

國立中正大學  
110 學年度碩士班招生考試  
試題

[第 3 節]

科目名稱	物理分析化學
系所組別	化學暨生物化學系

—作答注意事項—

※作答前請先核對「試題」、「試卷」與「准考證」之系所組別、科目名稱是否相符。

- 1.預備鈴響時即可入場，但至考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。
- 2.考試開始鈴響時，即可開始作答；考試結束鈴響畢，應即停止作答。
- 3.入場後於考試開始 40 分鐘內不得離場。
- 4.全部答題均須在試卷（答案卷）作答區內完成。
- 5.試卷作答限用藍色或黑色筆（含鉛筆）書寫。
- 6.試題須隨試卷繳還。



國立中正大學 110 學年度碩士班招生考試試題

科目名稱：物理分析化學

本科目共 5 頁 第 1 頁

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物理化學

基本物理常數

$$h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}; \quad k = 1.381 \times 10^{-23} \text{ J/K}; \quad 1 \text{ amu} = 1.661 \times 10^{-27} \text{ kg};$$

$$c = 2.998 \times 10^8 \text{ m/s}; \quad m_e = 9.109 \times 10^{-31} \text{ kg}; \quad 1 e = 1.602 \times 10^{-19} \text{ C}.$$

一、單選題 (每題 2 分, 共 56 分, 務必依考題順序填答, 否則不予以計分!)

- Which range of the electromagnetic waves is mainly used in the NMR spectroscopy?  
(A) Visible lights (B) X rays (C) Radiofrequencies  
(D) Microwaves (E) Infrared radiation
- Light has a wavelength of  $5.6 \times 10^2 \text{ nm}$ . What is the energy of a photon of this light?  
(A)  $2.53 \times 10^{18} \text{ J}$  (B)  $3.95 \times 10^{-20} \text{ J}$  (C)  $1.24 \times 10^{-18} \text{ J}$   
(D)  $1.18 \times 10^{-19} \text{ J}$  (E)  $3.55 \times 10^{-19} \text{ J}$
- Which of the following statements are true?  
I. An excited atom can return to its ground state by absorbing electromagnetic radiation.  
II. The energy of an atom is increased when electromagnetic radiation is emitted from it.  
III. The energy of electromagnetic radiation increases as its frequency increases.  
IV. An electron in the  $n = 4$  state in the hydrogen atom can go to the  $n = 2$  state by emitting electromagnetic radiation at the appropriate frequency.  
V. The frequency and wavelength of electromagnetic radiation are inversely proportional to each other.  
(A) III, V (B) II, III, IV (C) I, II, IV  
(D) I, II, III (E) III, IV, V
- The wavelength of light associated with the  $n = 2$  to  $n = 1$  electron transition in the hydrogen spectrum is  $1.216 \times 10^{-7} \text{ m}$ . By what coefficient should this wavelength be multiplied to obtain the wavelength associated with the same electron transition in the  $\text{Li}^{2+}$  ion?  
(A) 1 (B) 1/3 (C) 1/4 (D) 1/7 (E) 1/9
- For an electron in a one-dimensional box, what is the minimum energy to excite the electron from the ground state?  
(A)  $5h^2/8mL^2$  (B)  $2h^2/8mL^2$  (C)  $h^2/8mL^2$   
(D)  $3h^2/8mL^2$  (E)  $4h^2/8mL^2$
- What is the electron configuration for the chromium atom?  
(A)  $[\text{Kr}] 4s^1 3d^5$  (B)  $[\text{Ar}] 4s^2 3d^4$  (C)  $[\text{Kr}] 4s^2 3d^4$   
(D)  $[\text{Ar}] 4s^1 3d^5$  (E) none of these
- Consider the following sets of quantum numbers. Which set represents impossible combinations?  
(A)  $n = 1, l = 0, m_l = 0, m_s = +1/2$  (B)  $n = 2, l = 1, m_l = 2, m_s = -1/2$   
(C)  $n = 4, l = 3, m_l = -2, m_s = -1/2$  (D)  $n = 3, l = 2, m_l = -1, m_s = -1/2$
- Which of the following statements is true about the ionization energy of  $\text{Mg}^+$ ?  
(A) It will be equal to and opposite in sign to the electron affinity of Mg.  
(B) It will be equal to and opposite in sign to the electron affinity of  $\text{Mg}^+$ .  
(C) It will be equal to the ionization energy of Li.  
(D) It will be equal to and opposite in sign to the electron affinity of  $\text{Mg}^{2+}$ .  
(E) none of the above
- A polished metal surface requires  $1.75 \times 10^{-19} \text{ J}$  to remove electrons via the photoelectric effect. When photons with a wavelength of  $237 \text{ nm}$  strike the surface, what will be the kinetic energy of the ejected electrons?  
(A)  $1.75 \times 10^{-19} \text{ J}$  (B)  $1.01 \times 10^{-18} \text{ J}$  (C)  $8.39 \times 10^{-19} \text{ J}$   
(D)  $6.64 \times 10^{-19} \text{ J}$  (E) none of the above

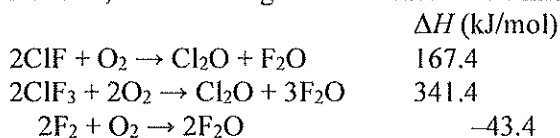
**Answer question 10 to 14 according to the following information.**

A general reaction written as  $2A + 2B \rightarrow C + 2D$  is studied and yields the following data.

