

## 一. 選擇題: (36 %)

- How many protons, neutrons, and electrons does  $^{56}\text{Fe}$  have?  
A) 26 protons, 26 neutrons, 30 electrons; B) 26 protons, 26 neutrons, 26 electrons; C) 30 protons, 30 neutrons, 30 electrons; D) 26 protons, 30 neutrons, 26 electrons; E) 56 protons, 26 neutrons, 56 electrons.
- What is the empirical formula of a hydrocarbon (a compound that consists of only carbon and hydrogen) that contains 81.7% carbon by mass?  
A)  $\text{C}_2\text{H}_6$  ; B)  $\text{C}_3\text{H}_8$  ; C)  $\text{C}_4\text{H}_{12}$  ; D)  $\text{C}_6\text{H}_{16}$  ; e) none of these
- When  $\text{NH}_3(\text{aq})$  is added to  $\text{Cu}^{2+}(\text{aq})$ , a precipitate initially forms. Its formula is:  
A)  $\text{Cu}(\text{NH}_3)_4^{2+}$ ; B)  $\text{Cu}(\text{NO}_3)_2$ ; C)  $\text{Cu}(\text{OH})_2$ ; D)  $\text{Cu}(\text{NH}_3)_2^{2+}$ ; E)  $\text{CuO}$ .
- If a 2.15-g sample of a gas occupies 750. mL at STP, what is the molar mass of the gas at 125 °C?  
A)  $3.07 \times 10^{-2}$ ; B) 64.2; C) 70.1; D) 75.0; E) Not enough information is given.
- When the substances in the equation below are at equilibrium at pressure P and temperature T, how can the equilibrium be shifted to favor the products?  
$$\text{CuO}(\text{s}) + \text{H}_2(\text{g}) \rightleftharpoons \text{Cu}(\text{s}) + \text{H}_2\text{O}(\text{g}); \quad \Delta H = -2.0 \text{ kJ}$$
  
A) decrease the temperature; B) add a catalyst; C) increase the pressure by adding an inert gas such as nitrogen; D) increase the pressure by means of a moving piston at constant temperature; E) None of the above.
- Calculate the osmotic pressure (in torr) of 6.00 L of an aqueous 0.108 M solution at 30 °C, if the solute concerned is totally ionized into three ions (e.g., it could be  $\text{Na}_2\text{SO}_4$  or  $\text{MgCl}_2$ ).  
A) 8.05; B)  $6.12 \times 10^3$ ; C)  $2.04 \times 10^3$ ; D)  $3.68 \times 10^4$ .
- A  $d^6$  ion ( $\text{Fe}^{2+}$ ) is complexed with six strong-field ligands (for example,  $\text{SCN}^-$ ). What is the number of unpaired electrons in this complex?  
A) 0; B) 1; C) 2; D) 3; E) 4
- In cation-exchange resins, what ion replaces  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$  in the hard water that is passed over the resin?  
A)  $\text{H}^+$ ; B)  $\text{Li}^+$ ; C)  $\text{Na}^+$ ; D)  $\text{K}^+$ ; E)  $\text{Ba}^{2+}$

(背面仍有題目,請繼續作答)

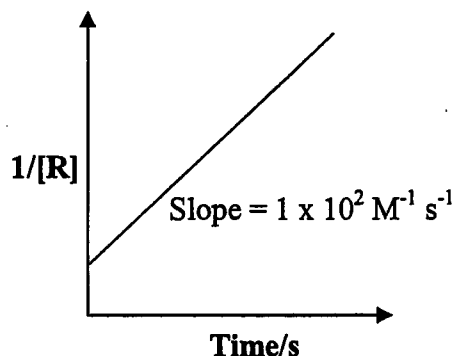
9. Which of the following Noble gases have been observed to form compounds?  
A) He and Ar ; B) Kr and Xe ; C) Ar, Kr, and Xe ; D) The Noble gases never form compounds since they have filled outer shells
10. The number of a certain radioactive nuclide present in a sample decays from  $1.00 \times 10^3$  to  $2.50 \times 10^2$  in 10 minutes. What is the half-life of this radioactive species  
A) 10 minutes ; B) 5 minutes ; C) 20 minutes ; D) 2.5 minutes ;  
E) not enough information given.
11. In which reaction is  $\Delta S^\circ$  expected to be positive  
A)  $I_2(g) \rightarrow I_2(s)$  ; B)  $H_2O(l) \rightarrow H_2O(s)$  ;  
C)  $CH_3OH(g) + (3/2)O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$   
D)  $2O_2(g) + 2SO(g) \rightarrow 2SO_3(g)$  ; E) none of these.
12. A fuel cell designed to react grain alcohol with oxygen has the following net reaction:  
 $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ .  
The maximum work one mole of alcohol can yield by this process is 1320 kJ.  
What is the theoretical maximum voltage this cell can achieve?  
A) 0.760 V ; B) 1.14 V ; C) 2.01 V ; d) 2.28 V ; E) 13.7 V.

## 二. 問答題與計算題: (64 %)

1. Write down the following equations or chemical reactions: (8 %)
- (a). The van der Waals equation (for real gas). (b). The Bragg diffraction equation.  
(c). The radical polymerization of polyethylene. (d). Nernst equation.
2. A buffer solution contains 0.25 M  $NH_3$  ( $K_b = 1.8 \times 10^{-5}$ ) and 0.40 M  $NH_4Cl$ . (8 %)
- (a). Calculate the pH of this solution ; (b). Calculate the pH of the solution that results when 0.10 mol of  $HCl(g)$  is added to 1.0 L the (a) buffer solution.
3. Write down an equation to define each of the thermodynamic properties; (8 %)
- Exp.  $\Delta E = q + w$ , (a).  $G$  ; (b).  $S$ ; (c).  $\Delta H$ ; (d).  $\Delta S_{surr}$ .

4. (a). Illustrate the equation of  $\ln K = -(\Delta H^0/R) 1/T + \Delta S^0/R$ .  
 (b). What is the enthalpy (H) of 2.0 moles of monatomic ideal gas at 27 °C? (6 %)
5. (a). Write down a Schrödinger equation for one-dimension box with infinitely high potential wall and potential energy (V) = 0 in the box.  
 (b). Write down the electron configuration of Cr (atomic number = 24);  
 (Hint: Ar has the electron configuration of  $1s^2 2s^2 2p^6 3s^2 3p^6$ ). (8 %)
6. (a). Draw a Lewis structure of  $I_3^-$ . Is the  $I_3^-$  a linear or V-shape molecule?  
 (b). What is the shape of  $SF_6$ ? What type hybridization of the S atom in  $SF_6$ .  
 (c). Why the  $O_2$  molecule is paramagnetic? (10 %)

7. (a). The right-hand figure is a plot of [reactant] vs. reaction time. What is the reaction order of that reaction? Why?  
 (b). Calculate the value of the reaction constant. (8 %)



8. Finish the following table by writing the functional group for each organics. (8 %)

Class	Functional group
Alcohols	-OH
Esters	(a)
Aldehyde	(b)
Esters	(c)
Amines	(d)