

國立成功大學

111學年度碩士班招生考試試題

編 號： 51

系 所： 地球科學系

科 目： 普通化學

日 期： 0220

節 次： 第 2 節

備 註： 不可使用計算機

※ 考生請注意：本試題不可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

一、選擇題：(60 %; 每題 2 分)

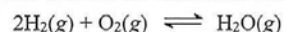
- How many protons, neutrons, and electrons does the atom  $^{31}\text{P}$  have (VA group)?  
(A) 15 protons, 15 neutrons, 31 electrons ; (B) 16 protons, 16 neutrons, 15 electrons  
(C) 15 protons, 15 neutrons, 15 electrons ; (D) 16 protons, 15 neutrons, 16 electrons  
(E) 15 protons, 16 neutrons, 15 electrons
- Which of the following has two  $\pi$  bonds?  
(A)  $\text{C}_2\text{H}_6$  (B)  $\text{C}_2\text{H}_4$  (C)  $\text{C}_2\text{H}_2$  (D)  $\text{C}_3\text{H}_6$  (E) None of the above
- The empirical formula of styrene is  $\text{CH}$ ; its molar mass is 104.1. What is the molecular formula of styrene?  
(A)  $\text{C}_2\text{H}_4$  (B)  $\text{C}_8\text{H}_8$  (C)  $\text{C}_{10}\text{H}_{12}$  (D)  $\text{C}_6\text{H}_6$  (E)  $\text{C}_4\text{H}_4$
- In which case must a reaction be spontaneous at all temperatures?  
(A)  $\Delta H$  is positive,  $\Delta S$  is positive ; (B)  $\Delta H = 0$ ,  $\Delta S$  is negative ; (C)  $\Delta S = 0$ ,  $\Delta H$  is positive ;  
(D)  $\Delta H$  is negative,  $\Delta S$  is negative; (E)  $\Delta H$  is negative,  $\Delta S$  is positive.
- Choose the correct molecular structure for  $\text{NO}_3^-$ .  
(A) trigonal bipyramidal ; (B) trigonal planar ; (C) tetrahedral ; (D) linear ; (E) none of these.
- The complex ion  $[\text{CrBr}_4]^{2-}$  is tetrahedral. How many unpaired electrons are there in the complex?  
(Cr:  $[\text{Ar}]4s^23d^4$ )  
(A) 2 ; (B) 3 ; (C) 4 ; (D) 5 ; (E) 6.
- Which of the following are state functions?  
(A) enthalpy, entropy, free energy ; (B) work, heat, enthalpy ; (C) internal energy, heat, enthalpy ;  
(D) enthalpy, internal energy, work. (E) none of these.
- Calculate  $\Delta E$  for a system that releases 30 J of heat while 58 J of work is done on it.  
(A) 28 J ; (B) 88 J ; (C) -88 J ; (D) -28 J ; (E) none of these.
- When 4.0 L of oxygen gas ( $\text{O}_2$ ) reacts with 2.0 L of nitrogen gas ( $\text{N}_2$ ), 4.0 L of gaseous product is formed. All volumes of gases are measured at the same temperature and pressure. What is the formula of the product?  
(A)  $\text{NO}_4$  ; (B)  $\text{NO}_2$  ; (C)  $\text{N}_2\text{O}_3$  ; (D)  $\text{N}_2\text{O}$  ; (E)  $\text{NO}$

10. What is the correct formula for Mn(IV) oxide?  
(A)  $Mn_3O_4$ ; (B)  $MnO_3$ ; (C)  $Mn_2O_3$ ; (D)  $MnO_2$ ; (E)  $Mn_4O$ .
11. Calculate the pH of the  $2.0 \times 10^{-12} M$   $HNO_3$  aqueous solutions at  $25^\circ C$ .  
(A)  $pH \approx 4.0-5.0$ ; (B)  $pH \approx 11.0-12.0$ ; (C)  $pH \approx 8.0-9.0$ ; (D)  $pH \approx 5.0-6.0$ ; (E)  $pH \approx 6.0-7.0$ .
12. Four identical 1.0-L flasks contain the gases  $H_2$ ,  $O_2$ ,  $CH_4$ , and  $NH_3$ , each at  $0^\circ C$  and 1.0 atm pressure. Which gas has the highest density?  
(A) He; (B)  $CH_4$ ; (C)  $NH_3$ ; (D)  $O_2$ ; (E) All the gases have the same density.
13. How many different possible tetramethylbenzenes exist?  
(A) 6; (B) 5; (C) 4; (D) 3; (E) 2
14. How many electrons are transferred in the following reaction?  
 $Cr_2O_7^{2-} + 14H^+ + 6Cl^- \rightarrow 2Cr^{3+} + 3Cl_2 + 7H_2O$   
(A) 2; (B) 4; (C) 6; (D) 8; (E) 10
15. Which of the following is the best reducing agent?  
 $Cl_2 + 2e^- \rightarrow 2Cl^- \quad E^\circ = 1.36 V$   
 $Mg^{2+} + 2e^- \rightarrow Mg \quad E^\circ = -2.37 V$   
 $2H^+ + 2e^- \rightarrow H_2 \quad E^\circ = 0.00 V$   
(A)  $Cl_2$ ; (B)  $H_2$ ; (C) Mg; (D)  $Mg^{2+}$ ; (E)  $Cl^-$
16. For which of the following transitions does the light emitted have the longest wavelength?  
(A)  $n = 4$  to  $n = 3$ ; (B)  $n = 4$  to  $n = 2$ ; (C)  $n = 4$  to  $n = 1$ ; (D)  $n = 3$  to  $n = 2$ ; (E)  $n = 2$  to  $n = 1$
17. For an electron in a one-dimensional box with a length of  $L$ , what is the minimum energy to excite the electron from the ground state?  
(A)  $h^2/8mL^2$ ; (B)  $2h^2/8mL^2$ ; (C)  $3h^2/8mL^2$ ; (D)  $4h^2/8mL^2$ ; (E)  $5h^2/8mL^2$
18. Which of the following molecules has a nonzero dipole moment?  
(A)  $CH_4$ ; (B)  $SO_3$ ; (C)  $CS_2$ ; (D)  $SiF_4$ ; (E)  $PBr_3$
19. Which of the following is diamagnetic?  
(A)  $O_2^-$ ; (B) BO; (C)  $B_2$ ; (D)  $F_2$ ; (E)  $O_2$

