※注意：請於試卷上「選擇題作答區」依序作答。

Total: 100 points

Multiple-Choice Questions: There is ***at least one correct*** answer.

(5 points each; 3 points for one incorrect choice; 0 point for two or more incorrect choice)

(1) Lithium metal, which has a work function of 279.7 kJ/mol, was used in photoelectric effect study. Which of the following statement is/are correct?
   a. The energy of an incident photon must be higher than 4.6×10^{-19} J to eject an electron from Li metal.
   b. By increasing the energy of incident light, the photocurrent is increased.
   c. To eject an electron from Li, the frequency of the incident light must be higher than 7.01×10^{11} Hz.
   d. To eject an electron from Li, the wavelength of the incident light must be shorter than 427 nm.
   e. None of the above

(2) In which of the following conditions, does the internal energy of the system increased? ($\Delta E > 0$)
   a. $q = -47$ kJ, $w = +88$ kJ
   b. $q = +82$ kJ, $w = -82$ kJ
   c. Expansion of an ideal gas at 10.0 L and 15 atm against external pressure of 2.00 atm at a constant temperature.
   d. Heating 0.1 mole of He gas from 273 K to 333 K inside a rigid steel bomb reactor.
   e. None of the above.

(3) Which of the following descriptions of elements is/are correct?
   a. Fluorine (F) is the most electronegative element.
   b. Oxygen (O) has higher first ionization energy than nitrogen (N)
   c. Boron (B) has three electrons.
   d. Chlorine (Cl) has the highest electron affinity.
   e. None of the above

(4) Which of the following description of ideal gas and ideal solution is/are correct?
   a. Ideal gas follows the ideal gas law, and can be achieve with high pressure gas
   b. Ideal solution follows the Henry's law
   c. Both ideal gas and ideal solution assume that there are no intermolecular interactions.
   d. In real word, no ideal gas and ideal solution can be achieved.
   e. None of the above.

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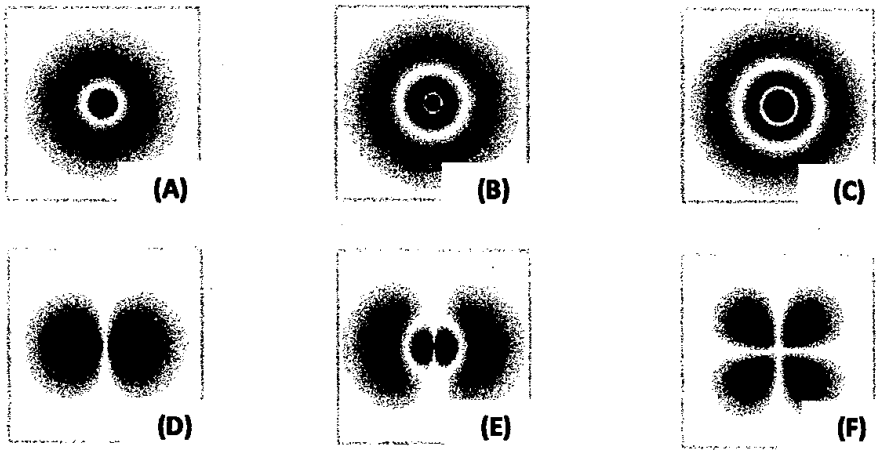
(5) Given the following probability density of selected atomic orbitals of hydrogen atom. Which set of orbitals have the same principal quantum number?



a. **A, B, C**
b. **A, D**
c. **B, E, F**
d. **C, F**
e. **D, E**

(6) Following **Q5**, which of the following statement is/are correct?
a. Orbital **A**, **B**, and **C** have the same number of angular nodes.
b. Orbital **A** and **D** have the same number of radial nodes.
c. Orbital **B** and **E** have the same number of nodes.
d. Both orbital **D** and **E** have one angular node.
e. Orbital **F** has a one more radial node than **D**.

(7) Which of the description of N_2 (28 g/mol) and CH_4 (16 g/mol) is/are correct?
a. The average kinetic energy of a CH_4 molecule at 546 K is 6.81 kJ.
b. At 300 K, CH_4 has lower average kinetic energy than N_2.
c. At 273 K, the root mean square velocity of N_2 is 15.59 m/s.
d. At 273 K, CH_4 has higher root mean square velocity than N_2.
e. None of the above.

(8) Which of the following statement of diatomic molecules is/are correct?
a. $[H_2]^+$ has a bond order of 0.5.
b. The O-O bond length in O_2 is shorter than that in $[O_2]^+$
c. N_2 has higher bond order than O_2
d. The F-F bond is stronger than Cl-Cl bond.
e. NO and CO molecules have the same bond order.

