

Physical Chemistry
物理化學

單選題 (每題 2.5 分，共 50 分)

1. A mole of ideal gas is compressed isothermally at 300 K to half of its original volume. What are the enthalpy and entropy changes in this process? (A) 2.5 kJ, 0 J/K (B) 0 kJ, 5.8 J/K (C) 2.5 kJ, 5.8 J/K (D) 0 kJ, 0 J/K (E) 0 kJ, -5.8 J/K.
2. Comparing the following energies in magnitude (1) ionization energy of H atom (2) bond energy of O₂ molecule (3) vibrational zero-point energy of H₂O (4) hydrogen bonding in HF dimer (5) lowest electronic excited state energy of benzene
(A) (2) > (1) > (3) > (5) > (4) (B) (5) > (1) > (2) > (4) > (3) (C) (1) > (2) > (3) > (5) > (4)
(D) (1) > (2) > (5) > (3) > (4) (E) (2) > (5) > (1) > (4) > (3)
3. Neon is a monatomic gas. What is its approximate molar heat capacity at constant volume? (A) 8.314 J/K (B) 20.8 J/K (C) 4.185 J/K (D) 12.5 J/K (E) 0.082 J/K
4. Which of the following gas molecules have the highest mean velocity at room temperature? (A) Carbon Dioxide (B) Oxygen (C) Water (D) Nitrogen (E) Methane.
5. A sodium lamp emits yellow light at 550 nm. What is the frequency of the yellow light? (speed of light = 2.998×10^8 m)
(A) 5.45×10^{11} s⁻¹ (B) 5.45×10^{14} s⁻¹ (C) 1.65×10^2 s⁻¹ (D) 1.65×10^5 s⁻¹ (E) 1.82×10^6 s⁻¹
6. The reaction $\text{N}_2 + 3 \text{H}_2 \rightarrow 2 \text{NH}_3$, $\Delta H = -92$ kJ. Which of the following statement is incorrect?
(A) The reaction rate increases as temperature increases.
(B) The entropy change is negative.
(C) Lowering temperature will shift the equilibrium to the right.
(D) Equilibrium constant decreases as the overall pressure increases.
(E) This reaction is exothermic.
7. What is the ground-state term symbol for the boron atom?
(A) $^2P_{1/2}$ (B) $^2P_{3/2}$ (C) 3P_2 (D) 1S_0 (E) $^2D_{3/2}$
8. If one wants to study the photochemistry of a highly conjugated chromophore, which of the following spectral method will definitely be used?
(A) NMR (B) UPS (C) UV-VIS (D) FT-IR (E) Microwave Spectroscopy
9. A radioactive material has a half-life of 1 hour. How much time is needed for 99% of the initial material to decay away?
(A) 7 hours (B) 99 hours (C) 10 days (D) 3 hours (E) 2.5 years
10. One mole of liquid water at 100 °C is in equilibrium with water vapor at 1 atm. If the enthalpy change associated with vaporization of liquid water at 100 °C is 40.6 kJ/mol, what is ΔG of the process?
(A) 40.6 kJ (B) 406 kJ (C) 0.0 kJ (D) 8.314 kJ (E) 22.4 kJ.

11. A heat engine operates between two temperatures, 500 K and 300 K. What is its maximum efficiency according to the second law of thermodynamics?
(A) 80% (B) 67% (C) 60% (D) 50% (E) 40%
12. The de Broglie wavelength of a particle is given by
(A) $h + mv$
(B) hmv
(C) h / mv
(D) mv / c
(E) mv
13. Which of the following is an allowed energy level for a quantum mechanical harmonic oscillator? (A) 0.0 hv (B) 1 hv (C) 0.25 hv (D) 1.5 hv (E) 2.0 hv
14. A system performs 213 kJ of work on its surroundings and loses 79 kJ of heat. What is the value (in kJ) of ΔE of the system?
(A) +292 (B) -292 (C) +134 (D) -134 (E) -213
15. Which one of the following sets of quantum numbers is unacceptable for a hydrogen-like atom?
- | n | l | m_l | m_s | n | l | m_l | m_s |
|-------|---|-------|-------|-------|---|-------|-------|
| (A) 4 | 3 | -2 | +1/2 | (B) 3 | 2 | -3 | -1/2 |
| (C) 3 | 0 | 0 | +1/2 | (D) 4 | 1 | 1 | -1/2 |
| (E) 2 | 0 | 0 | +1/2 | | | | |
16. The fundamental frequency of hydrogen molecule is 4159 cm^{-1} . What is the force constant of the H-H bond? ($1 \text{ amu} = 1.66 \times 10^{-27} \text{ kg}$)
(A) 509 N/m (B) 2080 N/m (C) 320 N/m (D) 1006 N/m (E) 254 N/m
17. The rate constant of a reaction increases 100 times from 200 K to 400 K, what is the activation energy of the reaction? ($\ln 10 = 2.303$)
(A) 3.7 kJ/mol (B) 4.6 kJ/mol (C) 10.5 kJ/mol (D) 15.3 kJ/mol (E) 38.3 kJ/mol
18. Which of the following is a correct approximation to the ground-state electronic wavefunction for helium atom?
(A) $1s(1)1s(2) [\alpha(1)\beta(2) - \alpha(2)\beta(1)]$
(B) $1s(1)1s(2) \alpha(1)\alpha(2)$
(C) $1s(1)1s(2) \alpha(1)\beta(2)$
(D) $1s(1)2s(2) \alpha(1)\alpha(2)$
(E) $1s(1)2s(2) \alpha(1)\beta(2)$
19. Which of the following molecule has a pure rotational spectrum?
(A) CCl_4
(B) H_2O
(C) BF_3
(D) C_6H_6
(E) CO_2

