

國立臺灣師範大學 114 學年度碩士班招生考試試題

科目：分析化學

適用系所：化學系

注意：1.本試題共 7 頁，請依序在答案卷上作答，並標明題號，不必抄題。2.答案必須寫在指定作答區內，否則依規定扣分。

1. You made field measurements of traces of iodide (I^-) in groundwater. The procedure is to oxidize I^- to I_2 and convert the I_2 into an intensely colored complex with the dye brilliant green in the organic solvent toluene. (10 points)

(1) 3.15×10^{-6} M solution of the colored complex exhibited an absorbance of 0.263 at 635 nm in a 1.000-cm cuvet. A blank solution made from distilled water in place of groundwater had an absorbance of 0.018. Find the molar absorptivity of the colored complex.

(A) 53500 (B) 63500 (C) 73500 (D) 83500 (E) 93500

(2) The absorbance of an unknown solution prepared from groundwater was 0.195. Find the concentration of the unknown.

(A) 1.34×10^{-6} M (B) 2.34×10^{-6} M (C) 3.34×10^{-6} M (D) 4.34×10^{-6} M
(E) 5.34×10^{-6} M

2. Selenium from 0.119 g of Vietnam nuts was converted into the fluorescent product, which was extracted into 10.0 mL of cyclohexane. Then 5.00 mL of the cyclohexane solution were placed in a cuvet for fluorescence measurement. Standard additions of fluorescent product containing $1.30 \mu\text{g Se/mL}$ are given in the table. (10 points)

Volume of Standard added (μL)	Fluorescence Intensity (arbitrary units)
0.0	41.5
10.0	49.1
20.0	56.5
30.0	63.9
40.0	70.2

(1) Construct a standard addition graph to find the concentration of Se in the 5.00-mL unknown solution.

(A) $0.015 \mu\text{g/mL}$ (B) $0.0015 \mu\text{g/mL}$ (C) $0.030 \mu\text{g/mL}$ (D) $0.0030 \mu\text{g/mL}$
(E) None of the Above

(2) Find the wt% of Se in the nuts.

(A) $1.24 \times 10^{-2} \%$ (B) $1.24 \times 10^{-3} \%$ (C) $1.24 \times 10^{-4} \%$ (D) $1.24 \times 10^{-5} \%$
(E) $1.24 \times 10^{-6} \%$

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3. An echellette grating containing 1550 blazes per millimeter was irradiated with a polychromatic beam at an incident angle 46 degrees to the grating normal. Calculate the wavelengths of radiation that would not appear at angles of reflection of +20 deg (angle r). (5 points)

(A) 171 nm (B) 228 nm (C) 324 nm (D) 684 nm (E) 885 nm

4. The following data are for a liquid chromatographic column:

Length of packing	25 cm
Flow rate	0.3 mL/min
V_M	1.37 mL
V_S	0.164 mL

A chromatogram of a mixture of species A, B, C, and D provided the following data:

	Retention Time, min	Width of Peak Base (W), min
Non-retained	3.1	---
A	5.5	0.41
B	13.3	1.07
C	14.2	1.15
D	21.5	1.71

(total 25 points, 3 points each, Question (1) is 4 points)

- (1) Calculate the distribution constant of peak A.

(A) 4.5 (B) 5.5 (C) 6.5 (D) 7.5 (E) 8.5

- (2) Calculate the retention factor of peak B.

(A) 3.3 (B) 4.3 (C) 5.3 (D) 6.3 (E) 7.2

- (3) Calculate the number of plates of peak C.

(A) 2040 (B) 2140 (C) 2240 (D) 2340 (E) 2440

- (4) Calculate the plate height for the column.

(A) 0.1 (B) 0.05 (C) 0.01 (D) 0.005 (E) 0.001

- (5) Calculate the selectivity factor of peak C and D.

(A) 1.55 (B) 1.66 (C) 1.77 (D) 1.88 (E) 1.99

- (6) Calculate the resolution of peak B and C.

(A) 0.5 (B) 0.6 (C) 0.7 (D) 0.8 (E) 0.9

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(7) Calculate the length of column necessary to separate the two species with a resolution of 1.5 for of species B and C.

