※ 考生請注意：本試題可使用計算機，並限「考選部核定之國家考試電子計算器」機型

Inorganic Chemistry and Analytical Chemistry (total points: 100)

Part I: Inorganic Chemistry (total points: 50)

(1) (a) A complex of nickel(III), $[NiCl_2(P\phi_3)_2]$ is paramagnetic. The analogous complex of palladium(II) is diamagnetic. Predict the number of isomers that will exist for each of these formulations. (5 pts)

(b) Which of the following is the most likely structure for pentacyanocobalt(III)-μ-cyanopentaamminecobalt(III)? **Why?** (5 pts)

$[(NH_3)_5Co-CN-Co(CN)_5]$ or $[(NH_3)_5Co-NC-Co(CN)_5]$

(2) Although we are accustomed to thinking of complexes of transition metals as brightly colored, there are several that are not. For each of the following exceptions, present a reason for its lack of intense color: (10 pts)

(a) $Cu(NH_3)^{4+}$ is a completely colorless complex in contrast to its sister complex, $Cu(NH_3)_4^{+2}$, which is intensely blue.

(b) $Co(H_2O)_6^{+2}$ is very pale pink, although $CoCl_4^{-2}$ is deep blue.

(c) $Au(CN)_4^-$ and $Co(CN)_6^{-3}$ complexes form white crystals when combined with colorless cations.

(d) Unlike Co^{+2}, Mn^{+2} forms pale pink complexes with both water and chloride ions as ligands: $Mn(H_2O)_6^{+2}$ and $MnCl_4^{-2}$.

(3) There are several *non*transition metal ions that are colorless when isolated, i.e., in solution: Cd^{+2}, Hg^{+2}, and Pb^{+2}. Nevertheless, when combined with certain anions that are also colorless in solution, the final compounds are strongly colored. **Explain.** (10 pts)

(4) Give the ground-state electron configurations of the oxygen molecule, O_2, the superoxide ion, O_2^-, and the peroxide ion, O_2^{-2}. (10 pts)

(5) (a) What is the structure of $[B_5H_5]^{-2}$? Explain your answer. (5 pts)

(b) Determine the charge on the cyclic silicate anion $[Si_3O_9]^{-n}$. (5 pts)

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Part II: Analytical Chemistry (Total points: 50)

(1) Human chorionic gonadotropin (hCG) is a naturally occurring substance that gas been abused by some athletes because of its ability to stimulate testosterone production. Two laboratories that conduct drug testing ate to be evaluated for their ability to measure this hormone by using the same sample and analysis method. The first laboratory obtains a mean hCG level of 2.99 IU/L (n_1 = 4) with a standard deviation of 0.06 IU/L, while the second laboratory reports a mean level of 3.13 IU/L (n_2 = 5) with a standard deviation of 0.08 IU/L. Are these mean results the same at the 95% confidence level? (10 pts)

Values of Students's t at the 95% confidence level

Degree of freedom	2	3	4	5	6	7
t	4.30	3.18	2.78	2.57	2.45	2.36

(2) A 25.00 mL water sample is titrated with 0.01500 M HCl to determin the water's alkalinity by using the general approach of acid-base titration. An end point due to carbonate is obtained at 2.52 mL and a second end point due to bicarbonate is detected at 11.35 mL. What were the concentrations of carbonate and bicarbonate in the original sample? (10 pts)

(3) Different types of glass will have different values for the refractive index of light. For instance, light with a wavelength of 589 nm has the following values of n for various type of glass: 1.51714 (ordinary crown glass), 1.52430 (borosilicate glass), and 1.65548 (dense flint glass). Air (n = 1.0003) and water (n =1.333)

   (a) Calculate the angle of refraction of 589 nm light as it passes from air into each of these glasses at an angle of 50.0° vs. the normal. (3 pts)

   (b) Repeat the calculation in Part (a), but now calculate the angle of refraction of 589 nm light as it passes from pure water into each of these glasses at an angle of 50.0° vs. the normal. (3 pts)

   (c) Use the results in Parts (a) and (b) to rand the three types of glass based on their ability to refract 589 nm light. Which type of glass gives the largest change in direction of travel for this light? Which type of glass gives the smallest change due to refraction? Explain these results using Snell's law. (4 pts)

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(4) Antibodies are commonly used as ligands in affinity chromatography. A 10-cm long and 4.1-mm inner diameter affinity column has a void volume of 1.0 mL and contains of 10 nmol of antibodies for HIV-1 reverse transcriptase. At pH 7.0 (the sample application conditions), these antibodies will bind to this enzyme with an association equilibrium constant equal to $1.0 \times 10^8 \, M^{-1}$. What is the retention factor for reverse transcriptase on this colume at pH 7.0? (10 pts)

(5) A chemist performs a colorimetric assay that selectively measures iron. A 20.0 mL portion of the original sample gives an absorbance reading of 0.367 and a 20.0 mL portion of the same sample that has been spiked with 5.00 mL of a $2.00 \times 10^{-2} \, M$ iron solution gives an absorbance of 0.538. What is the concentration of iron in the original sample? (10 pts)