類組：化學類　科目：綜合化學(1001)　　　　　　　　　※請在答案卡內作答
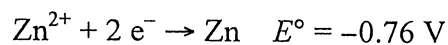
單選題：共 50 題，每題 2 分，答錯不倒扣

Gas constant R = 0.08206 atm L mol^{-1} K^{-1} = 8.314 J mol^{-1} K^{-1}
Planck's constant h = 6.626 × 10^{-34} J s
Speed of light c = 3.0 × 10^8 m/s
Faraday constant F = 96485 C/mol
log2 = 0.301, log3 = 0.477

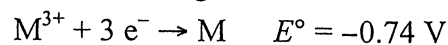1. At 25 °C, a zinc-copper battery is constructed as follows:
    $$Zn \mid Zn^{2+} (0.20\ M) \parallel Cu^{2+} (2.50\ M) \mid Cu$$
    The standard reduction potentials at 25 °C are
    $$Cu^{2+} + 2\ e^- \rightarrow Cu \quad E° = 0.34\ V$$
    $$Zn^{2+} + 2\ e^- \rightarrow Zn \quad E° = -0.76\ V$$
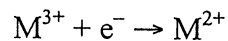   Calculate the cell potential when this battery is first connected.
    (A) 1.04 V　　(B) 1.07 V　　(C) 1.10 V　　(D) 1.13V　　(E) 1.17 V

2. Given the following two standard reduction potentials,
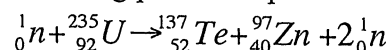 $$M^{3+} + 3\ e^- \rightarrow M \quad E° = -0.74\ V$$
    $$M^{2+} + 2\ e^- \rightarrow M \quad E° = -0.90\ V$$
    Determine for the standard reduction potential of the half-reaction
    $$M^{3+} + e^- \rightarrow M^{2+}$$
    (A) −0.42 V　　(B) −0.16 V　　(C) −1.64 V　　(D) 0.16 V　　(E) 0.42 V

3. The following process represents the type of reaction known as
    $$_{0}^{1}n + _{92}^{235}U \rightarrow _{52}^{137}Te + _{40}^{97}Zn + 2_{0}^{1}n$$

    (A) fusion
    (B) autocatalytic reaction
    (C) disproportionation
    (D) fission
    (E) electrochemical reaction

4. The phosphorescence spectrum of the excited species is due to
    (A) vibration modes
    (B) nuclear spin transition
    (C) electron spin transitions
    (D) singlet to triplet transitions
    (E) triplet to singlet transitions

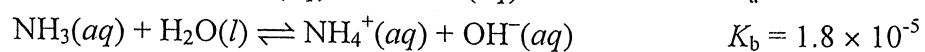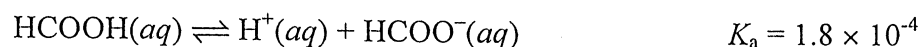5. One electron volt of energy (1 eV) is equivalent to a photon with a wavelength about
    (A) 3 nm　　(B) 30 nm　　(C) 300 nm　　(D) 120 nm　　(E) 1200 nm

注意：背面有試題

6. Given the following dissociation constants

$$HCOOH(aq) \rightleftharpoons H^+(aq) + HCOO^-(aq) \qquad K_a = 1.8 \times 10^{-4}$$

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq) \qquad K_b = 1.8 \times 10^{-5}$$

What is the pH of a 0.100 M aqueous solution of ammonium formate NH_4HCO_2?

(A) 4.24　　　(B) 6.50　　　(C) 7.00　　　(D) 7.80　　　(E) 8.20

7. The values of K_{a1} and K_{a2} for carbonic acid are 4.3×10^{-7} and 4.8×10^{-11}. The fraction of HCO_3^- at pH 7.00 is approximately

(A) 0.35　　　(B) 0.50　　　(C) 0.72　　　(D) 0.81　　　(E) 0.93

8. Aluminum ions react with the hydroxide ion to form the precipitate $Al(OH)_3(s)$, but can also react to form the soluble complex ion $Al(OH)_4^-$. $Al(OH)_3(s)$ will be more soluble in very acidic solutions. The solubility of $Al(OH)_3$, $S = [Al^{3+}] + [Al(OH)_4^-]$, is a function of $[H^+]$, and K is the equilibrium constant for $Al(OH)_3(s) + OH^-(aq) \rightleftharpoons Al(OH)_4^-(aq)$. K_{sp} is the solubility product constant for $Al(OH)_3(s) \rightleftharpoons Al^{3+}(aq) + 3 OH^-(aq)$. What is the correct equations to describe the relationship between $[H^+]$ and the solubility of $Al(OH)_3(s)$?

