1. Methylmercury partitions strongly into the lipid-rich tissues of fish; hence, it becomes highly bioconcentrated. Assume the BCF (i.e., bioconcentration factor) for fish is 10^6 liters/kg (i.e., assume an equilibrium partitioning model is an acceptable approximation to the real world). What fraction of the methylmercury in a lake would actually be in fish tissue, if the lake had a volume of 10^6 m^3 and contained a metric ton (i.e., 1000 kg) of fish? **[15 points]**

2. Aniline is widely used in the manufacture of dyes and pharmaceuticals. It undergoes a fully reversible acid-base reaction as follows:

$$C_6H_5NH_3^+ \quad = \quad C_6H_5NH_2 + H^+; \qquad K = 10^{-4.6}$$
　　anilinium ion　　　　　　aniline
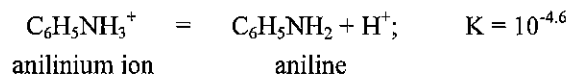
Below are absorption spectra for aniline and anilinium ion; note that the ionic and nonionic forms absorb light different.
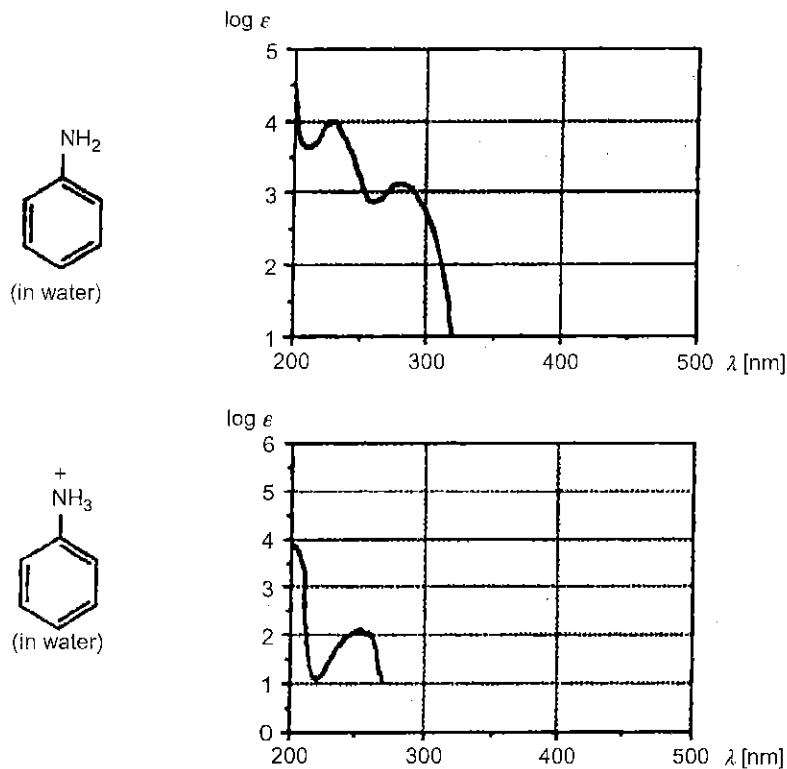
You are hoping to develop a scheme to treat aniline-contaminated groundwater by pumping it to the surface and exposing it to sunlight, with the intent of having it degrade via direct photolysis. The pH of the groundwater is 6.5. Before solar treatment, should you acidify the water to pH 3.5, or raise the pH of the water to 9.5, or leave the pH alone, with the intent of neutralizing the pH prior to discharge? **Note your logic and show your calculation. [20 points]**

3. You are interested in producing methane from an agricultural wastewater stream. The waste stream contains dissolved sugars (model as CH$_2$O, in which carbon has an average oxidation state of 0), an alkalinity of 0.8 meq/liter, and a pH of 7. The initial DO is negligible; however, the water is still in equilibrium with the atmosphere with respect to dissolved nitrogen (i.e., $P_{Nitrogen} = 0.8$ atm). You set up an experimental bioreactor (the closed tank in

注意：背面有試題

which you hope methanogenesis will take place) to do some experiments.　Assume CO_2 and CH_4 are the only products of CH_2O fermentation.

