

下列 50 題，皆為五選一選擇題，每題 2 分，答錯不倒扣分，共 100 分。

- The name of the ionic compound  $\text{NH}_4\text{CN}$  is \_\_\_\_\_.  
(A) nitrogen hydrogen cyanate (B) ammonium carbonitride (C) cyanonitride  
(D) ammonium cyanide (E) ammonium hydrogen cyanate
- Which one of the following equations is incorrect?  
(A)  $\text{pH} + \text{pOH} = -\log K_w$  (B)  $K_a = K_w \div K_b$  (C) rate constant  $k = Ae^{-E_a/RT}$   
(D)  $\Delta G = \Delta H + T\Delta S$  (E)  $q_{\text{rxn}} = -C_{\text{cal}} \times \Delta T$  (for bomb calorimetry)
- What is the bond order for  $\text{C}_2^{2-}$ ?  
(A) 1 (B) 1.5 (C) 2 (D) 2.5 (E) 3
- What is the most important scientific contribution by Ernest Rutherford?  
(A) discovery of proton (B) discovery of neutron (C) discovery of electron  
(D) discovery of photon (E) Charge-to-mass ratio
- What is the mathematical expression of the first law of thermodynamics?  
(A)  $\Delta G = \Delta H + T\Delta S$  (B)  $\Delta S(0 \text{ K}) = 0$  (C)  $\Delta S_{\text{univ}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}}$   
(D)  $\Delta E = q + w$  (E)  $S = k \log W$
- Which of the following are weak electrolytes?  
 $\text{HCl}, \text{HC}_2\text{H}_3\text{O}_2, \text{NH}_3, \text{KCl}$   
(A)  $\text{HCl}, \text{KCl}$  (B)  $\text{HCl}, \text{HC}_2\text{H}_3\text{O}_2, \text{NH}_3, \text{KCl}$  (C)  $\text{HC}_2\text{H}_3\text{O}_2, \text{KCl}$   
(D)  $\text{HC}_2\text{H}_3\text{O}_2, \text{NH}_3$  (E)  $\text{HCl}, \text{HC}_2\text{H}_3\text{O}_2, \text{KCl}$
- How many isomers are there of hexane,  $\text{C}_6\text{H}_{14}$ ?  
(A) 6 (B) 5 (C) 4 (D) 3 (E) 2
- The Boltzmann constant  $k$  can be expressed mathematically by:  
(A)  $R/N$  (B)  $R/c$  (C)  $N/R$  (D)  $c/R$  (E)  $h/R$   
where  $c$  = speed of light;  $R$  = gas constant;  $N$  = Avogadro's No.;  $h$  = Planck's constant.
- Of the metals below, only \_\_\_\_\_ will not dissolve in an aqueous solution containing nickel ions.  
(A) Aluminum (B) Chromium (C) Barium (D) Tin (E) Potassium
- The value of  $\Delta E$  for a system that performs 213 kJ of work on its surroundings and loses 79 kJ of heat is \_\_\_\_\_ kJ.  
(A) +292 (B) -292 (C) +134 (D) -134 (E) -213
- What is the wavelength of light (nm) that has a frequency  $4.62 \times 10^{14} \text{ s}^{-1}$  \_\_\_\_\_?  
(A) 932 (B) 649 (C)  $1.39 \times 10^{23}$  (D)  $1.54 \times 10^{-3}$  (E)  $1.07 \times 10^6$



