1. In solution, ion migration velocity can be expressed as:

$$v = \mu_e E$$

where v is ion migration velocity (m s^{-1}), μ_e is electrophoretic mobility (m^2 V^{-1} s^{-1}) and E is electric field strength (Vm^{-1}). Electrophoretic mobility can be further defined as:

$$\mu_e = \frac{q}{6\pi\eta r}$$

where q is the charge on the ion, η is the solution viscosity and r is the ion radius. Based on the equations please explain: (a) why the pH of running buffer is important in electrophoresis? (b) which components in the equation can be considered as "frictional coefficient"? (c) a basic protein such as histone will move toward cathode or anode in a pH neutral electrophoresis buffer? (d) addition of polysaccharides in electrophoresis buffer would increase or decrease ion migration velocity? (e) is it correct that in pH neutral buffer, an ion with multiple positive charges would move faster than those with only one positive charge? (f) the addition of sodium dodecyl sulfate can help to determine the molecular weight of proteins. Why? (g) the same protein molecule would move faster in a big gel or in a small gel if same voltage is applied? (10%)

2. Please explain briefly the purposes of the following assays or techniques. (a) promoter-reporter gene assay. (b) electromobility shift (or electrophoretic retardation) assay (c) Western blotting (d) isoelectric focusing (e) Ames test (10%)

3. Please describe how "cDNA microarray chip" technology works? What are the major applications of this technology? If we use oligonucleotide to replace cDNA on the array, what could be the major difference in manufacturing the chips and their applications? (10%)

4. Answer following questions: (a) The diameter of a DNA double helix. (b) The approximate gene number in the human haploid genome. (c) The approximate number of nucleotide in the human haploid genome (d) The size of a bacterium (such as *E. coli*). (e) The size of a red blood cell. (f) The maximal absorption wavelength within UV-visible range for DNA (g) The optimal temperature for Taq DNA polymerase (h) The approximate size of a SARS virus (i) The normal blood sugar level (j) The approximate molecular mass of a protein with 100 amino acid residues. (10%)

5. Glucose 6-phosphate dehydrogenase (G6PD) catalyzes the following reaction:

Glc-6-P + NADP$^+$ → 6-phosphogloconate + NADPH

The enzyme glucokinase catalyzes: Glc + ATP → Glc-6-P + ADP

Please explain how to diagnose G6PD deficiency using biochemical assay? Similarly, how to determine the glucose level in a serum sample? Comparing with NADP$^+$, NADPH is more reduced or oxidized? (10%)

6. If you were given the amino acid sequence of a protein which is believed to be an integral membrane protein, i.e., a protein containing one or more membrane-spanning segments in its sequence, how would you go about predicting which region(s) of the protein forms the membrane-spanning helices? (15%)

7. What are glycoproteins and proteoglycans? Please list two possible biological functions of the carbohydrate moieties on a glycoprotein or a proteoglycan. (15%)

8. What is the Chemiosmotic Theory which describes the coupling of electron transfer through the respiratory chain and phosphorylation of ADP to ATP in mitochondria? (10%)

9. Please draw the chemical structure of a dipeptide: NH_3^--Ala-Asp-COO.. (10%)