular weight of copper is about 64 g/mol), should you be concerned with Cu intake from copper pots? Please use the following reactions and neglect temperature effects to answer the questions. (16 points)



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