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: 20 × 4 = 80 points)

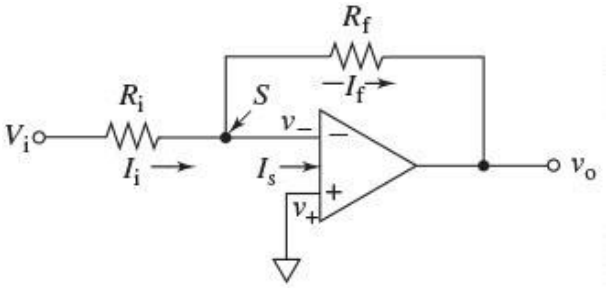
1. Which figure of merit represents bias?
   a) calibration sensitivity
   b) absolute systematic error
   c) relative standard deviation
   d) coefficient of selectivity
   e) absolute standard deviation

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

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

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

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



a) comparator
b) voltage follower
c) current follower
d) inverting voltage amplifier
e) rectifier

6. 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) power Law
d) Pythagorean theorem
e) Nyquist sampling theorem

7. Convert the binary number '01101' to decimal number.
a) 3
b) 5
c) 7
d) 13
e) 111

8. What types of noise are frequency-dependent?
(I) thermal noise; (II) shot noise; (III) flicker noise; (IV) environmental noise
a) I
b) I and II
c) II and III
d) I and IV
e) III and IV

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

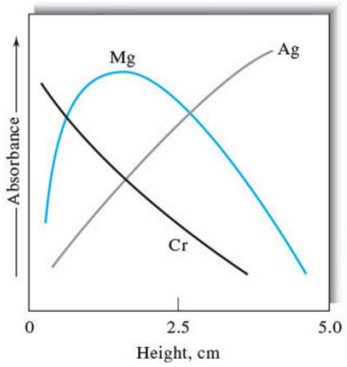
10. What has to be done to determine the signal corresponding to 0% transmittance in photometer?
a) increase electric current of light source
b) open mechanical shutter
c) close mechanical shutter
d) switch off transducer
e) place a sample in the sample cell

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

12. Which combination of fuel and oxidant would provide flame with the lowest temperature in flame atomization atomic absorption spectroscopy?
    a) acetylene and oxygen
    b) acetylene and air
    c) natural gas and oxygen
    d) natural gas and air
    e) acetylene and nitrous oxide

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

14. 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 forms oxides during its exposure to oxidant
    c) because Mg does not easily form oxides
    d) because Mg shows high atomization efficiency
    e) because Mg easily reacts with hydrogen in the flame

15. What is the limitation of glow-discharge atomization?
    a) The analytes need to be converted to hydrides.
    b) The sample has to be liquid.
    c) The sample volume has to be large.
    d) The sample pellet must be conductive.
    e) The sample pellet cannot be conductive.

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

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

18. 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 solute volatilization interferences.
    c) It corrects the signal for fluctuations in lamp intensity.
    d) It corrects the signal for interferences related to combustion products that absorb or scatter light.
    e) It corrects the signal for chemical interferences.

19. What is the function of strontium in the analysis of calcium in the presence of phosphate?
    a) releasing agent
    b) protective agent
    c) sputtering agent
    d) ionization suppressor
    e) radiation buffer

20. The zone in inductively coupled plasma source used for atomic emission spectroscopic measurements has a temperature of:
    a) ~ 200 °C
    b) ~ 600 K
    c) ~ 1000 K
    d) ~ 6000 K
    e) ~ 120000 K

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

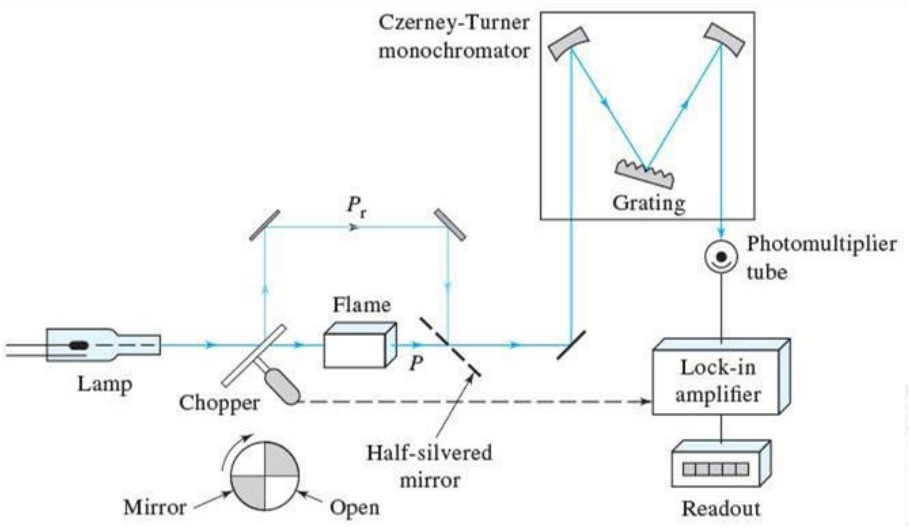
B. Provide classification of interferences in atomic absorption spectroscopy.
- answer length limit: 100 words

C. Describe operation of inductively coupled plasma source used in atomic emission spectroscopy. Draw a scheme of such a source.
- answer length limit: 100 words, 1 figure with labels

D. Describe operation of diffraction grating monochromator. Draw a scheme of such a monochromator.
- answer length limit: 100 words, 1 figure with labels

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

A.

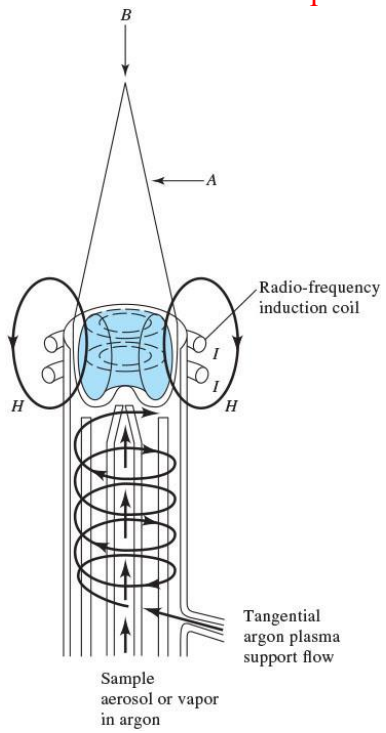


B.
- Spectral interferences
  - Two overlapping lines (rare)
  - Combustion products that absorb or scatter light
  - An interfering species present in the sample

- Chemical interferences
  - Formation of compounds of low volatility
  - Dissociation equilibria
  - Ionization equilibria

C.

Plasma is an electrically conducting gaseous mixture containing cations and electrons.
Plasmas achieve high temperatures (even 10,000 K).
The inductively coupled plasma (ICP) torch consists of concentric quartz tubes.
Argon is supplied at 5-20 L min^{-1}.
Induction coil is powered by radio-frequency (RF) generator (0.5-2 kW, MHz range).
Ions and electrons interact in the fluctuating magnetic field.
Heat is produced due to the movements of ions and electrons to induced by the magnetic field.
Tangential flow of argon cools the quartz elements and focuses plasma radially.



D.

Light can be dispersed by directing the beam through transmission grating or onto a surface of a reflection grating. Polychromatic light beam enters the monochromator through entrance slit, it is reflected from a mirror, and directed onto diffraction grating. Due to the diffraction process, wavelengths are separated. The beam is further reflected from a mirror, and exits the monochromator through exit slit.