系所組別： 化學系學士班

考試科目： 普通化學

考試日期：0710，節次：3

※ 考生請注意：本試題 ☑可 □不可 使用計算機

請將答案依序寫在答案卷上

一、選擇題:(60%,每題 2%)

1. According to the law of definite proportions,
   A) if the same two elements form two different compounds, they do so in the same ratio.
   B) it is not possible for the same two elements to form more than one compound.
   C) the ratio of the masses of the elements in a compound is always the same.
   D) the total mass after a chemical change is the same as before the change.

2. Which of the experiments listed below did *not* provide the information stated about the nature of the atom?
   A) The Rutherford experiment proved that the Thomson "plum pudding" model of the atom was essentially correct.
   B) The Rutherford experiment determined the charge on the nucleus.
   C) Millikan's oil-drop experiment showed that the charge on any particle was a simple multiple of the charge on the electron.
   D) The cathode-ray tube proved that electrons have a negative charge

3. Which of the following relationships is *not* true?
   A) PV = constant when temperature and moles of gas are held constant.
   B) V/T = constant when pressure and moles of gas are held constant.
   C) nT = constant when pressure and volume are held constant.
   D) P/n = constant when volume and temperature are held constant.
   E) All of these are true.

4. The kinetic-molecular theory of gases does *not* assume that
   A) gases are made up of tiny particles in constant chaotic motion.
   B) gas particles are very small compared to the average distance between the particles.
   C) gas particles collide with the walls of their container in elastic collisions.
   D) the average velocity of gas particles is directly proportional to the absolute temperature.
   E) All of these are correct.

5. For the reaction $2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$, what is the relationship between K and K_p at temperature T?
   A) $K = K_p$ B) $K = K_p(RT)^2$ C) $K_p = K(RT)^2$ D) $K = K_p(RT)$
   E) $K_p = K(RT)$

6. Which of the following statements about the following equilibrium is *false*?
   $H_2(g) + I_2(s) \rightleftharpoons 2HI(g)$ $\Delta H = +68.0$ kJ/mol
   A) If the system is heated, the right side is favored.
   B) This is a heterogeneous equilibrium.
   C) If the pressure on the system is increased by changing the volume, the left side is favored.
   D) Adding more $H_2(g)$ increases the equilibrium constant.
   E) Removing HI as it forms forces the equilibrium to the right.

7. Which of the following reactions is associated with the definition of K_a?
   A) $Al^{3+} + 6H_2O \rightleftharpoons Al(OH_2)_6^{3+}$
   B) $Al(OH_2)_6^{3+} \rightleftharpoons Al(OH)(OH_2)_5^{2+} + H^+$
   C) $OCl^- + H_2O \rightleftharpoons HOCl + OH^-$
   D) $CN^- + H^+ \rightleftharpoons HCN$

8. Which of the following species is *not* amphoteric?
   A) HSO_4^- B) $H_2PO_4^-$ C) HPO_4^{2-} D) H_2O
   E) All of these are amphoteric.

(背面仍有題目,請繼續作答)

※ 考生請注意：本試題 ☑可 ☐不可 使用計算機

9. The acids $HC_2H_3O_2$ and HF are both weak, but HF is a stronger acid than $HC_2H_3O_2$. HCl is a strong acid. Order the following according to base strength.
   A) $C_2H_3O_2^- > F^- > Cl^- > H_2O$ B) $C_2H_3O_2^- > F^- > H_2O > Cl^-$
   C) $Cl^- > F^- > C_2H_3O_2^- > H_2O$ D) $F^- > C_2H_3O_2^- > H_2O > Cl^-$
   E) none of these

10. You are given a solution of the weak base Novocain, Nvc. Its pH is 11.00. You add to the solution a small amount of a salt containing the conjugate acid of Novocain, $NvcH^+$. Which statement is true?
   A) The pH and the pOH both increase.
   B) The pH and the pOH both decrease.
   C) The pH and the pOH remain unchanged.
   D) The pH increases and pOH decreases.
   E) The pH decreases and the pOH increases.

11. The pH at the equivalence point of a titration of a weak acid with a strong base is
   A) less than 7.00. B) equal to 7.00.
   C) greater than 7.00. D) More data are needed to answer this question.

12. Which one of the following statements is *false*?
   A) The change in internal energy, ΔE, for a process is equal to the amount of heat absorbed at constant volume, q_v.
   B) The change in enthalpy, ΔH, for a process is equal to the amount of heat absorbed at constant pressure, q_p.
   C) A bomb calorimeter measures ΔH directly.
   D) If q_p for a process is negative, the process is exothermic.
   E) The freezing of water is an example of an exothermic reaction.