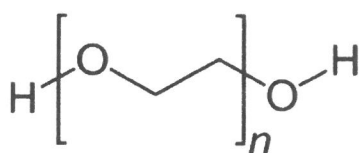
(A) 45 cm (B) 55 cm (C) 65 cm (D) 75 cm (E) 85 cm

(8) Calculate the time required to separate the two species B and C on the column.

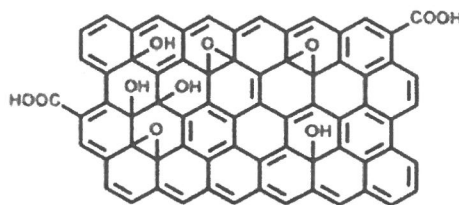
(A) 20 min (B) 30 min (C) 40 min (D) 50 min (E) 60 min

5. For Question (total 12 points, 2 points each)

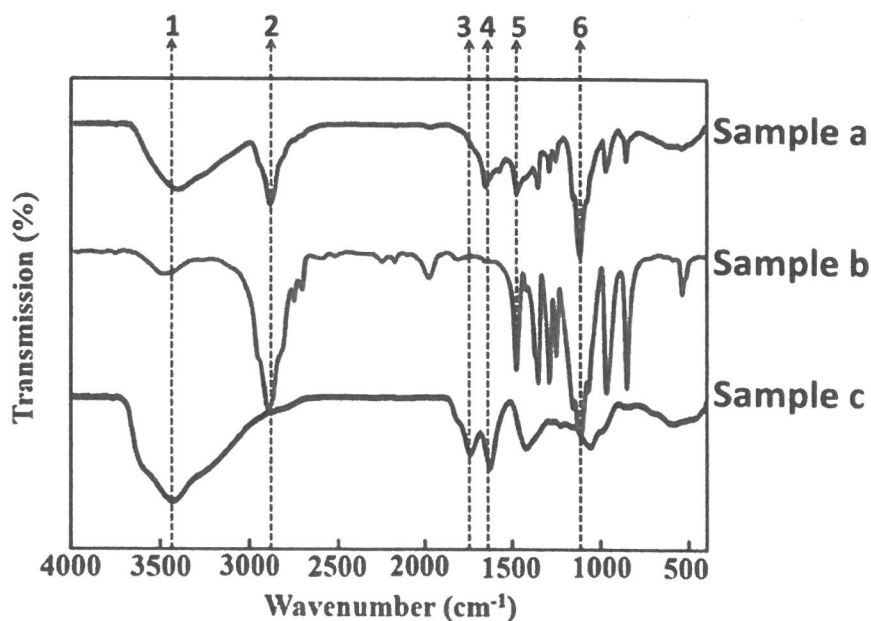
The FTIR spectra shown below were measured by using three compounds, including polyethylene glycol (PEG), graphene oxide (GO), and the composite of polyethylene glycol/graphene oxide (PEG/GO). Consider the molecular structures of PEG and GO shown below. Find the correct compounds for Sample a, b, and c.



**Polyethylene glycol
(PEG)**



**Graphene oxide
(GO)**



(1) Which chemical bond is indexed to peak 2 ($\sim 2920 \text{ cm}^{-1}$)?

(A) C–O stretching (B) C–H Asymmetric stretching (C) C=C stretching
(D) C=O stretching

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- (2) Which chemical bond is indexed to peak 4 ($\sim 1630\text{ cm}^{-1}$)?
(A) C–O stretching (B) C–H Asymmetric stretching (C) C=C stretching
(D) C=O stretching
- (3) Which chemical bond is indexed to peak 6 ($\sim 1125\text{ cm}^{-1}$)?
(A) C–O stretching (B) C–H Asymmetric stretching (C) C=C stretching
(D) C=O stretching
- (4) Which statement is correct for Sample a?
(A) Sample a is PEG due to the presence of peak 2, 5, and 6.
(B) Sample a is GO due to the presence of peak 2, 3, 4, 5, and 6.
(C) Sample a is PEG/GO due to the presence of peak 2, 3, 4, 5, and 6.
(D) All of the above are included.
- (5) Which statement is correct for Sample b?
(A) Sample b is PEG due to the presence of peak 2, 5, and 6.
(B) Sample b is GO due to the presence of peak 2, 5, and 6.
(C) Sample b is PEG/GO due to the presence of peak 2, 3, 4, 5, and 6.
(D) All of the above are included.
- (6) Which statement is correct for Sample c?
(A) Sample c is PEG due to the presence of peak 2, 5, and 6.
(B) Sample c is GO due to the presence of peak 3 and 4.
(C) Sample c is PEG/GO due to the presence of peak 2, 5, and 6.
(D) All of the above.

