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

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※ 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)

1. How many protons, neutrons, and electrons does the atom ^{31}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

2. Which of the following has two π bonds?
   (A) C_2H_6 (B) C_2H_4 (C) C_2H_2 (D) C_3H_6 (E) None of the above

3. The empirical formula of styrene is CH; its molar mass is 104.1. What is the molecular formula of styrene?
   (A) C_2H_4 (B) C_8H_8 (C) $C_{10}H_{12}$ (D) C_6H_6 (E) C_4H_4

4. In which case must a reaction be spontaneous at all temperatures?
   (A) ΔH is positive, ΔS is positive ; (B) $\Delta H = 0$, ΔS is negative ; (C) $\Delta S = 0$, ΔH is positive ;
   (D) ΔH is negative, ΔS is negative; (E) ΔH is negative, ΔS is positive.

5. Choose the correct molecular structure for NO_3^-.
   (A) trigonal bipyramidal ; (B) trigonal planar ; (C) tetrahedral ; (D) linear ; (E) none of these.

6. The complex ion $[CrBr_4]^{2-}$ is tetrahedral. How many unpaired electrons are there in the complex?.
   (Cr: $[Ar]4s^23d^4$)
   (A) 2 ; (B) 3 ; (C) 4 ; (D) 5 ; (E) 6.

7. 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.

8. Calculate ΔE 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.

9. When 4.0 L of oxygen gas (O_2) reacts with 2.0 L of nitrogen gas (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) NO_4 ; (B) NO_2 ; (C) N_2O_3 ; (D) N_2O ; (E) 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 2.0×10^{-12} *M* HNO_3 aqueous solutions at 25°C.
(A) pH ≈ 4.0–5.0 ; (B) pH ≈ 11.0–12.0 ; (C) pH ≈ 8.0–9.0 ; (D) pH ≈ 5.0–6.0 ; (E). pH ≈ 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°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?
$Cl_2 + 2e^- \rightarrow 2Cl^-$ $E° = 1.36$ V
$Mg^{2+} + 2e^- \rightarrow Mg$ $E° = -2.37$ V
$2H^+ + 2e^- \rightarrow H_2$ $E° = 0.00$ 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) $3\ h^2/8mL^2$; (D) $4h^2/8mL^2$; (E) $5\ h^2/8mL^2$

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_{12}?
(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 α and β decays. Calculate the number of α 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

$$2H_2(g) + O_2(g) \rightleftharpoons H_2O(g)$$

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

$$Sb_4O_6(s) + 6\,C(s) \rightarrow 4\,Sb(s) + 6\,CO(g) \qquad \triangle H = 750\ kJ$$

3. (a) Predict an aqueous solution of 1.0 M $Fe(NO_3)_3$ 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 Ca^{2+} ions? (4 %)

$$CO_3^{2-}(aq) + CO_2(aq) + H_2O(l) \rightleftharpoons 2\,HCO_3^-(aq)$$

4. (a) For the process involving compound A: $A(s) \rightarrow A(l)$, $\triangle H° = 8.0$ kJ/mol, and $\triangle S° = 40.0$ J/mol•K. What is the melting point of compound A? (4 %)
(b) Please calculate the $\triangle G$ at melting point of the compound A. (4 %)

5. (a) How many moles of HCl(g) must be added to 1.0 L of 2.0 M NaOH to achieve a pH of 0.00? (Neglect any volume change.) (3 %)
(b) An indicator HIn has $K_a = 1 \times 10^{-8}$. At pH = 6.0, what is the ratio HIn/In^-? (3 %)