

國立交通大學 103 學年度碩士班考試入學試題

科目：普通化學(4071)

考試日期：103年2月14日 第4節

系所班別：應用化學系分子科學碩士班

組別：分子碩

第()頁,共8頁

【不可使用計算機】*作答前請先核對試題、答案卷(試卷)與准考證之所組別與考科是否相符!!

單選題共 50 題，每題答對得 2 分，未作答或答錯不給分。請用答案卡作答。

$$c = 3.00 \times 10^8 \text{ m} \cdot \text{s}^{-1}$$

$$e = 1.60 \times 10^{-19} \text{ C}$$

$$F = 9.65 \times 10^4 \text{ C} \cdot \text{mol}^{-1}$$

$$h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}$$

$$R = 8.314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1} = 8.206 \times 10^{-2} \text{ atm} \cdot \text{L} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$$

- Given reaction $2 \text{NH}_3(\text{g}) + 3 \text{Cl}_2(\text{g}) \rightarrow \text{N}_2(\text{g}) + 6 \text{HCl}(\text{g})$, you react 5.0 L of NH_3 with 5.0 L of Cl_2 measured at the same conditions in a closed container. Calculate the ratio of pressures in the container ($P_{\text{final}}/P_{\text{initial}}$).
 (A) 0.75 (B) 1.00 (C) 1.33 (D) 1.50 (E) none of these
- A sample of O_3 gas is contaminated with a gas A of unknown molar mass. The partial pressure of each gas is known to be 200. torr at 25°C . The gases are allowed to effuse through a pinhole, and it is found that gas A escapes at 5 times the rate of O_3 . The molar mass of gas A is:
 (A) 1.92 g/mol (B) 240 g/mol (C) 9.60 g/mol (D) 1200 g/mol (E) none of these
- Which of the following is not an assumption of the kinetic molecular theory for a gas?
 (A) Gases are made up of tiny particles in constant chaotic motion.
 (B) Gas particles are very small compared to the average distance between the particles.
 (C) Gas particles collide with the walls of their container in elastic collisions.
 (D) The average velocity of the gas particles is directly proportional to the absolute temperature.
 (E) All of the above are assumptions of the kinetic molecular theory.
- Which statement is true of a process in which one mole of a gas is expanded from state A to state B?
 (A) When the gas expands from state A to state B, the surroundings are doing work on the system.
 (B) The amount of work done in the process must be the same, regardless of the path.
 (C) It is not possible to have more than one path for a change of state.
 (D) The final volume of the gas will depend on the path taken.
 (E) The amount of heat released in the process will depend on the path taken.
- For the reaction $\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{O}(\text{g})$ at 298 K and 1.0 atm, ΔH is more positive than ΔE by 2.5 kJ/mol. This quantity of energy can be considered to be
 (A) the heat flow required to maintain a constant temperature
 (B) the work done in pushing back the atmosphere
 (C) the difference in the H-O bond energy in $\text{H}_2\text{O}(\text{l})$ compared to $\text{H}_2\text{O}(\text{g})$
 (D) the value of ΔH itself
 (E) none of these

6. A chunk of iron at 85.7°C was added to 200.0 g of water at 15.5°C . The specific heat of iron is $0.449\text{ J/g}^{\circ}\text{C}$, and the specific heat of water is $4.18\text{ J/g}^{\circ}\text{C}$. When the temperature stabilized, the temperature of the mixture was 18.5°C . Assuming no heat was lost to the surroundings, what was the mass of iron added?
(A) 513 g (B) 65.2 g (C) 79.6 g (D) 83.1 g (E) none of these
7. All of the following statements about the greenhouse effect are true except:
(A) It occurs only on earth.
(B) The molecules H_2O and CO_2 play an important role in retaining the atmosphere's heat.
(C) Low humidity allows efficient radiation of heat back into space.
(D) The carbon dioxide content of the atmosphere is quite stable.
(E) statements (A) and (D)
8. Consider an atom traveling at 1% of the speed of light. The de Broglie wavelength is found to be $4.15 \times 10^{-3}\text{ pm}$. Which element is this?
(A) He (B) S (C) F (D) Cu (E) P
9. Which of the following statements is (are) true?
I. An excited atom can return to its ground state by absorbing electromagnetic radiation.
II. The energy of an atom is increased when electromagnetic radiation is emitted from it.
III. The energy of electromagnetic radiation increases as its frequency increases.
IV. An electron in the $n = 4$ state in the hydrogen atom can go to the $n = 2$ state by emitting electromagnetic radiation at the appropriate frequency.
V. The frequency and wavelength of electromagnetic radiation are inversely proportional to each other.
(A) II, III, IV (B) III, V (C) I, II, III (D) III, IV, V (E) I, II, IV
10. The small, but important, energy differences between $3s$, $3p$, and $3d$ orbitals are due mainly to
(A) the number of electrons they can hold
(B) their principal quantum number
(C) the Heisenberg uncertainty principle
(D) the penetration effect
(E) Hund's rule

