

國立臺灣大學103學年度轉學生招生考試試題

題號： 36

科目：普通化學(B)

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注意事項：

- 請於答案卷內之「非選擇題作答區」標明題號依序作答。
- Part I 和 Part II (亦即所有選擇題)必須依題號次序標示題號後作答，未標示題號或未依題序答題者，不予記分。
- 計算題應書明計算過程，且應考慮有效數字。

Part I - Multiple choices (30%)

Each item below consists of a stem and a set of options. Choose the only one answer that can be keyed as correct. No penalty will be applied for keying incorrectly.

1. Arrange the following compounds in increasing order of solubility in water.

I. butane II. EtOH III. acetone IV. EtOEt V. AcOH VI. MeOH

- (A) I < IV < III < II < VI < V (B) I < IV < II < VI < III < V (C) I < III < IV < II < VI < V
(D) I < IV < III < VI < II < V (E) I < IV < III < V < II < VI (F) none of these

2. Given the data below, what is the experimental rate law for the reaction $A + B \rightarrow \text{products}$?

$[A]_0$ (mol/L)	0.10	0.10	0.15	0.15	0.25
$[B]_0$ (mol/L)	0.05	0.10	0.10	0.15	0.15
Initial Rate (mol/L-s)	0.020	0.039	0.040	0.060	0.059

- (A) Rate = $k[A]$ (B) Rate = $k[B]$ (C) Rate = $k[A][B]$
(D) Rate = $k[A]^2[B]$ (E) Rate = $k[A][B]^2$ (F) none of these

3. A gaseous compound is made up of boron and hydrogen. A 2.00-g sample of the compound occupies 1.64 L at 1.00 atm and 3.5°C. What is the molecular formula for the compound? ($B=10.81$)

(A) BH_3 (B) B_2H_6 (C) B_4H_{10} (D) B_5H_9 (E) B_5H_{11} (F) B_6H_{10}

4. Heat can denature proteins by breaking apart the hydrogen bonding in their secondary structure. Which of the following options best describe the denaturation process?

(A) $\Delta H = 0$ and $\Delta S > 0$. (B) $\Delta H < 0$ and $\Delta S = 0$. (C) $\Delta H > 0$ and $\Delta S > 0$.
(D) $\Delta H > 0$ and $\Delta S < 0$. (E) $\Delta H < 0$ and $\Delta S > 0$. (F) None of these.

5. Oxidation of a primary alcohol produces a(n) _____, while oxidation of a secondary alcohol produces a(n) _____

(A) aldehyde, carboxylic acid (B) ketone, carboxylic acid (C) aldehyde, ketone
(D) amine, ketone (E) ketone, aldehyde (F) carboxylic acid, amine

6. The total number of the structural and geometric isomers of chloropropene is _____.

(A) 2 (B) 3 (C) 4 (D) 5 (E) 6 (F) 7

7. Which of the following does *not* produce a buffered solution?

(A) 50 mL of 0.2 M Na_2CO_3 and 50 mL of 0.1 M HCl (B) 50 mL of 0.2 M $NaHCO_3$ and 25 mL of 0.2 M HCl
(C) 50 mL of 0.2 M Na_2CO_3 and 75 mL of 0.2 M HCl (D) 50 mL of 0.2 M Na_2CO_3 and 10 mL of 0.5 M HCl
(E) 50 mL of 0.2 M $NaHCO_3$ and 50 mL of 0.1 M NaOH (F) none of these

8. The Shroud of Turin, which is a length of linen cloth bearing the image of a man suffering physical trauma in a manner consistent with crucifixion, is believed by some to be the burial shroud of Jesus of Nazareth. Assume that the cloth was made in the year 30 AD. Living organisms have a ^{14}C activity of 15.2 dpm/gC (i.e., undergo 15.2 disintegrations per minute per gram of carbon). The half-life of ^{14}C is 5730 years. The Shroud of Turin is now expected to have a ^{14}C activity closest to _____.

(A) 8.8 dpm/gC (B) 9.8 dpm/gC (C) 10.9 dpm/gC (D) 11.9 dpm/gC (E) 13.0 dpm/gC (F) 14.0 dpm/gC

9. In which of the following complexes does the transition metal have a d^6 configuration?

(A) $[Ni(NH_3)_6]^{3+}$ (B) $[Cu(H_2O)_6]^{2+}$ (C) $[Ni(CO)_4]$ (D) $[Co(CN)_6]^{3-}$ (E) $[Fe(CN)_6]^{2-}$ (F) $[PdBr_4]^{2-}$

10. An electrochemical cell is constructed with a platinum electrode immersed in 0.010 M Co^{2+} in one compartment and a nickel electrode immersed in 1.0 M Ni^{2+} in the other. What is the value of E for this cell at 25°C?

