Analytical Chemistry II – MIDTERM EXAM I

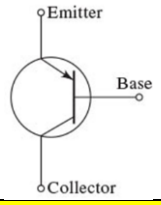
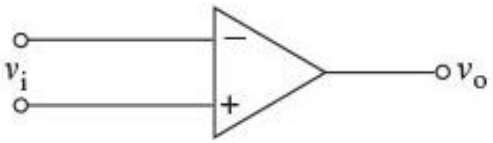
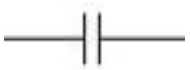
- **It is not allowed to put any additional items (*e.g.* cell phone, calculator) on the bench.**
- **Sign the exam paper, and sign the attendance list at the beginning of the exam.**
- **You have to hand in the exam paper before leaving the classroom.**
- **The exam consists of two parts (I and II).**
- **You can answer in English or Chinese language.**
- **Do not use pencil; use pen.**
- **If you cheat (*e.g.* use cell phone), you will get 0 points from this exam.**

I. Choose the most accurate answer:

Circle the letter corresponding to your choice, or write the answer letter next to the question.
(maximum: 15 × 4 = 60 points)

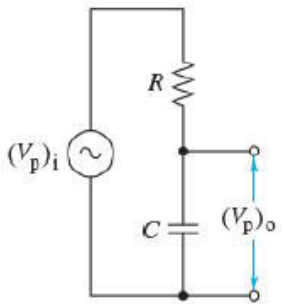
1. What characteristic property is measured using conductometry?
   a) mass
   b) capacitance
   c) power of transmitted light
   d) electrical resistance
   e) thermal characteristics

2. Match the symbols with the names of electronic elements.

1	2	3	4
			

   a) 1 – transistor; 2 – diode; 3 – operational amplifier; 4 – capacitor
   b) 1 – transistor; 2 – capacitor; 3 – operational amplifier; 4 – diode
   c) 1 – transistor; 2 – operational amplifier; 3 – diode; 4 – capacitor
   d) 1 – capacitor; 2 – operational amplifier; 3 – diode; 4 – transistor
   e) 1 – operational amplifier; 2 – diode; 3 – transistor; 4 – capacitor

3. What is the name/function of this electronic circuit?



   a) operational amplifier
   b) transistor
   c) rectifier
   d) low-pass filter
   e) high-pass filter

4. Convert 355 to BCD number.
   a) 101100011
   b) 101100010
   c) 0101 0101 0101
   d) 0011 0101 0101
   e) 355

5. ADCs digitize at different rates. What conversion rate is required if a chromatographic peak is to be sampled and digitized 25 times between the first positive deflection from the baseline until the peak returns to the baseline? The total baseline-to-baseline time is (i) 20 s and (ii) 1 s.
   a) (i) 20 Hz, (ii) 1 Hz
   b) (i) 0.8 Hz, (ii) 0.04 Hz
   c) (i) 1.25 Hz, (ii) 25 Hz
   d) (i) 25 Hz, (ii) 25 Hz
   e) (i) 500 Hz, (ii) 25 Hz

6. What type(s) of noise is/are frequency-dependent?
   a) flicker noise
   b) thermal noise
   c) shot noise
   d) environmental noise and thermal noise
   e) thermal noise and flicker noise

7. Which method of signal-to-noise ratio enhancement is software-based?
   a) use of amplifiers
   b) grounding
   c) ensemble averaging
   d) shielding
   e) analog filtering

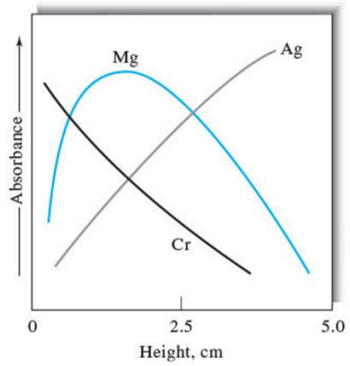
8. Which wavelength range of electromagnetic radiation corresponds to vacuum ultraviolet light?
   a) 10-180 nm
   b) 180-400 nm
   c) 400-780 nm
   d) 0.78-300 μm
   e) 0.6-10 m

9. 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) $A = \frac{P_0}{P}$
   d) $A = \frac{P}{P_0}$
   e) $A = P - P_0$

10. In atomic spectroscopy, we focus on the absorption/emission signals from:
   a) free ions
   b) free atoms
   c) molecules
   d) atoms within molecules
   e) solid aerosols

11. 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→desolvation→volatilization→dissociation→excitation
    e) nebulization→excitation→desolvation→volatilization→dissociation

12. The graph shows absorbances of three elements in relation to measurement height in flame atomization atomic absorption spectroscopy. Why does the Cr absorbance decrease with increasing measurement height?

