Analytical Chemistry II – MIDTERM EXAM I

- **It is not allowed to put any additional items (*e.g.* cell phone, calculator) on the bench.**
- **Sign the exam paper, and sign the attendance list at the beginning of the exam.**
- **You have to hand in the exam paper before leaving the classroom.**
- **The exam consists of two parts (I and II).**
- **You can answer in English or Chinese language.**
- **Do not use pencil; use pen.**
- **If you cheat (*e.g.* use cell phone), you will be punished.**

I. Choose the most accurate answer:

Circle the letter corresponding to your choice, or write the answer letter next to the question.
(maximum: 10 × 4 = 40 points)

1. Which figure of merit represents bias?
   a) relative standard deviation
   b) coefficient of selectivity
   c) calibration sensitivity
   d) absolute systematic error
   e) absolute standard deviation

2. Which figure(s) of merit describe dynamic range of an analytical method?
   a) limit of quantification and limit of linearity
   b) correction factor
   c) standard deviation
   d) systematic error
   e) coefficient of selectivity

3. What input transducer can be used in photometer?
   a) tungsten lamp
   b) electrical voltage
   c) photodiode
   d) digitizer
   e) glass-calomel electrode

4. Which concept refers to the minimum frequency of data points while recording electric potential changes as a function of time?
   a) Ohm's law
   b) Kirchoff's laws
   c) Nyquist sampling theorem
   d) Pythagorean theorem
   e) power law

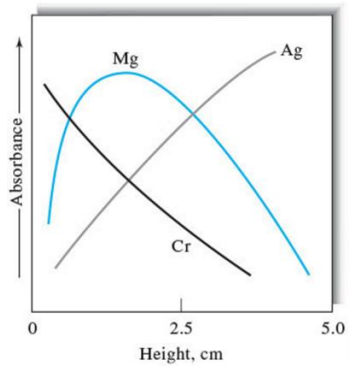
5. What is the definition of absorbance (A)? (P_0 – power of incident light, P – power of transmitted light)
   a) $A = \log\frac{P_0}{P}$
   b) $A = \log\frac{P}{P_0}$
   c) $A = P - P_0$
   d) $A = \frac{P_0}{P}$
   e) $A = \frac{P}{P_0}$

6. What is the correct equation for Beer's law?
   (A – absorbance, ε – molar absorptivity, b – optical pathlength, c – analyte concentration)
   a) $A = \varepsilon b \sin(c)$
   b) $A = \log(\varepsilon bc)$
   c) $A = \varepsilon bc$
   d) $A = \frac{\varepsilon}{bc}$
   e) $A = \frac{\varepsilon b}{c}$

7. What is the sequence of events in flame atomic absorption spectrometric analysis of liquid samples?
   a) dissociation→volatilization→nebulization→desolvation→excitation
   b) excitation→dissociation→volatilization→desolvation→nebulization
   c) nebulization→dissociation→excitation→desolvation→volatilization
   d) nebulization→excitation→desolvation→volatilization→dissociation
   e) nebulization→desolvation→volatilization→dissociation→excitation

8. Which oxidant should we use for analysis of refractory samples by flame atomization atomic absorption spectroscopy?
   a) hydrogen
   b) oxygen
   c) synthetic air
   d) butane
   e) air

9. The graph shows absorbances of three elements in relation to measurement height in flame atomization atomic absorption spectroscopy. Why does the Mg absorbance decrease with increasing measurement height above 2 cm?

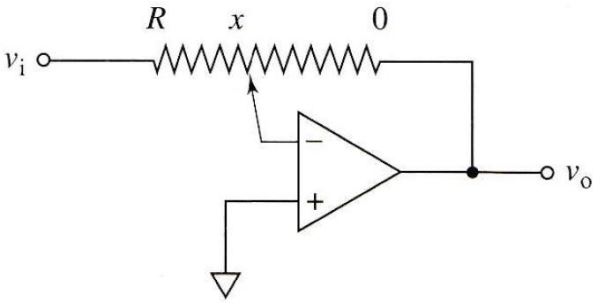


   a) because of increasing dissociation of Mg compounds
   b) because Mg does not easily form oxides
   c) because Mg forms oxides during its exposure to oxidant
   d) because Mg easily reacts with hydrogen in the flame
   e) because Mg shows high atomization efficiency

10. Which element can readily be analyzed by cold-vapor atomization atomic absorption spectroscopy?
    a) lithium
    b) potassium
    c) cadmium
    d) mercury
    e) silicon

II. Answer the following questions: (maximum: 4 × 15 = 60 points)
- Indicate the question letter before answering.
- Provide a complete, accurate, clear, high-quality answer to every part of each task.
- Adhere to the answer length limits. Up to 3 points may be deducted per question for exceeding the length limits.
- Handwriting must be clear.
- Schemes and graphs must be labeled.

A. In the following circuit, R is a variable resistor. Derive an equation that describes v_o as a function of v_i and the position x of the movable contact of the voltage divider. Perform the derivation such that x is zero if there is zero resistance in the feedback loop.
- answer length limit: 5 lines of text (including equations)



B. What types of noise are (i) frequency-dependent and (ii) frequency-independent?
- answer length limit: 20 words (2 items per category)

C. Characterize the mechanism of Doppler broadening and its influence on atomic line widths.
- answer length limit: 100 words

D. Describe operation of glow-discharge atomization of solid samples. Illustrate this description with a drawing.
- answer length limit: 100 words, 1 figure with labels

ANSWERS: (You can also use the reverse sides.)

A.

$$v_o = -ix \quad \text{and } v_+ = v_- = 0$$

$$v_i = i(R - x)$$

$$\frac{v_o}{v_i} = \frac{-ix}{i(R-x)} = -\frac{x}{R-x}$$

$$v_o = -\left(\frac{x}{R-x}\right)v_i$$

B.

Frequency-dependent noise sources: flicker and environmental noise.
Frequency-independent sources: thermal and shot noise.

C.

- When an atom moves toward a photon detector and emits radiation, the detector sees wave crests more often and detects radiation of higher frequency.
- When an atom moves away from a photon detector and emits radiation, the detector sees crests less frequently and detects radiation of lower frequency.
- Typically: 2 orders greater than natural line widths

D.

- The sample is pressed into a circular hole.
- Fine streams of argon impinge on the sample surface.
- The argon is ionized by a current between an anode (nozzles) and a cathode (sample).
- The argon ions sputter the sample atoms.
- The sputtered sample atoms are drawn to the axis of the cell where they absorb light from the spectroscope.
- The sample pellet must be conductive.