(A) $S = [H^+]^3 K_{sp}/K_w^3 + KK_w/[H^+]$

(B) $S = [H^+]^3 K_{sp}/K_w^3 + K/[H^+]$

(C) $S = [H^+]^2 K_{sp}/K_w^2 + KK_w/[H^+]$

(D) $S = [H^+]^3 K_w/K_{sp}^3 + KK_w/[H^+]$

(E) $S = [H^+]^3 K_{sp}/K_w^3 + KK_w/[H^+]^2$

9. A student titrates an unknown weak acid, HA, to a pale pink phenolphthalein endpoint with 25.0 mL of 0.100 M NaOH. The student then adds 13.0 mL of 0.100 M HCl. The pH of the resulting solution is 4.8. Which of the following statements is true?

(A) At pH 4.8, half of the conjugate base, A^-, has been converted to HA

(B) The pK_a of the acid is 4.8.

(C) The pK_a of the acid is greater than 4.8.

(D) The pK_a of the acid is less than 4.8.

(E) More than one of the above statements are correct.

10. The deuterium has a nuclear spin of

(A) 0　　　(B) 1/2　　　(C) 1　　　(D) 3/2　　　(E) 2

11. The frequency of the S–H stretching is 2000 cm^{-1} in the IR spectrum. What is the frequency of the S–D stretching?

(A) 1000 cm^{-1}　　　(B) 1440 cm^{-1}　　　(C) 2000 cm^{-1}　　　(D) 2880 cm^{-1}　　　(E) 4000 cm^{-1}

12. Batteries and concentration cells are galvanic cells. Which of the following statements is true?
    (A) E_{cell} increases as a battery discharges.
    (B) E_{cell} is negative when a battery reaches equilibrium.
    (C) For any operating concentration cell, both E_{cell} and $E_{cell}°$ must be positive.
    (D) For any operating concentration cell, $E_{cell}°$ must be negative and E_{cell} must be positive.
    (E) For any operating concentration cell, $E_{cell}°$ must be zero and E_{cell} must be positive.

13. Which of the following nuclei has the largest binding energy per nucleon?
    (A) ^{56}Fe　　(B) ^{84}Kr　　(C) ^{16}O　　(D) ^{12}C　　(E) ^{235}U

14. Electron capture transforms $^{40}_{19}K$ into what nuclide?

    (A) $^{40}_{20}Ca$　　　(B) $^{40}_{19}K^-$　　(C) $^{39}_{20}Ca$　　(D) $^{40}_{18}Ar$　　(E) $^{4}_{2}He$

15. Consider the following reaction,
    $$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H$$
    Masses of these nuclei (amu): $^{14}_{7}N : 14.003074$, $^{4}_{2}He : 4.002603$, $^{17}_{8}O : 16.999133$, $^{1}_{1}H : 1.007825$
    Which statement describes ΔE for the process?
    (A) 1.15×10^{11} J/mol is released.
    (B) 1.15×10^{11} J/mol is absorbed.
    (C) 1.15×10^{14} J/mol is released.
    (D) 1.15×10^{14} J/mol is absorbed.
    (E) No energy is released or absorbed.

16. The tertiary structure of a protein is stabilized by various types of interactions. Which of the interactions is covalent?
    (A) hydrophobic interaction
    (B) hydrogen bonding
    (C) electrostatic interaction
    (D) cation–π interaction
    (E) disulfide linkage

17. Which of the following amino acids has two chiral centers?
    (A) glycine　　(B) threonine　　(C) proline　　(D) arginine　　(E) tyrosine

18. Consider a reaction of the type aA → products, in which the rate law is found to be rate = k[A]^3. If the first half-life of the reaction is found to be 20 s, what is the time for the second half-life?
    (A) 5 s　　(B) 10 s　　(C) 20 s　　(D) 40 s　　(E) 80 s

19. Which of the following statements are true about starch?
    - I. The monomers are fructose and α-D-glucose.
    - II. The monomer is α-D-glucose.
    - III. The monomer is β-D-glucose.
    - IV. It is an addition polymer.
    - V. It is a condensation polymer.
    - VI. It consists of amylose and amylopectin.

    (A) I, V, VI
    (B) III, VI
    (C) III, V, VI
    (D) II, V, VI
    (E) II, V

20. Which of the following is NOT necessary for protein synthesis at the time and place where synthesis occurs?

    (A) DNA　　(B) tRNA　　(C) mRNA　　(D) amino acids　　(E) ribosomes

21. Which of the following statements are true about gas?
    - I. At constant temperature, the lighter the gas molecules, the faster the average speed of the gas molecules.
    - II. At constant temperature, the heavier the gas molecules, the larger the average kinetic energy of the gas molecules.
    - III. A real gas behavior most ideally when the container volume is relatively large and the gas molecules are moving relative fast.
    - IV. As temperature increases, the effect of interparticle interactions on gas behavior is increased.
    - V. The parameter b in the van der Waals equation is directly related to the molecular diameter.

