

# 國立中山大學 113 學年度

## 碩士班暨碩士在職專班招生考試試題

科目名稱：物理化學及分析化學【化學系碩士班】

### — 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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共 3 頁第 1 頁

選擇題：(單選題)

第 1-10 題，每題五分、共五十分

- How many milliliters of 3.00 M  $\text{H}_2\text{SO}_4$  are required to react with 4.35 g of solid containing 23.2 wt%  $\text{Ba}(\text{NO}_3)_2$  (FM 261.34 g/mol) if the reaction is  $\text{Ba}^{2+} + \text{SO}_4^{2-} \rightarrow \text{BaSO}_4(\text{s})$ ?  
(A) 12.9 (B) 1.29 (C) 4.36 (D) 14.36 (E) 12.1
- A 0.045 0 M solution of weak acid: HA is 0.60% dissociated. Calculate pKa for this acid.  
(A) 1.65 (B) 3.82 (C) 5.79 (D) 6.21 (E) 6.88
- Find the pH of 0.050 M  $\text{HClO}_4$  plus 0.050 M  $\text{HBr}$ . ( $\mu = 0.050 \text{ M} \Rightarrow \gamma_{\text{H}^+} = 0.86$ ;  $\mu = 0.10 \text{ M} \Rightarrow \gamma_{\text{H}^+} = 0.83$ ).  
(A) 0.043 (B) 1.37 (C) 2.37 (D) 0.083 (E) 1.08
- Calculate the pH of a solution prepared by dissolving 10.0 g of tris(hydroxymethyl)-aminomethane ("tris"; FM: 121.136 g/mol) plus 10.0 g of tris hydrochloride (FM: 157.597 g/mol) in 0.250 L of water.  
(A) 8.19 (B) 8.25 (C) 9.05 (D) 8.37 (E) 7.52
- Calculate the isoelectric pH of 0.010 M 8-hydroxyquinoline.  $\text{pK}_{\text{a}1}$ : 4.94,  $\text{pK}_{\text{a}2}$ : 9.82  
(A) 5.36 (B) 6.36 (C) 7.36 (D) 8.36 (E) 9.36
- Consider the diprotic acid  $\text{H}_2\text{A}$  with  $K_1 = 1.00 \times 10^{-4}$  and  $K_2 = 1.00 \times 10^{-8}$ . Find the pH of  $\text{HA}^-$  in 0.100 M  $\text{NaHA}$ .  
(A) 5.00 (B) 6.00 (C) 7.00 (D) 8.00 (E) 9.00
- How many milliliters of 0.202 M  $\text{NaOH}$  should be added to 25.0 mL of 0.023 3 M salicylic acid (2-hydroxybenzoic acid) to adjust the pH to 3.50? [salicylic acid ( $\text{H}_2\text{A}$ ,  $\text{pK}_1 = 2.972$ ,  $\text{pK}_2 = 13.7$ )]  
(A) 1.023 (B) 2.223 (C) 3.323 (D) 4.023 (E) 5.223
- A solution containing the complex formed between Bi(III) and thiourea has a molar absorptivity of  $9.32 \times 10^3 \text{ L mol}^{-1} \text{ cm}^{-1}$  at 470 nm. What is the absorbance of a  $3.79 \times 10^{-5} \text{ M}$  solution of the complex at 470 nm in a 1.00 cm cell?  
(A) 1.353 (B) 2.021 (C) 0.335 (D) 0.353 (E) 0.153
- What kind of interferences may cause the complex spectra in atomic mass spectrometry?  
(A) Isobaric Interferences (B) Polyatomic Ion Interferences (C) Oxide and Hydroxide Species' Interference (D) none of the above (E) all of the above
- A chromatography column with a length of 10.3 cm and an inner diameter of 4.61 mm is packed with a stationary phase that occupies 61.0% of the volume. If the volume flow rate is 1.13 mL/min, find the linear flow rate in cm/min.  
(A) 17.4 (B) 12.8 (C) 10.1 (D) 8.32 (E) 4.91

第 11-22 題，每題三分，共三十六分

- If the reaction  $2\text{HBr} \rightarrow \text{H}_2 + \text{Br}_2$  belongs to second-order reaction, which of the following will yield a linear plot?  
(A).  $\ln[\text{HBr}]$  vs time.  
(B).  $[\text{HBr}]$  vs time.  
(C).  $1/[\text{HBr}]$  vs time.  
(D).  $1/\ln[\text{HBr}]$  vs time.  
(E).  $1/[\text{HBr}]^2$  vs time.
- Which of the following phenomena or effect can be attributed to the quantum nature of light?  
(A). Blackbody radiation.  
(B). Photoelectric effect.  
(C). Laser.  
(D). Carrots look red.  
(E). All of these.