($Co^{2+} + 2e^- \rightarrow Co$ $E^\circ = -0.28$ V; $Ni^{2+} + 2e^- \rightarrow Ni$ $E^\circ = -0.23$ V)
(A) 0.56 V (B) 0.51 V (C) 0.37 V (D) 0.11 V (E) 0.07 V (F) 0.05 V

11. Which model(s) explain(s) the magnetism and color of coordination compounds?

I. VSEPR II. the crystal field model III. the localized electron model
(A) I and II (B) II and III (C) I and III (D) I only (E) II only (F) III only

12. The alcohol proof is defined in the United States as twice the percent by volume of pure ethanol in solution. That is, 90% (by volume) ethanol is 180 proof. Assume that the density of water is 1.000 g/mL and the density of ethanol is 0.800 g/mL. The molarity of ethanol in a vodka of 80 proof in the United States is _____ M.

(A) 0.078 (B) 0.78 (C) 3.8 (D) 4.0 (E) 5.5 (F) 7.0

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13. An X-ray light has a wavelength of 6.24 Å. The energy of a photon of this light is closest to _____.
 (A) 1.10×10^{-20} J (B) 4.80×10^{17} J (C) 3.18×10^{-16} J (D) 1.99×10^7 J (E) 6.63×10^{-34} J (F) 1.33×10^{-8} J
14. The atomic masses of ^1H and ^4He are 1.0078 amu and 4.0026 amu, respectively. The binding energy per nucleon for the ^4He nucleus ($1 \text{ MeV} = 1.60 \times 10^{-13} \text{ J}$) is _____.
 (A) 0.79 MeV (B) 2.36 MeV (C) 5.02 MeV (D) 7.13 MeV (E) 8.79 MeV (F) 10.24 MeV
15. The pH of a 0.15 M solution of the salt NaA is 9.00. Thus, the K_a for the acid HA is _____.
 (A) 1.5×10^{-5} (B) 1.7×10^{-4} (C) 1.2×10^2 (D) 1.1×10^{-10} (E) 1.3×10^{-2} (F) 1.1×10^{-7}

Part II - Multiple responses (40%) (每題 4 分，答錯每題倒扣 2 分)

Each item below consists of a stem and a set of options. Choose all the answers that can be keyed as correct. Penalty will be applied for keying incorrectly.

16. Which of the following reactions is consistent with the definition of K_b ?
 (A) $\text{OCI}^- + \text{H}_2\text{O} \rightleftharpoons \text{HOCl} + \text{OH}^-$ (B) $\text{Cu}^{2+} + 4\text{H}_2\text{O} \rightleftharpoons \text{Cu}(\text{H}_2\text{O})_4^{2+}$
 (C) $\text{Al}(\text{OH})_3 + \text{H}^+ \rightleftharpoons \text{Al}(\text{OH})(\text{OH}_2)^2 + \text{H}^+$ (D) $\text{CaO} + \text{H}_2\text{O} \rightleftharpoons \text{Ca}(\text{OH})_2$
 (E) $\text{SCN}^- + \text{H}^+ \rightleftharpoons \text{HSCN}$ (F) $\text{NH}_4^+ + \text{OH}^- \rightleftharpoons \text{NH}_3 + \text{H}_2\text{O}$
17. Which of the following represent a set of isotopes? The neutral atom of an element contains
 (A) 8 protons and 8 neutrons. (B) 10 neutrons and 9 electrons (C) 9 neutrons and 8 electrons
 (D) 10 protons and 10 electrons. (E) 17 neutrons and 16 electrons (F) none of these
18. Consider the following equilibrium: $2\text{H}_2(\text{g}) + \text{C}(\text{s}) \rightleftharpoons \text{CH}_4(\text{g}) \quad \Delta H = -75 \text{ kJ/mol}$ Which of the following statements about the equilibrium is correct?
 (A) If the pressure on the system is increased by changing the volume, the left side is favored.
 (B) Increasing the temperature of the system at equilibrium changes the value of its equilibrium constant.
 (C) Adding more $\text{H}_2(\text{g})$ increases the equilibrium constant.
 (D) Removing CH_4 from the system forces the equilibrium to the right.
 (E) If the system is heated, the right side is favored.
 (F) The reaction of H_2 with C to form methane is endothermic.
19. Which of the following does(do) *not* have the correct chemical formula for the compound named?
 (A) Mg_3N_2 magnesium nitride (B) HClO hypochloric acid (C) $\text{Sn}(\text{SCN})_2$ stannic thiocyanate
 (D) $\text{K}_3\text{Fe}(\text{CN})_6$ potassium hexacyanoiron(III) (E) $[\text{Pt}(\text{NH}_3)_3\text{Br}]\text{Cl}$ triamminebromoplatinum(II) chloride
 (F) $[\text{Co}(\text{NH}_3)_4(\text{ONO})\text{Cl}]\text{Cl}$ tetraamminechloronitritocobalt(III) chloride
20. Which of the following process(es) has(have) a negative value of ΔS ?
 (A) raising the temperature of 10 g of Ni from 25 °C to 25 °C. (B) mixing 10 mL of methanol with 90 mL of water
 (C) grinding a large crystal of tin oxide to powder (D) evaporation of 1 mol of ether
 (E) compressing 1 mol of Ar at constant temperature from 1.0 atm to 0.5 atm (F) none of these
21. In 1.00 M KCl solution at 25 °C, which of the following will be close to 1.00 ± 0.15 ?
 (A) the mass percent of K^+ (B) the molality of the solution (C) the specific gravity of the solution
 (D) the mass ratio of K^+ and Cl^- (E) the mole fraction of K^+ (F) the mole ratio of K^+ and Cl^-
22. Which of the following compounds may have cis and trans isomers?
 (A) dichloroethyne (B) 2,3-dimethyl-2-butene (C) meta-bromotoluene
 (D) 1,3-dimethylcyclohexanol (E) 2,3-dibromo-2-butene (F) decahydronaphthalene
23. The half-life of $^{230}_{90}\text{Th}$ is 8.0×10^4 years. It decays via first-order kinetics. Which of the following is correct?
 (A) The amount of a 1.000-mg sample of $^{230}_{90}\text{Th}$ remaining after 3.2×10^5 years is 0.062 mg.
 (B) The so-called magic numbers in nuclear chemistry include 20, 28, 82, and 126.
 (C) $^{230}_{90}\text{Th}$ decays by α -particle production.
 (D) The rate constant of $^{230}_{90}\text{Th}$ decay is $8.66 \times 10^{-6} \text{ year}^{-1}$.
 (E) A sample contains 6.0×10^8 nuclides of $^{230}_{90}\text{Th}$. The time required for 90% of the nuclides to decompose is 2.66×10^5 year.
 (F) $^{230}_{90}\text{Th}$ resides in the zone of stability.

