科目名稱	普通化學A	類組代碼	共同考科
		科目碼	E0017

※本項考試依簡章規定各考科均「不可以」使用計算機　　　本科試題共計 3 頁

說明：答案一律寫在答案卷上；請依序作答，並標明題號。

($K_a(HNO_2)$= 4.0 x 10^{-4},　$K_a(HCN)$= 6.2 x 10^{-10},　$K_a(NH_4^+)$= 5.6 x 10^{-10},　log 4 = 0.6,
H_2CO_3: (K_{a1} = 4.3 x 10^{-7}, K_{a2}= 5.0 x 10^{-11}),　ln 2 = 0.693,　$2^{0.5}$ = 1.41,　$5^{0.5}$ = 2.24)

一、選擇題：（單選 25 題，每題 3 分，不倒扣，共 75 分）

1. Equimolar amounts of the gases N_2 and H_2 are mixed in a closed container fitted with a piston (allowing the volume of the container to change, thus keeping the pressure constant). Calculate the ratio of the final volume of the container to the initial volume of the container when the reaction $N_2 + 3H_2 \rightarrow 2NH_3$ goes to completion.
   (A)2/3　(B)3/2　(C)1　(D)1/3　(E)none of these

2. The wavelength of light associated with the $n = 2$ to $n = 1$ electron transition in the hydrogen spectrum is 1.216×10^{-7} m. By what coefficient should this wavelength be multiplied to obtain the wavelength associated with the same electron transition in the Li^{2+} ion?
   (A)1/3　(B)3　(C)1/4　(D)9　(E)1/9

3. How many of the following 0.10 M solutions ($CaBr_2$, KNO_2, NH_4ClO_4, NH_4NO_2, NH_4CN) are acidic?
   (A)3　(B)2　(C)1　(D)4　(E)5

4. Samples of the gases H_2 and SO_2 have equal masses and are at the same temperature and volume. Calculate the ratio of rates of impact with the walls ($H_2 : SO_2$).
   (A)1　(B)6　(C)32　(D)90　(E)180

5. Sodium oxide (Na_2O) crystallizes in a structure in which the O^{2-} ions are in a face-centered cubic lattice and the Na^+ ions are in tetrahedral holes. What is the number of Na^+ ions in the unit cell?
   (A)2　(B)4　(C)6　(D)8　(E)none of these

6. What's $[H^+]$ (in 10^{-7} M) in a 1.0 x10^{-7} M HNO_3 solution?
   (A)1.4　(B)1.6　(C)1.72　(D)1.85　(E)2.0

7. Calculate $[H^+]$ (in 10^{-13} M) in a 2.0 M solution of Na_2CO_3.
   (A)2.0　(B)3.0　(C)5.0　(D)7.0　(E)9.0

8. How many unpaired electrons are found in $[Co(CN)_4]^{3-}$ (square planar)?
   (A)0　(B)1　(C)2　(D)4　(E)5

9. Which of the following shows the bonds in order of decreasing polarity?
   (A)N–Cl, P–Cl, As–C　(B)P–Cl, N–Cl, As–Cl　(C)As–Cl, N–Cl, P–Cl
   (D)P–Cl, As–Cl, N–Cl　(E)As–Cl, P–Cl, N–Cl

10. A 50.0-mL sample of 2.0 x 10^{-4} M $CuNO_3$ is added to 50.0 mL of 4.0 M NaCN. Cu^+ reacts with CN^- to form the complex ion $Cu(CN)_3^{2-}$:
    $$Cu(CN)_3^{2-} \rightleftharpoons Cu^+ + 3CN^- \qquad K = 1.0 \text{ x } 10^{-9}$$
    What's $[Cu(CN)_3^{2-}]$ (in 10^{-4} M) at equilibrium?
    (A)0.5　(B)1.0　(C)1.3　(D)1.5　(E)2.0

11. What's equilibrium $[Cu^+]$ (in 10^{-14} M) in Problem 10?
    (A)1.2　(B)2.0　(C)3.6　(D)5.1　(E)7.4

12. For how many of the following species (Be_2, Si_2, H_2, O_2) does the bond order decrease if one electron is added?
    (A)0　(B)1　(C)2　(D)3　(E)4

13. The energy equation for a particle in a cubic box of dimensions $L_x = L_y = L_z$ is

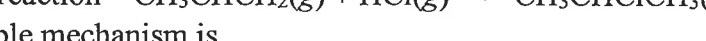$$E = \frac{h^2}{8\,mL^2}\left[n_x^2 + n_y^2 + n_z^2 \right]$$

How many degenerate energy levels have energy equal to 14 $h^2/8mL^2$?
(A)1　(B)3　(C)6　(D)8　(E)12

14. How many of the following molecules (IF_5, PF_5, SOF_4, BrF_3, SF_4) have trigonal bipyradimal structures?

(A)1　(B)2　(C)3　(D)4　(E)5

15. How many molecules in Problem 14 have a hybridization of dsp^3 on the central atom?
(A)1　(B)2　(C)3　(D)4　(E)5

16. What's the total number of structural and geometric isomers of C_3H_4?
(A)3　(B)2　(C)5　(D)6　(E)4

17. Which of the following is paramagnetic?
(A)$[Fe(en)_3]^{2+}$ (strong field)　　(B)$[Cu(en)_3]^+$　　(C)$[Co(en)_6]^{3+}$ (strong field)
(D)$[Mn(CN)_6]^{4-}$ (strong field)　　(E)$[Zn(H_2O)_6]^{2+}$
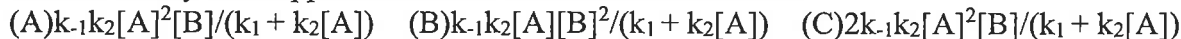
18. Consider the following reduction potentials:

$$Cu^{2+} + 2e^- \rightarrow Cu \qquad E° = +0.34 \text{ V}$$
$$Pb^{2+} + 2e^- \rightarrow Pb \qquad E° = -0.13 \text{ V}$$

