1. (12%) Enthalpy is an important quantity in thermal physics and chemistry. **(A)** What is the definition of enthalpy? **(B)** Explain the difference between the change of enthalpy and the change in internal energy in a chemical or physics process. **(C)** Why is enthalpy more useful than internal energy in measuring heat transferred to the system in most biological processes?

2. (12%) In a chemical reaction taking place at 300K, the change in enthalpy was -60 kJ mol^{-1} and the change in entropy was -100 J $K^{-1}mol^{-1}$. **(A)** Calculate the change in Gibbs energy. **(B)** Is the reaction spontaneous? **(C)** Calculate the total change in entropy of the system and the surroundings.

3. (10%) Describe the basic quantum principle of electron microscopy. Why can it achieve a much higher resolution than the conventional optical microscopy does?

4. (15%) **(A)** Please describe the gross selection rule for infrared absorption spectra. **(B)** Which of the following molecules are infrared active: O_2, H_2O, and CH_4?

5. (15%) **(A)** Please explain what an isosbestic point is in spectroscopy. **(B)** The reaction of molecule A converting to molecule B was monitored overtime by a uv-vis spectrometer. The absorption spectra of this reaction exhibit an isosbestic point. What does it imply?

6. (6%) If you have charged amino acids into a hydrophobic environment, like inside of membrane bilayer, how their pKa changes (shift up or down)? State your reason (please consider both positively and negatively charged residues).

7. (5%) Please write down and explain Stokes-Einstein equation. How can we use the relationship to estimate molar mass of a molecule?
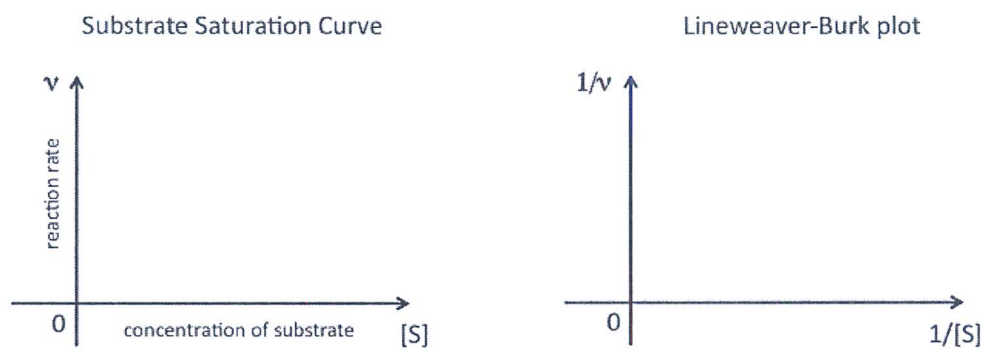
8.　(10%) Please describe Michaelis-Menten equation and make plots of **(A)** regular substrate saturation curve and **(B)** Lineweaver-Burk plot. In the plots, please label the critical parameters of V_{max}, K_M, X- and Y-intercepts and slope in the plot.

Substrate Saturation Curve

v (reaction rate) vs. concentration of substrate [S]

Lineweaver-Burk plot

1/v vs. 1/[S]

9.　(15 %) There is a enzyme reaction that the following data represents on the rate of formation of product (d[P]/dt) in different substrate concentrations. Plot these data according to the Lineweaver-Burk plot and determine values of K_M and V_{max}. If the reaction contains 0.1 mM enzyme, please calculate the K_{cat} value.

Substrate concentration (mM)	2.5	5.0	10.0	15.0	20.0
d[P]/dt (mM·S^{-1})	0.24	0.36	0.53	0.60	0.64