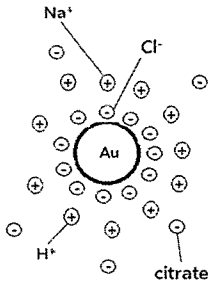
※ 注意：全部題目均請作答於試卷內之「非選擇題作答區」，請標明題號依序作答。

Section A. Multiple Choice Questions

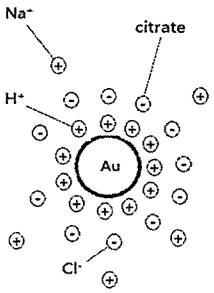
(*Each question may contain single or multiple answers*)

1. One 40 nm gold nanoparticle was reduced from tetrachloroauric acid by excess amount of 0.1 M sodium citrate solution. Which one of the following is the best model to describe the dielectrical double layer formation mechanism for this solution? (10%)

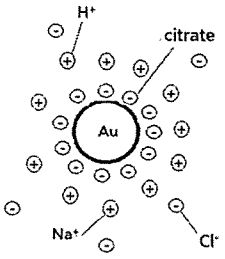
(A)



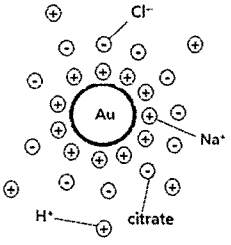
(B)



(C)



(D)



2. The concentration of an analyte is measured by its absorbance of light in spectrophotometry. Five reagent blanks were also measured and gave values of 0.0012, 0.0015, 0.0008, 0.0010, and 0.0009. A calibration curve was conducted using a series of standard solutions. The concentrations and the absorbance of the standards are listed in the following table. (Absorbance is a dimensionless quantity.)

Concentration (ppb)	Absorbance
0.01	0.0078
0.10	0.0880
0.50	0.4467
1.00	0.8980
2.50	1.8770

2-1. Calculate the standard deviation of absorbance of the five reagent blanks. (5%)

(A) 0.26 (B) 0.0011 (C) 0.76 (D) 0.00028

2-2. Find the concentration detection limit (k=3). (5%)

(A) 0.0019 ppb (B) 0.0011 ppb (C) 0.0019 ppm (D) 0.0025 ppb

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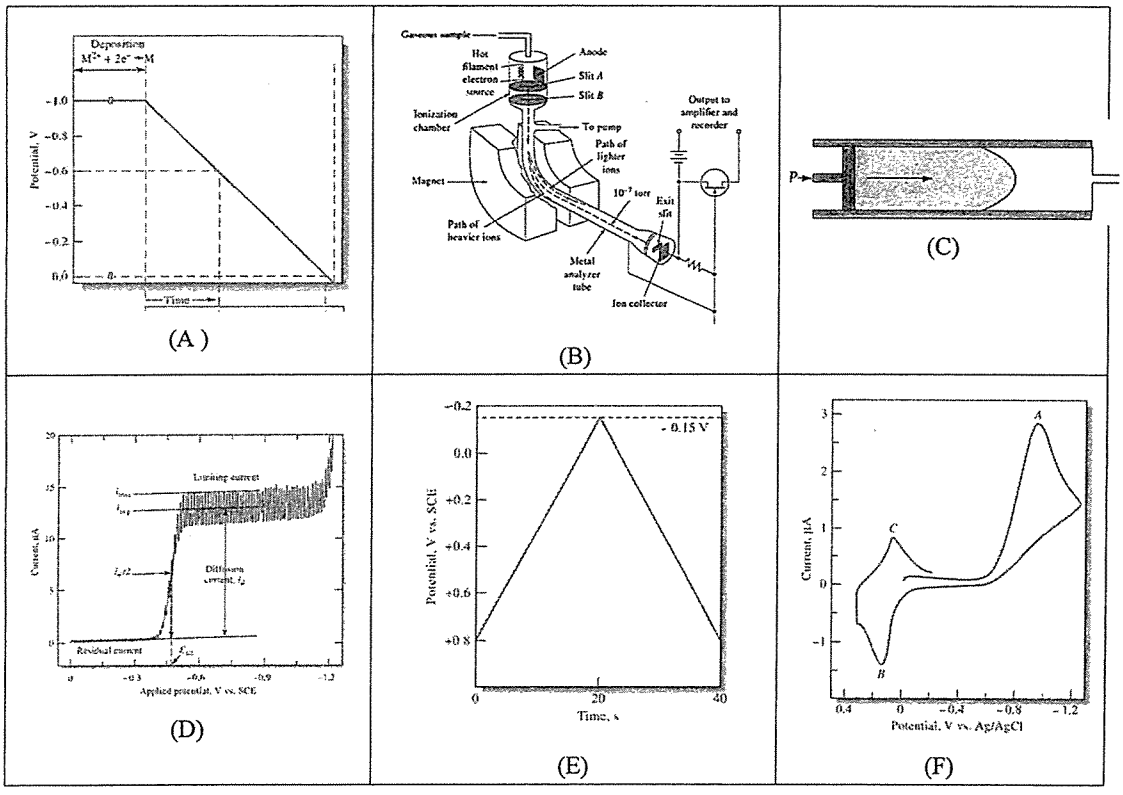
3. A soluble complex is formed in the Liebig titration of cyanide ion; at the equivalence point, solid silver cyanide is formed, signaling the end point:

