

科目：綜合化學

校系所組：中大化學學系 清大化學系 交大分子科學研究所

共有 50 題單選題，每題 2 分，答錯不倒扣。

Useful Information:

PERIODIC TABLE OF THE ELEMENTS

1A	2A	3B	4B	5B	6B	7B	8B	8B	8B	1B	2B	3A	4A	5A	6A	7A	8A
1 H 1.008																	2 He 4.003
3 Li 6.939	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (99)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 181.0	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 182.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0	89 Ac 227.0	104 Unq (261)	105 Unp (262)	106 Unh (263)	107 Uns (262)	108 Uno (265)	109 Une (266)									

Formulae

$$t_{1/2} = (\ln 2/k), \ln 2 = 0.693$$

$$nFE = RT \ln K$$

$$\Delta G^\circ = -nFE^\circ$$

$$s = k_H P$$

$$v = R(1/n_1^2 - 1/n_2^2), R = 3.29 \times 10^{15} \text{ Hz}$$

$$\Delta E^\circ = E^\circ(\text{cathode}) - E^\circ(\text{anode})$$

$$\Delta E = \Delta E^\circ - (0.05916/n) \log Q$$

Constants

$$R = 8.314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$$

$$= 8.314 \text{ L} \cdot \text{kPa} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$$

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

$$= 62.363 \text{ L} \cdot \text{torr} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$$

$$1 \text{ atm} = 760 \text{ Torr}$$

$$= 1.01 \times 10^5 \text{ Pa}$$

$$= 0.0821 \text{ L atm} / \text{K mol}$$

$$= 8.314 \text{ L kPa} / \text{K mol}$$

$$c = 2.99 \times 10^8 \text{ m/s}$$

$$h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s}$$

$$\hbar = 1.05 \times 10^{-34} \text{ J} \cdot \text{s}$$

$$F = 96,500 \text{ Coulombs/mole}$$

參考用

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- Which of the following statements is true regarding electromagnetic radiation?
  - Electromagnetic radiation with a wavelength of 400 nm travels faster than that with a wavelength of 600 nm.
  - The frequency of electromagnetic radiation determines how fast it travels.
  - Electromagnetic radiation with a wavelength of 400 nm has a frequency that is smaller than that with a wavelength of 600 nm.
  - Electromagnetic radiation with a wavelength of 600 nm travels faster than that with a wavelength of 400 nm.
  - Electromagnetic radiation with a wavelength of 600 nm has a frequency that is smaller than that with a wavelength of 400 nm.
- Which one of the following statements is incorrect?
  - For a one-dimensional particle in a box, as the mass of the particle becomes larger the separation between neighboring energy levels increases.
  - For a one-dimensional particle in a box, the separation between neighboring energy levels decreases as the length of the container increases.
  - For a one-dimensional particle in a box, the separation between neighboring energy levels becomes zero when the walls of the box are infinitely far apart.
  - Argon atoms in a cylinder can be treated as though their translational energy were not quantized.
  - A billiard ball on a table has a completely negligible *zero-point energy*.
- Which of the following is correct with respect to the photoelectric effect?
  - A plot of the kinetic energy of the ejected electrons versus the frequency of the incident radiation has a slope that is equal to the value of the work function.
  - All metals have the same work function.
  - The kinetic energy of the ejected electrons increases with the intensity of the incident radiation.
  - A plot of the kinetic energy of the ejected electrons versus the frequency of the incident radiation is linear.
- For dinitrogen monoxide, the arrangement of the atoms is N-N-O. In the Lewis structure with a double bond between NN and NO, the formal charges on N, N, and O, respectively, are
  - 0, -1, +1; B) -1, +1, 0; C) 0, +1, -1; D) 0, 0, 0; E) 2, +1, +1
- Which of the following has resonance structures?
  - XeOF<sub>2</sub> B) N<sub>2</sub>H<sub>4</sub> C) CH<sub>3</sub>CONH D) H<sub>2</sub>CO
- What is the shape of IF<sub>4</sub><sup>+</sup>?
  - tetrahedral D) square planar
  - seesaw E) T-shaped
  - trigonal bipyramidal