6. For Question (total 22 points, 2 points each, Question (8) is 6 points)

A 1.2 g of commercial vitamin C ($\text{C}_6\text{H}_8\text{O}_6$, 176 g/mol; $\text{p}K_{\text{a}1} = 4.70$; $\text{p}K_{\text{a}2} = 11.8$) tablet was dissolved in 100 mL of water. A 50 mL aliquot was taken out and titrated by 12 mL of 0.15 M I_2 standard solution to afford **Reaction 5**. When it was close to the equivalent point, an indicator can be considered to add into the aliquot. On the other hand, another 50 mL aliquot was taken out and neutralized by 0.10 M NaOH to afford **Reaction 6**.



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(1) Complete Reaction 5.

- (A) $1\text{C}_6\text{H}_8\text{O}_6 (\text{aq.}) + 1\text{I}_2 (\text{aq.}) \leftrightarrow 1\text{C}_6\text{H}_6\text{O}_6^{2-} (\text{aq.}) + 1\text{H}^+ (\text{aq.}) + 1\text{I}^- (\text{aq.})$
(B) $1\text{C}_6\text{H}_8\text{O}_6 (\text{aq.}) + 1\text{I}_2 (\text{aq.}) \leftrightarrow 2\text{C}_6\text{H}_6\text{O}_6^{2-} (\text{aq.}) + 2\text{H}^+ (\text{aq.}) + 2\text{I}^- (\text{aq.})$
(C) $2\text{C}_6\text{H}_8\text{O}_6 (\text{aq.}) + 2\text{I}_2 (\text{aq.}) \leftrightarrow 1\text{C}_6\text{H}_6\text{O}_6^{2-} (\text{aq.}) + 1\text{H}^+ (\text{aq.}) + 1\text{I}^- (\text{aq.})$
(D) $1\text{C}_6\text{H}_8\text{O}_6 (\text{aq.}) + 1\text{I}_2 (\text{aq.}) \leftrightarrow 1\text{C}_6\text{H}_6\text{O}_6^{2-} (\text{aq.}) + 2\text{H}^+ (\text{aq.}) + 2\text{I}^- (\text{aq.})$

(2) In Reaction 5, which chemical is the oxidant?

- (A) $\text{C}_6\text{H}_8\text{O}_6 (\text{aq.})$ (B) $\text{I}_2 (\text{aq.})$ (C) $\text{C}_6\text{H}_6\text{O}_6^{2-} (\text{aq.})$ (D) $\text{I}^- (\text{aq.})$

(3) Without an indicator, what's the color change slightly before and after equivalent point in the sample solution?

- (A) from transparent to yellow (B) from yellow to grey
(C) from grey to black (D) from black to transparent

(4) With a starch as the indicator, what's the color change slightly before and after equivalent point in the sample solution?

- (A) from transparent to yellow (B) from transparent to green
(C) from transparent to blue (D) from transparent to purple

(5) Calculate the weight (g) of vitamin C in the tablet.

- (A) 603.6 g (B) 633.6 g (C) 663.6 g (D) 693.6 g

(6) Calculate the weight percent (%) of vitamin C in the tablet.

- (A) 57.8% (B) 55.3% (C) 52.8% (D) 50.3%

(7) Complete Reaction 6.

