1. Describe and compare the nutritional requirements of autotrophic and heterotrophic bacteria. (15 points)

2. The detection of pathogens in water is difficult, uneconomical, and impractical in routine water analyses. Instead, water is tested using a surrogate that is an indicator of fecal contamination. Of the many indicator organisms, the total coliform group of bacteria is the one most commonly used.
   2.1 What are coliforms? (10 points)
   2.2 What is the differentiation between total and fecal coliforms? (5 points)

3. Composting is the biological decomposition of organic matter under controlled aerobic conditions. Therefore, microbiology is the heart of the composting process.
   3.1 List the major microorganisms that are able to utilize different carbon source in the composting process. (5 points)
   3.2 List the major factors affecting the decomposition of organic matter by these microorganisms. (10 points)

4. In contrast to the enormous efforts dedicated to the abatement of pollution by organic compounds, nitrogen and phosphorus, treatment of sulfur-induced pollution has received rather limited attention. However, in recent years, natural as well as man-made ecosystems have been increasingly affected by sulfur pollution.
   4.1 Please describe the biological sulfur cycle in natural environment. (5 points)
   4.2 What groups or species of bacteria are involved in the sulfur conversions in the biological sulfur cycle? (5 points)
   4.3 What adverse effects are the caused by biological sulfur cycle (sulfur pollution)? (5 points)
   4.4 What kinds of environmental technology and bioremediation belong to the application of biological sulfur cycle? (5 points)
5. For the environmental biotechnologies, the microbial ecology (identification and enumeration) is very important for researchers and engineers to explain the mechanisms and kinetics of these technologies.

5.1 What traditional enrichment methods (culture-based techniques) of bacteria are used for studying the microbial ecology? (5 points)

5.2 What will be the problems when we use these traditional enrichment methods in the study of microbial ecology? (5 points)

5.3 In order to overcome the above problems, numerous methods based on molecular biology can be used in the study of microbial ecology. Please write one of the molecular methods and briefly describe the principles of this method. (10 points)

6. The rate at which microbes consume substrate and grow is important to all waste treatment processes. Numerous models have been proposed to describe the rate of substrate use in solution. One of the most commonly used of these models was proposed by Monod (1942).

6.1 Illustrate “the effect of limiting substrate concentration on the rate of substrate use by a microbe” with a figure. (5 points)

6.2 Based on this figure, propose a hyperbolic relationship of the form. (10 points)