國立成功大學

114學年度碩士班招生考試試題

編　號：44

系　所：化學系

科　目：分析化學

日　期：0211

節　次：第 4 節

注　意：1.不可使用計算機
2.請於答案卷(卡)作答，於試題上作答，不予計分。

Part I (25%):

Single-answer questions. Each question has only one answer. (Note: Each question earns 5 points)

1. The calculation (0.203 + 0.139) / 2.766 should be reported as
(a) 0.123644 (b) 0.1236 (c) 0.123 (d) 0.124 (e) 0.12

2. At what wavelength would the Stokes Raman lines for CCl_4 appear ($\Delta\nu = 790\ cm^{-1}$) using a He/Ne laser (633 nm)?
(a) 633 nm (b) 666 nm (c) 603 nm (d) 1423 nm (e) 790 nm

3. The pH of a 0.01 M solution of the acid HA is 5. What is the ionization constant of the acid?
(a) 10^{-2} (b) 10^{-3} (c) 10^{-5} (d) 10^{-8} (e) 10^{-10}

4. What is the ionic strength of an aqueous solution of 0.10 M $Pb(NO_3)_2$?
(a) 0.10 M (b) 0.20 M (c) 0.30 M (d) 0.40 M (e) 0.60 M

5. Sponge Bob and Patrice Star made a phosphate buffer by mixing 0.45 mole KH_2PO_4 and 0.45 mole K_2HPO_4 in one liter of solution. They then added 0.15 moles of KOH to this 1 L buffer solution. What is the resulting pH after this addition? For H_3PO_4, $pKa_1 = 2.12$, $pKa_2 = 7.21$, and $pKa_3 = 12.32$.
(a) 7.51 (b) 7.36 (c) 7.21 (d) 7.06 (e) 6.91

Part II (25%):

Single or Multiple-answer questions. Each question has one or more answers.

(Note: Each question earns 5 points if all answers are correct.)

6. Which of the following statements is/are "**false**" based on the Beer-Lambert Law?
(a) it states that transmittance is linearly related to concentration
(b) it requires that the product of absorptivity and path length be known before absorbance can be related to concentration
(c) it requires that absorptivity be independent of wavelength
(d) it cannot be used if more than one absorbing species is present in a sample
(e) increasing absorptivity will decrease the transmittance

7. Which of the following statements is/are "**false**" regarding the absorption of photons with a frequency of 6×10^{14} cycles/sec by molecules?
(a) absorption of a photon results in a change in the energy state of the molecule
(b) there is a correspondence between the energy of the photon and the difference in energy between the initial and final energy states (i.e., the states before and after the absorption) of the molecule
(c) the frequency of 6×10^{14} cycles/sec refers to an infrared photon
(d) an infrared photon can only be absorbed when the photon frequency matches a vibrational frequency of the molecule
(e) the energy associated with a vibrational transition is greater than the energy corresponding to electronic transitions

8. Which of the following device(s) require(s) RF (radio frequency) for operation?
(a) inductively coupled plasma
(b) quadrupole
(c) monochromator
(d) electron multiplier
(e) Faraday cup

9. Which of the following statements is/are "**false**" for chromatography?

(a) chromatography technique for separating components of a mixture mainly based on the interaction of the components with stationary and mobile phases

(b) refractive index (RI) detector is usually used in gas chromatography (GC)

(c) the atomic emission detector (AED) used in gas chromatography (GC) is non-destructive

(d) in normal phase HPLC, the mobile phase is polar and the stationary phase is nonpolar

(e) in gas and liquid chromatography, the concentration of a substance can be determined by comparison of the peak areas of the substance vs. that of an internal standard

10. Which of the following statements is/are "**false**" for optical components?

(a) a D_2 arc lamp is the most widely used source of visible photons

(b) double-beam spectrometers employ an optical chopper or beam director to alternate the source beam between the reference and sample compartments

(c) a hollow cathode lamp is usually used for AES while inductively coupled plasma is used for AAS

