

## Analytical Chemistry II – MIDTERM EXAM II

- 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.

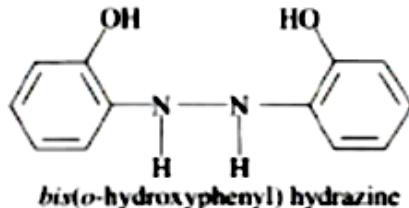
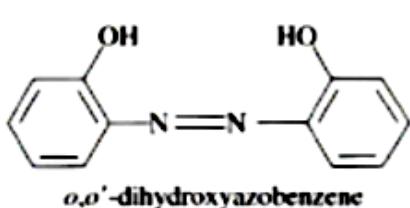
### I. Choose the most accurate answer:

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

1. What kind of analysis could you easily perform by glow-discharge optical emission spectroscopy?
  - a) determine the presence of sodium in tap water
  - b) determine the presence of caffeine in coffee
  - c) determine the presence of copper in brass
  - d) determine the presence of iron in blood
  - e) determine the presence of lead in river water
2. If the transmittance has the value of 0.01, then what is the value of absorbance?
  - a) 0.01
  - b) 0.1
  - c) 1
  - d) 2
  - e) 3
3. Which light source is suitable for molecular absorption spectroscopy at 200-300 nm?
  - a) HCL lamp
  - b) nichrome wire
  - c) tungsten lamp
  - d) deuterium lamp
  - e) Globar
4. Which of the following is the characteristic of photodiode array detector?
  - a) It enables recording full spectrum in a very short time.
  - b) It is much more sensitive to light than photomultiplier tube.
  - c) It emits light at one wavelength only.
  - d) It cannot be used in the visible region.
  - e) It has very slow response.

5. What is the typical effect of stray radiation on absorption measurements?
- a) No effect.
  - b) Measured absorbance is equal to real absorbance.
  - c) At high real absorbance, measured absorbance is much higher than real absorbance.
  - d) At low real absorbance, measured absorbance is much higher than real absorbance.
  - e) At high real absorbance, measured absorbance is lower than real absorbance.
6. Taking into account spectral interferences, which sample solvent would be most suitable for UV absorption measurements at 210 nm?
- a) dioxane
  - b) water
  - c) acetone
  - d) phenol
  - e) chlorobenzene
7. Why does  $\beta$ -carotene absorb blue light?
- a) due to the presence of conjugated double bonds
  - b) due to the presence of one aromatic ring
  - c) due to the presence of fused aromatic rings
  - d) due to blue shift
  - e) due to formation of a complex with metal ions
8. How do we call the process, in which a molecule changes from a higher electronic state to an upper vibrational level of a lower electronic state in which the vibrational energy is great enough to rupture the bond?
- a) bioluminescence
  - b) predissociation
  - c) vibrational relaxation
  - d) phosphorescence
  - e) fluorescence
9. Intersystem crossing
- a) is the process in which a molecule in one spin state changes to another spin state with nearly the same total energy.
  - b) occurs when radiation promotes a molecule directly to a state with sufficient kinetic energy for a bond to break.
  - c) is observed when an excited species emits radiation of the same frequency as that used to cause the excitation.
  - d) is a radiationless process in which a molecule loses electronic energy while transferring that energy to the solvent or another solute.
  - e) is required for fluorescence to occur.
10. Sulfur dioxide is a nonlinear molecule. How many vibrational modes will this compound have?
- a) 0
  - b) 1
  - c) 2
  - d) 3
  - e) 4

11. Which compound would you expect to have a greater fluorescence quantum yield and why?



- a) *bis(o-hydroxyphenyl)hydrazine* because it exhibits significant predissociation
- b) *bis(o-hydroxyphenyl)hydrazine* because the  $-\text{NH}-\text{NH}-$  group provides high rigidity that is absent in the  $-\text{N}=\text{N}-$  group
- c) *bis(o-hydroxyphenyl)hydrazine* because the  $-\text{NH}-\text{NH}-$  group decreases rigidity of the molecule
- d) *o,o'*-dihydroxyazobenzene because it exhibits significant predissociation
- e) *o,o'*-dihydroxyazobenzene because the  $-\text{N}=\text{N}-$  group provides high rigidity that is absent in the  $-\text{NH}-\text{NH}-$  group

12. Which device is the key component in modern infrared spectrometers that enable recording infrared absorption spectra?

