

國立清華大學 105 學年度碩士班考試入學試題

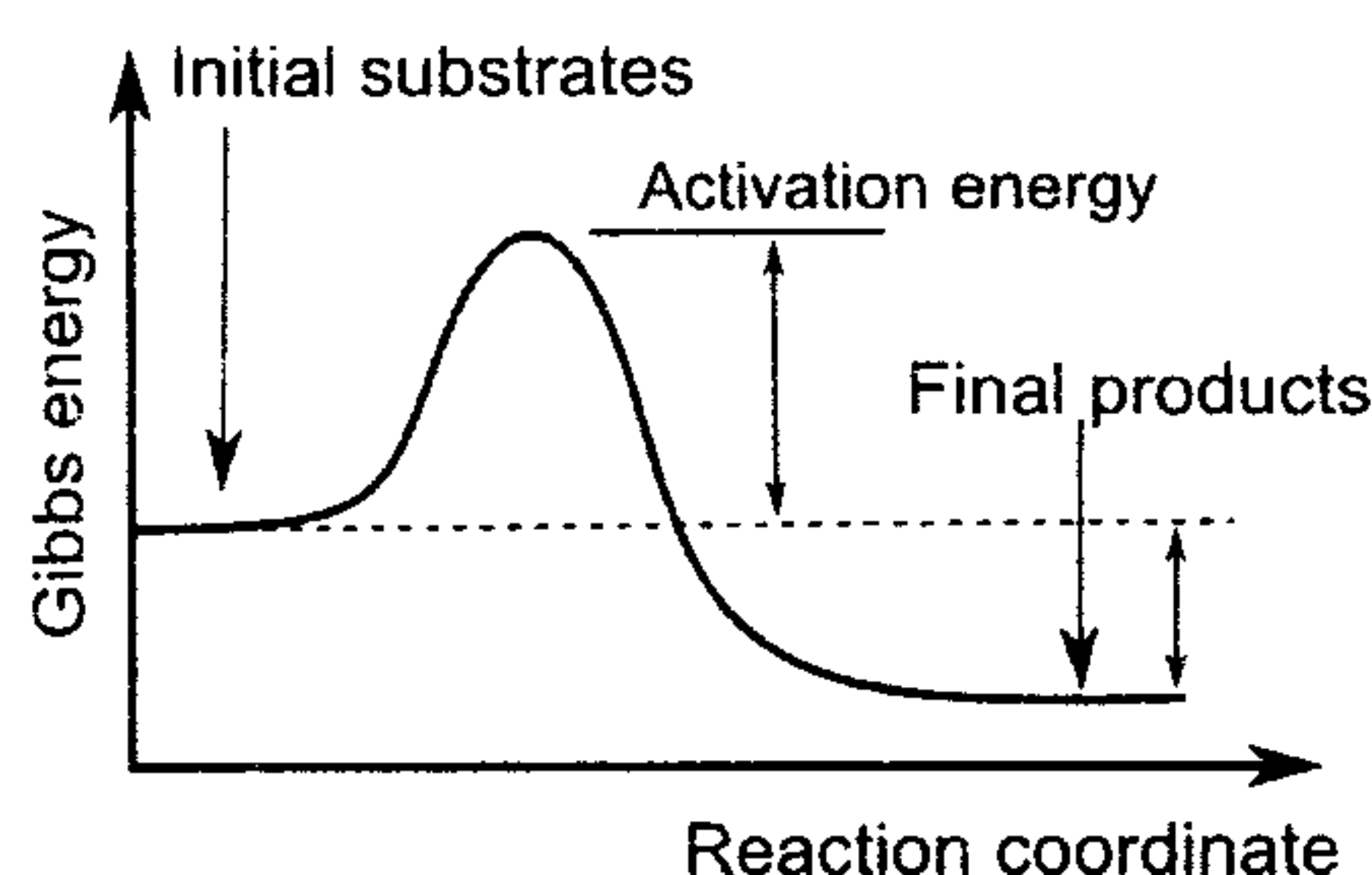
系所班組別：生命科學院丙組

考試科目（代碼）：物理化學(0603)