國立中正大學九十八學年度碩士班招生考試試題
系所別：化學暨生物化學系

科目：物理分析化學

第 2 節

第 3 頁，共 6 頁

20. Which of following process in liquid is the fastest on average?
(A) intersystem crossing (B) molecular rotation (C) vibrational relaxation (D) diffusion (E)
crystallization in supersaturated solution

分析化學 (50 分)

一、單選題 (每題三分)

- (21) Which of the following analytical tool(s) can be used to determine protein molecular weights?
- (A) Static light scattering spectroscopy
 - (B) Electrospray ionization mass spectrometry
 - (C) Size exclusion liquid chromatography
 - (D) Gel electrophoresis
 - (E) All of the above
- (22) Which of the following statement is CORRECT?
- (A) Visible absorption spectroscopy is a direct and rapid method to determine electronic transition energy levels of organic molecules.
 - (B) Inductively coupled plasma mass spectrometry (ICP-MS) is a direct and rapid method to identify electronic transition energy levels.
 - (C) Infra red spectroscopy is a direct and rapid method to determine rotational energy levels of organic molecules.
 - (D) Matrix assisted laser desorption ionization mass spectrometry (MALDI-MS) is a direct and rapid method to determine rotational energy levels of organic molecules.
 - (E) None of the above
- (23) Activity coefficient γ of an ionic species in a solution can be governed by which of the following relation.
- (A) Hess law
 - (B) Debye-Hückel limiting law
 - (C) Navier-Stokes equation
 - (D) Schrödinger equation
 - (E) Nernst equation
- (24) Please choose the correct order of AgCl solubility in the following solutions. I. 0.0001 M starch solution; II. 0.01 M KNO_3 solution; III. 0.001 M NaCl solution
- (A) I > II > III
 - (B) II > I > III
 - (C) II > III > I
 - (D) III > I > II
 - (E) None of the above

- (25) Which statement(s) about aptamers is correct?
- (A) Aptamer is a synthetic carbohydrate
 - (B) Aptamer is a synthetic nucleic acid
 - (C) Aptamer is an enzyme
 - (D) Aptamer is a co-factor
 - (E) None of the above
- (26) When the reduction potential of an electrode determined relative to a standard hydrogen electrode is -0.70 volt, what is the reduction potential of this same electrode relative to a saturated calomel electrode? [Hint: the reduction potentials of a standard hydrogen electrode and a saturated calomel electrode are $+0.0$ and 0.24 volt respectively.]
- (A) -0.94 V
 - (B) -0.46 V
 - (C) -0.24 V
 - (D) 0.0 V
 - (E) $+0.94$ V
- (27) When a recorded spectrum has the signal-to-noise ratio 3, please calculate the signal-to-noise ratio for the average of 36 spectra recorded in the same manner.
- (A) 108
 - (B) 36
 - (C) 18
 - (D) 12
 - (E) 3
- (28) Please calculate the pH value of the following solution system: diprotic acid H_2A (100 mL, 0.1 M) of which k_1 and k_2 are 10^{-5} and 10^{-9} M respectively, mixed with NaOH (5 mL, 1M)
- (A) 3
 - (B) 4
 - (C) 5
 - (D) 7
 - (E) 9
- (29) Please calculate the pH value at the equivalence point when a dilute weak acidic solution (100 mL; 0.1 M) is titrated with NaOH (1M) when the dissociation constant of this weak acid is 10^{-5} M.
- (A) 3
 - (B) 5
 - (C) 7
 - (D) 9
 - (E) None of the above

- (30) When the measurement bias of a standard sample using a new method is acceptable but nearly unacceptable at 95% confidence level, in which confidence level this method will be unacceptable?
- (A) 99.5%
 - (B) 99 %
 - (C) 97.5%
 - (D) 96%
 - (E) 90%

二、簡答題（無須計算過程；每題四分）

- (31) Estimate the ratio of the number of moles of ferrous ion (Fe^{2+}) to the number of moles of bromine (Br_2), when Fe^{2+} is completely reacted with Br_2 ? (moles of Fe^{2+} / moles of Br_2)
- (32) What is the expression of solubility product constant of a slightly soluble salt M_2X ?
- (33) The pressure environment of electron impact (EI) ionization processes is vacuum or ambient?
- (34) The pressure environment of fast atom bombardment (FAB) ionization processes is vacuum or ambient?

三、問答題（每題四分）

- (35) Explain why using liquid chromatography is more convenient to separate and measure polar compounds than using gas chromatography.