參考用

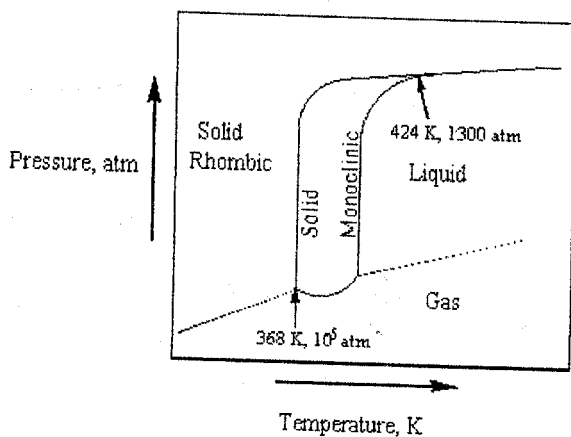
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14. Calculate  $\Delta S_{\text{total}}$  for the isothermal irreversible free expansion of 1.00 mol of ideal gas from 8.00 L to 20.00 L at 298 K.
- A) 0  
 B)  $+15.2 \text{ J K}^{-1} \text{ mol}^{-1}$   
 C)  $+7.6 \text{ J K}^{-1} \text{ mol}^{-1}$   
 D)  $-15.2 \text{ J K}^{-1} \text{ mol}^{-1}$   
 E)  $-7.6 \text{ J K}^{-1} \text{ mol}^{-1}$
15. The standard free energy of formation of  $\text{CS}_2(\text{l})$  is  $65.27 \text{ kJ mol}^{-1}$  at 298 K. This means that at 298 K
- A)  $\text{CS}_2(\text{l})$  will not spontaneously form  $\text{C}(\text{s}) + 2\text{S}(\text{s})$ .  
 B)  $\text{CS}_2(\text{l})$  is thermodynamically unstable.  
 C)  $\text{CS}_2(\text{l})$  is thermodynamically stable.  
 D) No catalyst can be found to decompose  $\text{CS}_2(\text{l})$  into its elements.  
 E)  $\text{CS}_2(\text{l})$  has a negative entropy.
16. Estimate the enthalpy of vaporization of water given that at  $25^\circ\text{C}$  and  $35^\circ\text{C}$  its vapor pressure is 23.8 and 42 Torr, respectively. Assume that the enthalpy of vaporization is independent of the temperature.
- A)  $415 \text{ J mol}^{-1}$   
 B)  $221 \text{ kJ mol}^{-1}$   
 C)  $41.5 \text{ kJ mol}^{-1}$   
 D)  $5.21 \text{ kJ mol}^{-1}$   
 E)  $43.4 \text{ kJ mol}^{-1}$
17. Which of the following liquids freeze at a lower temperature when pressure is applied?
- A) water  
 B) acetic acid  
 C) benzene  
 D) methanol  
 E) carbon tetrachloride
18. The phase diagram for sulfur is given below.



- Which of the following is true?
- A) Sulfur has 2 triple points.  
 B) Monoclinic sulfur does not sublime.  
 C) Sulfur has 0 triple points.  
 D) Sulfur has 3 triple points.  
 E) Rhombic sulfur cannot be directly converted to liquid.

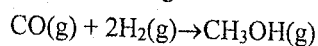
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19. Consider the following reaction:

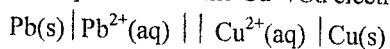


At room temperature,  $K$  is approximately  $2 \times 10^4$ , but at a higher temperature  $K$  is substantially smaller.

Which of the following is true?

- A) The reaction is endothermic.
- B) The value of  $K_c$  for this reaction is smaller at all temperatures.
- C) At the higher temperature, more  $\text{CH}_3\text{OH(g)}$  is produced.
- D) The reaction is exothermic.
- E) The reaction becomes spontaneous at higher temperatures.

20. The standard potential of the  $\text{Cu}^{2+}/\text{Cu}$  electrode is +0.34 V and the standard potential of the cell



is +0.47 V. What is the standard potential of the  $\text{Pb}^{2+}/\text{Pb}$  electrode?

- A) -0.26 V
- B) +0.81 V
- C) -0.81 V
- D) -0.13 V
- E) +0.13 V

21. If the standard potentials for the couples  $\text{Cu}^{2+}/\text{Cu}$ ,  $\text{Ag}^+/\text{Ag}$ , and  $\text{Fe}^{2+}/\text{Fe}$  are +0.34, +0.80, and -0.44 V, respectively, which is the strongest reducing agent?

- A) Fe
- B) Ag
- C)  $\text{Ag}^+$
- D) Cu
- E)  $\text{Fe}^{2+}$

22. A first-order reaction has a rate constant of  $0.00300 \text{ s}^{-1}$ . The time required for 60% reaction is

- A) 153 s.
- B) 73.9 s.
- C) 170 s.
- D) 133 s.
- E) 305 s.