- a) ion source
- b) prism
- c) diffraction grating
- d) diffraction wedge
- e) Michelson interferometer

13. Which transducer used in IR spectroscopy relies on change of polarization within a crystal?

- a) pyroelectric cell
- b) bolometer
- c) photodiode
- d) photoconductor
- e) thermocouple

14. Which material is not suitable for making optical elements of spectrophotometer operating in the wavelength range 7-10  $\mu\text{m}$ ?

- a) zinc selenide
- b) thallium bromide
- c) potassium bromide
- d) sodium chloride
- e) quartz

15. In mass spectrometry, exact mass is

- a) sum of the nominal masses of the constituent atoms.
- b) experimentally determined mass of an ion of known charge.
- c) calculated mass of an ion or molecule with specified isotopic composition.
- d) mass of a compound quantity that is numerically equal to molecular mass.
- e) mass in kilograms.

**II. Answer the following questions:** (maximum:  $4 \times 10 = 40$  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. Define the following terms:**

- i. resonance fluorescence
- ii. vibrational relaxation
- iii. internal conversion
- iv. external conversion

*- answer length limit: 200 words*

**B. Why do some absorbing compounds fluoresce but others do not?**

*- answer length limit: 100 words*

**C. Draw scheme of portable IR photometer designed for sensitive gas analysis.**

*- answer length limit: 1 figure with labels*

**D. Draw block diagram of mass spectrometer. Indicate the main components of this instrument.**

*- answer length limit: 1 figure with labels*

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

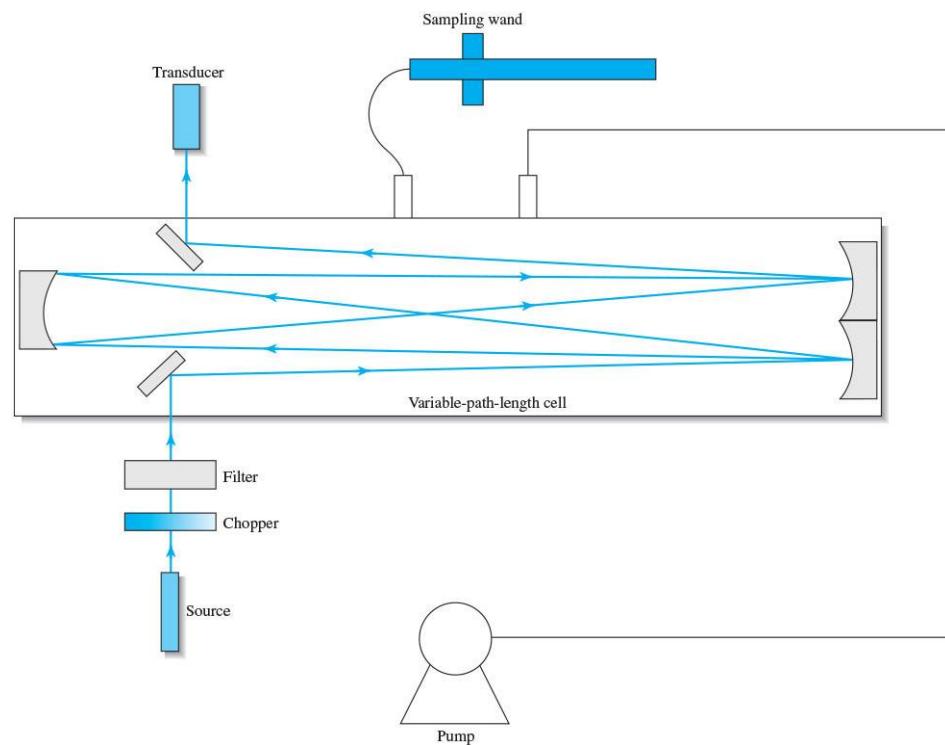
**A.**

- i. Resonance fluorescence is observed when an excited species emits radiation of the same frequency as that used to cause the excitation.
- ii. Vibrational relaxation is the process by which a molecule loses its excess vibrational energy without emitting radiation.
- iii. Internal conversion is the intermolecular process in which a molecule crosses to a lower electronic state without emitting radiation.
- iv. External conversion is a radiationless process in which a molecule loses electronic energy while transferring that energy to the solvent or another solute.

**B.**

Compounds that fluoresce have structures that slow the rate of nonradiative relaxation to the point where there is time for fluorescence to occur. Compounds that do not fluoresce have structures that permit rapid relaxation by nonradiative processes.

C.



D.