- (A) $1\text{C}_6\text{H}_8\text{O}_6 (\text{aq.}) + 1\text{OH}^- (\text{aq.}) \leftrightarrow 1\text{C}_6\text{H}_6\text{O}_6^{2-} (\text{aq.}) + 1\text{H}_2\text{O} (\text{l})$
(B) $1\text{C}_6\text{H}_8\text{O}_6 (\text{aq.}) + 1\text{OH}^- (\text{aq.}) \leftrightarrow 2\text{C}_6\text{H}_6\text{O}_6^{2-} (\text{aq.}) + 2\text{H}_2\text{O} (\text{l})$
(C) $2\text{C}_6\text{H}_8\text{O}_6 (\text{aq.}) + 2\text{OH}^- (\text{aq.}) \leftrightarrow 1\text{C}_6\text{H}_6\text{O}_6^{2-} (\text{aq.}) + 1\text{H}_2\text{O} (\text{l})$
(D) $1\text{C}_6\text{H}_8\text{O}_6 (\text{aq.}) + 2\text{OH}^- (\text{aq.}) \leftrightarrow 1\text{C}_6\text{H}_6\text{O}_6^{2-} (\text{aq.}) + 2\text{H}_2\text{O} (\text{l})$

(8) Consider the $\text{p}K_a$ of vitamin C, calculate the pH value at the 1st equivalent point. (6 points) (此題為計算題，需列出計算過程)

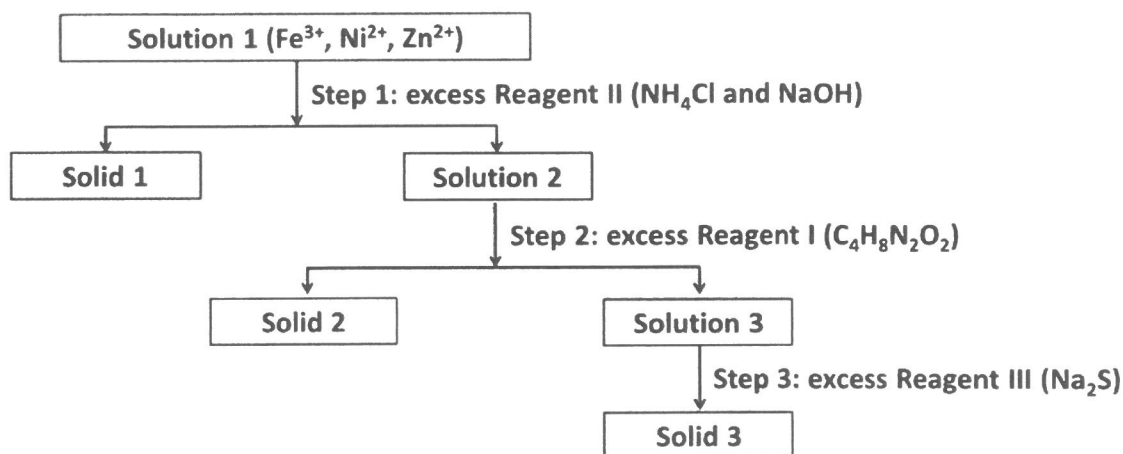
(9) Consider the $\text{p}K_a$ of vitamin C, choose a suitable indicator for the 1st equivalent point.

- (A) Methyl red (4.2→6.3 / Red→Yellow)
(B) Bromocresol blue (6.2→7.6 / Yellow→Blue)
(C) Cresol purple (7.6→9.2 / Yellow→Purple)
(D) Thymolphthalein (9.3→10.5 / Colorless→Blue)

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7. In **Table 1**, Reagent I ($\text{C}_4\text{H}_8\text{N}_2\text{O}_2$), Reagent II (NH_4Cl and NaOH), and Reagent III (Na_2S) are used to test the reactivities of different metal ions (Fe^{3+} , Ni^{2+} , and Zn^{2+}). Among them, Reagent I ($\text{C}_4\text{H}_8\text{N}_2\text{O}_2$) is an organic ligand to form the metal complex: $n(\text{C}_4\text{H}_8\text{N}_2\text{O}_2) + \text{M}^{n+} \rightarrow \text{M}(\text{C}_4\text{H}_7\text{N}_2\text{O}_2)_n + n\text{H}^+$. Accordingly, find out a good method to separate three metal ions (Fe^{3+} , Ni^{2+} , and Zn^{2+}) in the sample solution 1 by using the flowchart below. Each step is conducted to complete remove one kind of metal cation. (total 16 points, 2 points each)

