

(皆為單選題)

第 1~第 33 每題 3 分, 第 34 題 1 分, 共計 34 題, 總分 100 分

1. A beam of light with an intensity of 15 W is incident on a copper plate (work function is $7.43 \times 10^{-19} \text{ J}$). Electrons with a minimum wavelength of $3.75 \times 10^{-10} \text{ m}$ are ejected from the surface of the copper. Calculate the frequency of the incident light.

[Hint: Planck constant = $6.626 \times 10^{-34} \text{ J} \cdot \text{s}$](A) $3.71 \times 10^{15} \text{ Hz}$, (B) $3.71 \times 10^{16} \text{ Hz}$, (C) $3.71 \times 10^{17} \text{ Hz}$, (D) $3.71 \times 10^{18} \text{ Hz}$, (E) none of above

2. If a new light source (its energy is $7.19 \times 10^{-19} \text{ J}$) with an intensity of 35 W is incident on the copper surface, what is the maximum number of electrons that can be ejected from a 6.0 second pulse of light? (A) 0, (B) 3.71×10^{16} , (C) 3.71×10^{17} , (D) 3.71×10^{18} , (E) none of above

3. Order the following atoms and ions in order of increasing atomic radius: Cl, Te, Te^{2-} , S

(A) $\text{Cl} < \text{Te} < \text{S} < \text{Te}^{2-}$, (B) $\text{Cl} < \text{S} < \text{Te}^{2-} < \text{Te}$, (C) $\text{Te}^{2-} < \text{Te} < \text{S} < \text{Cl}$, (D) $\text{Cl} < \text{S} < \text{Te} < \text{Te}^{2-}$, (E) none of above

4. How many electrons in a single atom can have the following two quantum numbers: $n = 7$, $m_l = -3$? (A) 2, (B) 4, (C) 6, (D) 8, (E) none of above

5. Calculate the pH in a solution prepared by dissolving 0.050 mol of acetic acid (CH_3COOH) and 0.20 mol of sodium acetate (NaCH_3COO) in water and adjusting the volume to 500 mL. The pK_a for acetic (CH_3COOH) is 4.75.

[Hint: $\log(0.25) = -0.602$]

(A) 4.35, (B) 5.35, (C) 6.35, (D) 7.35, (E) none of above

6. A 10.0 mL sample of 0.20 M $\text{HNO}_{2(\text{aq})}$ solution is titrated with 0.10 M $\text{NaOH}_{(\text{aq})}$. (K_a of HNO_2 is 4.3×10^{-4}). Initial mol of NO_2^- is 0.0667 M. Calculate the pH at the equivalence point.

[Hint: $\log(1.247 \times 10^{-6}) = -5.9$]

(A) 5.1, (B) 6.1, (C) 7.1, (D) 8.1, (E) none of above

7. Consider the formation of $\text{MgO}_{(\text{s})}$. Assume that ΔH° and ΔS° are independent of temperature. Calculate the temperature at which the formation of MgO switches from spontaneous to non-spontaneous or vice versa?

[Hint: $\text{Mg}_{(\text{s})} + \frac{1}{2} \text{O}_{2(\text{g})} \rightarrow \text{MgO}_{(\text{s})}$; $\Delta H^\circ = -602 \text{ kJ/mol}$; $\Delta S^\circ = -108 \text{ J/K} \cdot \text{mol}$]

(A) 2,574K, (B) 3,574K, (C) 4,574K, (D) 5,574K, (E) none of above

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參考用

8. Oxygen at pressures that are not too high obeys the equation $P(V - b) = RT$, Where P is pressure; V is volume, R is $8.314 \text{ JK}^{-1}\text{mol}^{-1}$, T is temperature, $b = 0.021 \text{ dm}^3 / \text{mol}$, Estimate the fugacity of oxygen at 25°C and 1 bar pressure.