22. The concentration of iodide ions in a saturated solution of lead (II) iodide is \_\_\_\_\_ M. The solubility product constant of  $\text{PbI}_2$  is  $1.4 \times 10^{-8}$ .
- (A)  $3.8 \times 10^{-4}$       (B)  $3.0 \times 10^{-3}$       (C)  $1.5 \times 10^{-3}$       (D)  $3.5 \times 10^{-9}$   
 (E)  $1.4 \times 10^{-8}$
23. Given the normal freezing point of ammonia is  $-78^\circ\text{C}$ . Predict the signs of  $\Delta H$ ,  $\Delta S$ , and  $\Delta G$  for ammonia when it freezes at  $-80^\circ\text{C}$  and 1 atm.
- | $\Delta H$ | $\Delta S$ | $\Delta G$ | $\Delta H$ | $\Delta S$ | $\Delta G$ |
|------------|------------|------------|------------|------------|------------|
| (A) -      | -          | 0          | (B) -      | +          | -          |
| (C) +      | -          | +          | (D) +      | +          | 0          |
| (E) -      | -          | -          |            |            |            |
24. Which one of the following molecules is tetrahedral?
- (A)  $\text{XeF}_4$       (B)  $\text{BF}_3$       (C)  $\text{PtCl}_4$       (D)  $\text{CF}_4$       (E)  $\text{NH}_3$
25. Of the salts  $\text{PbCO}_3$ ,  $\text{PbCl}_2$ ,  $\text{PbI}_2$ , and  $\text{PbS}$ , which would be significantly more soluble in acidic solution than in pure water?
- (A)  $\text{PbI}_2$ ,  $\text{PbS}$  and  $\text{PbCO}_3$       (B) only  $\text{PbCO}_3$  and  $\text{PbS}$       (C) only  $\text{PbCl}_2$  and  $\text{PbI}_2$   
 (D) only  $\text{PbCO}_3$       (E) all four
26. Which of the following shows a decrease in entropy?
- (A) precipitation      (B) melting ice      (C) a burning piece of wood  
 (D) gaseous reactants forming a liquid      (E) none of these
27. What is the correct Henderson-Hasselbalch equation for calculating the buffer capacity or the pH of a buffer solution?
- (A)  $\text{p}K_a = \text{pH} + \log[\text{base}]/[\text{acid}]$       (B)  $\text{p}K_a = \text{pH} - \log[\text{acid}]/[\text{base}]$   
 (C)  $\text{pH} = \text{p}K_a - \log[\text{acid}]/[\text{base}]$       (D)  $\text{pH} = \text{p}K_a + \log[\text{base}]/[\text{acid}]$   
 (E)  $\text{p}K_a = \text{pH} + \log[\text{acid}]/[\text{base}]$
28. Arrange the acids  $\text{H}_2\text{Se}$ ,  $\text{H}_2\text{Te}$ , and  $\text{H}_2\text{S}$  in order of increasing acid strength.
- (A)  $\text{H}_2\text{S} < \text{H}_2\text{Se} < \text{H}_2\text{Te}$       (B)  $\text{H}_2\text{S} < \text{H}_2\text{Te} < \text{H}_2\text{Se}$       (C)  $\text{H}_2\text{Te} < \text{H}_2\text{S} < \text{H}_2\text{Se}$   
 (D)  $\text{H}_2\text{Se} < \text{H}_2\text{S} < \text{H}_2\text{Te}$       (E)  $\text{H}_2\text{Se} < \text{H}_2\text{Te} < \text{H}_2\text{S}$
29. For what reaction-order does the half-life get longer as the initial concentration increases?
- (A) zero-order      (B) first-order      (C) second-order      (D) third-order  
 (E) none of them because half-life is always independent of the initial concentration.
30. What are the ionic species present in an aqueous solution of sodium acetate? Arrange them in order of decreasing concentration.
- (A)  $[\text{OH}^-] > [\text{CH}_3\text{COO}^-] > [\text{Na}^+]$       (B)  $[\text{CH}_3\text{COO}^-] > [\text{OH}^-] > [\text{Na}^+]$   
 (C)  $[\text{Na}^+] > [\text{CH}_3\text{COO}^-] > [\text{OH}^-]$       (D)  $[\text{Na}^+] > [\text{OH}^-] > [\text{CH}_3\text{COO}^-]$   
 (E)  $[\text{OH}^-] > [\text{Na}^+] > [\text{CH}_3\text{COO}^-]$

