科目：分析化學(2005)　　校系所組：中大化學學系　交大應用化學系甲組　清大化學系

選擇題(單選，每題3分，答錯不倒扣分數)

1. In FT-IR instrumentation an interferometer is employed to coup with a major obstacle. Identify the purpose of having an interferometer. (a) instability of the light source. (b) poor detection sensitivity. (c) slow detection and electronics. (d) it is employed to improve the resolution of a grating.
2. Which of the following statements directly lead to an increase in FT-IR resolution? 1. scan time domain signal sufficiently long; 2. increase the number of measurements. 3. Increase the light path. 4. Increase the mirror drive distance. 5. Increase the speed of motor drive. Your answer: (a) 1 and 2; (b) 3 and 4; (c) 2 and 5; (d) 1 and 4; (e) 3, 4 and 5.
3. Which of the following statements of combination could explain the poor sensitivity with flame AAS? 1. short light-path; 2. weak light source; 3. low steady state analyte concentration in the flame; 4. low resolution of the monochromator; 5. poor nebulization efficiency. (a) 1 and 3; (b) 2 and 3; (c) 2 and 4; (d) 3 and 5.
4. In early 1977, the two Viking landers began sending data on the elemental makeup of Mars surface soil, whose results suggested that the main components were SiO_2(45%), Fe_2O_3(18%), Al_2O_3(5%), MgO (8%), CaO (5%) and SO_3(8%). What instrument was in use on these spacecrafts which allowed instantaneous analysis of elements in soil and rocks of Mars. (a) AAS; (b) AES; (c) ICP-MS; (d) XRF; (e) ET-AAS.
5. In Taiwan diesel used for fishing boats is frequently being smuggled to the shore for motor vehicle use due to the large price difference. Off-road inspection and sampling of diesel from trucks coupled with in-lab analysis is the most effect way to trace the illegal supply of the fishing boat diesel. Which of the following analytical methods is used in this type of investigation? (a) hydrocarbon content by GC; (b) lead content by AAS; (c) water content by HPLC; (d) sulfur by XRF.
6. In the incident of tainted milk imported from China that we heard a lot about, melamine was deliberately added in milk to fortify the content of nitrogen, an index of protein content. This criminal act cannot be detected by the conventional Kjedahl method. Why? (a) It's sensitivity for melamine is too low; (b) it is based on acid-base titration; (c) it is based on gravimetric method; (d) no distinguish between nitrogen from protein and melamine; (e) because melamine is not a protein.
7. Continued from question 6. Techniques involving HPLC can detect the presence of melamine in tainted milk with a detection limit = 0.50 ppm. Which of the following statements are false? 1. If a sample contains 0.5 ppm melamine, the

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method can always find its presence; 2. There is a slight possibility that samples containing no melamine will give a signal greater than 0.5 ppm; 3. The D.L. can be lowered, if MS rather than UV detection is used; 4. If a product claims not to contain melamine as confirmed by HPLC/MS, one should consider the product is melamine free. Your answer: (a) 1 and 4; (b) 2 and 3; (c) 3 and 4; (d) 1, 2 and 4.

8. When one uses a 25.00 ± 0.03 mL Class A volumetric pipet to deliver 100 mL of water. What is the uncertainty in the 100 mL water? (Hint: the precision can be as small as ± 0.006 mL). (a) ± 0.12 mL; (b) ± 0.06 mL; (c) ± 0.012 mL; (d) 0.06 – 0.12 mL.
9. Which of the following practices have little to do with improving accuracy? 1. Analyze standard reference materials; 2. Repeat analysis; 3. Run blanks; 4. Increase recovery; 5. Increase sample volume. Your answer: (a) 1 and 3; (b) 2 and 3; (c) 1, 3 and 4; (d) 2 and 5.
10. Which instrument was used on-board the Gassini spacecraft to measure chemical composition of Titan's atmosphere (note: Titan is Saturn's largest moon). In this expedition, H_2, CH_4, Ar, CO_2 and C^{13}/C^{12}, as well as N^{15}/N^{14} were measured. (a) XRF; (b) FT-IR; (c) GC; (d) GC-MS; (e) cyclic voltammetry.
11. Which of the following statements concerning the Karl Fischer method are true? 1. It works based on acid-base titration; 2. It is used to determine alcohol content in solution; 3. It can be a coulometric procedure; 4. It works based on redox reactions; 5. Its reagents involve iodide. Your answer: (a) 1; (b) 1 and 2; (c) 3 and 4; (d) 3, 4, and 5; (e) 4 and 5.
12. Which technique fits to the following descriptions: 1. It is the most sensitive electrochemical analytical technique; 2. It can be used to determine trace amount of heavy metals in solution; 3. Its high sensitivity is owing to an enrichment process; 4. The measured current is proportional to the analyte concentration. Your answer: (a) cyclic voltammetry; (b) amperometry; (c) coulometry; (d) stripping voltammetry; (e) sampled current polarography.
13. Which instrument that could involve a device that fit to the following descriptions: 1. Sample liquid is pushed through a tiny charged capillary; 2. The liquid pushes itself out of the capillary and forms aerosol; 3. The aerosol is produced by a process involving the formation of a Taylor cone; 4. As the solvent evaporates, the analyte molecules are forced closer together, repel each other and break up the droplets. Your answer: (a) HPLC-MS; (b) ICP-MS; (c) ICP-OES; (d) CE.
14. If an analytical method is found to have a constant low recovery, which of the following problems are likely to be responsible for? 1. Matrix effect; 2. Interfering species binding with the analyte; 3. Contaminated blank solvent in which