共 4 頁，第 1 頁

*請在【答案卷】作答

1. (10%) Enzymes accelerate reactions that have a substantial activation energy. The plot below shows the energy surface for a reaction without enzyme. **A.** Please draw a curve indicating how the energy surface changes when an enzyme is added to the reaction. (5%) **B.** How does a rise of temperature affect the reaction velocity? Why? (5%)



2. (10%) A tennis game is being played in a quantum-mechanical world. A player first hits the ball across the net. Her opponent runs the spot where the ball is expected to bounce and prepare to make a strike. Assume that the uncertainty of the velocity of the ball is 5 nm s^{-1} , that it weighs $2.1 \times 10^{-22} \text{ kg}$ and that the racket has a diameter of 50 nm . **A.** Based on Heisenberg's uncertainty principle, what is the uncertainty in the position of the ball? (5%) **B.** Can the opponent hit the ball? ($\hbar = 1.05 \times 10^{-34}$) (5%)
3. (15%) **A.** Scanning tunneling microscope (STM) can image surface of an object at the atomic level. What quantum physics phenomenon is STM based? (5%) **B.** Explain how STM works. (5%). **C.** Why STM has limited use for biological samples? (5%)

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4. (10%) Consider a quantum vibrator formed by a diatomic molecule with the energy states:

$$E = \left(v + \frac{1}{2} \right) \hbar \omega ,$$

Where v is the quantum number and ω is the angular frequency, which is given by $\omega = \sqrt{k/m}$. k is the equivalent spring constant of the bond between the two atoms and m is the effective mass of the molecule.

- A. If $k = 4000 \text{ Nm}^{-1}$ and $m = 1 \times 10^{-25} \text{ kg}$. What is the absorption wavelength of this molecule when it makes transitions between neighboring states?
Assume the speed of light $= 3 \times 10^8 \text{ m}$. (6%)
- B. Explain why the vibrational spectrum can often be used for identification of molecule composition. (4%)
5. (5%) A Carnot cycle is a cycle composed of two isothermal lines and two adiabatic lines. Illustrate a Carnot cycle on a pressure-volume diagram and on an entropy-temperature diagram.
6. (10%) A Carnot engine is operating between two reservoirs at temperature T_H (hot) and T_C (cold), respectively. ΔT represents a small change in temperature. To increase the efficiency of the engine, would it better to increase T_H by ΔT while keeping T_C constant, or decrease T_C by ΔT while keeping T_H constant? Explain your argument. Both T_H and T_C are much higher than the ambient temperature.