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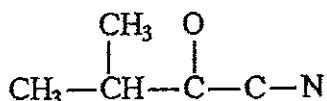
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11. Which of the following statements is true?
 (A) The exact location of an electron can be determined if we know its energy.
 (B) An electron in a $2s$ orbital can have the same n , l , and m_l quantum numbers as an electron in a $3s$ orbital.
 (C) Ni has two unpaired electrons in its $3d$ orbitals.
 (D) In the buildup of atoms, electrons occupy the $4f$ orbitals before the $6s$ orbitals.
 (E) Only three quantum numbers are needed to uniquely describe an electron.
12. Sodium losing an electron is an _____ process and fluorine losing an electron is an _____ process.
 (A) endothermic, exothermic (B) exothermic, endothermic
 (C) endothermic, endothermic (D) exothermic, exothermic
 (E) more information needed
13. Which of the following arrangements is in order of increasing size?
 (A) $\text{Ga}^{3+} < \text{Ca}^{2+} < \text{K}^+ < \text{Cl}^- < \text{S}^{2-}$ (B) $\text{S}^{2-} < \text{Cl}^- < \text{K}^+ < \text{Ca}^{2+} < \text{Ga}^{3+}$
 (C) $\text{Ga}^{3+} < \text{S}^{2-} < \text{Ca}^{2+} < \text{Cl}^- < \text{K}^+$ (D) $\text{Ga}^{3+} < \text{Ca}^{2+} < \text{S}^{2-} < \text{Cl}^- < \text{K}^+$
 (E) $\text{Ga}^{3+} < \text{Ca}^{2+} < \text{S}^{2-} < \text{K}^+ < \text{Cl}^-$
14. Calculate the lattice energy for $\text{LiCl}(s)$ given the following:
 sublimation energy for $\text{Li}(s)$ +166 kJ/mol
 ΔH_f for $\text{Cl}(g)$ +119 kJ/mol
 first ionization energy of $\text{Li}(g)$ +520. kJ/mol
 electron affinity of $\text{Cl}(g)$ -349 kJ/mol
 enthalpy of formation of $\text{LiCl}(s)$ -409 kJ/mol
 (A) 47 kJ/mol (B) 171 kJ/mol (C) -580 kJ/mol (D) -865 kJ/mol (E) none of these
15. Complete the Lewis structure for the molecule:



This molecule has _____ single bonds and _____ multiple bonds.

- (A) 4, 2 (B) 6, 3 (C) 11, 5 (D) 11, 2 (E) 13, 0

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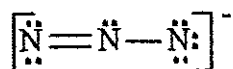
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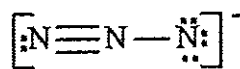
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16. Which of the following is not a valid resonance structure for N_3^- ?

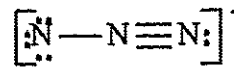
(A)



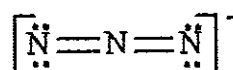
(B)



(C)



(D)



(E)

all are correct

17. Which of the following species has a trigonal bipyramid structure?

(A) NH_3

(B) IF_5

(C) I_3^-

(D) PCl_5

(E) none of these

18. The hybridization of the central atom in ClF_2^+ is:

(A) sp

(B) sp^2

(C) sp^3

(D) dsp^3

(E) d^2sp^3

19. Which of the following has the greatest bond strength?

(A) B_2

(B) O_2^-

(C) CN^-

(D) O_2^+

(E) NO^-

20. If a molecule demonstrates paramagnetism, then :

I. The substance can have both paired and unpaired electrons.

II. The bond order is not a whole number.

III. It can be determined by drawing a Lewis structure.

IV. It must be an ion.

(A) I, II

(B) I, II, IV

(C) II, III

(D) I only

(E) all are correct

21. If equal, rigid spheres are arranged in a simple cubic lattice in the usual way (i.e., in such a way that they touch each other), what fraction of the corresponding solid will be empty space?

