國立中山大學114學年度
碩士班考試入學招生考試試題

科目名稱：基礎熱力學【材光系碩士班選考、材料前瞻應材碩士班選考、材光聯合碩士班選考】

—作答注意事項—

考試時間：100分鐘

- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
- **答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示**，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，請衡酌作答。
- 答案卡請以2B鉛筆劃記，不可使用修正液（帶）塗改，未使用2B鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，後果由考生自負。
- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。
- 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶書籍、紙張（應考證不得做計算紙書寫）、具有通訊、記憶、傳輸或收發等功能之相關電子產品或其他有礙試場安寧、考試公平之各類器材入場。
- **試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。**
- **試題採雙面列印，考生應注意試題頁數確實作答。**
- **違規者依本校招生考試試場規則及違規處理辦法處理。**

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Single-choice questions

Instructions: For each question, you must identify the answer that best answer the question. There is only one correct answer for each question.
(5 points each)

1. Which of the following is not a characteristic of an ideal gas?
   A. Ideal gases have negligible volume.
   B. Ideal gases do not collide.
   C. Ideal gases are constantly in random motion.
   D. Ideal gases do not have intermolecular interactions.

2. Free energy change of a chemical reaction can be positive, zero, or negative. Which of the following is a correct statement regarding Gibbs Free energy?
   A. When Gibbs free energy change is positive, the chemical reaction cannot proceed in appreciable time.
   B. When Gibb's free energy change is negative, the chemical reaction must proceed.
   C. When Gibb's free energy is zero, the chemical reaction must proceed.
   D. None of the above.

3. The Clausius-Clapeyron equation describes how surface pressure changes with temperature. What can this equation be used for?
   A. Clausius-Clapeyron equation can be used to evaluate the slope of phase transformation boundaries on a P-V phase diagram
   B. Clausius-Clapeyron equation can be used to predict mobility of molecules at the surface of liquids.
   C. Clausius-Clapeyron equation can be used to evaluate the slope of a vapor dome on a P-V phase diagram.
   D. Clausius-Clapeyron equation can be used to evaluate the shape of phase boundaries on a P-T phase diagram.

4. A eutectic phase diagram describes the phases in a system. Which of the following statements must be true about a eutectic system?
   A. A eutectic system only contains solids.
   B. A eutectic system must contain at least two elements.
   C. Liquid phases in a eutectic mixture can exist below the eutectic temperature.
   D. The composition of any point on a eutectic diagram can be described using the lever rule that compare the ratios of each elements' compositions.

5. A thermodynamic engine runs in a cycle to transform heat into appreciable and useful work. Which of the following is true about a thermodynamic heat engine?
   A. A thermodynamic engine runs in a cycle, so it must be a perpetual motion machine.
   B. Heat input into a thermodynamic engine must be used for phase transformation.
   C. Efficiency of a thermodynamic engine is a ratio of output work versus heat input.
   D. The only ideal thermodynamic engine utilizes the Carnot cycle.

6. What does configurational entropy describe?
   A. Configurational entropy is the total measurement of chaos in a system.
   B. Configurational entropy is a measure of chaos based on the number of possible arrangements in a system.
   C. Configurational entropy is an evaluation on the crystallinity of a material.
   D. Configurational entropy is the difference between Gibbs free energy and enthalpy.

7. According to the laws of thermodynamics, which of the following scenario is clearly impossible?
   A. A rubber ball dropped from a high point bounces weaker and lower with each bounce.
   B. A liquid under high pressure transforms into a solid.
   C. A semi-crystalline sample gains greater intrinsic defect concentration when lowered in temperature.
   D. A hot air balloon rises into the sky, and it slowly floats down when the hot air balloon burner stops.

8. Hess's law allows one to calculate thermodynamic quantities of a process without needing to conduct actual experiment. What is the underlying reasoning to allow hess's law's functions?
   A. Hess's law adds the thermodynamic quantities together to get the combined quantities.
   B. Thermodynamic quantities are state functions, so they can be compared arithmetically without worrying about the path taken.
   C. Hess's law does not consider friction, so it is applicable for chemical reactions.
   D. Entropy never decreases, so it will eventually end up in the same universal reservoir. Hence, Hess's law can add it all together.

9. A reversible reaction can achieve equilibrium over time, which of the following must be true about a chemical reaction system that has achieved equilibrium?
   A. All molecules in the equilibrated system must be motionless.
   B. The temperature of the equilibrated system must be at zero Kelvin.
   C. The entropy of the system must be maximized at equilibrium.
   D. The concentration of components in the system must change very slowly.

10. Which of the following is a correct description of a catalyst's function?
    A. Catalysts do not get consumed in reaction because catalysts do not affect reaction.
    B. Greater catalyst concentration will always make a chemical reaction more spontaneous.
    C. Catalysts do not affect the spontaneity of chemical reactions.
    D. Catalysts are universal, so all reactions can use the same catalyst.

11. What is the sum of internal energy and gaseous work?
    A. Gibbs free energy
    B. Entropy
    C. Heat capacity
    D. Enthalpy

12. Heat capacities of crystalline solids are based on the amount of heat required to increase movement of molecules in a solid. Of the following choices, which one is the most accurate model for making estimations?
    A. Heat capacity per mole is 3R.
    B. Heat capacity per mole can be estimated when solids are modeled as molecules held in place by spring-like chemical bonds unaffected by surrounding molecules.
    C. Heat capacity per mole can be estimated by modeling molecules as independent oscillators with discrete energy levels.
    D. Heat capacity per mole can be estimated by treating molecules as a collective wave that can transform and deform together to alter individual energy levels.

Long Answer questions

Instructions: The questions require more extensive work and calculations. Please circle your final answers. Some questions may require an explanation, please circle your explanations. (10 points each)

13. You found two of your friends arguing about the rection rates of two hypothetical chemical reactions. Examine their arguments and answer the question.

    Friend Albert: *"My reaction between benzaldehyde and aniline will be faster because the Schiff base reaction will have a lower energy barrier than your reaction."*
    Friend Betty: *"My reaction between benzaldehyde and water will be faster because it has a negative change in Gibbs free energy."*
    Question - Which one of the two friends is correct? Are they both correct? Or are they both wrong? Explain your answer with reasoning.

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14. Given a thermodynamic cycle that follows the following functions when operating between 25°C to 300°C;
P = 600-V
P = 600 – 1.5V
P = 2200 – 6V
P = 1700 -6V

How much work can this thermodynamic cycle achieve in one cycle?
(P is pressure in kPa, and volume in Liters)

15. Johnny has a 1.0 L helium balloon that he bought from a vendor in New York. He then goes on a cruise adventure to Antarctica. When he decides to exit the ship's chambers to look at the penguins from the ship's deck, he donned his thick fluffy winter jacket and brought his balloon with him. He noticed from the thermometer that there's a 70°C difference between New York and Antarctica. Once he got onto the deck of the ship, the cold hit him and he noticed that his balloon had shrank significantly, but his jacket stayed unchanged. Please answer the following questions;
    A. By what percentage does the balloon shrink? (5 points)
    B. Why does the balloon shrink, but the fluffy jacket does not? (5 points)

16. Starting from $\Delta G = \Delta H - T\Delta S$, please derive the Gibbs-Helmholtz equation.