$$2CN^- + Ag^+ \rightarrow Ag(CN)_2^- \quad \text{(titration)}$$
$$Ag(CN)_2^- + Ag^+ \rightarrow Ag[Ag(CN)_2] \quad \text{(end point)}$$

If 20.0 mL of 0.15 M $AgNO_3$ was required to titrate a 0.78 g sample of KCN (M.W. = 65.12), what is the percent purity of the KCN sample? (10%)
(A) 98% (B) 25% (C) 50% (D) 0.49%

4. Several analytical techniques and figures or equations are shown below. Please assign the appropriate items to the corresponding techniques. (Tick all that apply)
   4-1. Fluorescence spectroscopy (2%, no partial credit.)
   4-2. Capillary electrophoresis (2%, no partial credit.)
   4-3. Polarography (2%, no partial credit.)
   4-4. Liquid chromatography (2%, no partial credit.)
   4-5. Mass spectrometry (2%, no partial credit.)



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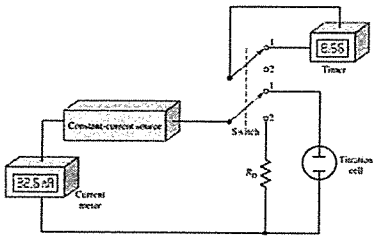
$$\phi_F = \frac{k_F}{k_F + k_{nr}}$$

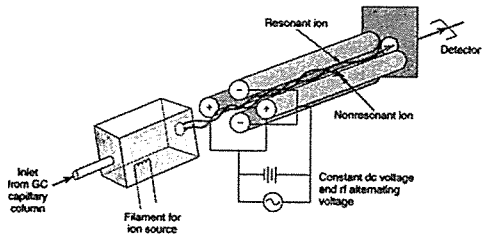
(G)



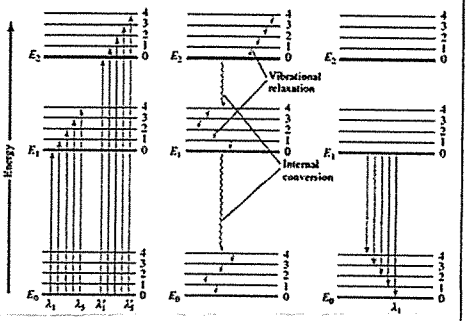
(H)

$$H = A + \frac{B}{u} + C_S u$$

(I)



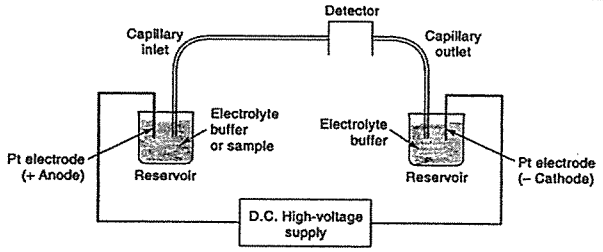
(J)



