※ 注意：請於答案卷內之「選擇題作答區」依序作答。
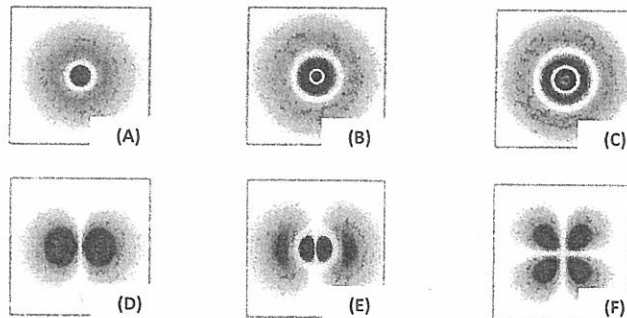
General Chemistry C
Total: 100 points

Part I: (question 1 – 4, *only one correct* answer for each question, **total 16 points**)
Given the following probability density of selected atomic orbitals of hydrogen atom.
Please answer the following questions:

(1)　Properties of atomic orbital of hydrogen vs. quantum numbers of orbital:
　　　a.　The energy of orbital is determined only by the principal quantum number.
　　　b.　Angular momentum quantum number of s orbital is 1.
　　　c.　For principal quantum number of 1, there are three angular momentum quantum numbers (1, 0, -1).
　　　d.　The shape of orbital is determined by both principal quantum number and angular momentum quantum number.
　　　e.　None of the above.

(2)　Orbitals having the same principal quantum number are:
　　　a.　**D, F**
　　　b.　**A, B, C**
　　　c.　**A, E**
　　　d.　**B, E, F**
　　　e.　None of the above

(3)　For atomic orbitals, there are two types of nodes, angular and radial nodes.
　　　a.　There are two angular nodes in orbital **E**.
　　　b.　Both orbital **D** and **E** have one radial node.
　　　c.　Orbital **D** and **F** do not have radial node.
　　　d.　Orbital **A** and **E** have the same number nodes.
　　　e.　None of the above

(4)　Correct description of the orbital energies.
　　　a.　Orbital **A** and **E** have the same energy.
　　　b.　Orbital **D** and **F** have the same energy.
　　　c.　Orbital **F** is higher in energy than orbital **B**.
　　　d.　Orbital **C** is lower in energy than orbital **F**
　　　e.　None of the above

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Part II: (question 5 – 9, *only one correct* answer for each question, **total 20 points**)
With the given atomic symbols of copper, please answer the following question.

$$^{63}_{29}\text{Cu} \qquad ^{65}_{29}\text{Cu}$$
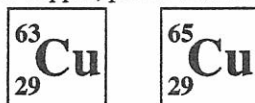
(5) Which of the following description of copper atom is correct?
   a. These two copper atoms are isotopes because they have the same number of neutrons and electrons.
   b. ^{63}Cu has 29 electrons, 29 protons and 34 neutrons.
   c. ^{63}Cu and ^{65}Cu have totally different chemical reactions.
   d. All of the above
   e. None of the above

(6) Assume that there are only two isotope of copper, ^{63}Cu and ^{65}Cu, and the atomic weight of copper is 63.55 g/mol. What is the % abundance of ^{63}Cu or ^{65}Cu?
   a. The % abundance of ^{65}Cu is 23.5 %.
   b. The % abundance of ^{65}Cu is 25.5 %.
   c. The % abundance of ^{63}Cu is 72.5 %.
   d. The % abundance of ^{63}Cu is 75.5 %.
   e. None of the above

(7) Since Cu crystalizes in face-centered cubic structure, which of the following description is correct?
   a. There is one Cu atom in a unit cell.
   b. There are two Cu atoms in a unit cell.
   c. There are four Cu atoms in a unit cell.
   d. There are six Cu atoms in a unit cell.
   e. None of the above

(8) Following the previous question, if the atomic radius of Cu is 135.0 pm, what is the length of the cell edge?
   a. 190.9 pm
   b. 270.0 pm
   c. 311.8 pm
   d. 381.8 pm
   e. None of the above

(9) What is the density of Cu?
   a. 4.58 g/cm^3
   b. 5.36 g/cm^3
   c. 6.96 g/cm^3
   d. 7.59 g/cm^3
   e. None of the above