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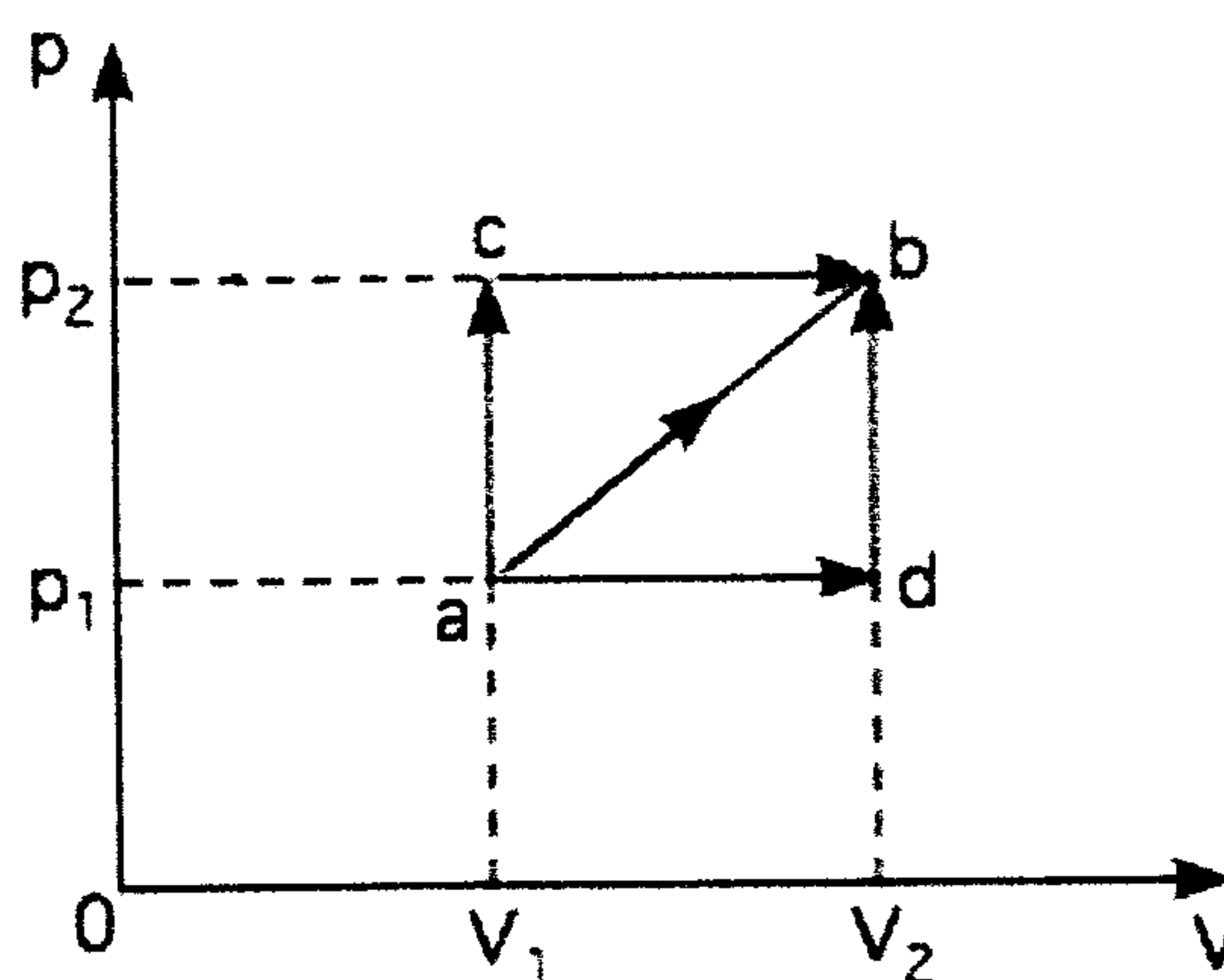
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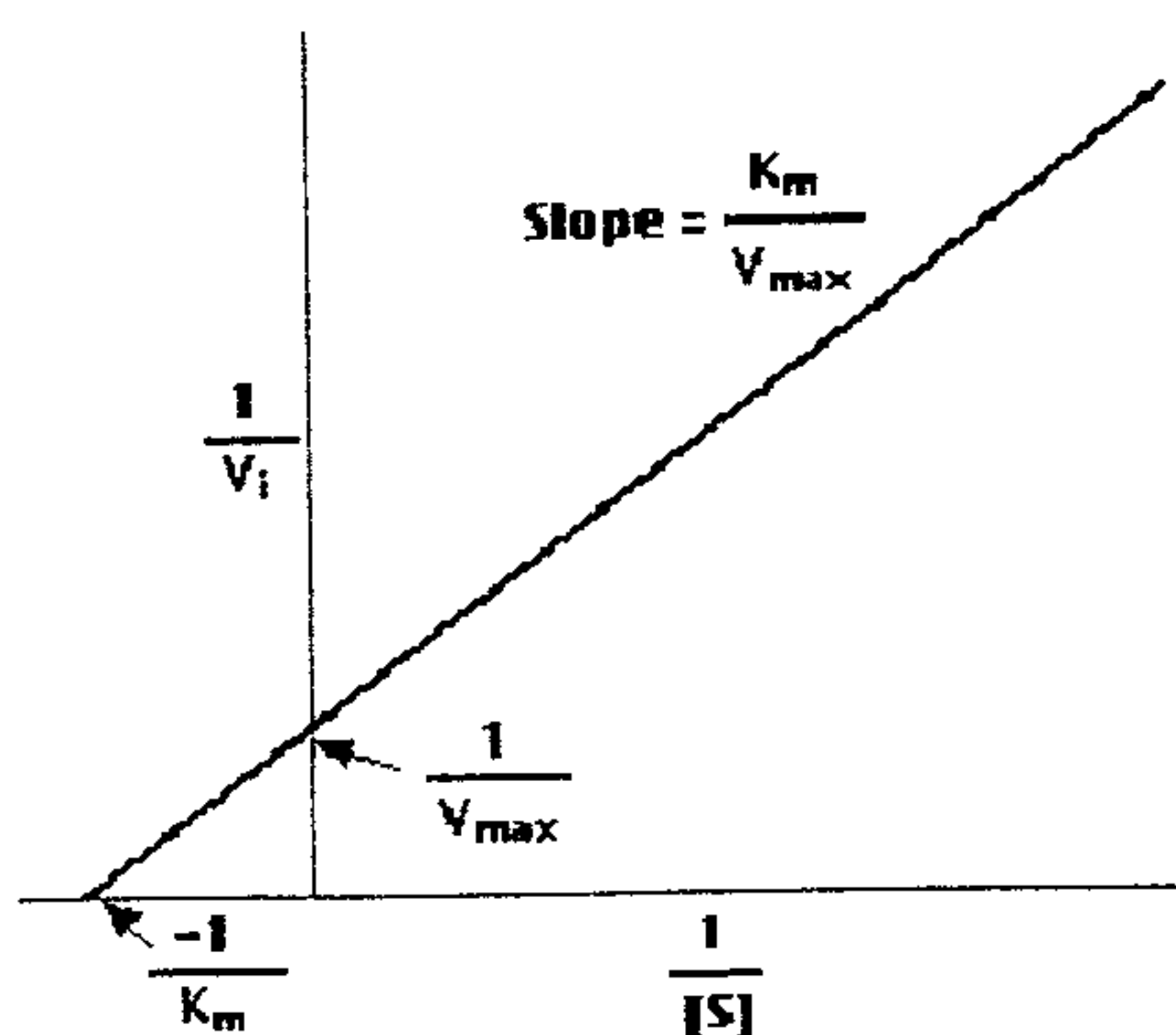
共 4 頁，第 3 頁