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standard reference material is spiked; 4. Poor reproducibility or precision. Your answer: (a) 1 and 2; (b) 2 and 3; (c) 1, 2 and 3; (d) 1, 2 and 4.

15. For amino acid aniline (H_2A) to dissolve in water, whose pK_1=2.34 and pK_2=9.87. 1. Its isoelectric pH for 0.010M alanine = 6.11; 2. Its isoionic pH for 0.10M alanine = 6.10; 3. At the isoionic point, $[H_2A^+] = [A^-]$; 4. At the isoelectric point, $[H_2A^+] = [A^-]$; 5. Isoelectric focusing technique is a sensitive way to separate proteins. Which of the above five statements are correct? You answer: (a) 1, 3; (b) 2 and 3; (c) 2, 4 and 5; (d) 4 and 5.

簡答題:

1. (5 pts) (a) Name three mechanisms with which ions or molecules are transported from the bulk of electrolyte solution toward or away from an electrode. (b) Why concentrated supporting electrolyte is usually needed in electrochemical experiments?
2. (5 pts) (a) Describe the mechanism of the production of an MNN Auger electron. (b) How can one distinguish between X-ray photoelectron peaks and Auger electron peaks in a spectrum?
3. (5 pts) Scanning tunneling microscope (STM) and atomic force microscope (AFM) represent two of the most common types of scanning probe microscope. (a) What are the advantage of STM and AFM ? (b) What are the limitations of each type?
4. (6 pts) The following cell was found to have a potential 0.2897 V.
   SCE (saturated calomel electrode) $||Mg^{2+}$ ($a = 3.32 \times 10^{-3}$ M) |membrane electrode for Mg^{2+} (E° for SCE = 0.244 V)
   (a) When the solution of known magnesium activity was replaced with an unknown solution, the potential was found to be 0.2041 V. what was the pMg of this unknown solution?
   (b) Assuming an uncertainty of ± 0.002 V in the junction potential, what is the range of Mg^{2+} activities within which the true value might be expected?
   (c) What is the relative error in $[Mg^{2+}]$ associated with the uncertainty in E_j?
5. (4 pts) (a) Define Nernstian response in ion-selective electrode. (b) Define the selectivity coefficient in ion-selective electrode?
6. (4 pts) Oxygen can be reduced to H_2O_2 or H_2O via 2-electron or 4-electron pathway. Rotational ring - disk electrodes (RRDE) is one of the best ways to differentiate the mechanism of oxygen reduction. How one can use RRDE to study the reduction mechanism of oxygen reduction.

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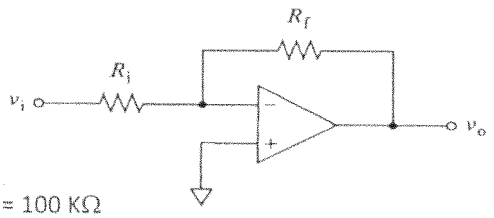
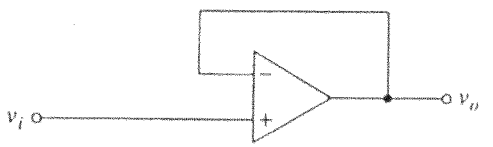
7. (4 pts) Cyclic voltammetry represents one of the most important methods to probe the redox property of electrochemical system. Name three criteria with which one can diagnose the reversibility of a redox couple in voltammetry.
8. (5 pts) Stripping analysis using Hg electrode has been one of the most sensitive methods in electrochemistry. What are the advantages of mercury electrode?
9. (5 pts) Differential pulse voltammetry is known to be more sensitive than traditional linear sweep voltammetry. Why is this so?
10. (6 pts) Define (a) charging current in electrochemistry. (b) What factors determine the magnitude of charging current? (c) Given the solution resistance of 0.1 Ω and electrode capacitance of 30 μF, calculate the time needed to charge up the electrode to 95% of its capacity.
11. (6 pts) A low-frequency sine wave voltage is the input to the following circuit. Sketch the anticipated output of each circuit.