31. Of the compounds below, the one that requires the shortest wavelength for photoionization is \_\_\_\_\_.
- (A) O      (B) O<sub>2</sub>      (C) NO      (D) N<sub>2</sub>      (E) all the same.
32. Which one of the following is always positive when a spontaneous process occurs?
- (A)  $\Delta S_{\text{system}}$       (B)  $\Delta S_{\text{surroundings}}$       (C)  $\Delta S_{\text{universe}}$       (D)  $\Delta H_{\text{universe}}$   
(E)  $\Delta H_{\text{surroundings}}$
33. Which reaction produces an increase in the entropy of the system?
- (A)  $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$       (B)  $\text{CO}_2(\text{s}) \rightarrow \text{CO}_2(\text{g})$   
(C)  $\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2 \text{HCl}(\text{g})$       (D)  $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 3 \text{NH}_3(\text{g})$   
(E)  $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{s})$
34. The following reaction is an example of \_\_\_\_\_.
- $${}_{20}^{41}\text{Ca} \rightarrow {}_{19}^{41}\text{K} + \text{_____}$$
- (A)  $\alpha$  decay      (B)  $\beta$  decay      (C) positron decay      (D) electron capture  
(E) gamma emission
35. Of the following, \_\_\_\_\_ has the odor of rotting eggs.
- (A) NH<sub>3</sub>      (B) H<sub>2</sub>S      (C) CO      (D) NO<sub>2</sub>      (E) HCN
36. Of the following substances, \_\_\_\_\_ has the highest boiling point.
- (A) H<sub>2</sub>O      (B) CO<sub>2</sub>      (C) CH<sub>4</sub>      (D) Kr      (E) NH<sub>3</sub>
37. The units for second order rate constant are:
- (A) Ms<sup>-1</sup>      (B) M<sup>-1</sup>s<sup>-1</sup>      (C) s<sup>-1</sup>      (D) M<sup>2</sup>s<sup>-1</sup>      (E) M<sup>-1</sup>s
38. Compare the melting points (m.p.) and boiling points (b.p.) of the following compounds: Benzene, C<sub>6</sub>H<sub>6</sub> (1); Toluene, CH<sub>3</sub>-C<sub>6</sub>H<sub>5</sub> (2); Phenol, HO-C<sub>6</sub>H<sub>5</sub>, (3)
- (A) m.p.: (1) > (2) > (3)      (B) m.p.: (3) > (2) > (1)      (C) m.p.: (1) > (3) > (2)  
(D) b.p.: (1) > (2) > (3)      (E) b.p.: (3) > (2) > (1)
39. Which of the following is paramagnetic?
- (A) H<sub>2</sub>      (B) Li<sub>2</sub>      (C) B<sub>2</sub>      (D) C<sub>2</sub>      (E) N<sub>2</sub>
40. Predict the structure and polarity of the SO<sub>3</sub> molecule.
- (A) T-shape, nonpolar      (B) Y-shape, polar      (C) trigonal planar, nonpolar  
(D) trigonal planar, polar      (E) Y-shape, nonpolar
41. The energy released by the sun is the result of:
- (A) natural radioactivity      (B) nuclear fission      (C) combustion of hydrogen

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42. A protein is  
 (A) a polysaccharide. (B) one of the units composing a nucleic acid.  
 (C) a saturated ester of glycerol. (D) a polymer of amino acid units.  
 (E) an aromatic hydrocarbon with a fused ring structure.
43. Which of the following mixtures of gases can be most easily separated by gaseous effusion?  
 (A)  $\text{NH}_3$  and  $\text{Cl}_2$  (B) Ar and  $\text{O}_2$  (C) Ne and He (D)  $\text{Cl}_2$  and Kr  
 (E)  $\text{N}_2$  and  $\text{O}_2$
44. Will a precipitate of  $\text{MgF}_2$  form when 200 mL of  $1.9 \times 10^{-3}$  M  $\text{MgCl}_2$  solution is added to 500 mL of  $1.2 \times 10^{-3}$  M NaF?  $K_{sp}(\text{MgF}_2) = 6.9 \times 10^{-9}$  M.  
 (A) yes,  $Q > K_{sp}$  (B) no,  $Q < K_{sp}$  (C) no,  $Q = K_{sp}$   
 (D) yes,  $Q < K_{sp}$  (E) no,  $Q > K_{sp}$
45. Which one of the following sets of quantum numbers is unacceptable?
- |     | 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  |     |   |   |       |       |
46. Which group shows the correct order of first ionization energy?  
 (A)  $\text{Na} > \text{P} > \text{Cl}$  (B)  $\text{Cs} > \text{Na} > \text{K}$  (C)  $\text{K} > \text{Ca} > \text{Ge}$   
 (D)  $\text{Cs} < \text{Rb} < \text{Na}$  (E)  $\text{Al} > \text{Si} > \text{P}$
47. A voltaic cell has an  $E^\circ$  value of +1.00 V. The reaction  
 (A) is not spontaneous (B) has  $K = 1$  (C) has  $K < 1$  (D) has  $\Delta G = 0$ .  
 (E) has negative  $\Delta G$ .
48. Which of the following diatomic molecules has incorrect bond order when Lewis structure is applied?  
 (A)  $\text{C}_2$  (B)  $\text{N}_2$  (C)  $\text{O}_2$  (D) NO (E) CO
49. According to crystal field theory, how many unpaired electrons are present in the complex ion  $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ . The water molecules are weak field ligands.  
 (A) 1 (B) 2 (C) 3 (D) 4 (E) 5
50. The complex  $[\text{Zn}(\text{NH}_3)_2\text{Cl}_2]^{2+}$  does not exhibit *cis-trans*-isomerism. The geometry of this complex must be \_\_\_\_\_.  
 (A) tetrahedral (B) trigonal bipyramidal (C) octahedral  
 (D) square planar (E) either tetrahedral or square planar