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, you will get 0 points from this exam.**

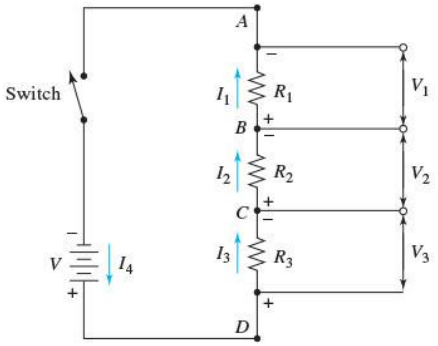
I. Choose the most accurate answer:

Circle the letter corresponding to your choice, or write the answer letter next to the question. (maximum: 20 × 4 = 80 points)

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

2. Convert the binary number '00101' to decimal number.
   a) 3
   b) 5
   c) 7
   d) 11
   e) 111

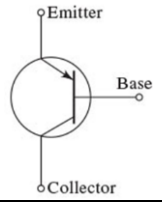
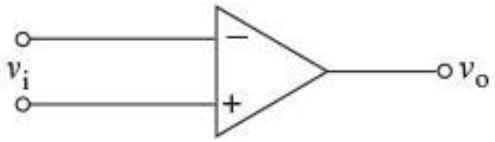
3. Which formula relates V_1 with V, R_1, R_2, and R_3 in the circuit below?



   a) $V_1 = V(R_1 + R_2 + R_3)$
   b) $V_1 = V\left(\frac{R_2+R_3}{R_1+R_2+R_3}\right)$
   c) $V_1 = V\left(\frac{R_1}{R_1+R_2+R_3}\right)$
   d) $V_1 = V\left(\frac{R_1+R_2+R_3}{R_1}\right)$
   e) $V_1 = V\left(\frac{R_1+R_2+R_3}{R_2+R_3}\right)$

4. Loading error in voltage measurements
   a) does not depend on the meter resistance and source resistance.
   b) is always so small that it can be neglected.
   c) is particularly high when using op amps for voltage measurements.
   d) becomes smaller as the meter resistance becomes larger relative to the source resistance.
   e) becomes larger as the meter resistance becomes larger relative to the source resistance.

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

1	2	3	4
			

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

6. Which wavelength range of electromagnetic radiation corresponds to visible light?
   a) 10-180 nm
   b) 180-400 nm
   c) 400-700 nm
   d) 0.78-300 μm
   e) 0.6-10 m

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

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

9. What input transducer can be used in photometer?
   a) tungsten lamp
   b) flame
   c) photodiode
   d) glass electrode
   e) ion source

10. What is the typical value of natural line width in atomic spectroscopy?
    a) ~ 10^{-7} nm
    b) ~ 10^{-5} nm
    c) ~ 10^{-3} nm
    d) ~ 10^{-1} nm
    e) ~ 10 nm

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

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

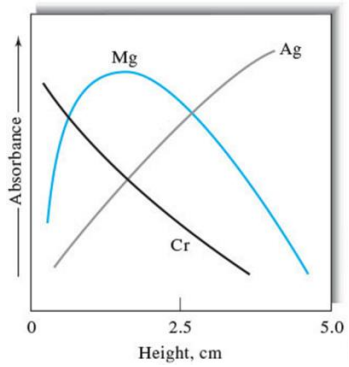
13. Which oxidant should we use for analysis of refractory samples by flame atomization atomic absorption spectroscopy?
    a) hydrogen
    b) air
    c) oxygen
    d) natural gas
    e) butane

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

15. Which atomic absorption spectroscopy technique is used for direct analysis of conducting solids?
    a) FIA
    b) pneumatic nebulization
    c) hydride generation
    d) flame
    e) glow-discharge atomization

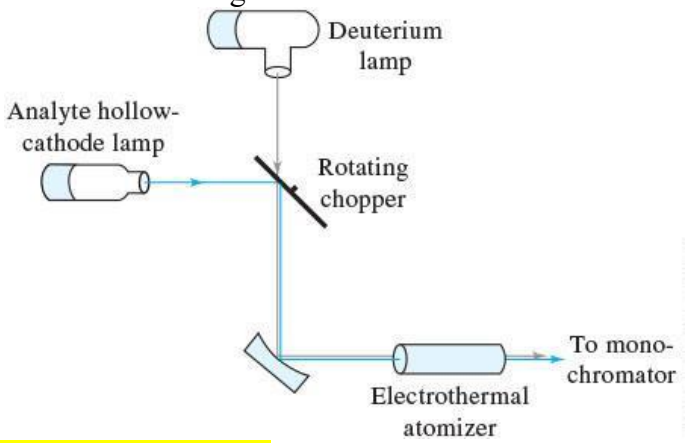
16. What is the advantage of double-beam atomic absorption spectrophotometer as compared with single-beam atomic absorption spectrophotometer?
    a) It corrects the signal for fluctuations in flame temperature.
    b) It corrects the signal for fluctuations in lamp output intensity.
    c) It corrects the signal for solute volatilization interferences.
    d) It corrects the signal for chemical interferences.
    e) It corrects the signal for interferences related to combustion products that absorb or scatter light.