(L) (M) (N)

$$(i_d)_{\max} = 708nD^{1/2}m^{2/3}t^{1/6}c$$

(K)



(O)

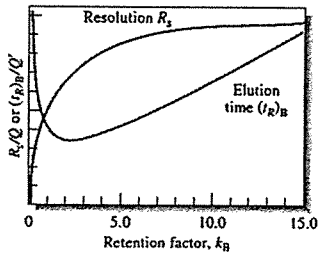
$$R_s = \frac{\Delta Z}{\frac{W_A}{2} + \frac{W_B}{2}} = \frac{2\Delta Z}{W_A + W_B} = \frac{2[(t_R)_B - (t_R)_A]}{W_A + W_B}$$

(P)

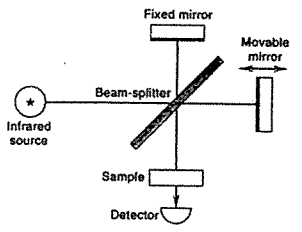
$$N = \frac{\mu_e V}{2D}$$

(Q)

(R)



(S)



(T)

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Section B. Concepts

(*Please write down your explanation in detail*)

5. Please give the typical potentiostat instrumental setup and explain each component's function in detail. (10%)

6. (10%) An ideal gas follows the equation of state: $PV = nRT$.

   (a). Show that the work (w) of reversible isothermal expansion of an ideal gas from V_i to V_f at temperature T is $w = -nRT \ln \frac{V_f}{V_i}$.

   (Note: We use the sign convention that work done on the system is positive and heat adding to the system is positive.)

   (b). The pressure of an ideal gas that undergoes reversible adiabatic expansion from V_i to V_f is related to its initial pressure by $P_f (V_f)^\gamma = P_i (V_i)^\gamma$, where $\gamma = \frac{C_p}{C_v}$, and C_p and C_v are the molar heat capacity at constant pressure and the molar heat capacity at constant volume of an ideal gas, respectively. Explain why the work done in the reversible adiabatic expansion is less than that in the reversible isothermal expansion.

7. (8%) For a harmonic oscillator, the unnormalized wavefunction of the vibrational ground state is $\varphi(x) = N e^{-\frac{1}{2}y^2}$, where N is the normalization factor, $y = \frac{x}{\alpha}$, and $\alpha = \left(\frac{h^2}{4\pi^2 mk}\right)^{1/4}$ with the definitions of h: Planck's constant, m: the mass of the oscillator, and k: the force constant of the oscillator. Find the normalized wavefunction of vibrational ground state for the harmonic oscillator.

   (Note: $\int_0^\infty e^{-a x^2} dx = \frac{1}{2}\left(\frac{\pi}{a}\right)^{1/2}$.)

8. (10%) H_3^+ is the simplest polyatomic molecule, in which two electrons hold three protons together to form a stable molecule. The H_3^+ molecule has an equilateral triangular structure.

   (a) Use the Hückel approximation to find the electronic energies of molecular orbitals in H_3^+ by solving the Hückel secular equation, draw an energy level diagram for the orbitals, and determine the binding energy of H_3^+.

   (b) Accurate quantum mechanical calculations give the dissociation energy for the process $H_3^+ \rightarrow H + H + H^+$ as 849 kJ/mol. Experimental investigation gives the dissociation energy of H_2 as 436 kJ/mol. From these data, calculate the enthalpy of the reaction $H^+ + H_2 \rightarrow H_3^+$.

   (Note: The hydrogen-related chemical species in this question are all in gas phase.)

9. (6%) Describe the entropy (熵) which is defined by classical thermodynamics and by statistical thermodynamics.

10. (8%) Describe the tunneling effect in quantum mechanics. Could you give two examples to explain this quantum phenomenon (現象) of the tunneling effect in a microscopic world?

11. (8%) Describe the uncertainty principle in quantum mechanics. Could you give two examples to explain this quantum phenomenon of the uncertainty principle in a microscopic world?

試題隨卷繳回