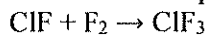
[A] <sub>0</sub>	[B] <sub>0</sub>	Initial $\Delta[C]/\Delta t$
0.100 M	0.100 M	$4.00 \times 10^{-5}$ mol/L·s
0.200 M	0.100 M	$4.00 \times 10^{-5}$ mol/L·s
0.100 M	0.200 M	$8.00 \times 10^{-5}$ mol/L·s

10. For the first of the reactions in the table of data, determine  $-\Delta[B]/\Delta t$ .  
 (A)  $8.00 \times 10^{-5}$  (B)  $1.60 \times 10^{-4}$  (C)  $4.00 \times 10^{-5}$   
 (D)  $2.00 \times 10^{-5}$  (E) none of these
11. What is the order of the reaction with respect to B?  
 (A) 3 (B) 2 (C) 4 (D) 1 (E) 0
12. What is the overall order of the reaction?  
 (A) 0 (B) 2 (C) 3 (D) 4 (E) 1
13. What are the proper units for the rate constant for the reaction?  
 (A)  $L \cdot mol^{-1} \cdot s^{-1}$  (B)  $s^{-1}$  (C)  $L^3 \cdot mol^{-3} \cdot s^{-1}$   
 (D)  $mol \cdot L^{-1} \cdot s^{-1}$  (E)  $L^2 \cdot mol^{-2} \cdot s^{-1}$
14. What is the numerical value of the rate constant?  
 (A)  $4.00 \times 10^{-1}$  (B)  $4.00 \times 10^{-2}$  (C)  $4.00 \times 10^{-3}$   
 (D)  $4.00 \times 10^{-4}$  (E) none of these
15. Which process would take longest time?  
 (A) internal conversion (B) vibrational relaxation (C) intersystem crossing  
 (D) fluorescence (E) phosphorescence
16. Which partition function of energy states is least sensitive the temperature?  
 (A) electronic states (B) vibrational states (C) rotational states  
 (D) electronic spin states (E) nuclear spin states
17. Based on the Boltzmann distribution and degeneracies, which kind of energy states does not populate the most on the lowest energy state?  
 (A) electronic states (B) vibrational states (C) rotational states  
 (D) electronic spin states (E) nuclear spin states
18. Which of the following statements is correct?  
 (A) The system does work on the surroundings when an ideal gas expands against a constant external pressure.  
 (B) The internal energy of a system increases when more work is done by the system than heat is flowing into the system.  
 (C) The internal energy of a system decreases when work is done on the system and heat is flowing into the system.  
 (D) All the statements are true.  
 (E) All the statements are false.
19. When a student performs an endothermic reaction in a calorimeter, how (if any) does the calculated value of  $\Delta H$  differ from the actual value if the heat exchanged with the calorimeter is not taken into account?  
 (A)  $\Delta H_{calc}$  is less positive because the reaction absorbs heat from the calorimeter.  
 (B)  $\Delta H_{calc}$  equals the actual value because the calorimeter does not absorb heat.  
 (C)  $\Delta H_{calc}$  is more negative because the calorimeter always absorbs heat from the reaction.  
 (D)  $\Delta H_{calc}$  is less negative because the calorimeter absorbs heat from the reaction.  
 (E)  $\Delta H_{calc}$  is more positive because the reaction absorbs heat from the calorimeter.

20. At 25°C, the following heats of reaction are known:



At the same temperature, calculate  $\Delta H$  for the following reaction:



- (A) -217.5 kJ/mol                      (B) -108.7 kJ/mol                      (C) +217.5 kJ/mol  
(D) -130.2 kJ/mol                      (E) none of these

**Answer question 20 to 25 according the following information.**

The process  $\text{H}_2\text{O}_{(g)} \rightarrow \text{H}_2\text{O}_{(l)}$  takes place at 1 atm and 95°C.

21. What is  $w$ ?  
(A) greater than zero                      (B) More information is needed.  
(C) equal to zero                          (D) less than zero
22. What is  $q$ ?  
(A) greater than zero                      (B) More information is needed.  
(C) equal to zero                          (D) less than zero
23. What is  $\Delta H$ ?  
(A) less than zero                          (B) More information is needed.  
(C) greater than zero                      (D) equal to zero
24. What is  $\Delta S$ ?  
(A) More information is needed.                      (B) less than zero  
(C) equal to zero                          (D) greater than zero
25. What is  $\Delta G$ ?  
(A) less than zero                          (B) equal to zero  
(C) greater than zero                      (D) More information is needed.