(A) 0.52

(B) 0.32

(C) 0.68

(D) 0.48

(E) none of these

22. In the unit cell of sphalerite, Zn^{2+} ions occupy half the tetrahedral holes in a face-centered cubic lattice of S^{2-} ions. The number of formula units of ZnS in the unit cell is:

(A) 6

(B) 4

(C) 3

(D) 2

(E) 1

23. Choose the compound with the most ionic bond.

(A) LiCl

(B) KF

(C) NaCl

(D) LiF

(E) KCl

24. The melting point of water is 0°C at 1 atm pressure because under these conditions:
 (A) ΔS and ΔS_{surr} for the process $\text{H}_2\text{O}(s) \rightarrow \text{H}_2\text{O}(l)$ are different in magnitude and opposite in sign.
 (B) ΔS and ΔS_{surr} for the process $\text{H}_2\text{O}(s) \rightarrow \text{H}_2\text{O}(l)$ are different in magnitude and both positive.
 (C) ΔS and ΔS_{surr} for the process $\text{H}_2\text{O}(s) \rightarrow \text{H}_2\text{O}(l)$ are equal in magnitude and opposite in sign.
 (D) ΔS and ΔS_{surr} for the process $\text{H}_2\text{O}(s) \rightarrow \text{H}_2\text{O}(l)$ are equal in magnitude and both positive.
 (E) None of these is correct.
25. At constant pressure, the following reaction $2\text{NO}_2(g) \rightarrow \text{N}_2\text{O}_4(g)$ is exothermic. The reaction is
 (A) always spontaneous.
 (B) spontaneous at low temperatures, but not high temperatures.
 (C) spontaneous at high temperatures, but not low temperatures.
 (D) never spontaneous.
 (E) cannot tell.
26. Which of the following oxides/hydroxides is not an amphoteric compound?
 (A) BeO (B) $\text{B}(\text{OH})_3$ (C) $\text{Al}(\text{OH})_3$ (D) ZnO (E) PbO
27. What is the ΔG° of the reaction: $\text{Fe}(s) + 2\text{Ag}^+(aq) \rightarrow \text{Fe}^{2+}(aq) + 2\text{Ag}(s)$?
 $E^{\circ}(\text{Ag}^+/\text{Ag}) = +0.80\text{ V}$; $E^{\circ}(\text{Fe}^{2+}/\text{Fe}) = -0.44\text{ V}$
 (A) $-235\text{ kJ}\cdot\text{mol}^{-1}$ (B) $-162\text{ kJ}\cdot\text{mol}^{-1}$ (C) $-118\text{ kJ}\cdot\text{mol}^{-1}$
 (D) $-69\text{ kJ}\cdot\text{mol}^{-1}$ (E) $+118\text{ kJ}\cdot\text{mol}^{-1}$
28. For a second-order reaction $2\text{A} \rightarrow \text{B}$, it takes 10 minute for the concentration of A decreasing from $[\text{A}]_0$ to $[\text{A}]_0/2$. How much time is required for the concentration of A decreasing from $[\text{A}]_0/2$ to $[\text{A}]_0/8$ under the same condition?
 (A) 7.5 min (B) 15 min (C) 20min (D) 40 min (E) 60 min
29. Which of the following systematic names is correct?
 (A) 5-methyl-3-ethylhexane (B) tetramethylamine
 (C) *trans*-1,2-diiodocyclooctane (D) 2,3-bisiodio-1-heptene
 (E) 4-chloro-3-propylnonane
30. How many unpaired d-electrons are there in the tetrahedral complex ion $[\text{FeCl}_4]^{2-}$ (in the ground state)?
 (A) 0 (B) 2 (C) 3 (D) 4 (E) 5

