注意：考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。

國立清華大學 109 學年度碩士班考試入學試題

系所班組別：生命科學院
丙組

科目代碼：0603

考試科目：物理化學

—作答注意事項—

1. 請核對答案卷（卡）上之准考證號、科目名稱是否正確。
2. 作答中如有發現試題印刷不清，得舉手請監試人員處理，但不得要求解釋題意。
3. 考生限在答案卷上標記「由此開始作答」區內作答，且不可書寫姓名、准考證號或與作答無關之其他文字或符號。
4. 答案卷用盡不得要求加頁。
5. 答案卷可用任何書寫工具作答，惟為方便閱卷辨識，請儘量使用藍色或黑色書寫；答案卡限用 2B 鉛筆畫記；如畫記不清（含未依範例畫記）致光學閱讀機無法辨識答案者，其後果一律由考生自行負責。
6. 其他應考規則、違規處理及扣分方式，請自行詳閱准考證明上「**國立清華大學試場規則及違規處理辦法**」，無法因本試題封面作答注意事項中未列明而稱未知悉。

國立清華大學 109 學年度碩士班考試入學試題

系所班組別：生命科學院乙組、丙組

考試科目（代碼）：物理化學(0503、0603)

1. (15%) The molar Gibbs free energy (G) of incompressible liquid or solid with a constant temperature is given by $G(p_f) = G(p_i) + (p_f - p_i)V$,
where p_f and p_i are the final and initial pressure, respectively, and V is the molar volume of the substance. (A) For most substances, the molar volume is larger in the liquid state than in the solid state. On a G-p plot (G as the y axis and p as the x axis), draw two lines that represent the solid and liquid states of this type of substances based on the equation given above. (B) Explain why these substances exist as the liquid state with low pressure but make a phase transition to the solid state when the pressure is increased and passes a certain critical point. (C) Interestingly, water has a larger molar volume in the solid state than in the liquid state around 0°C. Plot a G-p plot for water and explain why ice melts under high pressure.

2. (15%) In a particular biological reaction taking place in the body at 37°C (310K), the change in enthalpy is 30.5 KJ mol^{-1} and the change in entropy is 100 J $K^{-1}mol^{-1}$. (A) Given that $\Delta G = \Delta H - T\Delta S$, calculate the change in Gibbs energy. (B) Is the reaction spontaneous? (C) If ΔH and ΔS remains the same, what happens to the reaction when the temperature drops to 27°C? Please calculate ΔG and provide your answer based on the calculation.

3. (10%) Molar heat capacitance can be measured under the constant pressure ($C_p = \Delta H/\Delta T$) or constant volume ($C_v = \Delta U/\Delta T$) conditions. (A) Given the definition of enthalpy $H = U + pV$, where U is the internal energy, p is the pressure and V is the molar volume, prove that for ideal gas, $C_p - C_v = R$, where R is the ideal gas constant. (B) Explain, from the molecular dynamics point of view, why is $C_{p,m} > C_{v,m}$ for the ideal gas?

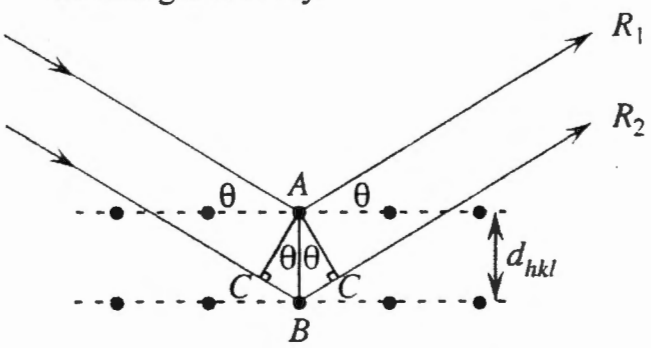
4. (10%) (A) Please explain the process of stimulated emission, and express the equation of rate of simulated emission. (B) If one photo hits the atom, how many photons will be produced under the condition of stimulated emission.

國立清華大學 109 學年度碩士班考試入學試題

系所班組別：生命科學院乙組、丙組

考試科目（代碼）：物理化學(0503、0603)

5. (10%) Please derive Bragg's law ($2d_{hkl}\sin\theta = n\lambda$), based on which R1 and R2 are constructive X-rays diffracted by electrons. n is a positive integral number; λ is the wavelength of X-ray.



6. (10%) The IR radiation from the Sun is absorbed by CO_2, which contributes to the greenhouse effect. The normal modes of vibration for CO_2 include asymmetric stretching, symmetric stretching and bending. (A) Which of the abovementioned vibrational modes are IR-active? (B) Which of the abovementioned vibrational modes are Raman-active?

7. (10%) In NMR spectroscopy, we use chemical shift to characterize the resonances of atoms. Can you explain how to define "chemical shift"? Which factors will influence Chemical shift?

8. (10%) Please write down Michaelis-Menten equation and explain how to use the equation to distinguish competitive, uncompetitive and noncompetitive inhibitions for different inhibitors binding enzymes.

9. (10%) To determine protein-protein interaction is very important for characterizing protein function. Please describe three different methods that enable to determine protein-protein interaction and the binding constant K_D. In your answer, please include the principles of how the three methods function.