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 115 學年度碩士班考試入學試題

系所班組別：分析與環境科學研究所

科目代碼：3001

考試科目：分析化學

－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. 考試開始後，請於作答前先翻閱整份試題，是否有污損或試題印刷不清，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. 提早交卷者不可攜出試題，請將試題連同答案卷(卡)交予監考人員，攜出將以違規論處。當節考試結束後試題將置於講台，可自行取回，本試場不負保管責任。
7. 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 115 學年度碩士班考試入學試題

系所班組別：分析與環境科學研究所

考試科目（代碼）：分析化學（3001）

1. (10%) What is a buffer solution and what are its properties? Considering solutions prepared by (a) dissolving 8.0 mmol of NaOAc in 200 mL of 0.1 M HOAc. (b) adding 100 mL of 0.05 M NaOH to 100 mL of 0.175 M HOAc. (c) adding 40 mL of 0.12 M HCl to 160 mLof 0.042 M NaOAc. In what respects do these solutions resemble one another? How do they differ? The pKa of acetic acid (HOAc) in water is 4.76.

2. (5%) A solution contains 2.0×10^{-4} M NaCl. Calculate the concentration of Na^+ in ppm. The atomic weights of Na and Cl are 23.0 and 35.5, respectively.

3. (7%) Compounds of Mn(II) are usually very weakly colored, whereas compounds of Mn(III) are often intensely colored. Explain this difference in terms of electronic transitions. A specific Mn complex has a molar absorptivity of 3200 L cm^{-1} mol^{-1} at its wavelength of maximum absorption (λ_{max}). Calculate the molar concentration of the complex if the percent transmittance is 35%, when measured in a 1.00-cm cell at λ_{max}.

4. (6%) Calculate the formation constant K_f for $Ag(CN)_2^-$:

   $Ag^+ + 2\ CN^- \rightleftharpoons Ag(CN)_2^-$

   if the cell

   $SCE\|\ Ag(CN)_2^-\ (7.5\times10^{-3}\ M),\ CN^-\ (0.025\ M)|Ag$

   develops a potential of -0.625V.

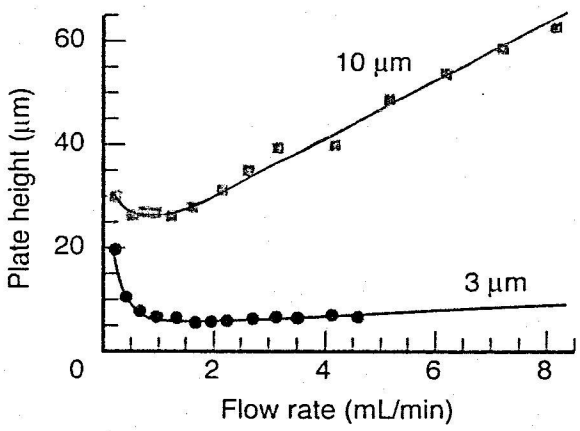
   (The electrode potential of SCE is 0.244 V at 25°C)

   ($Ag^+ + e^- \rightleftharpoons Ag_{(s)}$　$E^\circ = +0.799$ V)

5. (10%) Briefly distinguish between qualitative, semi-quantitative, and quantitative analysis. Explain how quantitative analysis is usually achieved in practice. How can the accuracy of an analytical result be evaluated? Additionally, describe how the standard addition method works and discuss when it should be used.

6. (10%) An aqueous sample contains $NaNO_3$ and KBr. The bromide ions are determined by argentometric titration using $AgNO_3$, with fluorescein as an adsorption indicator (Fajans method). Upon addition of $AgNO_3$, AgBr is formed as a colloidal precipitate. Please answer: (a) Before the equivalence point, what is the net charge on the surface of the AgBr colloidal particles? Explain the origin of this charge. (b) After a slight excess of $AgNO_3$ has been added beyond the equivalence point, what happens to the surface charge of the AgBr particles, and why? (c) Explain how the Fajans method detects the end point of the argentometric titration. (d) Identify the ions present in the counter-ion layer surrounding the AgBr particles (i) before and (ii) after the equivalence point.