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

18. What method is illustrated in the following scheme?



a) continuum-source background correction
b) background correction based on source self-reversal
c) background correction based on the Zeeman effect
d) double-beam atomic absorption spectrophotometer
e) solute volatilization

19. Addition of potassium to sample can improve sensitivity in analysis of strontium by flame atomization atomic absorption spectroscopy. In this case, potassium is:
a) releasing agent
b) protective agent
c) radiation buffer
d) solute volatilization interferent
e) ionization suppressor

20. In inductively coupled plasma source, plasma state is generated with the aid of:
a) DC electric field
b) permanent magnet
c) microwave transducer
d) laser light
e) RF magnetic field

II. Answer the following questions: (maximum: 4 × 5 = 20 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. Draw scheme of single-beam photometer for absorption measurements in the visible region.
- answer length limit: 1 figure with labels

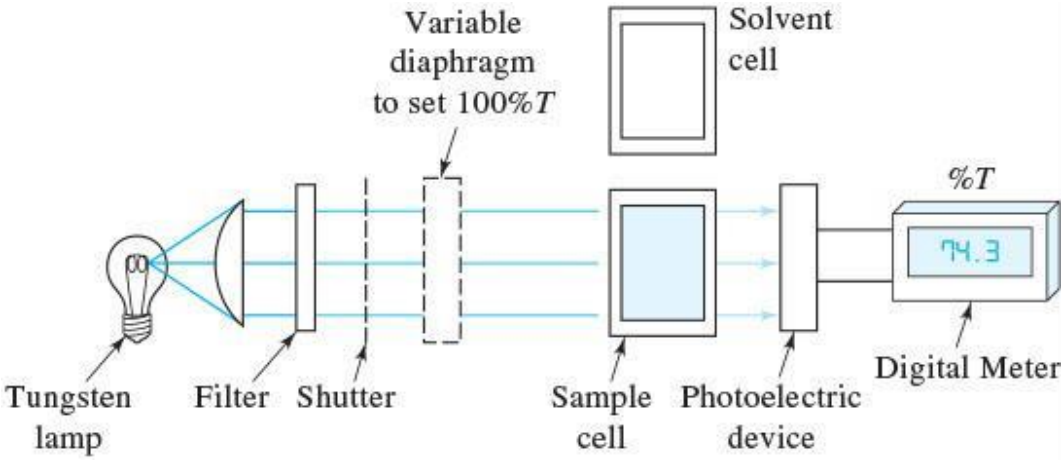
B. Draw scheme and explain the operational principle of hollow-cathode lamp used in atomic absorption spectroscopy.
- answer length limit: 1 figure with labels, 100 words

C. Explain the difference between releasing agent and protective agent in atomic absorption spectroscopy.
- answer length limit: 100 words

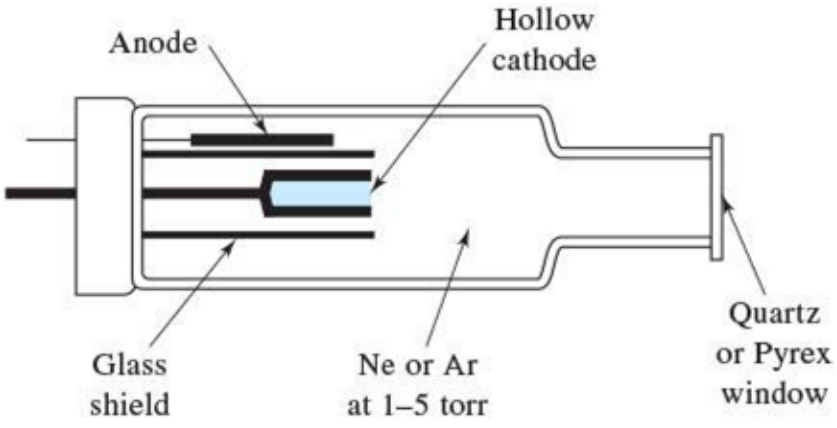
D. Draw scheme of atomic fluorescence spectroscopy system.
- answer length limit: 1 figure with labels

ANSWERS:

A.



B.



- Cylindrical cathode supports the metal whose spectrum is desired.
- At 300 V, the inert gas is ionized.
- The formed cations dislodge some of the metal atoms from the cathode surface and produce an atomic cloud (sputtering).
- Some of the metal atoms are in excited state, and emit their characteristic radiation.
- The lamp can contain one metal or a mixture of metals.

C.

- A releasing agent is a cation that preferentially reacts with a species that would otherwise react with the analyte to cause a chemical interference.
- A protective agent prevents interference by forming stable and volatile products with the analyte.

D.