國立成功大學

115學年度碩士班招生考試試題

編　號：38

系　所：化學系

科　目：分析化學

日　期：0203

節　次：第 4 節

注　意：1.不可使用計算機
2.請於答案卷(卡)作答，於試題上作答，不予計分。

Part I (25%):

Single or Multiple-answer questions. Each question has one or more answers.

Note: Each question earns **5** points (all correct), **2** points (one error), and **0** points (more than one error)

1. Which of the following statements is **correct**?

(A) TD glassware is calibrated to contain a known volume of liquid at a given temperature that is printed on the glassware. However, TC glassware is calibrated to deliver a known volume at a given temperature, which 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 in terms of 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.

2. Which of the following statements **correctly** describes the ionic strength of a solution?

(A) The size of ions

(B) The total charge of the ions (sum of charges of all ions)

(C) The concentration of the ions

(D) The mass-to-charge ratio of the ions

(E) The dielectric constant of the solvent

3. The solubility products (K_{sp}) for a series of iodides are as follows:

Compound	K_{sp}
CuI	1.0×10^{-12}
AgI	8.3×10^{-17}
PbI_2	7.1×10^{-9}
BiI_3	8.1×10^{-19}

While these iodide compounds dissolve in a 0.020 M solution of the solute cation, which of the following statements **correctly** lists any three of the four compounds in order of decreasing molar solubility?

(A) $PbI_2 > AgI > BiI_3$

(B) $PbI_2 > BiI_3 > CuI$

(C) $BiI_3 > CuI > PbI_2$

(D) $PbI_2 > CuI > BiI_3$

(E) $BiI_3 > CuI > AgI$

4. Consider the following 0.10 M aqueous solutions: NaF, $NaC_2H_3O_2$, C_5H_5NHCl, KOH, and HCN. Relevant equilibrium constants are given below:

$K_a(\mathrm{HF}) = 7.2 \times 10^{-4}$

$K_a(\mathrm{HC_2H_3O_2}) = 1.8 \times 10^{-5}$

$K_b(\mathrm{C_5H_5N}) = 1.7 \times 10^{-9}$

$K_a(\mathrm{HCN}) = 6.2 \times 10^{-10}$

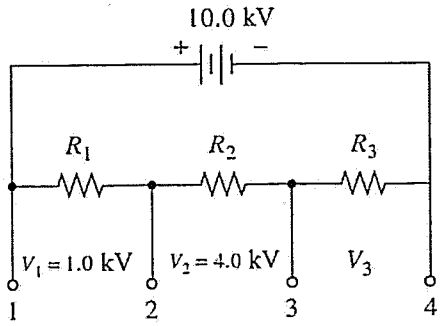
Which of the following options **correctly** lists any four of the five solutions in order of increasing pH?

(A) $\mathrm{C_5H_5NHCl} < \mathrm{HCN} < \mathrm{NaC_2H_3O_2} < \mathrm{NaF}$
(B) $\mathrm{C_5H_5NHCl} < \mathrm{HCN} < \mathrm{NaF} < \mathrm{NaC_2H_3O_2}$
(C) $\mathrm{HCN} < \mathrm{C_5H_5NHCl} < \mathrm{NaF} < \mathrm{NaC_2H_3O_2}$
(D) $\mathrm{HCN} < \mathrm{C_5H_5NHCl} < \mathrm{NaC_2H_3O_2} < \mathrm{NaF}$
(E) $\mathrm{C_5H_5NHCl} < \mathrm{NaC_2H_3O_2} < \mathrm{NaF} < \mathrm{KOH}$

5. Which of the following statements is/are **correct**?
(A) Photomultiplier tubes are inefficient for detecting infrared light because the photon energy is often too low to produce a measurable number of photoelectrons from typical photocathodes.
(B) Photomultiplier tubes are not suitable for detecting ultraviolet light because high-intensity UV radiation can damage the photocathode.
(C) Microwave photons carry more energy than infrared photons.
(D) For a diffraction grating operated at a fixed angle of incidence, each wavelength is diffracted at only one angle.
(E) The angle of incidence of photons striking a diffraction grating must be held constant for the grating to function properly as a dispersive optical element.

Part II (75%):
Short answer questions.

6. (20%) Many instrument detectors require multiple high-voltage power supplies. Imagine that, in the laboratory, your instrument requires two high-voltage inputs of 1 kV and 4 kV, respectively. You find a single 10 kV high-voltage power supply (maximum power: 50 W) available in the lab and decide to generate the required voltages using a voltage divider (see the figure below).