    (A) I, III, IV
    (B) I, II, III
    (C) I, III, V
    (D) II, III, V
    (E) II, III, IV

22. Consider the reaction $X(g) + 2\,Y(g) \rightleftharpoons 2\,Z(g)$ in a rigid container at 27 °C. The initial concentrations of X and Y are 1.0 mol/L and 3.0 mol/L, and 1.0 mol/L of Z will be produced at equilibrium. If you want to prepare 0.40 atm of Z from an initial pressure of 2.0 atm of Y, what would be the initial pressure of X?

    (A) 0.21 atm　　(B) 0.33 atm　　(C) 1.3 atm　　(D) 3.3 atm　　(E) 13 atm

注意：背面有試題

23. Consider a sample containing 5.00 moles of a monatomic ideal gas that is taken from **state A** (P_A = 3.00 atm, V_A = 15.0 L) to **state B** (P_A = 3.00 atm, V_A = 55.0 L). For this process, assume that the external pressure is constant and equals the final pressure of the gas. Which of the following is true?
    (A) It is a reversible process.
    (B) ΔH = 30.4 kJ
    (C) ΔE = –18.2 kJ
    (D) q (heat) = 0
    (E) w (work) = 12.2 kJ

24. Consider two perfectly insulated vessels. Vessel **I** initially contains an ice at 0 °C. Vessel **II** initially contains an ice cube at 0 °C and a NaCl solution at 0 °C. Consider the process $H_2O(s) \rightarrow H_2O(l)$. Which of the following statements is NOT true?
    (A) For the process in vessel **I**, ΔS_{sys} = 0.
    (B) For the process in vessel **I**, ΔS_{surr} = 0.
    (C) For the process in vessel **I**, ΔS_{univ} > 0.
    (D) For the process in vessel **II**, ΔS_{sys} > 0.
    (E) For the process in vessel **II**, ΔS_{univ} > 0.

25. Consider an adiabatic and reversible expansion process from **state 1** to **state 2**. Which of the following statements is true?
    (A) The final temperature will be higher than the initial temperature.
    (B) $P_1V_1 = P_2V_2$
    (C) $T_1V_1^{\gamma} = T_2V_2^{\gamma}$, $\gamma = C_p/C_v$
    (D) The final volume of the gas is much greater than if the expansion were carried out isothermally.
    (E) The work delivered to the surrounding is much smaller than if the expansion were carried out isothermally.

26. What is the total probability of finding a particle in a one-dimensional box with a length of L in level n = 3 between x = 0 and x = $L/2$?
    (A) 1/4　　　(B) 1/3　　　(C) 1/2　　　(D) 2/3　　　(E) 1

27. For the vaporization of water at 1.00 atm, ΔH = 43.6 kJ/mol at 25 °C and ΔH = 40.7 kJ/mol at 100 °C. The constant-pressure heat capacity of liquid water is 75.4 J mol^{-1} K^{-1}. What is the constant-pressure heat capacity for $H_2O(g)$ in the unit of J mol^{-1} K^{-1}.
   (A) 36.7　　　(B) 40.2　　　(C) 50.6　　　(D) 75.3　　　(E) 80.1

28. An unknown element X is a nonmetal and has a valence electron configuration of ns^2np^4. Which of the following statements about X is NOT true?
    (A) X has 6 valence electrons.
    (B) X could be selenium.
    (C) The formula of the compound formed by X and cesium would be Cs_2X.
    (D) X has a larger radius than barium.
    (E) X has a smaller ionization energy than fluorine.

29. The following data were collected in two studies of the reaction

    $A + 2B \rightarrow C + D$, where rate = $\dfrac{-d[A]}{dt}$.
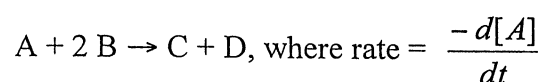
Time (s)	Expt. 1 [A] (mM)	Expt. 2 [A] (mM)
0	75.0	75.0
20	50.0	37.5
40	37.5	30.0
60	30.0	18.8
80	25.0	15.0
100	21.5	12.5
120	18.8	10.7

    In Expt. 1, $[B]_0$ = 3.0 M. In Expt. 2, $[B]_0$ = 6.0 M.
    According to the data, three possible mechanisms were proposed.