(1) In addition to those given, what further constraints on water chemistry must be met if methane production is to begin immediately after you fill the bioreactor?　You have already inoculated the batch with a suitable microbial consortium.　Ionic strength, pH, and temperature (30°C) are all acceptable and there are no toxic materials in the wastewater.　Mention specific chemical species.　**[5 points]**

(2) You have installed a glass window in your experimental reactor so that you can look for signs of action.　After 3 days you see the first signs of bubbles.　At this time, what is your best estimate of the aqueous concentration of methane, whose dimensionless Henry's law constant is 27 at the temperature of the bioreactor?　(Although oxygen cannot get in, your bioreactor is not pressurized.)　You may neglect the partial pressure of carbon dioxide, because CO_2 is so soluble.　**[15 points]**

(3) At this exciting moment, what is your best estimate of the pH in the reactor?　You can just provide a molar concentration of H^+, and neglect the possible effects of uptake of ammonium, or other biological effects on the alkalinity of the water.　(pK_{a1} and pK_{a2} of dissolved carbonic acid are 6.3 and 10.3, respectively)　**[25 points]**

4. Below is a modified schematic representation of a microbial fuel cell.　**[5 points for each question]**

(1) Show the direction of electron flow between the anode and cathode electrodes.　Why?

(2) Which chamber (anode or cathode) should be inoculated with anaerobes?　Why?

(3) Which electrode (anode or cathode) can chemolithotrophs grow on?　Why?

(4) If an aquifer is contaminated with elevated concentrations of hexavalent uranium (i.e., U^{6+}), and it has been known that reduction of U^{6+} to U^{4+} results in precipitation of uranium.　To treat this contaminated groundwater, which chamber should be used, anode or cathode?　Why?
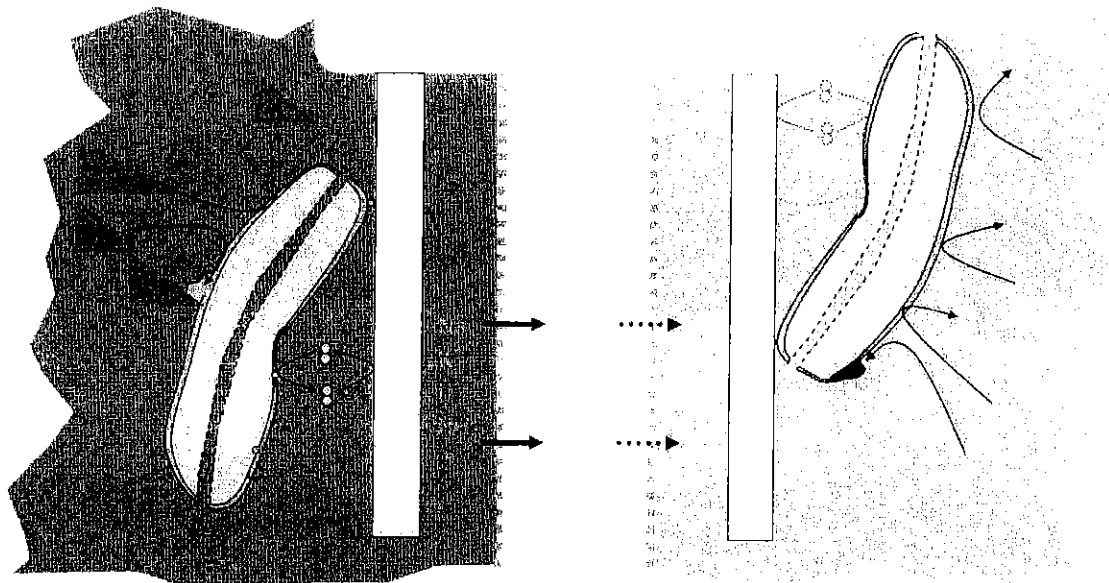
ANODE　　　　CATHODE　　(Rabaey et al., ISME 2007, modified)