類組：化學類　科目：分析化學(1005)　　共 7 頁 第 1 頁

一、單選題 (答案請填於答案卡，答錯不倒扣，每題 2.5 分，共 100 分)

1. How much of the 12.0 M HCl solution needs to be diluted in order to create 2.00 L of a 0.25 M HCl solution?

(A) 41.67 mL (B) 96.87 mL (C) 10.32 mL (D) 24.23 mL (E) 16.05 mL

2. What is the mass of $CaCO_3$ (molecular weight = 100.00 g/mol) required to prepare a 200.0 mL solution containing 100.0 ppm Ca^{2+} (molar mass of calcium = 40.0 g/mol)?

(A) 0.012 g (B) 0.050 g (C) 1.875 g (D) 0.533 g (E) 29.90 g

3. A solution of NaCl (molecular weight = 58.44) contains 33.5 wt% and has a density of 1.05 g/mL. What is the molarity of this solution?

(A) 3.05 M (B) 8.03 M (C) 6.01 M (D) 10.05 M (E) 1.05 M

4. Acid washing of glassware can remove low levels of cations on the surface with H^+ ions. What acids, commonly used at concentrations of 3–6 M, are typically employed for cleaning glassware?

I. acetic acid
II. nitric acid
III. hydrochloric acid
IV. phosphoric acid

(A) I or II (B) II or III (C) III or IV (D) II or IV (E) I or III

5. For a fixed absolute uncertainty, as the magnitude of the measurement _____, the percent relative uncertainty _____.

(A) increases; decreases (B) increases; increases (C) decreases; decreases
(D) decreases; remains constant (E) increases; remains constant

6. Solid-phase extraction is a technique used for sample preparation. Which of the following statement(s) is/are **NOT TRUE** regarding aqueous solid-phase extraction?

I. Solid-phase extraction isolates the analyte from the sample matrix using a chromatographic stationary phase.
II. An aliquot of the aqueous sample is introduced into the solid-phase extraction tube, followed by washing with additional sample and a water rinse.
III. The analyte adheres to the column, while the water rinse eliminates all species that do not bind to the column.
IV. An organic solvent is utilized to elute the analyte from the column.
V. The organic phase containing the analyte is evaporated to dryness, and the resulting solid is re-dissolved in water for analysis.

(A) III (B) I (C) II and III (D) IV (E) II

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7. Rose gold is a gold alloy that contains a small amount of copper. The copper content of rose gold was measured by two methods for six different samples collected from a jewelry production plant.

Sample	Method 1	Method 2
a	2.2%	2.5%
b	1.8%	2.2%
c	3.0%	3.2%
d	2.5%	3.0%
e	2.6%	2.3%
f	2.6%	2.7%

Which test would you use to determine if the results obtained by the two methods agree within experimental error?
(A) Grubbs test
(B) F test
(C) paired t test to compare individual difference
(D) t test to compare mean values of two sets of replicate measurements
(E) compare a measured value to a "known" value

8. Student's test (t-test) is a statistical tool used most frequently to
I. determine if a questionable data point should be discarded
II. compare results from different experiments
III. evaluate the probability of an experimental value agreeing with a "known" value
IV. express confidence intervals
(A) I (B) II (C) I and II (D) II, III and IV (E) I, II, III, and IV

9. _____ is the concentration range over which there is measurable instrument response.
(A) Accuracy range (B) Dynamic range (C) Linear range
(D) Detection range (E) Precision range

10. A(n) _____ is a specific quantity of a compound, distinct from the analyte, that is introduced into the unknown sample.
(A) standard addition (B) internal standard (C) external standard
(D) self-contained standard (E) known standard

11. Which of the following metal ions is used for the Argentometric titrations?
(A) Au^{+} (B) Ag^{+} (C) Ar^{+} (D) Al^{3+} (E) As^{3-}

12. Calculate the ionic strength of 0.10 M $Al(NO_3)_3$.
(A) 0.45 (B) 0.10 (C) 0.20 (D) 0.40 (E) 0.60

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13. Which of the following statements describing pH is **NOT TRUE**?
(A) $pH = -\log[H^+]\gamma H^+$
(B) $pH = -\log[H^+]$ when $\mu = 0$
(C) The pH = pOH for pure water
(D) The pH of water rises as the ionic strength increases
(E) The ionic strength of pure water is 1.0×10^{-7} M