For a galvanic cell employing the Cu, Cu^{2+} and Pb, Pb^{2+} couples, calculate the maximum amount of work (in kJ) that would accompany the reaction of 1 mol of lead under standard conditions.
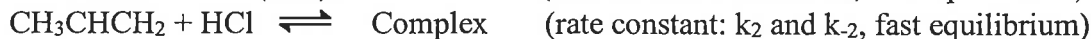(A)-22.6　(B)-34.5　(C)-90.7　(D)-45.3　(E)-69.0

19. At a particular temperature, N_2O_5 decomposes according to a first-order rate law with a half-life of 3.0 s. If the initial concentration of N_2O_5 is 1.0 x 10^{16} molecules/cm^3, what will be the concentration (in 10^{14} molecules/cm^3) after 12.0 s?

(A)6.25　(B)25.0　(C)12.5　(D)50.0　(E)3.13

20. For the reaction $2A + B \rightarrow$ products
the following mechanism is proposed:

$$A + B \rightleftharpoons M \qquad \text{(rate constant: } k_1 \text{ and } k_{-1})$$
$$A + M \rightarrow \text{products} \qquad \text{(rate constant } k_2)$$

Use the steady-state approximation to determine the rate law.
(A)$k_{-1}k_2[A]^2[B]/(k_1 + k_2[A])$　(B)$k_{-1}k_2[A][B]^2/(k_1 + k_2[A])$　(C)$2k_{-1}k_2[A]^2[B]/(k_1 + k_2[A])$
(D)$k_1k_2[A]^2[B]/(k_{-1} + k_2[A])$　(E)$k_1k_2[A][B]^2/(k_{-1} + k_2[A])$

21. For the reaction $CH_3CHCH_2(g) + HCl(g) \rightarrow CH_3CHClCH_3(g)$
a possible mechanism is

$$2HCl \rightleftharpoons (HCl)_2 \qquad \text{(rate constant: } k_1 \text{ and } k_{-1}, \text{ fast equilibrium)}$$
$$CH_3CHCH_2 + HCl \rightleftharpoons \text{Complex} \qquad \text{(rate constant: } k_2 \text{ and } k_{-2}, \text{ fast equilibrium)}$$
$$\text{Complex} + (HCl)_2 \rightarrow CH_3CHClCH_3 + 2HCl \qquad \text{(rate constant } k_3, \text{ slow)}$$

What's the rate law for this reaction?
(A)$(k_{-1}k_{-2}k_3/k_1k_2)[HCl]^2[CH_3CHCH_2]$　(B)$(k_1k_2k_3/k_{-1}k_{-2})[HCl]^{3/2}[CH_3CHCH_2]$
(C)$(k_1k_2k_3/k_{-1}k_{-2})[HCl]^3[CH_3CHCH_2]$　(D)$(k_{-1}k_{-2}k_3/k_1k_2)[HCl]^{3/2}[CH_3CHCH_2]$
(E)$(k_{-1}k_{-2}k_3/k_1k_2)[HCl]^3[CH_3CHCH_2]$

22. The H-NMR spectra for a certain molecule have a triplet signal and a quartet signal, with area ratio 3:2. Which of the following molecules is possible?
(A)CH_3OCH_2Cl　(B)$CH_2ClCHCl_2$　(C)$CHCl_2OCH_3$　(D)CH_3CH_2Cl　(E)CH_3CH_2COOH

23. A student gave a molecule the following name: 3-methyl-4-isopropylpentane. What is the correct IUPAC name?
(A)4-isopropyl-3-methylpentane　(B)2-isopropyl-3-methylpentane
(C)1,1,2,3-tetramethylpentane　(D)2,3,4-trimethylhexane　(E)3,4-dimethylheptane

24. When C_4H_8 is treated with water and H_2SO_4, a tertiary alcohol is produced. Which of the following structures could represent C_4H_8 in this reaction?
(A)$CH_3CH=CHCH_3$　(B)$CH_3CH_2CH=CH_2$　(C)$(CH_3)_2C=CH_2$
(D)$CH_3CH_2CH_2CH_3$　(E)none of these

25. What's the total number of aldehydes and ketones that have the formula $C_5H_{10}O$?
(A)6　(B)5　(C)9　(D)8　(E)7

二、計算題：（共 25 分，務必列出計算過程，只寫答案不計分）

1. The observed solubility of the salt MX in 4.0 M strong acid is 2.0 x 10^{-3} M. The K_a value for the acid HX is 1.0 x 10^{-9}. Calculate the value of K_{sp} for the salt MX. (7 %)

2. Consider 2.0 mol of a monatomic ideal gas that is taken from state A (3.0 atm, 10.0 L) to state B (3.0 atm, 30.0 L), and then to state C (1.0 atm, 30.0 L), followed by the isothermal and reversible compression back to state A. Calculate (a)q_{AB} (in atm L), (b)ΔS_{AB} (in R), (c)ΔE_{BC} (in atm L), and (d)work in a cycle (in atm L). (18 %)