Table 1	Reagent I: $\text{C}_4\text{H}_8\text{N}_2\text{O}_2$	Reagent II: NH_4Cl and NaOH	Reagent III: Na_2S
Fe^{3+} (Yellow aq.)	Black Ion	Orange/Brown Solid	Black Solid
Ni^{2+} (Green aq.)	Pink Solid	Light Green Ion	Dark green Solid
Zn^{2+} (Transparent aq.)	White Solid	Transparent Ion	White Solid



- (1) Write the chemical formula for Solid 1.
(A) $\text{Ni}(\text{OH})_2$ (B) $\text{Zn}(\text{OH})_2$ (C) $\text{Fe}(\text{OH})_3$ (D) All of the above
- (2) Write the chemical formula for Solid 2.
(A) $(\text{C}_4\text{H}_7\text{N}_2\text{O}_2)_2\text{-Ni}$ (B) $(\text{C}_4\text{H}_7\text{N}_2\text{O}_2)_2\text{-Zn}$ (C) $(\text{C}_4\text{H}_7\text{N}_2\text{O}_2)_3\text{-Fe}$
(D) All of the above
- (3) Write the chemical formula for Solid 3.
(A) NiS (B) ZnS (C) Fe_2S_3 (D) All of the above
- (4) Write the chemical formula for Solution 2.
(A) $\text{Fe}(\text{H}_2\text{O})_6^{3+}$ and $\text{Ni}(\text{H}_2\text{O})_6^{2+}$ (B) $(\text{NiCl}_4)^{2-}$ and $(\text{ZnCl}_4)^{2-}$
(C) $\text{Fe}(\text{NH}_3)_6^{3+}$ and $\text{Ni}(\text{NH}_3)_6^{2+}$ (D) $\text{Ni}(\text{NH}_3)_6^{2+}$ and $\text{Zn}(\text{NH}_3)_6^{2+}$

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- (5) When adding Fe^{3+} (Yellow aq.) to the Solid 2, we can get a black ionic product in the aqueous solution. Which of the following statement is correct?
- (A) Reagent I have the stronger coordination to Ni^{2+} than Fe^{3+}
(B) Reagent I have the stronger coordination to Ni^{2+} than Zn^{2+}
(C) Reagent I have the stronger coordination to Fe^{3+} than Ni^{2+}
(D) Reagent I have the stronger coordination to Zn^{2+} than Ni^{2+}
- (6) When adding Ni^{2+} (Green aq.) to the white solid of $(\text{C}_4\text{H}_7\text{N}_2\text{O}_2)_2\text{-Zn}$, we can get the Solid 2. Which of the following statement is correct?
- (A) Reagent I have the stronger coordination to Ni^{2+} than Fe^{3+}
(B) Reagent I have the stronger coordination to Ni^{2+} than Zn^{2+}
(C) Reagent I have the stronger coordination to Fe^{3+} than Ni^{2+}
(D) Reagent I have the stronger coordination to Zn^{2+} than Ni^{2+}
- (7) From Question (5)-(6), list the order of formation constant (K_f) of Reagent I toward three metal cations (Fe^{3+} , Ni^{2+} , and Zn^{2+}) ?
- (A) $\text{Fe}^{3+} > \text{Ni}^{2+} > \text{Zn}^{2+}$ (B) $\text{Fe}^{3+} = \text{Ni}^{2+} = \text{Zn}^{2+}$ (C) $\text{Fe}^{3+} < \text{Ni}^{2+} < \text{Zn}^{2+}$
(D) None of the above
- (8) Which statement is correct to compare the reactivity of Reagent III toward three metal cations (Fe^{3+} , Ni^{2+} , and Zn^{2+}) ?
- (A) Add Reagent III to Solution 1 to confirm the reactivity of Ni^{2+} and Zn^{2+}
(B) Add Reagent III to Solution 2 to confirm the reactivity of Fe^{3+} and Ni^{2+}
(C) Add Reagent III to Solution 3 to confirm the reactivity of Fe^{2+} and Zn^{2+}
(D) None of the above