14. Identify the charge balance equation for the buffer prepared from NaH_2PO_4 and Na_2HPO_4.
(A) $[Na^+] + [H^+] = [H_2PO_4^-] + 2[HPO_4^{2-}] + 3[PO_4^{3-}] + [OH^-]$
(B) $3[Na^+] + [H^+] = [H_2PO_4^-] + 2[HPO_4^{2-}] + 3[PO_4^{3-}] + [OH^-]$
(C) $3[Na^+] + [H^+] = [H_2PO_4^-] + [HPO_4^{2-}] + [PO_4^{3-}] + [OH^-]$
(D) $[Na^+] = [H_2PO_4^-] + 2[HPO_4^{2-}] + 3[PO_4^{3-}]$
(E) $[Na^+] + [H^+] = [H_2PO_4^-] + [HPO_4^{2-}] + [PO_4^{3-}] + [OH^-]$

15. Which is **NOT** a property of buffers?
(A) Buffers resist changes in pH when a small amount of acid or base is added to the buffer or when a small dilution of the buffer occurs.
(B) Buffers are a mixture of a weak acid and its conjugate base.
(C) The pH of a buffer is independent of ionic strength.
(D) The pH of a buffer is dependent on temperature.
(E) Buffers are a mixture of a weak base and its conjugate acid.

16. EDTA forms a _____ complex with all metal ions regardless of the charges on the ion.
(A) 1:1　(B) 1:2　(C) 1:3　(D) 1:4　(E) 6:1

17. Which of the following statements about the Beer-Lambert law are **TRUE**?
I. Absorbance increases as concentration increases.
II. Absorbance decreases as path length increases.
III. The molar absorptivity value is chromophore and wavelength specific.
IV. The absorption spectrum is a graph showing how absorbance changes with wavelength.
(A) I, II, and III　(B) I, III, and IV　(C) II, III, and IV　(D) I and III　(E) I, II, III, and IV

18. Regarding galvanic cells, which of the following statements is **FALSE**?
(A) Galvanic cells are spontaneous.
(B) Oxidation occurs at the anode, and reduction occurs at the cathode.
(C) Electrons move toward the more negative electrical potential.
(D) Galvanic cells are composed of two half-cells connected by a salt bridge.
(E) The salt bridge maintains electroneutrality throughout the cell.

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19. Which of the following species has the strongest oxidizing power?

$O_3(g) + 2H^+ + 2e^- \rightleftharpoons O_2(g) + H_2O$	$E° = 2.075$ V
$Ag^+ + e^- \rightleftharpoons Ag(s)$	$E° = 0.799$ V
$Li^+ + e^- \rightleftharpoons Li(s)$	$E° = -3.040$ V
$2H^+ + 2e^- \rightleftharpoons H_2(g)$	$E° = 0.00$ V
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	$E° = 1.507$ V

(A) O_3　(B) Ag^+　(C) Li^+　(D) H^+　(E) MnO_4^-

20. When the concentration of H^+ ions is very low and the concentration of Na^+ ions is high, the apparent pH measured by a glass pH electrode is
(A) lower than the true pH of the solution
(B) higher than the true pH of the solution
(C) the same as the true pH of the solution
(D) equal to twice the concentration of the Na^+ ions
(E) equal to half the concentration of the Na^+ ions

21. Which instrumental method primarily measures the absorption of visible light to determine the concentrations of analytes?
(A) fluorescence emission spectroscopy　(B) photometry　(C) nephelometry
(D) potentiometry　(E) gravimetry

22. Which input transducer is frequently used to convert ion current to electric signal in mass spectrometer?
(A) filter　(B) photodiode　(C) glass electrode　(D) electron multiplier　(E) ion source

23. In atomic absorption spectrometry, which atomization method is most suitable for analyses of various elements in microliter-range liquid samples with high sensitivity?
(A) glow-discharge atomization　(B) hydride atomization　(C) cold-vapor atomization
(D) flame atomization　(E) electrothermal atomization

24. Which statement about atomic absorption and emission spectrometry is TRUE?
(A) Only a small fraction of atoms is excited at the temperature of a typical flame
(B) Temperature fluctuations do not affect the proportion of excited state atoms
(C) Temperature fluctuations do not affect the intensity of emitted light in atomic emission spectra
(D) Line broadening due to the uncertainty effect dominates over Doppler broadening in practical spectrometry applications
(E) Line broadening due to the uncertainty effect dominates over pressure broadening in practical spectrometry applications

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25. Which statement about electrodeless discharge lamp (EDL) used in atomic spectrometry is TRUE?
(A) EDL provides a continuum spectrum
(B) EDL provides a line spectrum
(C) EDL provides lower radiant intensity than a hollow-cathode lamp under standard operating conditions
(D) EDL is most suitable for production of plasma in atomic emission spectrometry with an ICP source
(E) EDL is most suitable for atomic mass spectrometry with an electron ionization source