    (a) $A + B \rightleftharpoons E$ (fast equilibrium)
          $E + B \rightarrow C + D$ (slow)
    (b) $A + B \rightleftharpoons E$ (fast equilibrium)
          $E + A \rightarrow C + D$ (slow)
    (c) $A + A \rightarrow E$ (slow)
          $E + B \rightarrow C + D$ (fast)

    Which of the following statements is true about this reaction?
    (A) The rate law is rate = $k[A][B]$
    (B) The rate law is rate = $k[A][B]^2$
    (C) (b) could be the correct mechanism.
    (D) (c) could be the correct mechanism.
    (E) The reaction is zero order in [B].

30. Use the molecular orbital model to determine which of the following has the smallest ionization energy.
    (A) N_2^{2-} (B) N_2^- (C) N_2 (D) O_2 (E) O_2^+

注意：背面有試題

31. Which of the following statements is (are) true?
   I. The molecules SeS_3, SeS_2, PCl_5, $TeCl_4$, ICl_3, and $XeCl_2$ all exhibit at least one bond angle which is approximately 120°.
   II. Central atoms in a molecule adopts a geometry of the bonded atoms and lone pairs about the central atom in order to maximize electron repulsions.
   III. In the compound O_2F_2, the oxidation state of oxygen is +1 and the formal charge of fluorine is 0.
   IV. The bond angle in SO_2 should be similar to the bond angle in CS_2 or SCl_2.
   V. Of the compounds CF_4, KrF_4, and SeF_4, only SeF_4 is polar.
   (A) V only
   (B) III, V
   (C) I, III, V
   (D) III, IV
   (E) II, IV

32. For a simple cubic array, what is the radius of an interior sphere (cubic hole) in terms of the radius (r) of a sphere in the array?

   (A) $\sqrt{2}r$　　(B) $\sqrt{3}r$　　(C) $(\sqrt{2}-1)r$　　(D) $(\sqrt{2}+1)r$　　(E) $(\sqrt{3}-1)r$

33. The compound $K_3[FeF_6]$ has a magnetic moment of 5.9 Bohr magnetons, whereas $K_3[Fe(CN)_6]$ has a magnetic moment of 2.4 Bohr magnetons. The accepted explanation for this difference includes which of the following statements?
   (A) Iron has a different oxidation number in the two compounds.
   (B) Cyanide ions cause more d-orbital splitting than fluoride ions do.
   (C) Fluorine is more electronegative than is either carbon or nitrogen.
   (D) There are fewer unpaired electrons in $K_3[FeF_6]$.
   (E) $K_3[Fe(CN)_6]$ is a high-spin complex.

34. Which of the following is NOT a direct product of the electrolysis of aqueous sodium chloride or the reaction of one of these products with water?
   (A) NaH　　　(B) NaOH　　　(C) HOCl　　　(D) H_2　　(E) Cl_2

35. The Miller indices are often used in the area of
   (A) single crystal
   (B) polymer
   (C) solution
   (D) surface chemistry
   (E) molecular spectrum

注意：背面有試題

36. Give the Russell-Saunders terms of the configuration: $3p^2$
    (A) $^1D, ^1P$
    (B) $^3P, ^2S$
    (C) $^1D, ^3P, ^1S$
    (D) $^3D, ^1P, ^2S$
    (E) $^2D, ^3P, ^1S$

37. Which of the following groups contains the molecules with a same point group?
    (A) H_2O_2 and C_2H_2
    (B) OCS and CO_2
    (C) NHF_2 and NH_3
    (D) SO_2Cl_2 and H_2O
    (E) $SiCl_4$ and XeF_4

38. ZrI_4 can be described as cubic closest packed anions with the cations in tetrahedral holes. What fraction of the tetrahedral holes is occupied by the cations?
    (A) 1　　　　(B) 1/2　　　　(C) 1/4　　　　(D) 1/6　　　　(E) 1/8

39. Which of the following elements has the most allotropes?
    (A) oxygen　　　　(B) sulfur　　　　(C) phosphorus　　　　(D) boron　　　　(E) silicon

40. Which of the following statements about the complex ion $Co(en)_2Cl_2^+$ is true? (en = ethylenediamine, $NH_2CH_2CH_2NH_2$)
    (A) cis-$Co(en)_2Cl_2^+$ is paramagnetic.
    (B) The oxidation number of cobalt is +1.
    (C) cis-$Co(en)_2Cl_2^+$ has a C_2 symmetry.
    (D) Both cis-$Co(en)_2Cl_2^+$ and $trans$-$Co(en)_2Cl_2^+$ have optical isomers.
    (E) The geometrical isomers of this complex ion have identical chemical properties.