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共 3 頁第 2 頁

13. A particle with mass  $m$  is moving freely in one dimension along  $x$  with zero potential energy. From the viewpoint of quantum mechanics, which following statement is wrong?
- (A). The time-independent Schrodinger equation is  $-\frac{\hbar^2}{2m} \frac{d^2}{dx^2} \psi = E\psi$ .
- (B).  $\psi(x) = e^{ikx}$  can be the wavefunction for the particle with single linear momentum  $+\hbar k$ .
- (C).  $\psi(x) = \cos(kx)$  is one of solutions of its time-independent Schrodinger equation.
- (D). The total energy of the particle is quantized.
- (E). For  $\psi(x) = \cos(kx)$ , its expectation value of the operator  $\hat{p} = \frac{\hbar}{i} \frac{d}{dx}$  is equal to zero.
14. A particle is confined in a one-dimensional box with a finite length. The potential energies inside and outside the box are equal to zero and infinity, respectively. From the viewpoint of quantum mechanics, which of the following statement is wrong?
- (A). The degeneracy of each energy level is one.
- (B). The zero-point energy is equal to zero.
- (C). The wavefunction with a higher total energy has a larger number of nodes.
- (D). Outside the box, the value of the wavefunction is equal to zero.
- (E). The total energy is inversely proportional to the square of the length of the box.
15. The Schrodinger equation of a harmonic oscillator is  $\left(-\frac{\hbar^2}{2m} \frac{d^2}{dx^2} + \frac{1}{2} kx^2\right) \psi = E\psi$ , where  $x$  is displacement from the equilibrium position,  $m$  is mass and  $k$  is force constant. Which following statement is wrong?
- (A). The vibrational frequency is proportional to  $(k/m)^{1/2}$ .
- (B). The zero-point energy is not equal to zero.
- (C). The total energy is linearly proportional to vibrational frequency.
- (D). The expectation value of  $x$ ,  $\langle x \rangle$ , is equal to zero.
- (E). The degeneracy of each energy level is two.
16. For the ground state of helium atom, which following statement is wrong?
- (A). The total angular momentum of two electrons is zero.
- (B). A helium atom in the ground state is diamagnetic.
- (C). The term symbol is  $^1S_0$ .
- (D). Two electrons in helium are distinguishable.
- (E). The shielding effect of two 1s electrons to 2s orbital is smaller than that to 2p orbital.
17. For Born Oppenheimer approximation, which of the following statement is correct?
- (A). The motion of nuclei and the motion of the electrons are coupled.
- (B). The motion of electrons is much faster than that of nuclei due to their big differences in mass.
- (C). In the Hamiltonian operator, the electron-nucleus interactions are removed.
- (D). The electrons and nuclei are considered to have a similar speed.
- (E). The energy of electrons depends on positions and velocities of nuclei.
18. For reversible isothermal expansion of an ideal gas (system), which of the following statement is wrong?
- (A). The heat transfer is zero.
- (B). The change in the internal energy of the system is zero.
- (C). The work done by the system is not zero.
- (D). The entropy change of the system is positive.
- (E). The enthalpy change of the system is zero.

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共 3 頁第 3 頁

19. For reversible adiabatic expansion of an ideal gas (system), which of the following statement is wrong?
- (A). The heat transfer is zero.  
 (B). The change in the internal energy of the system is zero.  
 (C). The work done by the system is not zero.  
 (D). The entropy change of the system is zero.  
 (E). The enthalpy change of the system is not zero.
20. For Gibbs energy,  $G$ , which of the following statement is wrong?
- (A). For a spontaneous process at constant temperature and pressure, the change in  $G$  is negative.  
 (B).  $G$  is defined by the equation:  $G = H - TS$ .  
 (C). Its fundamental thermodynamic relation is:  $dG = -SdT + PdV$ .  
 (D). The chemical potential of a pure substance is equal to its molar Gibbs energy.  
 (E).  $G$  is a state function.
21. If the reaction  $\text{CH}_3\text{NC} \rightarrow \text{CH}_3\text{CN}$  belongs to second-order reaction, which of the following will yield a linear plot?
- (A).  $\ln[\text{CH}_3\text{NC}]$  vs time  
 (B).  $[\text{CH}_3\text{NC}]$  vs time  
 (C).  $1/[\text{CH}_3\text{NC}]$  vs time  
 (D).  $1/\ln[\text{CH}_3\text{NC}]$  vs time  
 (E).  $1/[\text{CH}_3\text{NC}]^2$  vs time
22. For the Arrhenius equation,  $k = A \exp(-E_a/RT)$ , which of the following statement is wrong?
- (A). The effect of catalyst is to increase the magnitude of  $A$ .  
 (B). The pre-exponential factor  $A$  is associated with the collision frequency of reactants.  
 (C). The activation energy  $E_a$  can be positive or negative.  
 (D). The pre-exponential factor  $A$  includes the steric factor of reaction.  
 (E).  $\exp(-E_a/RT)$  represents the fraction of molecules with a kinetic energy larger than  $E_a$ .

計算題，每題七分，共十四分

1. One mole of  $\text{N}_2(\text{g})$  at 298 K expands adiabatically from a volume of 5.0 atm to 1.0 atm in following two conditions: (a) reversibly, and (b) against a constant external pressure of 1.0 atm. The molar heat capacity at constant volume is equal to  $5R/2$ . Determine the values of final temperature of  $\text{N}_2(\text{g})$ , for conditions (a) and (b).  $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1} = 0.082 \text{ L atm K}^{-1} \text{ mol}^{-1}$

2. Consider the base-catalyzed reaction:  $\text{OCl}^-(\text{aq}) + \text{I}^-(\text{aq}) \rightarrow \text{OI}^-(\text{aq}) + \text{Cl}^-(\text{aq})$ . Use the following data of initial rate  $v_0$  to determine (a) the rate law and (b) the corresponding rate constant, including the unit, for the reaction.

$[\text{OCl}^-] / \text{M}$	$[\text{I}^-] / \text{M}$	$[\text{OH}^-] / \text{M}$	$v_0 / \text{M s}^{-1}$
$1.60 \times 10^{-3}$	$1.60 \times 10^{-3}$	0.52	$2.01 \times 10^{-4}$
$1.60 \times 10^{-3}$	$3.98 \times 10^{-3}$	0.52	$4.97 \times 10^{-4}$
$2.71 \times 10^{-3}$	$1.60 \times 10^{-3}$	0.84	$2.10 \times 10^{-4}$
$1.60 \times 10^{-3}$	$3.98 \times 10^{-3}$	1.01	$2.57 \times 10^{-4}$