(a)



R_i = 10 KΩ and R_f = 100 KΩ

(b)



科目：應用數學(3001)　校系所組：中大照明與顯示科技研究所甲組、天文研究所
交大電子物理學系丙組、物理研究所
清大物理學系、先進光源科技學位學程物理組、天文研究所
陽明生醫光電研究所理工組 A

1 (1a) Solve the differential equation $\frac{dy}{dt} = e^{y+t}$ for $y(t)$. (11 points)

(1b) Find the general solution of $\frac{d^2y}{dx^2} - \frac{4}{x}\frac{dy}{dx} + \frac{6}{x^2}y = \frac{4}{x^3}$. (11 points)

(1c) A tank initially contains 40 g of salt mixed in 100 liters of water. A solution contains 4 g of salt per liter is pumped into the tank at a rate of 5 liter/min. The stirred mixture flows out the tank at the same rate. How much salt is in the tank after 20 minutes? (12 points)

2 (17 points)

(a) Given a 2×2 hermitian matrix $B = \begin{pmatrix} 0 & \theta \\ \theta & 0 \end{pmatrix}$, and $x = \begin{pmatrix} a \\ b \end{pmatrix}$ as a column matrix, (i) solve the eigenvalue problem $Bx = \lambda x$ for the eigenvalues and eigenvectors, and then (ii) find a matrix S such that $B_s = SBS^{-1}$ becomes a diagonized matrix.

(b) Prove that $\det \exp[iA] = \exp[iTrA]$ for any $n \times n$ hermitian matrix A. Prove this result from the fact that any hermitian matrix A can always be diagonized.

[Remark: $\det B$ and $Tr\, B$ are the determinant and the trace of the matrix B respectively. θ, a and b are constant parameters. $\exp[A] = \sum_{k=0}^{\infty}[A]^k/k!$ defines the exponential mapping of any matrix A.]

3 (16 points)
Define a $27(= 3 \times 3 \times 3)$ components 3-index function A_{ijk} for all $i, j, k = 1, 2, 3$ as a totally antisymmetric 3-index function with $A_{123} = 1$. Here totally antisymmetric means that $A_{ijk} = -A_{jik} = -A_{ikj}$ for all $i, j, k = 1, 2, 3$.

(a) (i) List all non-vanishing components of A_{ijk}, e.g. $A_{132} = -1$, and $\cdots$ from the antisymmetric properties of A_{ijk}. (ii) Also give a reason, from the symmetric properties of A_{ijk}, to explain why there are totally $k(=?)$ non-vanishing components.

(b) The determinant of any 3×3 matrix B can be defined as $\det B = \sum_{i=1}^{3}\sum_{j=1}^{3}\sum_{k=1}^{3} A_{ijk}[B_{1i}B_{2j}B_{3k}]$. From the symmetric properties of A_{ijk}, show that $A_{lmn} \det B = \sum_{i=1}^{3}\sum_{j=1}^{3}\sum_{k=1}^{3} A_{ijk}[B_{li}B_{mj}B_{nk}]$.

[Remark: This definition agrees with the conventional definition of the determinant of any 3×3 matrix B that $\det B = \det \begin{pmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \\ B_{31} & B_{32} & B_{33} \end{pmatrix} = B_{11}[B_{22}B_{33} - B_{23}B_{32}] - B_{21}[\cdots] + B_{31}[\cdots].]$

4 Consider the function

$$f(z) = \frac{1}{1+z}.$$

(a) Expand $f(z)$ about the point $z = 0$. What is the convergence radius? (5 points)
(b) Expand $f(z)$ about the point $z = i$. What is the convergence radius? (5 points)

5 Perform the following integrals.

(a) For $\omega > 0$ and t is real, calculate

$$\frac{1}{\pi}\int_{-\infty}^{\infty} \frac{e^{-ikt}}{k^2 + \omega^2} dk. \quad (8 \text{ points})$$

(b) For $\sigma > 0$, calculate

$$\frac{1}{\pi}\int_{-\infty}^{\infty} \frac{x \sin x}{x^2 - \sigma^2} dx. \quad (10 \text{ points})$$

(c) For $\sigma > 0$ and $\epsilon > 0$, calculate

$$\lim_{\epsilon \to 0} \frac{1}{\pi}\int_{-\infty}^{\infty} \frac{x \sin x}{x^2 - (\sigma - i\epsilon)^2} dx. \quad (5 \text{ points})$$