1. 名詞解釋 (30%)
(1) bioaccumulation
(2) acid deposition
(3) cogeneration power
(4) eutrophication
(5) ecological footprint
(6) median lethal dose (LD50)
(7) photochemical smog
(8) volatile organic compounds
(9) sustainable society
(10) hazardous waste

2. Exposing to some chemicals, which are called chemical carcinogens, may cause human cancer. The process of forming cancer in human bodies is called carcinogenesis. (1) Please explain the mechanism of carcinogenesis at cellular level by a chemical carcinogen; (2) Sketch a hypothetical dose-response curve for a carcinogenic potency test of a chemical carcinogen by using animals; (3) Discuss whether there is a threshold of chronicle daily intake of a chemical carcinogen for carcinogenic effects, and why. (10%)

3. Greenhouse gases, such as $CO_2$, have been well known as key factors to cause global warming. Numerous carbon capture and storage (CCS) approaches have been proposed; some of them have been implemented in pilot-scale tests. Please argue the following three methods regarding their potentials and concerns. (10%)
(a) Removal of $CO_2$ from smokestacks and pumping it deep underground into abandoned coal beds and oil/gas fields.
(b) Planting large areas of degraded land with fast-growing perennial plants, which can remove $CO_2$ from the air and store it in the soil and be harvested to produce biofuels such as ethanol.
(c) Seeding the oceans with iron to promote the growth of more marine algae and other phytoplankton, which absorb huge amounts of $CO_2$ from the atmosphere as they grow.

4. Nitrogen fixation by microorganisms, including some algal species, is one of the major nitrogen sources for all forms of life on earth. (1) Please write down the oxidation-reductive half reaction of nitrogen fixation, (2) If carbohydrate (can be expressed as "$CH_2O$") were used for microorganisms to convert nitrogen to ammonium ion and carbon dioxide, write down and balance the complete reaction equation and predict the change of pH and alkalinity, (3) Please describe the environmental conditions and materials required for microbial nitrogen fixation. (10%)

5. (1) Please describe the new method of drilling natural gas by using hydraulic fracturing (or "fracking") technique; (2) What would be the potential impacts of

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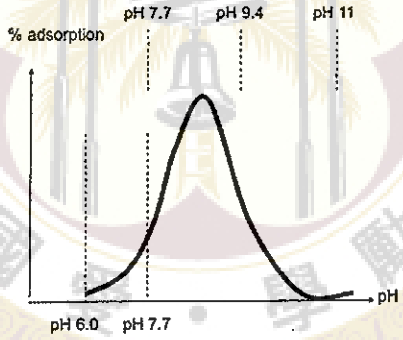
this method on the local environment? (3) What will be the global environmental impacts of the invention of this method? (10%)

6. What are the environmental concerns about the genetically engineered plants, like cotton and corn, of which the resistance to herbicides has been greatly enhanced? (10%)

7. Electronic wastes (e-wastes), such as discarded TV, cell phones, computers, and other electronic devices, have been the fastest-growing solid waste problem in the world. Using a notebook computer as the example, proposing your "cradle-to-grave" waste management plan through engineering, economic, and politic approaches. (10%)

8. Please explain the following figure showing the percentage of adsorption of the total lead (Pb(II)) on alumina ($\gamma$-$Al_2O_3$) at different pH. You may first write down the mass balance equations of surface species and lead, change all terms into function of $[H^+]$ by using the information of the equilibrium constants of all surface and aqueous species, and assume that total concentration of lead, $Pb_T$, is much smaller than total number of adsorption sites, $\equiv X_T$, (mol/L) (i.e. solid mass (g/L) * site density (mol/g)). (10%)




The governing mass law:

| | |
|---|---|
| $H_2O = H^+ + OH^-$ | $K_w = 10^{-14}$ |
| $\equiv XOH_2^+ = H^+ + \equiv XOH$ | $K_{a1}^{app} = 10^{-6.0}$ |
| $\equiv XOH = H^+ + \equiv XO^-$ | $K_{a2}^{app} = 10^{-7.7}$ |
| $\equiv XOPb^+ = \equiv XO^- + Pb^{2+}$ | $K_1^{app} = 10^{-6.1}$ |
| $Pb^{2+} + H_2O = PbOH^+ + H^+$ | $K_{OH} = 10^{-7.7}$ |

$K_{a1}^{app}$ and $K_{a2}^{app}$ are the first and second dissociation equilibrium constants of aluminum oxide surface species, $\equiv XOH_2^+$. $\equiv XOPb^+$ is the surface complex of $Pb^{2+}$ on alumina. $K_1^{app}$ is the equilibrium constant of the formation of complex from surface species, $\equiv XO^-$, and lead ion, $Pb^{2+}$.

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