1. What are the approximate concentration of the following phosphate species in 1 M phosphate solution at pH values of 2, 6, and 10? (10%)
   (a) H_3PO_4 (b) $H_2PO_4^-$ (c) HPO_4^{2-} (d)PO_4^{3-}

   Note that:

   $$H_3PO_4 \xleftrightarrow{pKa = 2.15} H_2PO_4^- \xleftrightarrow{pKa = 7.2} HPO_4^{2-} \xleftrightarrow{pKa = 12.4} PO_4^{3-}$$

2. Please answer the following questions regarding the properties of amino acids and protein. (10%)
   a. What is the absorbance wavelength most commonly used for determining protein concentration?
   b. Considering the amino acid composition of two proteins A and B listed in the table below:
      i. Which one is expected to have higher molar extinction coefficient at the wavelength you indicated above? Please provide the rationale for your answer.
      ii. Which one is more likely to have molecular weight ranging between 40 kD and 60 kD? Please provide the rationale for your answer.
      iii. Please suggest two experiments to confirm your answer in the question above (ii) for determining the molecular weight of these proteins?

Amino acid	A	C	D	E	F	G	H	I	K	L	M	N	P	Q	R	S	T	V	W	Y
Protein A	31	14	20	32	37	41	15	22	36	28	12	24	23	14	23	27	26	28	9	19
Protein B	73	15	49	70	27	76	19	68	74	70	32	40	39	34	32	46	43	63	3	20

（背面仍有題目，請繼續作答）

3. Please answer the following questions regarding the structural and functional characteristics of lipid membrane and proteins. (10%)
   a. Considering the importance of maintaining fluidity of biological membrane, please predict which of the following organism will have the highest percentage of unsaturated phospholipids in their membranes. Please explain your answer.
      i. Antarctic fish
      ii. Desert snake
      iii. Human being
      iv. Polar bear
      v. Thermophilic bacterium

   b. For integral membrane proteins, α-helices play an important role in anchoring the protein to the membrane. Please explain why a helix is a thermodynamically stable structural element to embed in a membrane.
   c. Which of the three 20-amino acid sequences listed below in the single letter amino acid code is the most likely candidate to form a transmembrane region of a transmembrane protein? Please explain your answer.
      i. ITLIYFGNMSSVTQTILLIS
      ii. LLLIFFGVMALVIVVILLIA
      iii. LLKKFFRDMAAVHETILEES

4. The genes encoding enzymes involved in tricarboxylic acid cycle (TCA cycle) are often called "house-keeping gene". (10%)
   a. Please define "house-keeping gene".
   b. Why are those enzymes involved in TCA cycle called "house-keeping gene"?
   c. Please write down two reactions that produce NADH in TCA cycle and the names of the enzymes that catalyzed the reactions.

5. Please answer the following questions bearing in mind the facts that living organisms are able to pass on their life and genetic messages to next generation with high consistency. (10%)
   a. What is "central dogma of molecular biology"?
   b. Please compare DNA and RNA molecules for the similarity and difference in terms of their structures and functions. You are encouraged to use table(s) to clarify your answer.
   c. Please compare gene transcription and translation in terms of their (1) purposes, (2) molecules participate, (3) localization and (4) the starting sites of the processes on the sequence templates (The binding sites of mediated machinery).

6. Please answer the following questions regarding lipid metabolism. (10%)
   a. What is the immediate source of carbons for fatty acid biosynthesis?
   b. What is the role of the citrate-pyruvate shuttle in making carbon compounds available for fatty acid biosynthesis?
   c. Why do mammals require certain essential fatty acids in their diet?

7. Please fill in the answers for (A)(B)(C)(D) and (E).
   The two metabolic reactions below occur in the process of __(A)__ . In the first step nitrate is reduced to nitrite while in the second step nitrite is converted to ammonium. Step (1) is catalyzed by ___(B)___ and step (2) is catalyzed by ___(C)___.

   i. $NO_3^- + 2H^+ + 2e^- \rightarrow NO_2^- + H_2O$
   ii. $NO_2^- + 8H^+ + 6e^- \rightarrow NH_4^+ + H_2O$

   The enzyme___(D)___ is responsible for catalysis of the following reaction in a process known as ___(E)___. (10%)

   $N_2 + 8H^+ + 8e^- \rightarrow 2NH_3 + H_2$

（背面仍有題目，請繼續作答）

8. Compare and contrast SDS-PAGE and modern two-dimensional gel electrophoresis of proteins. (10%)

9. The result of Human Genome Project reveals that there are approximately 20,000-25,000 genes in human DNA. However, it is estimated that more than 25,000 types of proteins are required for maintaining a normal and functioning physical condition in human. Please describe **four** mechanisms by which more than one biological functions can be accomplished by the products of a single gene. (10%)

10. Please briefly describe the methods or tools listed below for their principles underlined and application or tasks achieved. (10%)
    a. RNA interference techniques
    b. Dominant negative techniques
    c. Flow cytometry
    d. Tet-On and Tet-Off expression systems