23. Technetium-99 ( $^{99}\text{Tc}$ ), used to image the heart and brain, has a half-life of 6.00 h. What fraction of  $^{99}\text{Tc}$  remains in the body after 1 day?

- A) 0.0625
- B) 0.250
- C) 0.0313
- D) 0.125

24. For a second-order reaction, a straight line is obtained from a plot of

- A)  $1/[\text{A}]$  vs  $t$ .
- B)  $\ln(1/t)$  vs  $[\text{A}]$ .
- C)  $[\text{A}]$  vs  $t$ .
- D)  $\ln[\text{A}]$  vs  $t$ .
- E)  $\ln(t)$  vs  $[\text{A}]$ .

25. A catalyst facilitates a reaction by

- A) increasing the activation energy for the reverse reaction.
- B) lowering the activation energy of the reaction.
- C) shifting the position of the equilibrium of the reaction.
- D) decreasing the temperature at which the reaction will proceed spontaneously.
- E) making the reaction more exothermic.

26. Which of the following molecules would require the most energy to split into gaseous atoms?

- A)  $\text{O}_2$
- B)  $\text{N}_2$
- C)  $\text{Cl}_2$
- D)  $\text{CO}$

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27. Hydrogen can be made from fossil fuels in a series of two catalyzed reactions. One of these reactions, the **re-forming reaction**, is
- A)  $\text{Zn(s)} + 2\text{HCl(aq)} \rightarrow \text{ZnCl}_2\text{(aq)} + \text{H}_2\text{(g)}$ .  
 B)  $\text{CH}_4\text{(g)} + \text{H}_2\text{O(g)} \rightarrow \text{CO(g)} + 3\text{H}_2\text{(g)}$ .  
 C)  $\text{Cu(s)} + 2\text{H}^+\text{(aq)} \rightarrow \text{Cu}^{2+}\text{(aq)} + \text{H}_2\text{(g)}$ .  
 D)  $\text{CH}_3\text{OH(l)} \rightarrow 2\text{H}_2\text{(g)} + \text{CO(g)}$ .
28. What type of particle is emitted in the transformation below?  
 $^{201}\text{Pt} \rightarrow ^{201}\text{Au}$
- A)  $\alpha$  particle    B)  $\beta$  particle    C)  $\gamma$  particle    D) positron
29. Which of the following compounds exist as geometric isomers?
- 1)  $\text{CH}_2=\text{C}(\text{CH}_3)(\text{CH}_2\text{CH}_3)$   
 2)  $\text{CH}_3\text{CH}=\text{CH}(\text{CH}_2\text{CH}_3)$   
 3)  $\text{ClCH}=\text{C}(\text{CH}_3)$   
 4)  $\text{ClCH}=\text{C}(\text{Cl})(\text{CH}_3)$
- A) 3 and 4    B) 2 and 4    C) 1, 2, and 4    D) 1, 2, 3, and 4
30. The solid ZnS has a radius ratio of 0.45 and adopts the zinc-blend structure. What is the coordination number of Zn in ZnS?
- A) 2    B) 6    C) 12    D) 4
31. Order the following acids from weakest to strongest:  $\text{HClO}$ ,  $\text{HClO}_4$ ,  $\text{HClO}_2$ , and  $\text{HClO}_3$ .
- A)  $\text{HClO}_4 < \text{HClO}_3 < \text{HClO}_2 < \text{HClO}$   
 B)  $\text{HClO} < \text{HClO}_3 < \text{HClO}_4 < \text{HClO}_2$   
 C)  $\text{HClO} < \text{HClO}_2 < \text{HClO}_3 < \text{HClO}_4$   
 D)  $\text{HClO} < \text{HClO}_4 < \text{HClO}_3 < \text{HClO}_2$
32. What is the *d*-electron configuration of the tetrahedral complex ion  $[\text{FeCl}_4]^-$ ?
- A)  $e^5$     B)  $e^2t^3$     C)  $e^3t^2$     D)  $e^4t^1$
33. The lattice enthalpies of ionic compounds of fluoride tend to be very high because
- A) fluorine gas is very reactive.  
 B) the fluoride ion is small.  
 C) fluoride ion has an oxidation state of -1.  
 D) fluorine is a strong oxidant.
34. Which of the following complex ions has the smallest *d*-orbital splitting energy?
- A)  $[\text{Co}(\text{OH}_2)_6]^{2+}$     B)  $[\text{Co}(\text{NH}_3)_6]^{2+}$     C)  $[\text{CoCl}_4]^{2-}$     D)  $[\text{Co}(\text{CN})_6]^{4-}$