$$V_m - \frac{RT}{P} = b$$

[Hint: The equation of state is

Where P_1 is 0 bar]

$$\int_{P_1}^{P_2} \left(V_m - \frac{RT}{P} \right) dP = \int_{P_1}^{P_2} b dP = b(P_2 - P_1)$$

(A) $f_2 = \exp\left(\frac{0.021 \times 10^0 \text{ Pa} \cdot \text{m}^3 / \text{mol}}{8.314(\text{JK}^{-1}\text{mol}^{-1}) \times 298\text{K}}\right)$; (B) $f_2 = \exp\left(\frac{0.021 \times 10^1 \text{ Pa} \cdot \text{m}^3 / \text{mol}}{8.314(\text{JK}^{-1}\text{mol}^{-1}) \times 298\text{K}}\right)$;

(C) $f_2 = \exp\left(\frac{0.021 \times 10^2 \text{ Pa} \cdot \text{m}^3 / \text{mol}}{8.314(\text{JK}^{-1}\text{mol}^{-1}) \times 298\text{K}}\right)$; (D) $f_2 = \exp\left(\frac{0.021 \times 10^3 \text{ Pa} \cdot \text{m}^3 / \text{mol}}{8.314(\text{JK}^{-1}\text{mol}^{-1}) \times 298\text{K}}\right)$;

(E) $f_2 = \exp\left(\frac{0.021 \times 10^4 \text{ Pa} \cdot \text{m}^3 / \text{mol}}{8.314(\text{JK}^{-1}\text{mol}^{-1}) \times 298\text{K}}\right)$;

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9. The equilibrium constant for an association reaction $A + B \rightleftharpoons AB$ is $1.8 \times 10^3 \text{ dm}^3 / \text{mol}$ at 25°C and $3.45 \times 10^3 \text{ dm}^3 / \text{mol}$ at 40°C . Assuming ΔH° to be independent of temperature, calculate

$\Delta H^\circ = ?$ [Hint: $\ln\left(\frac{3.45}{1.80}\right) = 0.65$]

(A) 33.67 J/mol; (B) 336.7 J/mol; (C) 3367 J/mol; (D) 33.67 kJ/mol; (E) 336.7 kJ/mol;

10. A solution contains 1.50 g of solute in 30.0 g of benzene and its freezing point is 3.74°C . The freezing point of pure benzene is 5.48°C . Calculate the molar mass of the solute. [Hint:

Freezing point depression constant (K_f) for benzene is $4.9^\circ\text{C} \cdot \text{kg} / \text{mol}$]

(A) 1.47g/mol, (B) 14.7g/mol, (C) 147g/mol, (D) 1,470g/mol, (E) 14.7kg/mol

11. Toluene (methylbenzene) and water are immiscible. If boiled together under an atmosphere pressure of 755.0 Torr at 83°C , what is the ratio of toluene to water

$(W_{\text{toluene}} / W_{\text{water}})$ in the distillate? The vapor pressure of pure toluene and water 83°C are 322.0

Torr and 400.6 Torr, respectively.

$(W_{\text{toluene}} / W_{\text{water}}) =$ (A) 1.11, (B) 2.11, (C) 3.11, (D) 4.11, (E) 5.11

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12. An aqueous solution of gold(III) nitride, $\text{Au}(\text{NO}_3)_3$, was electrolyzed with a current of 0.0250A until 1.200g of Au (atomic weight 197.0) had been deposited at the cathode. Calculate the quantity of electricity passed.

[Hint: The reaction at the cathode is $3e^- + \text{Au}^{3+} \rightarrow \text{Au}$; The equation for the liberation of O_2 is $2\text{H}_2\text{O} \rightarrow \text{O}_2 + 4\text{H}^+ + 4e^-$]

(A) 1.76 C, (B) 17.6C, (C) 176C, (D) 1,760C, (E) 17,600C

13. The Electromotive Force (emf) of the cell $\text{Pt}, \text{H}_2(1\text{bar}) | \text{HCl}(0.01\text{m}) | \text{AgCl}(s) | \text{Ag}$ is 0.2002V at 25°C , $\partial E / \partial T$ is $-8.665 \times 10^{-5} \text{V/K}$.

