

科目：普通化學

適用：應化系

編號：376

考生注意：

1. 依次序作答，只要標明題號，不必抄題。
2. 答案必須寫在答案卷上，否則不予計分。
3. 限用藍、黑色筆作答；試題須隨卷繳回。

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第 1 頁

## 一、單選題：(60% total, 3% each)

1. Which of the following equations correctly describes the combustion of  $\text{CH}_4$  and  $\text{O}_2$  to produce water ( $\text{H}_2\text{O}$ ) and carbon dioxide ( $\text{CO}_2$ )?
  - A)  $\text{CH}_4 + (1/2)\text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
  - B)  $\text{CH}_4 + \text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
  - C)  $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$
  - D)  $\text{CH}_4 + 3\text{O}_2 \rightarrow 2\text{CO}_2 + \text{H}_2\text{O}$
2. Which of the following statements is(are) true?
  - A) Oxidation and reduction cannot occur independently of each other.
  - B) Oxidation and reduction describe the loss and gain of electron(s), respectively.
  - C) Oxidation and reduction result in a change in the oxidation states of the species involved.
  - D) Two of these.
  - E) All of these.
3. Samples of the gases  $\text{H}_2(\text{g})$  and  $\text{O}_2(\text{g})$  have equal masses and are at the same temperature and pressure. Calculate the ratio of the root-mean-square velocities  $u_{\text{rms}}(\text{H}_2) / u_{\text{rms}}(\text{O}_2)$ . (H: 1.0, O:16)
  - A) 32
  - B) 16
  - C) 1
  - D) 4
  - E) 0.25
4. When the substances in the equation  $\text{CuO}(\text{s}) + \text{H}_2(\text{g}) \rightleftharpoons \text{Cu}(\text{s}) + \text{H}_2\text{O}(\text{g})$   $\Delta H = -2.0 \text{ kJ}$  at equilibrium at pressure  $P$  and temperature  $T$ , how can the equilibrium be shifted to favor the products?
  - A) Allow some gas to escape at constant pressure and temperature.
  - B) Decrease the temperature.
  - C) Increase the pressure by adding an inert gas such as nitrogen.
  - D) Add a catalyst.
  - E) Increase the pressure by means of a moving piston at constant temperature.
5. Which of the following reactions is the definition of  $K_a$ ?
  - A)  $\text{Zn}(\text{OH})_2^{2+} \rightleftharpoons [\text{Zn}(\text{OH})_2\text{OH}]^+ + \text{H}^+$
  - B)  $\text{F}^- + \text{H}_2\text{O} \rightleftharpoons \text{HF} + \text{OH}^-$
  - C)  $\text{HCN} + \text{OH}^- \rightleftharpoons \text{CN}^- + \text{H}_2\text{O}$
  - D)  $\text{Cr}^{3+} + 6\text{H}_2\text{O} \rightleftharpoons \text{Cr}(\text{OH})_6^{3+}$
6. Methyl orange is an indicator with a  $K_a$  of  $1 \times 10^{-4}$ . Its acid form,  $\text{HIn}$ , is red, while its base form,  $\text{In}^-$ , is yellow. At pH 6.0, the indicator will be
  - A) blue
  - B) orange
  - C) red
  - D) yellow
  - E) not enough information
7. The solubility, in moles per liter, of  $\text{Ag}_2\text{CrO}_4$  is  $1.3 \times 10^{-4} \text{ M}$  at  $25^\circ\text{C}$ . Calculate  $K_{\text{sp}}$  for this compound.
  - A)  $8.8 \times 10^{-3}$
  - B)  $6.1 \times 10^{-9}$
  - C)  $8.8 \times 10^{-12}$
  - D)  $4.7 \times 10^{-13}$
  - E)  $2.3 \times 10^{-13}$
8. The enthalpy of formation of an element in its standard state is
  - A) zero.
  - B) the enthalpy of its reaction with oxygen.
  - C) determined by its melting point.
  - D) the enthalpy of its reaction with hydrogen.
  - E) none of these

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9. Specific heat capacities are tabulated on a

- A) mole basis.                      B) mass basis.                      C) pressure basis.                      D) volume basis.