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38. Under 1800°C , $\text{CaO} + \text{C} \rightarrow \text{X} + \text{Y}$. The product X can react with water for producing an inflammable gas Z. What are X, Y, and Z?
 (A) Ca, CO, H₂ (B) Ca, CO₂, H₂ (C) Ca₂C, CO, C₂H₄
 (D) Ca₂C, CO₂, C₂H₂ (E) CaC₂, CO, C₂H₂
39. For the reaction mechanism:
 step 1: $\text{A} + \text{B} \rightarrow \text{X}$ fast, rate constant = k_1 & k_{-1} for the reverse
 step 2: $\text{X} + \text{A} \rightarrow \text{C}$ slow, rate constant = k_2
 What is the rate law? And which step is the rate-determining step?
 (A) $(k_1 k_2)[\text{A}]^2[\text{B}]$; step 2 (B) $(k_1/k_{-1})[\text{A}][\text{B}]$; step 1 (C) $(k_{-1} k_2/k_1)[\text{B}]$; step 2
 (D) $(k_{-1} k_2/k_1)[\text{B}]$; step 1 (E) $(k_1 k_2/k_{-1})[\text{A}]^2[\text{B}]$; step 2
40. Polonium is a radioactive element and may accumulate in the lung through tobacco smoke. It's one of the reasons for lung cancer. ^{210}Po , the most widely available isotope of polonium, is an alpha emitter and has a half-life of 138 days. What is the daughter nucleus of ^{210}Po ?
 (A) ^{206}Pb (B) ^{206}Tl (C) ^{210}Bi (D) ^{210}At (E) ^{214}Rn
41. How many secondary alcohols are there with the formula $\text{C}_5\text{H}_{11}\text{OH}$?
 (A) 2 (B) 3 (C) 6 (D) 8 (E) 9
42. Consider the reaction: $\text{Ni}_{(\text{s})} + 4 \text{CO}_{(\text{g})} \rightarrow \text{Ni}(\text{CO})_{4(\text{g})}$ At 30°C and $P_{\text{CO}} = 1 \text{ atm}$, Ni reacts with $\text{CO}_{(\text{g})}$ to form $\text{Ni}(\text{CO})_{4(\text{g})}$. At 200°C , $\text{Ni}(\text{CO})_{4(\text{g})}$ decomposes to $\text{Ni}_{(\text{s})}$ and $\text{CO}_{(\text{g})}$. This means
 (A) the forward reaction is endothermic.
 (B) K at 200°C is greater than K at 30°C .
 (C) the entropy of the forward reaction is negative.
 (D) a decrease in pressure favors the forward reaction.
 (E) the activation energy at 30°C is lower than at 200°C .
43. What the mass of barium metal ($137.3 \text{ g}\cdot\text{mol}^{-1}$) can be produced from 0.10 M aqueous solution of barium chloride by electrolysis using a current 4.0 A for 1.5 h ?
 (A) 0 g (B) 0.51 g (C) 10 g (D) 15 g (E) 31 g
44. Which of the following is not a Lewis acid?
 (A) BF_3 (B) CO_2 (C) H_3O^+ (D) Mg^{2+} (E) $\text{P}(\text{CH}_3)_3$

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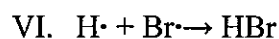
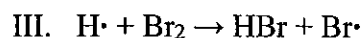
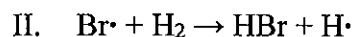
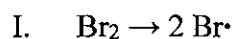
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45. The HBr synthesis is thought to involve the following reactions:



The chain termination reactions in this mechanism are reactions

- (A) I, II, III (B) II, III, IV (C) IV, V (D) IV, V, VI (E) VI only

46. Which of the following compounds/ions can not form a chelating complex with a metal ion?

(A) *o*-diaminobenzene

(B) *p*-diaminobenzene

(C) diethylenetriamine

(D) oxalate ion

(E) ethylenediaminetetraacetate ion

47. Which of the following compounds is chiral?

(A) phenol

(B) 2-bromo-2-propanol

(C) *cis*-1,2-dichlorocyclopentane

(D) *trans*-1,2-dichlorocyclopentane

(E) 1-ethyl-1-methylcyclohexane

48. Silver chloride is most soluble in

(A) ethanol

(B) pure water

(C) 0.1 M KCN

(D) 0.1 M KBr

(E) 0.1 M KNO₃

49. Which of the following statements about catalytic reactions is true?

(A) No catalytic reaction is zero-order.

(B) A catalyst may change the reaction order.

(C) The catalyst decreases the standard reaction enthalpy.

(D) Radicals are too active, so they never act as catalysts.

(E) A catalyst always increases the activation energy of the reverse reaction.

50. Which of the following polymers can be used as the coating for non-stick cookware?

(A) PS

(B) PETE

(C) PTFE

(D) LDPE

(E) HDPE