7. (10%) (a) Explain why plate height increases at (i) very low and (ii) very high flow rates in the following figure.



(b) Why is high pressure needed in high performance liquid chromatography (HPLC).

(c) When you try separating an unknown mixture by reversed-phase chromatography with 50% acetonitrile-50% water, the peaks are eluted between 1 and 3 min, and they are too close together to be well resolved for quantitative analysis. Should you use a higher or lower percentage of acetonitrile in the next run? Explain.

8. (5%) Match each gas chromatographic detector in Column I with the most appropriate description of its applicable samples in Column II.

Type of detector	Applicable samples
(a) Flame Ionization Detector	(i) Universal detector
(b) Thermal Conductivity Detector	(ii) Halogenated compounds
(c) Electron Capture Detector	(iii) Compounds containing N and P
(d) Thermionic Ionization Detector	(iv) Hydrocarbons
(e) Flame Photometric Detector	(v) Compounds containing P and S

9. (6%) Strong acid and weak acid cation-exchange resins differ in their chemical structures and ionization behaviors. (a) Describe the key structural differences between strong acid and weak acid cation-exchange resins. (b) Given a water sample containing Ca^{2+} and Mg^{2+} at pH 4.0, which type of resin would be more suitable for ion exchange? Explain your reasoning.

10. (10%) What is the role of the inductively coupled plasma (ICP) in inductively coupled plasma mass spectrometry (ICP-MS)? Name one of the most commonly used mass analyzers in ICP-MS and briefly describe its operating principle. Discuss the major advantages of ICP-MS over other elemental analysis techniques such as atomic absorption spectrometry and inductively coupled plasma-optical emission spectrometry.

11. (7%) For each molecule listed in the table below, indicate whether it is more suitable for infrared spectroscopy, Raman spectroscopy, or both. Briefly justify your answer for one of the molecules listed above.

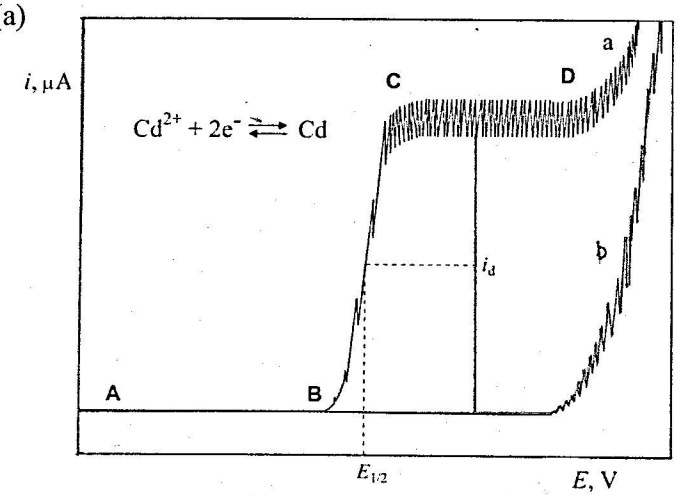
H_2O	O_2	H_2	CO_2	Aromatic Hydrocarbons

12. (6%) Ion-selective electrodes are powerful tools in clinical and environmental analysis and are widely used in potentiometric measurements for the determination of specific ions in solution. Explain the working principle of potentiometry and clearly distinguish it from amperometric measurements. Additionally, describe how an ion-selective electrode achieves selectivity toward a particular ion.

13. (4%) Differential Pulse Voltammetry (DPV) is widely used for trace electrochemical analysis. (a) Describe the potential waveform and current sampling strategy used in DPV. (b) Explain why DPV provides higher sensitivity and lower detection limits than conventional voltammetric techniques such as linear sweep or cyclic voltammetry.

14. (4%) Please assign a suitable name to the corresponding analytical techniques.

(a)



(b)