10. Which of the following result(s) in an increase in the entropy of the system?

- A)  $\text{Br}_2(g) \rightarrow \text{Br}_2(l)$                       B)  $\text{NaBr}(s) \rightarrow \text{Na}^+(aq) + \text{Br}^-(aq)$                       C)  $\text{O}_2(298 \text{ K}) \rightarrow \text{O}_2(373 \text{ K})$   
 D)  $\text{NH}_3(1 \text{ atm}, 298 \text{ K}) \rightarrow \text{NH}_3(3 \text{ atm}, 298 \text{ K})$                       E) B and C

11. A gas expands isothermally and irreversibly.  $q$ 

- A) equal to zero.                      B) greater than zero.                      C) less than zero.                      D) More information is needed.

12. The following two half-reactions take place in a galvanic cell.



At standard conditions, what species are produced at each electrode?

- A) Sn is produced at the anode, and  $\text{Cu}^{2+}$  is produced at the cathode.  
 B) Sn is produced at the cathode, and  $\text{Cu}^{2+}$  is produced at the anode.  
 C) Cu is produced at the anode, and  $\text{Sn}^{2+}$  is produced at the cathode.  
 D) Cu is produced at the cathode, and  $\text{Sn}^{2+}$  is produced at the anode.  
 E) Sn is produced at the anode, and Cu is produced at the cathode.

13. What is the probability of finding a particle in a one-dimensional box in energy level  $n = 3$  between  $x = L/3$  and  $x = 2L/3$ ? ( $L$  is the length of the box.)

- A) 25%                      B) 33%                      C) 37.5%                      D) 50%                      E) 12.5%

14. Which of the following statements is true?

- A) An electron in a 2s orbital can have the same  $n$ ,  $l$ , and  $m_l$  quantum numbers as an electron in a 3s orbital.  
 B) In the building up of atoms, electrons occupy the 4f orbitals before the 6s orbitals.  
 C) Ni has 2 unpaired electrons in its 3d orbitals.  
 D) We can determine the exact location of an electron if we know its energy.

15. Which of the following sets has elements with the most nearly identical atomic radii?

- A) Be, B, C, N                      B) C, P, Se, Br                      C) Cr, Fe, Co, Mn  
 D) Mg, Ca, Sr, Cs                      E) Ne, Kr, Ar, Xe

16. Atoms having greatly differing electronegativities are expected to form

- A) no bonds.                      B) nonpolar covalent bonds.                      C) polar covalent bonds.  
 D) covalent bonds.                      E) ionic bonds.

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17. Which of the molecules obeys the octet rule of Lewis structure?

- A)  $\text{SF}_6$       B)  $\text{BH}_3$       C)  $\text{NO}_2$       D)  $\text{O}_3$       E)  $\text{PCl}_5$

18. If three orbitals on one atom overlap three orbitals on a second atom, how many molecular orbitals will form?

- A) 3      B) 6      C) 12      D) 1      E) none of these.

19. Tabulated below are initial rate data for the reaction:  $2\text{Fe}(\text{CN})_6^{3-} + 2\text{I}^- \rightarrow 2\text{Fe}(\text{CN})_6^{4-} + \text{I}_2$ 

Run	$[\text{Fe}(\text{CN})_6^{3-}]_0$ (M)	$[\text{I}^-]_0$ (M)	$[\text{Fe}(\text{CN})_6^{4-}]_0$ (M)	$[\text{I}_2]_0$ (M)	Initial Rate (M/s)
1	0.01	0.01	0.01	0.01	$1 \times 10^{-5}$
2	0.01	0.02	0.01	0.01	$2 \times 10^{-5}$
3	0.02	0.02	0.01	0.01	$8 \times 10^{-5}$
4	0.02	0.02	0.02	0.01	$8 \times 10^{-5}$
5	0.02	0.02	0.02	0.02	$8 \times 10^{-5}$

What is the experimental rate law?