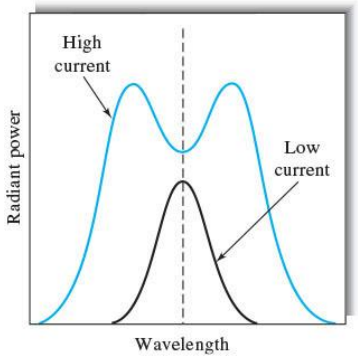


    a) because Cr does not easily form oxides
    b) because Cr shows high atomization efficiency
    c) because Cr forms very stable oxides
    d) because Cr easily reacts with hydrogen in the flame
    e) because of increasing dissociation of Cr compounds

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

14. The characteristic feature of HCL lamp is that:
    a) it exhibits line spectrum
    b) its spectrum has a broad band
    c) it contains hollow anode
    d) it uses microwaves to generate excited atoms
    e) it can only be used for analysis of mercury

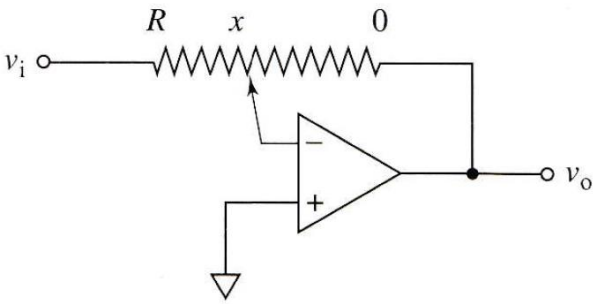
15. The graph shows emission profiles for HCL lamp at different currents. What is the reason of the local minimum at the observation wavelength in high-current operation?



    a) Zeeman effect
    b) isotopic effect
    c) contamination
    d) absorption of emitted radiation by argon ions in the lamp
    e) absorption of emitted radiation by unexcited atoms in the lamp

II. Answer the following questions: (maximum: 4 × 10 = 40 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. Why is an electrothermal atomizer more sensitive than a flame atomizer?
- *answer length limit: 50 words*

C. Draw a scheme of double-beam atomic absorption spectrophotometer.
- *answer length limit: 1 figure with labels*

D. Describe how a deuterium lamp can be used to provide a background correction for an atomic absorption spectrum.
- *answer length limit: 100 words, 1 figure with labels*

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

A.

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

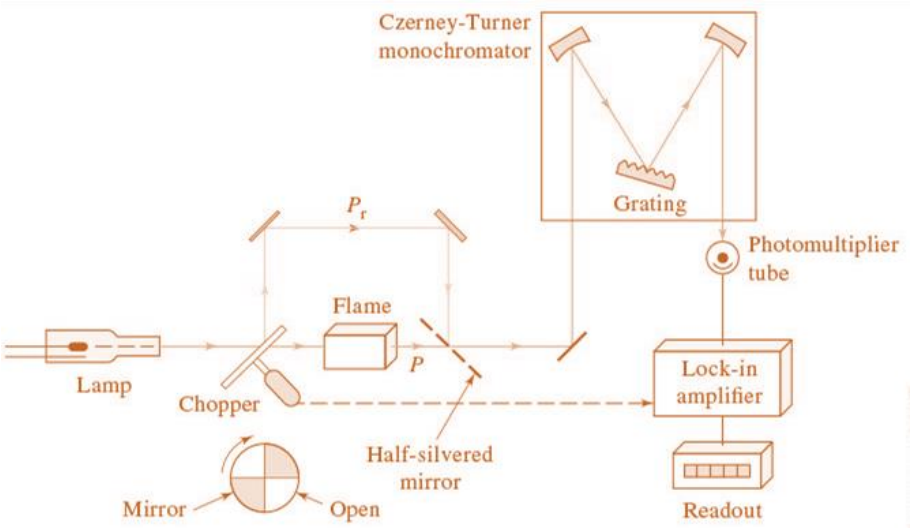
$$v_i = i(R - x)$$

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

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

B.
The electrothermal atomizer is a more efficient atomizer. It requires much less sample and keeps the atomic vapor in the beam for a longer time than does a flame.

C.



D.

The continuum radiation from the D_2 lamp is passed through the flame alternately with the hollow-cathode beam. Since the atomic lines are very narrow, the D_2 lamp is mostly absorbed by the background, whereas the hollow-cathode radiation is absorbed by the atoms. By comparing the radiant power of the two beams, the atomic absorption can be corrected for any background absorption.