Part III: (question 10 – 12, *only one correct* answer for each question, **total 12 points**)
The homogeneous mixture of solvent and solute is called a solution. The properties of the solution are greatly influenced by the nature of the solute.
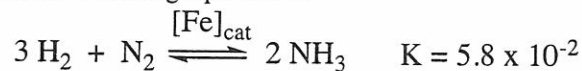
(10) Which of the following description of ideal gas and ideal solution is correct?
    a. Ideal gas should obey the ideal gas law and can only be achieved at low temperature.
    b. Ideal solution should obey the Raoult's law and can be achieved at all concentration of solute.
    c. Both ideal gas and ideal solution assume that there are no intermolecular interactions.
    d. In real world, no ideal gas and ideal solution can be achieved.
    e. None of the above.

(11) Two liquid volatile organic compounds were mixed with various mole fractions to form solution. The relationship between vapor pressure and mole fraction is shown below. Please select the correct answer.
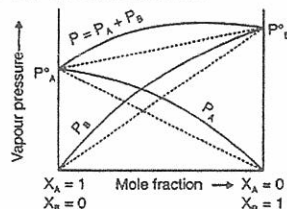

    a. The boiling point of liquid B is higher.
    b. The dissolution (mixing) process of liquid A and B is exothermic.
    c. The total volume of the solution is smaller than the sum of volumes of liquid A and B.
    d. The positive deviation from Raoult's law is because of the formation of strong A-B attractive force in solution.
    e. None of the above.

(12) There are four solutions prepared with the following compositions. Please select the correct answer.
        Solution **A**: 2 g of NaCl in 100 mL of water
        Solution **B**: 2 g of KCl in 100 mL of water
        Solution **C**: 2 g of glucose in 100 mL of water
        Solution **D**: 2 g of sucrose in 100 mL of water
    a. Boiling point of solution **A** is the highest.
    b. Solution **B** has the highest electric conductivity.
    c. The density of solution **D** is higher than that of solution **C**
    d. All of the above
    e. None of the above

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Part IV: (question 13 – 15, *only one correct* answer for each question, **total 12 points**)
Haber-Bosch process is the most important synthetic method for ammonia (NH_3). The reaction is based on the following equilibrium.

$$3\,H_2 + N_2 \xrightleftharpoons{[Fe]_{cat}} 2\,NH_3 \qquad K = 5.8 \times 10^{-2}$$

(13)　Which of the following mixture has reached the equilibrium?
    a.　$[H_2] = 0.40$ M, $[N_2] = 1.20$ M, $[NH_3] = 0.20$ M
    b.　$[H_2] = 0.90$ M, $[N_2] = 0.80$ M, $[NH_3] = 0.40$ M
    c.　$[H_2] = 1.20$ M, $[N_2] = 0.40$ M, $[NH_3] = 0.20$ M
    d.　$[H_2] = 3.00$ M, $[N_2] = 1.20$ M, $[NH_3] = 2.50$ M
    e.　None of the above

(14)　Which of the following description about this equilibrium is correct?
    a.　Addition of Fe increases the reverse reaction rate.
    b.　The equilibrium constant is larger at low pressure.
    c.　Fe can catalyze the reaction and shift the equilibrium to the product side.
    d.　The concentration of H_2 and N_2 are decreased with the same reaction rate.
    e.　None of the above

(15)　If the equilibrium constant of a reaction is greater than 1, which combination of the following figures is correct?