The following resistors are available for constructing the voltage divider: 250 kΩ, 500 kΩ, 750 kΩ, 1.00 MΩ, and 1.25 MΩ. Please answer the following questions:

(a) (**8%**) Using the available resistors, propose a suitable combination to construct the voltage divider that provides output voltages of 1.0 kV and 4.0 kV. Clearly specify **the resistor values** for R_1 and R_2.

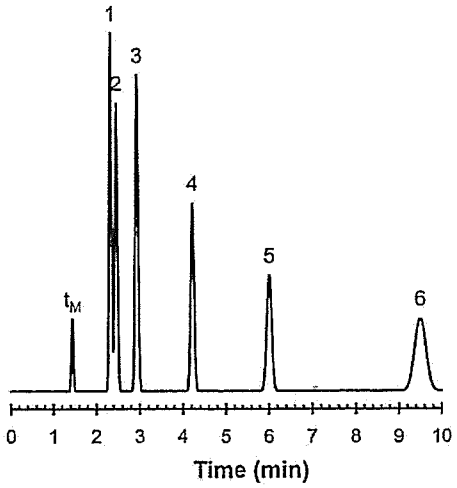
(b) (**4%**) What **current** is drawn from the power supply? (Express your answer in **mA**)

(c) (**4%**) What **power** is dissipated by the circuit (Express your answer in **W**)?

(d) (**4%**) Determine whether the 50 W power supply is sufficient to operate the circuit safely? (Express **yes** or **no** in your answer)

7. (**10%**) In the IC-packaging industry, manufacturers commonly employ techniques such as wire bonding, molding, trimming, and electroplating. Among these processes, electroplating generates the largest amount of heavy-metal waste. An IC-packaging company was found to have illegally discharged wastewater into a river. The wastewater contained Ni^{2+} and Cu^{2+} ions. An EPA chemist collected and analyzed a 100.0 mL sample of the wastewater. A 25.0 mL aliquot of the sample was titrated with 0.050 M EDTA, requiring 45.0 mL to complex both metal ions. Mercaptoacetic acid and ammonia were then added to selectively complex Cu^{2+}, releasing an equivalent amount of EDTA. The liberated EDTA was titrated with 0.080 M Mg^{2+}, requiring 25.0 mL. Calculate **the concentrations (in ppm)** of **Ni^{2+}** and **Cu^{2+}** in the original wastewater sample. (Ni: 58.69 g/mol; Cu: 63.55 g/mol)

8. (**23%**) The following chromatogram and report were obtained by gas chromatography using a 15-meter column. The sample was a plant extract containing six distinct polyprenols.



REPORT
(all times in minutes)

Peak	Ret. Time	Width @ Base
t_M	1.44	--
1	2.33	0.102
2	2.46	0.119
3	2.93	0.127
4	4.22	0.144
5	6.01	0.221
6	9.50	0.510

(a) (**8%**) Calculate the number of **theoretical plates** and the **plate height** for the peak with the lowest efficiency.

(b) (**8%**) Calculate the **resolution** and **selectivity factors** for the overlapping peaks.

(c) (**7%**) Recall that the column length is 15 meters. What is the minimum length of the column (in meters) required to separate the overlapping peaks completely? Assume all conditions are identical except for the column length.

9. (**22%**) Microvolume UV–Vis spectrophotometry is widely used for nucleic acid analysis because it requires only microliter sample volumes and does not require a cuvette. In such instruments, a 1 mm optical pathlength is typically used for standard measurements. Nucleic acid X has a mass absorptivity at 260 nm of 20 $Lg^{-1}cm^{-1}$. The transmittance of the nucleic acid X aqueous solution measured at 260 nm is 5.0%. (Useful logarithms: $\log 2 \approx 0.301$, $\log 3 \approx 0.477$, $\log 5 \approx 0.699$.)

(a) (**5%**) Calculate the **absorbance** instead of transmittance.

(b) (**5%**) Calculate the **concentration** of the nucleic acid solution in **mg/mL**.

(c) (**4%**) Compared with UV–Vis absorption spectroscopy, vibrational spectroscopy reveals unique spectral fingerprints for bases, sugars, and phosphate groups, allowing structural analysis (e.g., single vs. double strand, folding) and monitoring interactions (ions, heavy metals). Which vibrational spectroscopy technique would be suitable for analyzing aqueous nucleic acid solutions? Why?

(d) (**4%**) This nucleic acid X can bind to a specific protein Y, which contains multiple naturally fluorescent tryptophan residues. Which spectroscopic technique, UV–Vis absorption or fluorescence spectroscopy, is more suitable for detecting Protein Y at low concentrations? Explain your reasoning.

(e) (**4%**) Which spectroscopic technique, UV–Vis absorption or fluorescence spectroscopy, is more suitable for accurate quantification at moderate concentrations? Explain your reasoning.