

國立清華大學 101 學年度碩士班入學考試試題

系所班組別：生命科學院乙、丙組、醫學生物科技學程

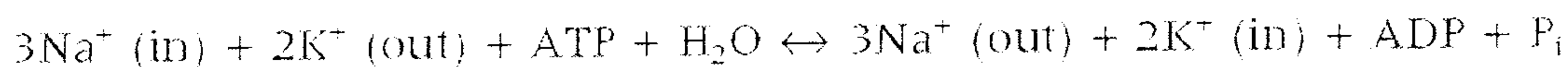
考試科目（代碼）：物理化學(0503、0603、0707)

共 5 頁，第 1 頁 *請在【答案卷】作答

Assistant tool for calculation:

R: $8.3 \text{ J mol}^{-1}\text{K}^{-1}$, F: $96.5 \text{ kJ V}^{-1}\text{mol}^{-1}$, $\ln 7.5 = 2.0$; $\ln 5 = 1.6$; $\ln 0.2 = -1.61$; $\ln 0.05 = -3.00$

1. (15%) Consider the Na^+/K^+ -ATPase reaction to be present in a membrane with the following conditions: Na^+ concentration inside, 20 mM; Na^+ concentration outside, 150 mM; K^+ concentration inside, 50 mM; K^+ concentration outside, 10 mM; V (inside) - V (outside), -50 mV; temperature, 310 K.



- Calculate the free-energy difference for moving Na^+ from the inside to the outside.
- Calculate the free-energy difference for moving K^+ from outside to the inside.
- Calculate the free-energy difference for moving both Na^+ and K^+ in the observed stoichiometry.
- Calculate the free energy change contributed by converting ATP to ADP (the standard free energy difference of $-31.3 \text{ kJ mol}^{-1}$), thousand-fold greater amount of ATP than ADP.
- Can this reaction occur spontaneously?

2. (5%) Calculate the pH at which the δ -carboxyl group of glutamic acid is 20% dissociated. (For the glutamic acid side chain, $\text{pK}_a = 4.5$)

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3. (20%) When a double-stranded oligonucleotide (D) in solution is heated, it melted to two single strands (F and B). The absorbance at 260 nm changes with the equilibrium between double and single stranded DNAs, according to:



A DNA duplex D whose concentration is 100 μM is melted in solution. Below 10°C, the solution contains only duplex and above 60°C, the solution only contains single strands. Assume the molar extinction coefficient ϵ is temperature-independent and F and B are with the same extinction coefficients.

- Please use the table below to calculate the individual molar extinction coefficients of D, F and B.
- Calculate the equilibrium constant K_D at 30°C.
- Calculate the corresponding ΔG° at 30°C.
- Please estimate the melting temperature, which is defined as the temperature at which the double stranded DNA is half melted.

Temperature (°C)	10	20	30	40	50	60
OD ₂₆₀ (Measured in a 1 cm pathlength cuvette)	0.790	0.813	0.852	0.940	0.990	1.114

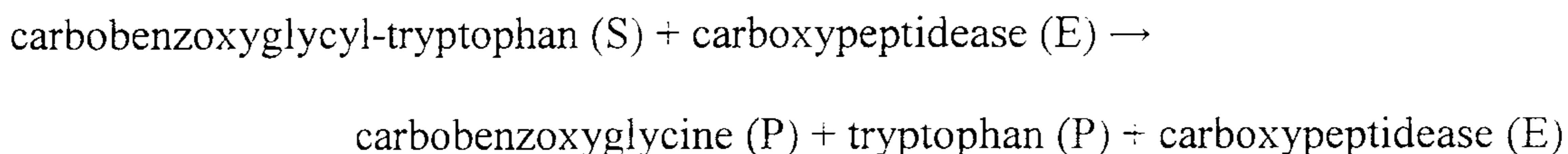
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4. (15%) (a) Please make plots of Lineweaver-Burk plot for Micaelis-Menten equation. In the plot, please label the x- and y-intercepts and slope by the teams of V_{\max} and K_M . (6%) (b) A student determined the hydrolysis of carbobenzoxyglycyl-tryptophan catalyzed by carboxypeptidase. It occurs according to the reaction:



He performed the experiment under $1 \mu\text{M}$ carboxypeptidase and got the following data on the rate of formation of tryptophan ($d[P]/dt$). Please use these data to determine the corresponding values of K_M , V_{\max} and k_{cat} . (9 %)

Substrate concentration (mM)	1.0	1.5	2.5	5.0	8.0
Rate, $d[P]/dt$ (mM \cdot S $^{-1}$)	0.011	0.015	0.024	0.036	0.044

5. (10%) An ideal gas (2.0 mol) is compressed isothermally and irreversibly by a constant pressure p_{ext} until $p_{\text{final}} = p_{\text{ext}}$. Calculate ΔS_{system} , $\Delta S_{\text{surroundings}}$ and ΔS_{total} . Please consider temperature $T = 27^\circ\text{C}$, $v_{\text{initial}} = 50 \text{ L}$, $v_{\text{final}} = 10 \text{ L}$.