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26. The "Precision" of an analytical procedure is not normally expressed as which of the following?
- (A) Recovery
  - (B) Repeatability
  - (C) CV (coefficient of variation)
  - (D) RSD (relative standard deviation)
27. Which of the following statement about UV/Vis spectrophotometry is **incorrect**?
- (A) The UV/Vis regions of the spectrum cover a range from approximately 200 to 800 nm.
  - (B) The measurement of light absorption by a solution of molecules is governed by the Beer-Lambert Law.
  - (C) Most UV absorption of organics due to  $\pi$ - $\pi^*$  and  $n$ - $\pi^*$  transitions
  - (D) If more double bonds are present in a structure in conjugation, UV absorption takes place at shorter wavelengths.
28. Which of the following parameter can increase column efficiency in liquid chromatography?
- (A) Large particle size of stationary phase
  - (B) Decreased column length
  - (C) Low column temperature
  - (D) None of the above

二、問答題 (分數標示於各題題目後，共 44 分)

1. Define the following terms. (12 points, 3 points for each term)
- (A) Gradient elution
  - (B) Detection limit
  - (C) Electroosmotic flow
  - (D) Guard column
2. Please draw a schematic diagram of fluorescence spectrophotometer and briefly describe how does it work? (10 points)
3. Please write three common detectors used in gas chromatography and briefly explain their detection mechanism. (12 points)

4. Two neutral analytes (A and B) were separated by capillary electrophoresis using a buffer consisting of 50 mM phosphate buffer at pH 9.0. Separation voltage was set at 20 kV and separation temperature is 25 °C. Only one signal was observed in the electropherogram. (as shown in Fig.1)

(A) Please describe how to improve the resolution between A and B. (5 points)

(B) When analytes A and B were separated successfully, please describe how to identify these two peaks. (5 points)

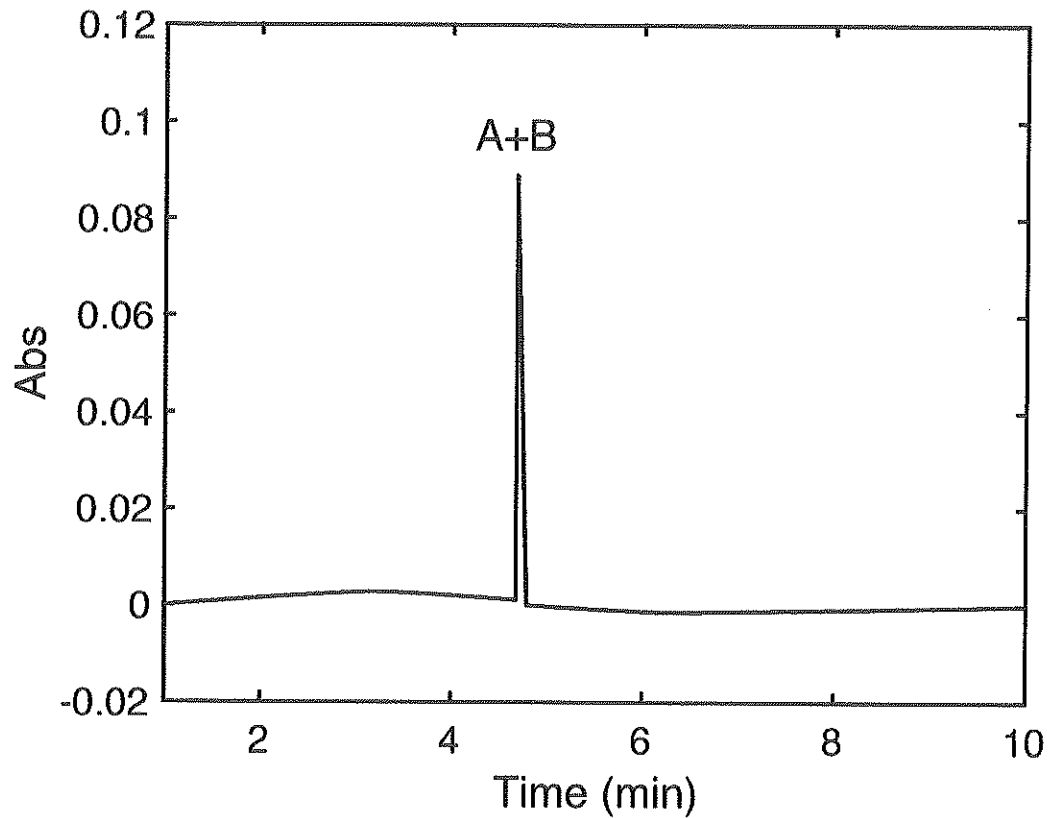


Fig. 1. The electropherogram of two neutral analytes (A and B)