41. The preferred conformation of $trans$-1,4-dimethylcyclohexane has the cyclohexane ring in the
    (A) chair form with both methyl groups equatorial
    (B) chair form with both methyl groups axial
    (C) chair form with one methyl group axial and one equatorial
    (D) boat form with the methyl groups pointing toward the center of the ring
    (E) boat form with the methyl groups pointing away from the ring

42. How many possible isomers exist for C_4H_8?
    (A) 3　　(B) 4　　(C) 5　　(D) 6　　(E) 7

注意：背面有試題

43. What is the concept to best explain the greater volatility of *o*-nitrophenol over *p*-nitrophenol during steam distillation of a mixture of the two compounds?
    (A) hyperconjugation
    (B) the *ortho*-effect
    (C) hydrogen bonding
    (D) symmetry
    (E) resonance

44. Ketones react with primary amines to give
    (A) Ureas　　　　(B) Amides　　　　(C) Oximes　　　　(D) Guanidines　　　　(E) Schiff bases

45. Which of the following compounds will yield a precipitate with alcoholic $AgNO_3$ solution?
    (A) benzyl chloride
    (B) *trans*-dichloroethylene
    (C) *cis*-dichloroethylene
    (D) vinyl bromide
    (E) chlorobenzene

46. Which of the following compounds would react fastest with N-bromosuccinimide (NBS)?
    (A) benzene　　　　(B) toluene　　　　(C) methane　　　　(D) pyridine　　　　(E) cyclopropane

47. Identify the two principal products of the reaction between ammonia and ethyl propionate:

$$CH_3-CH_2-\overset{\overset{\textstyle O}{\|}}{C}-O-CH_2-CH_3 \ + \ NH_3 \longrightarrow$$
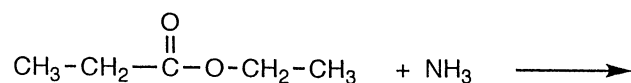
(A) $CH_3-\overset{\overset{\textstyle O}{\|}}{C}-NH_2 \ + \ CH_3-CH_2-CH_2-OH$

(B) $CH_3-CH_2-\overset{\overset{\textstyle O}{\|}}{C}-NH_2 \ + \ CH_3-CH_2-OH$

(C) $CH_3-CH_2-NH_2 \ + \ CH_3-CH_2-\overset{\overset{\textstyle O}{\|}}{C}-OH$

(D) $CH_3-CH_2-\overset{\overset{\textstyle O}{\|}}{C}-O-CH_2-NH_2 \ + \ CH_4$

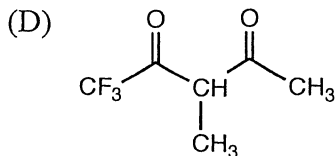(E) $CH_3-CH_2-O-\overset{\overset{\textstyle O}{\|}}{C}-NH_2 \ + \ CH_3-CH_3$

注意：背面有試題
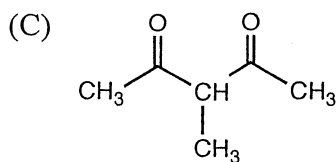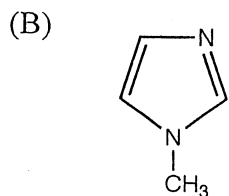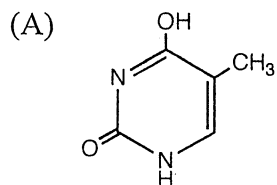
48. Which of the following polymers is a condensation polymer?
    (A) polystyrene
    (B) polyacrylonitrile
    (C) Dacron
    (D) Teflon
    (E) polyvinylchloride

49. What is the correct systematic name for the following compound?
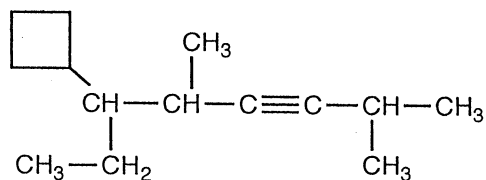
    (A) 2,5-dimethyl-3-octyne-6-cyclobutane
    (B) 4-cyclobutyl-1-isopropyl-3-methyl-1-hexyne
    (C) 3-cyclobutyl-4,7-dimethyl-5-octyne
    (D) 6-cyclobutyl-2,5-dimethyl-3-octyne
    (E) 3-cyclobutyl-4,7-dimethyl-5-octene

50. Which of the following compounds does NOT show tautomerism?
    (A)

    (B)

    (C)

    (D)

    (E)