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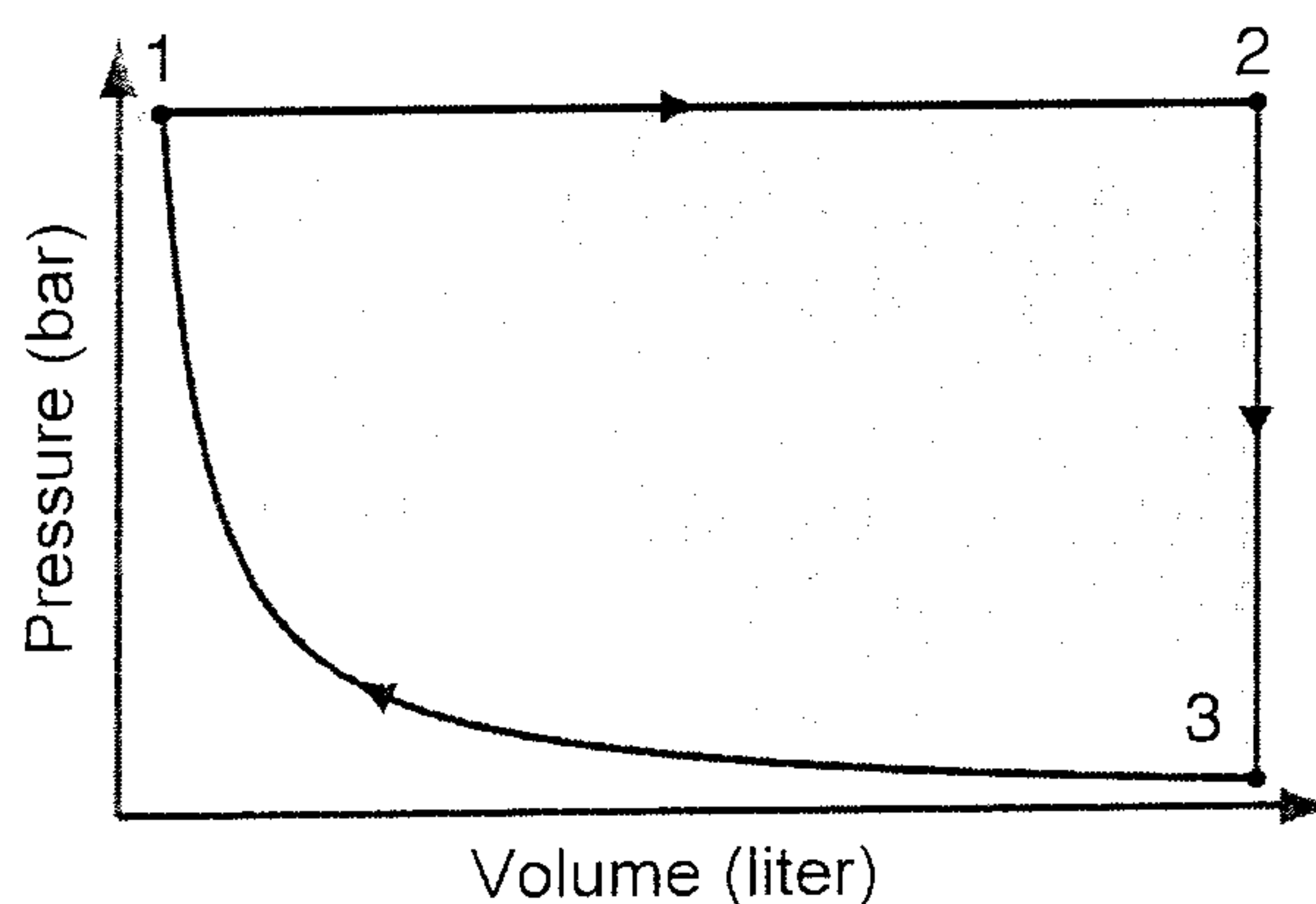
6. (5%) Fluorescence resonance energy transfer (FRET) can be used to measure distance between two chromophores of donor and acceptor (R_{DA}). The efficiency of energy transfer depends on the distance R_{DA} , according to the equation: efficiency = $R_0^6 / (R_0^6 + R_{DA}^6)$. We individually link fluorescence donor and acceptor to protein N- and C-terminal ends. If we study a protein with 100 amino acids and the corresponding value of $R_0 = 6$ nm. Under a special condition, we found FRET efficiency = 0.15. Please estimate the apparent distance R_{DA} between donor and acceptor. Based on the result, please speculate whether the protein is well folded or denatured under the condition if we assume a length of 3.5 \AA for an amino acid?

7. (14%) An ideal gas (2.0 mol) is taken through a cycle as indicated on the right p-v diagram in the direction indicated by arrows. Segment 3→1 is isothermal. Calculate q , w , ΔU and ΔH for each segment and for the whole cycle.

$$p_1 = 12 \text{ bar}; v_1 = 1 \text{ L}$$

$$p_2 = 12 \text{ bar}; v_2 = 20 \text{ L}$$

$$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$$



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8. (16%) For the following processes, fill all the blanks with either +, - or 0.

Process	ΔU	w	q	ΔH
Melting of ice at 0°C and 1 atm.				
Compression of an ideal gas reversibly and adiabatically.				
Cooling of an ideal gas reversibly at constant pressure.				
Free expansion of an ideal gas into twice the volume in a closed adiabatic box.				