

※ 考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

I. Single or multiple choice questions (Each question has one or more answers.). 5 pts for each question.

1. Which of the following statements is correct?

- (A) TD glassware is calibrated to deliver a known volume of liquid at a given temperature that is printed on the glassware. However, TC glassware is calibrated to contain a known volume at a given temperature that is printed on the glassware.
- (B) Precision describes the reproducibility of measurements or the closeness of the measurement to the true or accepted value. It can be expressed by standard deviation, variance and coefficient of variation.
- (C) Systematic errors (determinate error) have assignable causes and definite values. They are often unidirectional. Types of these errors include: instrumental errors, method errors and personal errors.
- (D) Constant errors are independent of the size of the sample being analyzed. The effect of a constant error becomes less serious as the size of the quantity measured decreases.
- (E) In the feedback system flow diagram, the difference between the two states is used to change a controllable quantity that results in a change in the state of the system. The process provides continuous monitoring and feedback to maintain the controllable quantity.

2. Which of the following methods can be used to measure the thickness of thin films?

- (A) Tunneling electron microscopy
- (B) Spectroscopic ellipsometry
- (C) Electrospray ionization mass spectrometry
- (D) Atomic force microscopy
- (E) Atomic X-ray spectrometry

3. Which of the following statements related to Raman vs. Infrared is correct?

- (A) For a given bond, the energy shifts observed in a Raman experiment should be different to the energies of its infrared absorption bands.
- (B) The molecule detected in Raman and Infrared need possess a permanent dipole moment.
- (C) Water can be used as a solvent in Raman measurement, but water cannot be used due to its intense absorption of Infrared region.
- (D) The vibration is Raman active if it causes a change in dipole moment, and vibration is Infrared active if there is change in polarizability.
- (E) Raman is due to the scattering of light by the vibrating molecules, and Infrared is the result of absorption of light by vibrating molecules.

4. Which of the following terms used to describe the theory of band broadening in chromatography?

- (A) The single and multiple path term, A.
- (B) The longitudinal and lateral diffusion term, B/u .
- (C) The stationary-phase mass-transfer term, $C_s u$.
- (D) The mobile-phase mass-transfer term, $C_M u$.
- (E) All above options are correct.

5. Which of the following statements related to ionization in mass spectrometry is correct?
- (A) Ions formation by electron ionization (EI) or electrospray ionization (ESI) must be in a vacuum.
 - (B) Matrix-assisted laser desorption/ionization (MALDI) enables to generate significant fragmentation, which is very informative about structure of a molecule.
 - (C) Fast atom bombardment (FAB) is an ionization technique used in mass spectrometry in which a beam of high speed atoms with low energy strikes a sample surface to create ions.
 - (D) Sample for ESI must be dissolved in an appropriate solvent, but sample for MALDI need be applied in an appropriate matrix.
 - (E) Chemical ionization (CI) generates much less fragments than with EI; it is more likely to observe an ion closely related to the original molecule.
6. Which of the following methods can provide elemental and chemical information?
- (A) Scanning tunneling microscopy
 - (B) Energy-dispersive X-ray spectroscopy
 - (C) Dynamic light scattering
 - (D) Inductively coupled plasma atomic emission spectroscopy
 - (E) X-ray photoelectron spectroscopy
7. Which of the following statements is correct?
- (A) In titration, the titrant may be a standard solution of a known chemical or an electric current of known magnitude.
 - (B) The end point is the point in a titration when the amount of added standard reagent is equivalent to the amount of analyte.
 - (C) Back-titrations are often required when the rate of reaction between the analyte and reagent is slow or when the standard solution lacks stability.
 - (D) There are three typical types of titration curves: the sigmoidal curve, the linear segment curve, and the Conchoid of de Sluze curve.
 - (E) In particulate gravimetry, the analyte can be determined by separating it from the matrix of sample using a filtration or an extraction.
8. Which of the following statements is correct?
- (A) When the gas diffuses across the permeable membrane of a gas-sensing electrode, it alters the composition of the inner solution, which is monitored with an ion-selective electrode.
 - (B) Potentiometric electrodes are designed to respond to molecules by using a chemical reaction that produces an ion whose concentration can be determined using a traditional ion-selective electrode.
 - (C) Polarography is a voltammetric technique that uses a mercury electrode and an unstirred solution.
 - (D) Amperometry is a potentiometric method in which applies an alternating potential difference to the electrode and measures the resulting current.
 - (E) Coulometric methods are based on Faraday's law that the partial charge or current passed during an electrolysis is inversely proportional to the amount of reactants and products in the redox reaction.

II. Problem-solving and short answer questions. Show all work, steps, calculation, units and explanation if applicable. 10 pts for each question.

- Salting out is an effect which is used as a method for protein purification in the laboratory. Salting out usually relies on changing the protein solubility by adding lots amount of salts (electrolytes) in to a protein solution. At higher salt concentration, protein solubility usually decreases, leading to protein precipitation. Please explain the principle of salting-out effect and the reason why proteins precipitate at higher salt concentration.
- The quantitative determination of mercury in all types of samples is vital important, due to the toxicity and widespread distribution of organic mercury compounds in the environment. Atomic absorption spectrometry (AAS) has been widely used to determine the concentration of elements in analytical samples. Please describe and explain the principle of the AAS-based method for determination of mercury concentration in samples.
- For the titration reaction $A + B \rightarrow C$, where A is the analyte, B is the titrant, and C is the product, the titration is carried out via a UV-Vis spectrophotometer. The end point of titration is detected at 550 nm, based on the absorbance information below. Please explain and draw the titration curve at 550 nm.

Substance	Wavelengths absorbed (nm)
A	400~600, 700~800
B	<400, 500~700
C	<400

- Ethylenediaminetetraacetic acid (EDTA) is widely used in complexometric titrations and analysis of water hardness. Water hardness is determined by titrating Ca^{2+} and Mg^{2+} ions with a EDTA solution at a buffered pH of 10. Please explain the following questions.
 - Why is the water sample buffered to the pH of 10 during water hardness analysis?
 - What problems might you expect at a higher pH or a lower pH of the water sample?
- Micro total analysis systems (μTAS), or so-called laboratory-on-a-chip (LOC), are the devices that automate and include all necessary steps for chemical analysis, such as sampling, sample transport, chemical reactions, separation and detection.
 - What is the advantages of the μTAS or LOC, compared to traditional chemical analysis methods?
 - Please describe the basic principle of separation approaches used in μTAS or LOC.
- Please explain the reason why compound **A** exhibits stronger fluorescence than compound **B** in acetonitrile.