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35. Which of the following statements is false?  
 A) Elements with low ionization energies commonly form ionic oxides.  
 B) Oxides of main-group metals are acidic.  
 C) Elements with intermediate ionization energies form amphoteric oxides.  
 D) Oxides of nonmetals are acidic.
36. Which of the following is optically active?  
 A)  $C(CH_3)_4$  B)  $NH_2CH(CH_3)COOH$  C)  $(CH_3)_2C(NH_2)COOH$  D)  $NH_2CH_2COOH$
37. All of the following are stable except  
 A)  $^{12}C$ . B)  $^{15}O$ . C)  $^{20}Ne$ . D)  $^{16}O$ .
38. Comparing  $[Co(CN)_6]^{3-}$  with  $[CoCl_6]^{4-}$ , which of the following statements is true?  
 A)  $[Co(CN)_6]^{3-}$  is diamagnetic while  $[CoCl_6]^{4-}$  is paramagnetic.  
 B)  $[Co(CN)_6]^{3-}$  has more *d*-electrons than  $[CoCl_6]^{4-}$ .  
 C)  $[Co(CN)_6]^{3-}$  has the same number of *d*-electrons as  $[CoCl_6]^{4-}$ .  
 D)  $[Co(CN)_6]^{3-}$  is paramagnetic while  $[CoCl_6]^{4-}$  is diamagnetic.
39. Which of the following are heterogeneous alloys?  
 A) tin-lead solder and bronze  
 B) bronze  
 C) mercury amalgam and tin-lead solder  
 D) coinage cupronickel
40. Oxygen can be produced in the laboratory by the following reaction:  

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$
  
 How many moles of potassium chlorate are needed to produce 257 mL of oxygen, collected over water at 14°C and 97.6 kPa? The vapor pressure of water at 14°C is 1.60 kPa.  
 A)  $2.06 \times 10^{-3}$  B)  $6.89 \times 10^{-3}$  C)  $7.00 \times 10^{-3}$  D)  $1.55 \times 10^{-3}$
41. What is the shape of  $BrF_5$ ?  
 A) square pyramidal B) trigonal bipyramidal C) octahedral D) seesaw
42. How many different isomers of all types are possible for the complex ion  $[Co(NCS)_2(NH_3)_4]^+$ ?  
 A) 9 B) 3 C) 6 D) 2
43. If the base sequence along a portion of one strand of a double helix is CTACACG, the corresponding sequence on the other strand is  
 A) CTUCUG. B) TCGTGTC. C) CTACACG. D) GATGTGC.

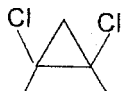
參考用

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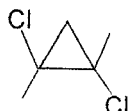
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44. Which of the following is diamagnetic?  
 A)  $O_2^-$  B)  $O_2$  C)  $O_2^{2-}$  D)  $NO_2$
45. The sublimation of *dry ice* is spontaneous at  $25^\circ C$  and 1 atm. What is the sign of  $\Delta H^\circ$  and  $\Delta S^\circ$ , respectively?  
 A) +, + B) -, - C) -, + D) +, -
46. For the compounds below, which statement is true?



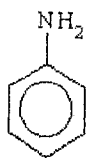
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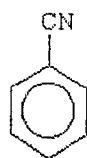
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- A) Compounds 1 and 2 are geometric isomers.  
 B) Compounds 1 and 2 are identical.  
 C) Compounds 1 and 2 are chiral.  
 D) Compound 1 is chiral.
47. Name the compound  $CH_3COO(CH_2)_4CH_3$ .  
 A) pentyl acetate B) methyl pentanoate C) hexanoic acid D) butyl acetate
48. A student has injected 45.2 g of a gas into a evacuated, constant-volume container at  $30^\circ C$  and atmospheric pressure. Now the student wants to heat the gas at constant pressure by allowing some of the gas to escape during the heating. What mass of gass must be released if the temperature is raised to  $100^\circ C$ .  
 A) 23.12 B) 6.74 C) 36.72 D) 13.56

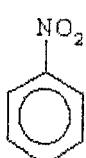
49. Which of the following undergo nitration faster than benzene?



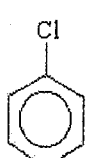
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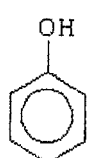
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3



4



5

- A) 1, 4, and 5 B) 1 and 2 C) 4 and 5 D) 2, 3, and 5

50. Which of the following produces a silver mirror with Tollen's reagent?  
 A)  $CH_3C(O)OCH_3$  B)  $CH_3OCH_3$  C)  $CH_3CHO$  D)  $CH_3COCH_3$

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