24. Choose the correct statement(s).
- (A) The wavelength of electromagnetic radiation is inversely proportional to its frequency.
 - (B) When electromagnetic radiation is emitted from an atom, the energy of the atom is increased.
 - (C) As the frequency of electromagnetic radiation increases, its energy increases.
 - (D) In the self-consistent field method, a given electron is assumed to be moving in a potential field that is a result of only the average electron density of all the other electrons in the atom.
 - (E) All quantized particles must possess a minimum energy, which is called the zero-point energy.
 - (F) The Bohr model of the atom can adequately predict the ionization energy of the valence electron(s) for elements.

25. Which of the following statements is(are) true?
- (A) Free energy is independent of temperature.
 - (B) ΔH is directly measured using a bomb calorimeter.
 - (C) An adiabatic process is defined as a process in which no energy as heat flows into the system.
 - (D) A reaction is spontaneous at all temperatures if $\Delta H < 0$ and $\Delta S > 0$.
 - (E) An endothermic reaction cannot be spontaneous.
 - (F) none of these

26.(5%) Calculate the percent dissociation in a solution of a weak acid ($K_a = 1.60 \times 10^{-5}$) in a 0.100 M solution.

- 27.(4%) Give the structure for each of the following compounds.
- (a) 6-bromo-2-methyl-2-hexanol
 - (b) *p*-di-tert-butylbenzene

28.(9%) (a) What is the spectrochemical series of ligands? (b) Use the molecular orbital model to explain why NH_3 lies higher (larger splitting) on the spectrochemical series than F^- . (c) Briefly sketch the related MO energy-level diagrams for CoF_6^{3-} and $\text{Co}(\text{NH}_3)_6^{3+}$ to predict their spin configurations (low or high spin).

29.(12%) The BrCl molecule decomposes according to the following equation:
 $2\text{BrCl}(\text{g}) \rightleftharpoons \text{Br}_2(\text{g}) + \text{Cl}_2(\text{g})$. Calculate (a) ΔG° for the reaction, (b) the equilibrium constant of the reaction, (c) the partial pressure of $\text{BrCl}(\text{g})$ when equilibrium is established at 60.0 °C, if initial pressure of $\text{BrCl}(\text{g})$ is 1.00 atm.

substance	ΔH_f° , kJ/mol	S° , J/K-mol
$\text{Br}_2(\text{g})$	30.91	245.4
$\text{Cl}_2(\text{g})$		223.0
$\text{BrCl}(\text{g})$	14.60	240.0

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