    a.　**A + B**
    b.　**A + D**
    c.　**B + C**
    d.　**C + D**
    e.　None of the above
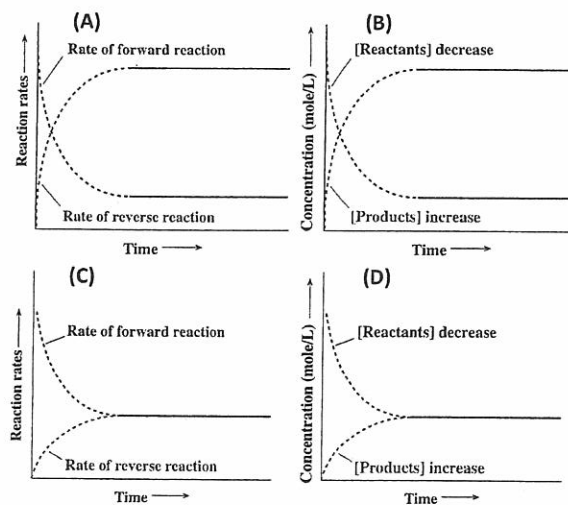
Part V: (question 16 – 20, *only one correct* answer for each question, **total 20 points**)
Acid-base titration is commonly used to determine the molarity of acid and base solution in laboratory. In most cases, indicator is used to identify the titration end point. However, to choose a right indictor requires some calculations before doing the actual titration. Now, assume that you are about to titrate 50 mL of 0.20 M nitrous acid with 0.10 M NaOH (HNO_2, $K_a = 4.0 \times 10^{-4}$).

(16) What is the pH value of the nitrous acid solution before addition of NaOH?
  a. 0.70
  b. 2.05
  c. 3.40
  d. 4.10
  e. None of the above

(17) After addition of 20 mL of NaOH, what is the pH value of the solution?
  a. 0.80
  b. 0.96
  c. 2.80
  d. 3.50
  e. None of the above

(18) What is the pH value of the solution at the equivalence point?
  a. 7.00
  b. 8.11
  c. 8.35
  d. 10.60
  e. None of the above

(19) What is the pH value of the solution when 110 mL of NaOH is added?
  a. 10.60
  b. 11.80
  c. 11.96
  d. 13.00
  e. None of the above

(20) Which indicator is the most suitable indicator for this titration experiment?
  a. Indicator A: $K_a = 1.0 \times 10^{-2}$
  b. Indicator B: $K_a = 1.0 \times 10^{-4}$
  c. Indicator C: $K_a = 1.0 \times 10^{-7}$
  d. Indicator C: $K_a = 1.0 \times 10^{-9}$
  e. Indicator D: $K_a = 1.0 \times 10^{-11}$

<div align="center">見背面</div>

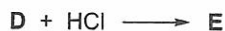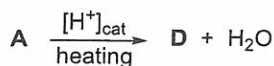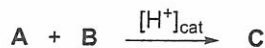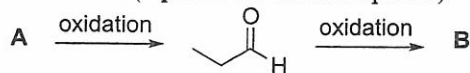**Part VI:** (question 21 – 22, **total 10 points**)

Please select the appropriate **answers** for the following questions. There is *at least one correct* answer. (*5 points* for each question; with *one incorrect* choice gets *3 points*, with *two or more incorrect* choices gets *0 point*)

(21)　Which of the following description(s) of hybridization is(are) correct?
　　　a. Hybrid orbital equals to molecular orbital
　　　b. The energy of sp hybrid orbital is lower than that of sp^2 hybrid orbital
　　　c. The sulfur atom in SF_4 is in d^2sp^3 hybridization
　　　d. The central atom in ClF_4^+ and PF_5 have the same hybridization
　　　e. The central atom in CO_2 and SO_5 have the same hybridization

(22)　Which of the following description(s) is(are) correct?
　　　a. Fluorine is the most electronegative element
　　　b. Chlorine has larger electron affinity than fluorine
　　　c. The F-F bond is stronger than Cl-Cl bond
　　　d. O_2 has higher bond order than $[O_2]^+$
　　　e. Both B_2 and O_2 have two un-paired electrons

※ 注意：請於答案卷內之「非選擇題作答區」作答，並應註明作答之題號。

Part VII: (question 23, **total 10 points**)

(23)　Structure of compound **A – E.** (**2 points** for each compound)

$$A \xrightarrow{\text{oxidation}} \underset{H}{\overset{O}{\parallel}}\!\!\!\!\!\!\!\!\!\diagup\!\!\!\!\searrow \xrightarrow{\text{oxidation}} B$$

$$A + B \xrightarrow{[H^+]_{cat}} C$$

$$A \xrightarrow[\text{heating}]{[H^+]_{cat}} D + H_2O$$

$$D + HCl \longrightarrow E$$

Appendix

Metal　Metaloid　Non-metal

試題隨卷繳回