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7. (10%) As shown in the figure on the right, an ideal gas is taken from state **a** (at temperature T_1) to state **b** (at T_2) via three different paths: acb, adb, and ab. Let $p_2 = 2 p_1$ and $V_2 = 2 V_1$. **A.** Compute the heat supplied to the gas along each of the three paths in terms of R (gas constant) and T_1 . **B.** What is the heat capacity C_{ab} of the gas for the process ab?



8. (5%) For the dimerization reaction $2A \rightarrow A_2$, with $\Delta G > 0$ and $\Delta H > 0$, suggest two ways to improve the yield of A_2 .
9. (5%) What is the difference between a liposome and a micelle?
10. (8%) Please make Lineweaver-Burk plots for (i) competitive inhibition; (ii) pure non-competitive inhibition and (iii) uncompetitive inhibition. Comparing to the condition without inhibitor, please describe how K_M and V_{max} change under the different conditions (K_M and V_{max} increase or decrease or no change).



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11. (8%) **A.** Please write down the Beer-Lambert law. (2%) **B.** NADH and NAD^+ are important biological substances. The two compounds have equal absorption coefficients, $1.8 \times 10^4 \text{ dm}^3 \text{ mol}^{-1} \text{ cm}^{-1}$, at 260 nm (as the isosbestic point). However, at 340 nm, NAD^+ has no absorption but NADH has an absorption coefficient of $6.22 \times 10^3 \text{ dm}^3 \text{ mol}^{-1} \text{ cm}^{-1}$. A solution containing both substances has an absorbance of 0.43 at 340 nm and of 1.7 at 260 nm. Please calculate the concentration of each substance. (6%)
12. (4 %) For a light-penetrable solution, if it shows purple color, can you predict the wavelength (nm) with maximum absorption (ϵ_{max}) in VIS spectrum? Explain your answer.