26. Which statement accurately describes a characteristic or operation of an Echelle monochromator used in atomic spectrometry?
(A) Echelle monochromators are characterized with low dispersion
(B) To cover broad spectral range, it is necessary to use many diffraction orders
(C) One does not need to use an additional dispersive element (*e.g.* a prism or grating) to complement Echelle grating in monochromator system
(D) In Echelle grating, long side of the blaze is used
(E) The wavelength regions from different diffraction orders do not overlap

27. Which radiation source is most commonly used for UV absorption measurements at 210 nm?
(A) Nichrome wire　(B) Globar　(C) Ar lamp　(D) Tungsten lamp　(E) D_2 lamp

28. Which statement most accurately describes the effect of stray radiation in UV absorption spectrometry?
(A) Stray radiation is often caused by chemiluminescence in the sample
(B) Stray radiation is caused by red shift due to benzene ring substitution
(C) Due to stray radiation, measured absorbance is lower than real absorbance (at high absorbance values)
(D) Due to stray radiation, measured absorbance is higher than real absorbance (at high absorbance values)
(E) Stray radiation causes peak splitting

29. Charge-transfer transitions involve electron transfer between a donor and an acceptor species, unlike d-d or π-π^* transitions. Which substance primarily absorbs radiation due to charge-transfer transitions dominating its electronic spectrum?
(A) Ni^{2+}　(B) NaOH　(C) acetone　(D) $Fe(SCN)^{2+}$　(E) benzene

30. Which factor directly enhances the fluorescence emission intensity of molecules?
(A) high rate of intersystem crossing
(B) high rate of predissociation
(C) high temperature
(D) solvents with heavy atoms
(E) rigid structure of the molecule

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31. What is the primary function of a Michelson interferometer in analytical instrumentation for IR spectroscopy?
(A) to separate light of different wavelengths by means of diffraction
(B) to modulate radiation in the optical region
(C) to eliminate matrix interference
(D) to decrease interference between DC and AC signals
(E) to suppress infrared radiation in UV-Vis absorption analysis

32. In ICP-MS, nickel produces a peak at the *m/z* 58. Which non-analyte species can interfere with the measurement of this nickel signal?
(A) Na　(B) ^{40}ArO　(C) ^{42}CaO　(D) ^{42}CaOH　(E) ^{40}ArNa

33. Which ionization technique causes most extensive fragmentation of organic molecules?
(A) electron ionization
(B) electrospray ionization
(C) chemical ionization
(D) desorption electrospray ionization
(E) matrix-assisted laser desorption/ionization

34. What is the primary advantage of a double-focusing mass spectrometer compared to a single-focusing mass spectrometer?
(A) to enable tandem mass spectrometry
(B) to make the mass spectrometer compatible with electron ionization
(C) to minimize directional and energy aberrations of a population of ions
(D) to eliminate the use of magnetic field
(E) to enable detection by a desorption-based detector

35. Quadrupole ion trap mass analyzer, introduced by Paul, has several unique characteristics. What is the key feature that distinguishes this analyzer from others?
(A) large size
(B) tandem-in-time capability
(C) incompatibility with electrospray ionization
(D) *m/z* is determined based on time of flight in the field-free region
(E) high resolution

36. What is the typical way to address the general elution problem in gas chromatography?
(A) by cooling down the column below the room temperature
(B) by temperature programming
(C) by introducing the eluted compounds to an online detector
(D) by splitting the eluate to two flow lines
(E) by using a highly specific detector

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37. Which factor decreases zone broadening in chromatography?
(A) large particle diameters for stationary phases
(B) very high or very low flow rates of mobile phase
(C) excessively high temperature (in gas chromatography)
(D) small plate height
(E) thick layer of the immobilized liquid stationary phase

38. Which factor in chromatography either reduces or fails to improve zone separation?
(A) column packing that produces distribution constants for analytes that differ significantly
(B) increase in the column length
(C) decrease in the column length
(D) optimizing column temperature (in gas chromatography)
(E) optimizing pH of mobile phase (in liquid chromatography)

39. Which detector used in gas chromatography is particularly suitable for sensitive analysis of halogenated compounds?
(A) electron capture detector
(B) halogen lamp detector
(C) thermal conductivity detector
(D) thermionic detector
(E) UV absorption detector

40. What is the primary application of gel filtration chromatography?
(A) removal of millimeter-sized precipitates from real samples
(B) extraction of volatile organic compounds for further analysis
(C) separation of free amino acids according to their polarity
(D) separation of water-soluble high-molecular-mass molecules from low-molecular-mass species
(E) separation of high-molecular-mass molecules dissolved in less-polar organic solvents from low-molecular-mass species