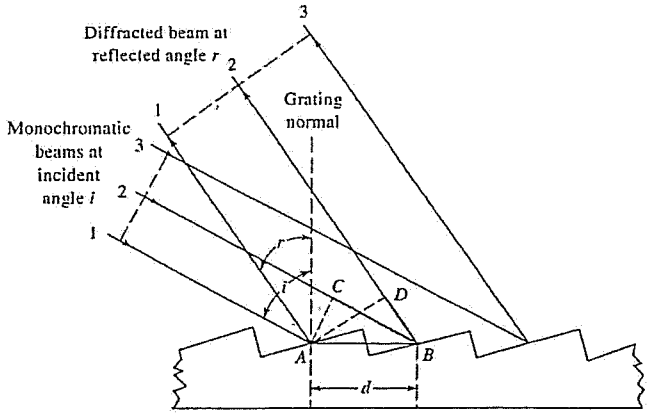
(d) fused silica (or quartz) prism covers well from UV to Near IR range

(e) absorption filters usually have narrower bandwidth than interference filters

Part III (50%):

Short answer questions.

1. **(25%)** According to the figure below, the principle of how gratings disperse light can be illustrated by constructive interference resulting from differences in travel distances.



(a) How many lines per millimeter would be required for the first-order diffraction line for λ=500 nm to be observed at a reflection angle of 17° when the angle of incidence is 45°? (cos17°=0.956, cos45°=0.707, sin17°=0.292)

(b) A monochromator has a focal length of 0.500 m and a collimating mirror with a diameter of 10.0 cm. The dispersing device has replaced a new grating with 2500 lines/mm from (a). For first-order diffraction, what is the resolving power of the monochromator if a collimated beam is illuminated 2.0 cm of the grating?

(c) The *f-number* (*F*) provides a measure of the ability of a monochromator to collect the radiation that emerges from the entrance slit. What is the *f-number* of the monochromator from (b)?

(d) The reciprocal linear dispersion can be expressed by $D^{-1}= \frac{dcosr}{nf}$, where d is groove spacing, n is diffraction order and f is focal length. To simplify the calculation, assume cos(r)=1. For first-order diffraction, what is the reciprocal linear dispersion (D^{-1}) of the monochromator from (b)?

(e) According to (c), what slit width (in mm) of the monochromator would be required to separate the sodium lines at 589.00 and 589.60 nm by the reciprocal linear dispersion (D^{-1})?

2. **(25%)** A time-of-flight (TOF) mass analyzer requires ions to be accelerated. Explain how ions can be accelerated by considering the electrical potential energy and kinetic energy of each ion in terms of z (charge number), e (elementary charge), V (electrical field in volts), m (mass of ion), and v (ion velocity).

(a) Given a field-free distance (L), write an equation that relates the arrival time of ion (t) to the mass-to-charge ratio (m/z).

(b) A three-level nitrogen laser is used as the matrix-assisted laser desorption/ionization (MALDI) source in a MALDI-TOF mass spectrometer with the TOF mass analyzer. Explain how population inversion works in a three-level laser system. Please emphasize the energy levels involved in the laser output, such as E (x) -> E (y).

Energy level 1_____

2_____

3_____ ground state

(c) According to (a), two signals with arrival times of 59.99 μs and 49.99 μs were observed and assigned to the intact ions of a molecule and their fragment, respectively. The m/z of the fragment ions is 1000. Additionally, an isotope peak of the intact molecule is found at m/z +0.5. What is the actual mass of the intact molecule?

(d) It turns out that this molecule is a peptide drug with a molar absorptivity of 5000 $L \cdot mol^{-1} \cdot cm^{-1}$ at 280 nm. One tablet weighing 2.3 g is dissolved in water and diluted to a volume of 2000 mL in a volumetric flask. If the solution exhibits an absorbance of 2.0 at 280 nm (using a 1.0 cm pathlength cell), what is the weight percent of the peptide in the tablet?

(e) What percentage of light is transmitted through the sample when it has an absorbance of 2.0?