[Hint: The electrode reactions of cell are $\frac{1}{2}\text{H}_2 \rightarrow \text{H}^+ + e^-$; The cell reaction is $e^- + \text{AgCl}(s) \rightarrow \text{Ag} + \text{Cl}^-$

$\frac{1}{2}\text{H}_2 + \text{AgCl}(s) \rightarrow \text{Ag} + \text{H}^+ + \text{Cl}^-$; $e = 1.602 \times 10^{-19} \text{C}$]

The Gibbs energy change of the cell reaction is

$\Delta G =$ (A) -1.932 J/mol, (B) -19.32 J/mol, (C) -193.2 J/mol, (D) -1,932 J/mol, (E) -19,320 J/mol

14. What is the degree of the degeneracy if the three quantum numbers $n_1, n_2,$ and n_3 can have the values 1, 2, and 3?

(A) 2, (B) 4, (C) 6, (D) 8, (E) 10

15. KF has an ionic bond with a bond length of 0.217nm. Calculate the ΔE in kJ/mol, for the formation of a KF bond from the neutral atoms K and F. For this calculation, assume that the potassium and fluorine ions are point charges. Ionization Energy and Electron Affinity for K and F are provided in the table below. [Hint: Overall: $\text{K} + \text{F} \rightarrow \text{KF}$;

$\epsilon_0 = 8.854 \times 10^{-12} \text{C}^2/\text{J}\cdot\text{m}$; $e = 1.602 \times 10^{-19} \text{C}$]

	Ionization Energy (kJ/mol)	Electron Affinity (kJ/mol)
Potassium (K)	418	48
Fluorine (F)	1680	328

(A) $-5.50 \times 10^{-2} \text{J/mol}$, (B) -55 J/mol, (C) -550 J/mol, (D) -550 kJ/mol, (E) -5,500 kJ/mol

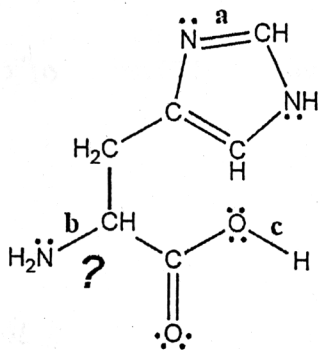
16. Among (A) NaCl, (B) SiO_2 , (C) CH_4 , (D) CO_2 and (E) Fe, which one is ionic crystal?

17. Among (A) NaCl, (B) SiO_2 , (C) CH_4 , (D) CO_2 and (E) Fe, which one has highest melting point?

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參考用

18. The structure of the amino acid histidine is provided below. For the indicated bond b,

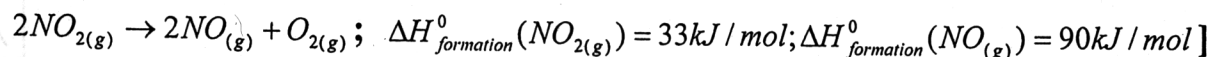


What could form the bonds of N-C bond, b?

- (A) $\sigma(N:2sp^2;C:2sp^2)$, (B) $\pi(N:2p_y;C:2p_y)$, (C) $\pi(N:2p_x;C:2p_x)$, (D) $\sigma(N:2sp^3;C:2sp^3)$, (E) $\sigma(O:2sp^3;H:1s)$

19. Determine the bond order (BO) of the cyanide molecule, CN and the cyanide ion, CN⁻¹. Bond order (BO) of (A) CN is 0.5; CN⁻¹ is 1, (B) CN is 1.5; CN⁻¹ is 2, (C) CN is 2.5; CN⁻¹ is 3, (D) CN is 3.5; CN⁻¹ is 4, (E) CN is 4.5; CN⁻¹ is 5