20. A certain solid substance that is very hard, has a high melting point, and is nonconducting unless melted is most likely to be  
(A) Graphite ; (B) diamond ; (C)  $S_8$  ; (D) NaCl ; (E) Cu
21. A salt solution sits in an open beaker. Assuming constant temperature and pressure, the vapor pressure of the solution  
(A) increases over time. ; (B) decreases over time. ; (C) stays the same over time. ;  
(D) We need to know which salt is in the solution to answer this;  
(E) We need to know the temperature and pressure to answer this.
22. A cucumber is placed in a concentrated salt solution. What is most likely to happen?  
(A) Water will flow from the cucumber to the solution. ; (B) Salt will precipitate out. ;  
(C) Salt will flow into the cucumber. ; (D) No change will occur. ;  
(E) Water will flow from the solution to the cucumber.
23. Which of the following ions interfere(s) with the action of detergents in hard water?  
(A)  $Na^+$  and  $Ca^{2+}$ ; (B)  $Mg^{2+}$ ; (C)  $Ca^{2+}$ ; (D)  $Mg^{2+}$  and  $Ca^{2+}$ ; (E)  $Na^+$ ,  $Mg^{2+}$  and  $Ca^{2+}$
24. Which of the following is the most abundant metal on earth?  
(A) calcium ; (B) iron ; (C) copper ; (D) aluminum ; (E) zinc
25. Fluoride ion ranks low in the spectrochemical series and produces a weak crystal field in complex ions. Based on this information, predict the number of unpaired electrons in  $[CrF_6]^{3-}$ . (Cr:  $[Ar]4s^23d^4$ )  
(A) 1 ; (B) 2 ; (C) 3 ; (D) 4 ; (E) 0
26. Which of the following transition metals is a component of vitamin B<sub>12</sub>?  
(A) Mg ; (B) Cr ; (C) Co ; (D) Cu ; (E) Zn
27. Which of the following processes increases the atomic number by 1?  
(A) gamma-ray production ; (B) alpha production ; (C) neutron-particle production ;  
(D) beta-particle production ; (E) proton production
28. The U-238 nucleus decays to form Pb-206 by  $\alpha$  and  $\beta$  decays. Calculate the number of  $\alpha$  decays.  
(A) 2 ; (B) 4 ; (C) 6 ; (D) 8 ; (E) 10

29. The oxidation of secondary alcohols results in  
(A) ketones. ; (B) secondary alcohols. ; (C) aldehydes. ; (D) esters. ; (E) ethers.

30. To increase the value of  $K$  for the exothermic reaction



We should

- (A) increase the total pressure. ; (B) decrease the total pressure. ; (C) increase the temperature. ;  
(D) decrease the temperature. ; (E) Two of these are necessary.

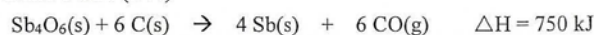
**二、問答與計算題 (40 % ; 計算與問答題需寫過程否則不予計分)**

1. (a) Derive the integrated rate law of second-order reaction. (6 %)

(b) Draw the energy vs. reaction progress curves for catalyzed and uncatalyzed pathway for an exothermic chemical reaction. (4 %)

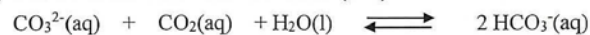
2. (a) Why heat ( $q$ ) spontaneously transfers from higher  $T$  to lower  $T$ ? (3 %)

(b) Predict the  $\Delta S$  larger than 0 or smaller than 0, and calculate the  $\Delta S_{\text{SURR}}$  values for the following reaction at 27 °C and 1 atm. (5 %)



3. (a) Predict an aqueous solution of 1.0 M  $\text{Fe}(\text{NO}_3)_3$  will be acidic, basic or neutral. why? (4 %)

(b) Use the gas solubility and following equilibrium equation to explain why the boiler scale(鍋垢) was generally formed in hot water with  $\text{Ca}^{2+}$  ions? (4 %)



4. (a) For the process involving compound A:  $\text{A}(\text{s}) \rightarrow \text{A}(\text{l})$ ,  $\Delta H^\circ = 8.0 \text{ kJ/mol}$ , and  $\Delta S^\circ = 40.0 \text{ J/mol}\cdot\text{K}$ . What is the melting point of compound A? (4 %)

(b) Please calculate the  $\Delta G$  at melting point of the compound A. (4 %)

5. (a) How many moles of  $\text{HCl}(\text{g})$  must be added to 1.0 L of 2.0 M  $\text{NaOH}$  to achieve a pH of 0.00? (Neglect any volume change.) (3 %)

(b) An indicator  $\text{HIn}$  has  $K_a = 1 \times 10^{-8}$ . At pH = 6.0, what is the ratio  $\text{HIn}/\text{In}^-$ ? (3 %)