13. Suppose you add 45 J of heat to a system, let it do 10. J of expansion work, and then return the system to its initial state by cooling and compression. Which statement is true for this process?
   A) $\Delta H < \Delta E$
   B) The work done in compressing the system must exactly equal the work done by the system in the expansion step.
   C) $\Delta H = 70.$ J
   D) The change in the internal energy for this process is zero.

14. A gas expands isothermally and irreversibly, w is
   A) less than zero. B) equal to zero.
   C) greater than zero. D) More information is needed.

15. Which statement is true?
   A) All real processes are irreversible.
   B) A thermodynamically reversible process takes place infinitely fast.
   C) In a reversible process, the state functions of the system are always much greater than those of the surroundings.
   D) There is always more heat given off to the surroundings in a reversible process than in an unharnessed one.
   E) All these statements are true.

※ 考生請注意：本試題 ☑可 ☐不可 使用計算機

16. Choose the correct statement.
A) Exothermic reactions are always spontaneous.
B) Free energy is independent of temperature.
C) A reaction that exhibits a negative value of ΔS cannot be spontaneous.
D) At constant pressure and temperature, a decrease in free energy ensures an increase in the entropy of the system.
E) none of these

17. The following two half-reactions take place in a galvanic cell. At standard conditions, what species are produced at each electrode?
$Sn^{2+} + 2e^- \rightarrow Sn$ $E° = -0.14$ V; $Cu^{2+} + 2e^- \rightarrow Cu$ $E° = 0.34$ V
A) Sn is produced at the anode, and Cu^{2+} is produced at the cathode.
B) Sn is produced at the anode, and Cu is produced at the cathode.
C) Sn is produced at the cathode, and Cu^{2+} is produced at the anode.
D) Cu is produced at the cathode, and Sn^{2+} is produced at the anode.
E) Cu is produced at the anode, and Sn^{2+} is produced at the cathode.

18. Choose the correct statement(s) given the following information:
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$ $E° = 0.77$ V
$Fe(CN)_6^{3-} + e^- \rightarrow Fe(CN)_6^{4-}$ $E° = 0.36$ V
I. $Fe^{2+}(aq)$ is more likely to be oxidized than Fe^{2+} complexed to CN^-.
II. $Fe^{3+}(aq)$ is more likely to be reduced than Fe^{3+} complexed to CN^-.
III. Complexation of Fe ions with CN^- has no effect on their tendencies to become oxidized or reduced.
A) I only B) II only C) I and II D) III only
E) None of these is true.

19. For a reaction in a voltaic cell, both $\Delta H°$ and $\Delta S°$ are positive. Which of the following statements is true?
A) $E°_{cell}$ will increase with an increase in temperature.
B) $E°_{cell}$ will decrease with an increase in temperature.
C) $E°_{cell}$ will not change when the temperature increases.
D) $\Delta G° > 0$ for all temperatures.
E) None of the above statements is true.

20. The energy expressions for the electrons in the He^+ ion and the hydrogen atom are
$E_n(H) = -a/n^2$ and $E_n(He^+) = -4a/n^2$
Which of the following statements is(are) correct?
I. For the transitions $n_1 \rightarrow n_2$, the frequency is larger for H than for He^+.
II. The first ionization energy of the H atom is smaller than the second ionization energy of the He atom.
III. The 1s orbital in He^+ is larger (in the sense that the probability density is shifted outward) than the 1s orbital in H.
A) I only B) II only C) III only D) I and II only
E) I, II, and III

21. Which of the following shows these molecules in order from most polar to least polar?
A) $CH_4 > CF_2Cl_2 > CF_2H_2 > CCl_4 > CCl_2H_2$
B) $CH_4 > CF_2H_2 > CF_2Cl_2 > CCl_4 > CCl_2H_2$
C) $CF_2Cl_2 > CF_2H_2 > CCl_2H_2 > CH_4 = CCl_4$
D) $CF_2H_2 > CCl_2H_2 > CF_2Cl_2 > CH_4 = CCl_4$
E) $CF_2Cl_2 > CF_2H_2 > CCl_4 > CCl_2H_2 > CH_4$

(背面仍有題目,請繼續作答)

※ 考生請注意：本試題 ☑可 ☐不可 使用計算機

22. Choose the statement that best describes the $PbCl_4$ molecule in the gas phase.
A) The bond angles are all about 109°. B) The molecule is polar.
C) The molecule has a dipole moment. D) The bonds are nonpolar.
E) The molecule is polar with bond angles of about 109°.