20. Consider the reaction below for the conversion nitrogen dioxide to nitric oxide and O₂. Calculate the ΔH° (per mole of O₂ formed) for the reaction at 298 K. [Hint:



- (A) 114.1 J, (B) 1.141 kJ, (C) 11.41 kJ, (D) 114.1 kJ, (E) 1,141 kJ

21. Which of the following has the highest energy per photon?

- (A) infrared, (B) blue light, (C) green light, (D) orange light, (E) red light

22. Metals rarely lose electrons in chemical reactions because

- (A) their electron affinities are too high. (B) their ionic radii become too small. (C) their ionization energies are too small. (D) their size is too small. (E) their ionization energies are too high.

23. What is the shape of SO₃²⁻?

- (A) T-shaped, (B) trigonal pyramidal, (C) seesaw, (D) tetrahedral, (E) trigonal planar

24. A plot of the Maxwell distribution for the same gas against temperature shows that (A) at high temperatures, most molecules have speeds close to their average speed. (B) as the temperature increases, a high proportion of molecules have very slow speeds. (C) as the temperature decreases, the spread of speeds widens. (D) as the temperature decreases, a high proportion of molecules have very high speeds. (E) at low temperatures, most molecules have speeds close to their average speed.

參考用

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25. Which of the following statements is true?

(A) 1,1-Dichloro-2-methyl-1-propene has a higher boiling point than trans-2,3-dichloro-2-butene. (B) CH_4 has a higher boiling point than CCl_4 . (C) o-Dichlorobenzene has a lower boiling point than p-dichlorobenzene. (D) HI has a lower boiling point than HBr. (E) Butane, C_4H_{10} , has a higher boiling point than acetone, CH_3COCH_3 .

26. How do alloys solidify and melt?

(A) At precise temperature. (B) Over a range of temperatures. (C) At strict high temperature. (D) At exact low temperature. (E) None of above.

27. Gamma-rays cause radiation damage when they interact with matter by producing

(A) ions and free radicals, (B) isotopes, (C) daughter products, (D) oxidation, (E) reduction.

28. Which of the following has the lowest standard molar entropy?

(A) $\text{C}_{(\text{graphite})}$, (B) $\text{P}_{4(\text{s})}$, (C) $\text{S}_{8(\text{s})}$, (D) $\text{C}_{60(\text{s})}$, (E) $\text{C}_{(\text{diamond})}$

29. Which of the following liquids freeze at a lower temperature when pressure is applied?

(A) water, (B) acetic acid, (C) benzene, (D) methanol, (E) carbon tetrachloride

30. Which of the following 0.10 M aqueous solutions has the lowest pH?

(A) $\text{B}(\text{OH})_3$, (B) HIO , (C) $\text{C}_2\text{H}_5\text{NH}_3\text{Cl}$, (D) $\text{C}_6\text{H}_5\text{OH}$

31. Choose the effective pH range of an aniline/anilinium chloride buffer. The value of the K_b for aniline is 4.3×10^{-10} .

(A) 3.6~5.6, (B) 8.4~10.4, (C) 1.1~3.1, (D) 5.1~7.1, (E) 10.1~12.1

32. If the standard potentials for the couples Cu^{2+}/Cu , Ag^+/Ag , and Fe^{2+}/Fe are +0.34, +0.80, and -0.44 V, respectively, which is the strongest reducing agent?

(A) Fe, (B) Ag, (C) Ag^+ , (D) Cu, (E) Fe^{2+}

33. If the rate of reaction increases by a factor of 9.6 when the concentration of reactant increases by a factor of 3.1, the order of the reaction with respect to this reactant is

(A) 1.5, (B) 3, (C) 4, (D) 2, (E) 1

34. Which of the following does not act as a Lewis acid?

(A) Na_2O , (B) NO , (C) NO_2 , (D) SO_3 , (E) CO_2

參考用