- A)  $\frac{\Delta[\text{I}_2]}{\Delta t} = k[\text{Fe}(\text{CN})_6^{3-}][\text{I}^-]^2$
- B)  $\frac{\Delta[\text{I}_2]}{\Delta t} = k[\text{Fe}(\text{CN})_6^{3-}][\text{I}^-][\text{Fe}(\text{CN})_6^{4-}]$
- C)  $\frac{\Delta[\text{I}_2]}{\Delta t} = k[\text{Fe}(\text{CN})_6^{3-}]^2[\text{I}^-]$
- D)  $\frac{\Delta[\text{I}_2]}{\Delta t} = k[\text{Fe}(\text{CN})_6^{3-}]^2[\text{I}^-]^2[\text{Fe}(\text{CN})_6^{4-}]^2[\text{I}_2]$
- E)  $\frac{\Delta[\text{I}_2]}{\Delta t} = k[\text{Fe}(\text{CN})_6^{3-}]^2[\text{I}^-][\text{Fe}(\text{CN})_6^{4-}][\text{I}_2]$

20. In the unit cell of sphalerite,  $\text{Zn}^{2+}$  ions occupy half the tetrahedral holes in a face-centered cubic lattice of  $\text{S}^{2-}$  ions. What is the number of formula units of  $\text{ZnS}$  in the unit cell?

- A) 4      B) 3      C) 2      D) 1      E) 5

## 二、簡答與計算題 (40%)，請列出關鍵公式與計算過程。

1. Give the correct chemical formula for the following compound named. (6% total, 2% each)

- (a) Aluminum hydroxide
- (b) Hydrobromic acid
- (c) Chlorous acid

2. The empirical formula of sugar is  $\text{CH}_2\text{O}$  and its molar mass is 180.2 g/mole. If one teaspoon of sugar weighs 9.01 g, (9% total, 3% each)

- (a) What is the molecular formula of sugar? (C: 12.01, H: 1.008, O: 16.00)
- (b) How many moles of sugar are present?
- (c) How many molecules of sugar are present?

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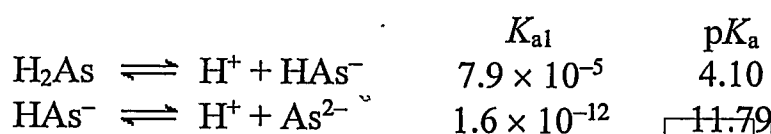
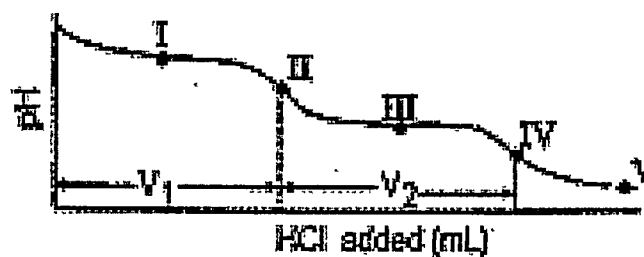
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3. Balance the equation:  $\text{KI} + \text{HNO}_3 \rightarrow \text{KNO}_3 + \text{NO} + \text{I}_2 + \text{H}_2\text{O}$  (3%)4. How many milliliters of 0.1500 M  $\text{CaCl}_2$  must be added to 100.00 milliliters of 0.4000 M  $\text{KCl}$  to give a final solution that has  $[\text{Cl}^-] = 0.3500 \text{ M}$ ? (4%)5. Oxygen gas, generated by the decomposition of potassium chlorate, is collected over water at 300K in a 4.103-L vessel at a total pressure of 710. torr. (The vapor pressure of  $\text{H}_2\text{O}$  at 300K is 26.0 torr.)

(a) Write the balanced chemical equation for the decomposition of potassium chlorate (the other product is potassium chloride). (3%)

(b) How many moles of  $\text{KClO}_3$  were consumed in the reaction? (4%)6. Consider the following information about the diprotic acid ascorbic acid ( $\text{H}_2\text{As}$  for short).The titration curve for disodium ascorbate,  $\text{Na}_2\text{As}$ , with standard  $\text{HCl}$  is shown right:

(a) What is a major species present at point IV? (3%)

(b) What is the pH at point I ( $V_1/2$  HCl added)? (3%)

7. Explain how the solubility of an ionic solid at a constant temperature for a given ionic solid can vary. (5%)

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