23. Which of the following has the shortest N-O bond?
A) NO_3^- B) NO^+ C) N_2 D) NO_2^-
E) none of these

24. The reaction A → B + C is known to be zero order in A with a rate constant of 5.0×10^{-2} mol/L • s at 25° C. An experiment was run at 25°C where $[A]_0 = 1.0 \times 10^{-3} M$. What is the integrated rate law?
A) $[A] = kt$ B) $[A] - [A]_0 = kt$ C) $\frac{[A]}{[A]_0} = kt$
D) $\ln \frac{[A]}{[A]_0} = kt$ E) $[A]_0 - [A] = kt$

25. Which statement regarding water is true?
A) Energy must be given off in order to break down the crystal lattice of ice to a liquid.
B) Hydrogen bonds are stronger than covalent bonds.
C) Liquid water is less dense than solid water.
D) Only covalent bonds are broken when ice melts.
E) All of these statements are false.

26. A liquid-liquid solution is called an ideal solution if
I. it obeys $PV = nRT$.
II. it obeys Raoult's law.
III. solute-solute, solvent-solvent, and solute-solvent interactions are very similar.
IV. solute-solute, solvent-solvent, and solute-solvent interactions are quite different
A) I, II, III B) I, II, IV C) II, III D) II, IV
E) I, II

27. What reason is given for the stability of C—C, N—N, and O—O bonds, compared to the instability of Si—Si, P—P, and S—S bonds?
A) Their metallic character varies greatly.
B) There are large differences in their ionization energies.
C) There are large differences in their electronegativities.
D) There are large differences in their abilities to form strong pi bonds.
E) none of these

28. Which of the following statements is true about coordination complexes?
A) The metal is a Lewis base and the ligands are Lewis acids.
B) Only complexes with coordination number 6 are found in nature.
C) When the ligands approach a transition metal ion in an octahedral field, the d_{xz}, d_{yz}, and d_{xy} atomic orbitals are affected the least by the ligands.
D) None of these is true.
E) All of these are true.

29. For which of the following metal ions would there be no distinction between low spin and high spin in octahedral complexes?
A) Cr^{2+} B) V^{2+} C) Co^{3+} D) Mn^{2+} E) Ni^{3+}

※ 考生請注意：本試題 ☑可 ☐不可 使用計算機

30. Which of the following names is a correct one?
A) 3,4-dichloropentane
B) 1-chloro-2,4-methyl-3-ethylcyclohexane
C) 1,1-dimethyl-2,2-diethylpentane
D) *cis*-1,3-dimethylbutane
E) 2-bromo-1-chloro-4,4-diethyloctane

二、問答題 (40%)

1. Two drops of indicator HIn ($K_a = 1.0 \times 10^{-9}$), where HIn is yellow and In^- is blue, are placed in 100.0 ml of 0.1 *M* HCl.
a). What color is the solution initially ? (3%)
b). This solution is titrated with 0.10 *M* NaOH. At what pH will the color change (yellow to greenish) occur ? (4%)
c). What color will the solution be after 200.0 ml of NaOH has been added ? (3%)

2. An enzyme-catalyzed reaction was carried out in a 0.2 *M* Tris buffer, pH 7.8. As a result of the reaction, 0.03 mole/liter of H^+ was produced. (a) What were the concentrations of $Tris^+$ and $Tris^0$ at the start of the reaction? (5%) (b) What was the pH at the end of the reaction? (5%)
The pK_a of Tris is 8.1.

3. a). Using the following equation and experimental data to determine $\triangle H^\circ$ and $\triangle S^\circ$ for the autoionization of water: (5%)

$$\ln(K) = \frac{-\Delta H^\circ}{RT} + \frac{\Delta S^\circ}{R}$$

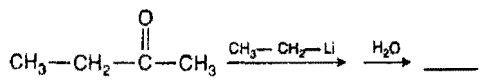
$$H_2O(l) \rightleftarrows H^+(aq) + OH^-(aq)$$

T (°C)	K
0	1.14×10^{-15}
25	1.00×10^{-14}
35	2.09×10^{-14}
40	2.92×10^{-14}
50	5.47×10^{-14}

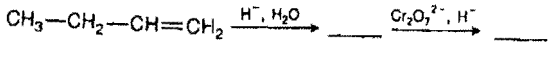
b). Estimate the value of $\triangle G^\circ$ for the autoionization of water at the critical temperature, 374 °C (5%)

4. Complete the following reactions by filling in the expected product or the missing organic and/or inorganic substances: (10%)

a).



b).



c).