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(9) Assume that there are only two isotopes of copper, ^{63}Cu and ^{65}Cu, and the atomic weight of copper is 63.55 g/mol, which of the following statement is/are correct?
   a. ^{63}Cu and ^{65}Cu have the same number of protons and electrons.
   b. ^{63}Cu and ^{65}Cu have totally different chemical reactions.
   c. The % abundance of ^{63}Cu is 72.5 %.
   d. The % abundance of ^{65}Cu is 23.5 %.
   e. None of the above

(10) Following **Q9**, if the atomic radius of Cu is 135.0 pm and Cu crystalizes in body-centered cubic structure, which of the following description is/are correct?
   a. There is one Cu atom in a unit cell.
   b. There are four Cu atoms in a unit cell.
   c. The edge length of its unit cell is 270.0 pm.
   d. The edge length of its unit cell is 311.8 pm.
   e. The edge length of its unit cell is 381.9 pm.

(11) Following **Q9** & **Q10**, what is the density of Cu?
   a. 3.79 g/cm^3
   b. 4.19 g/cm^3
   c. 5.36 g/cm^3
   d. 6.96 g/cm^3
   e. None of the above

(12) A compound, XF_5, contains 72.82% of fluorine by weight. Which of the following statements are correct?
   a. This molecule is PF_5
   b. This is a polar molecule
   c. The hybridization of X is dsp^3
   d. Geometry of this molecule is square pyramidal
   e. None of the above

(13) There are four solutions prepared with the following compositions. Please select the correct answer.

Solution **A**: 10 g of NaCl in 100 mL of water
Solution **B**: 10 g of KCl in 100 mL of water
Solution **C**: 10 g of glucose (葡萄糖) in 100 mL of water
Solution **D**: 10 g of sucrose (蔗糖) 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 **C** and **D** are the same.
   d. The freezing point of solution **C** and **D** are the same.
   e. All solutions have the same water vapor pressure at room temperature.

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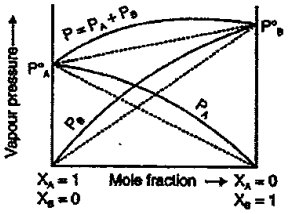
(14) The relationship between vapor pressure and mole fraction of a solution prepared from mixing two liquid organic compounds is shown below. Please select the correct answer.



a. The boiling point of liquid B is higher.
b. The A+B mixing process is exothermic.
c. The volume of the solution prepared from 100 mL of A and 100 mL of B is greater than 200 mL.
d. The positive deviation from Raoult's law is the result of strong A-B attractive force in the solution.
e. None of the above

(15) In Haber-Bosch process, iron (Fe) metal is an effective catalyst to promote reaction of N_2 and H_2 to yield NH_3. Which of the following description about this iron-catalyzed reaction is/are correct?
a. The addition of Fe increases the reverse reaction rate.
b. The equilibrium constant of this reaction is larger at low pressure.
c. Fe catalyzes the reaction and shifts the equilibrium to the product side.
d. The concentration of H_2 and N_2 are decreased with the same rate.
e. None of the above

(16) Which of the following description 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_2 have the same hybridization

(17) H_2 gas generated from the reaction of Na (MW = 23 g/mol) and acetic acid was collected over water at 303 K and 1.00 atm.

$$2\,Na(s) + 2\,CH_3COOH\,(aq) \rightarrow 2\,CH_3COONa\,(aq) + H_2$$

If the total pressure inside the gas collecting bottle equals to the atmospheric pressure, which of the following description is correct?
a. The partial pressure of H_2 inside the bottle is 760 torr.
b. To generate 240 mL of gas, 0.23 g of Na must have reacted.
c. 40 mL of 0.5 M acetic acid is able to consume 0.43 g of Na.
d. The solution obtained from the reaction of 1.0 mole of Na and 1.0 mole of acetic acid has a pH value higher than 7. (pH >7)
e. None of the above.

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(18) MgO (MW = 40.3 g/mol) has a density of 3.58 g/cm^3 and has a crystal structure like NaCl. Which of the following description is/are correct?

a. There are four Mg^{2+} ions in a unit cell.
b. The r_{Mg2+}/r_{O2-} is larger than 0.2247, but smaller than 0.414
c. The length of the edge of the unit cell (*d*) is 3.55 Å.
d. The lattice energy of MgO is roughly four-times larger than that of NaCl.
e. None of the above

(19) Which of the following condition or reaction is/are spontaneous?

a. $\Delta S_{sys} = -15$ J/K, $\Delta S_{univ.} = +5$ J/K
b. $\Delta H = +25$ kJ, $\Delta S = +100$ J/K, $T = 300$ K
c. $2\ Li^+(aq) + Cu(s) \rightarrow 2\ Li(s) + Cu^{2+}(aq)$
d. $2\ F^-(aq) + H_2(g) \rightarrow F_2(g) + 2H^-(aq)$
e. None of the above.

(20) According to the following thermodynamic data of ethanol (CH_3CH_2OH) , which of the following description is/are correct?

Property	
Boiling point	78.45 °C
$\Delta_{fus}H°$	+ 4.9 kJ/mol
$\Delta_{fus}S°$	+31 J/mol K
$\Delta_{vap}H°$	+ 38.56 kJ/mol

a. The melting point of ethanol is 158.06 °C
b. The $\Delta_{vap}S°$ is 109.67 J/mol K
c. Ethanol can be oxidized to ketone
d. Dimethyl ether (CH_3OCH_3) is an isomer of ethanol
e. None of the above.

試題隨卷繳回