

科目：普通化學 適用：應化系

編號：496

考生注意：

1. 依次序作答，只要標明題號，不必抄題。
2. 答案必須寫在答案卷上，否則不予計分。
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## I. Multiple choices (2% each; total 50%)

1. Please select the correct acid-base pair?

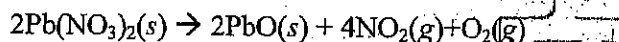
- (A)  $\text{HNO}_3$  and  $\text{NO}_3^-$  (B)  $\text{HCl}$  and  $\text{NaOH}$  (C)  $\text{H}_2\text{PO}_4^-$  and  $\text{PO}_4^{3-}$   
(D)  $\text{HSO}_4^-$  and  $\text{SO}_3^{2-}$  (E) none of these

2. What is the wavelength of light that is emitted when an excited electron in the hydrogen atom falls from the  $n = 4$  level to the  $n = 2$  level?

- (A)  $9.12 \times 10^{-7} \text{ m}$  (B)  $4.87 \times 10^{-7} \text{ m}$  (C)  $5.21 \times 10^{-7} \text{ m}$   
(D)  $7.82 \times 10^{-7} \text{ m}$  (E) none of these

3. Please recognize the missing element in the following equation:  ${}_{92}^{238}\text{U} \rightarrow {}_2^4\text{He} + ?$ 

- (A)  ${}_{90}^{242}\text{Th}$  (B)  ${}_{90}^{234}\text{Th}$  (C)  ${}_{94}^{242}\text{Pu}$   
(D)  ${}_{92}^{234}\text{U}$  (E) none of these

4. A 6.62-g sample of lead nitrate  $\text{Pb}(\text{NO}_3)_2$ , molar mass = 331 g/mol, is heated in an evacuated cylinder with a volume of 1.62 L. The salt decomposes when heated, according to the equation

- (A) 0.76 atm (B) 0.66 atm (C) 0.45 atm  
(D) 1.38 atm (E) none of these

Assuming complete decomposition, what is the pressure in the cylinder after decomposition and cooling to a temperature of 300K? Assume the  $\text{PbO}(s)$  takes up negligible volume.5. Calculate the  $\text{H}^+(aq)$  concentration in 1 M  $\text{HCN}(aq)$  ( $K_a$  for  $\text{HCN}$  is  $5.0 \times 10^{-10}$ )

- (A)  $5.0 \times 10^{-6}$  (B)  $5.0 \times 10^{-10}$  (C)  $2.2 \times 10^{-5}$   
(D)  $5.0 \times 10^{-5}$  (E)  $2.5 \times 10^{-18}$

6. A 0.10-mL sample of a solution containing  ${}^3\text{H}$  that produces  $6.48 \times 10^3$  cps is injected into the bloodstream of an animal. After circulatory equilibrium has been established, a 0.10-mL sample of blood is found to have an activity of 18 cps. Calculate the blood volume of the animal.

- (A) 60 mL (B) 20 mL (C) 36 mL  
(D) 100 mL (E) none of these

7. Determine the correct electron configuration of the  $\text{Co(II)}$  ion.

- (A)  $[\text{Ar}]4s^24d^2$  (B)  $[\text{Ar}]4s^23d^5$  (C)  $[\text{Ar}]4s^23d^7$   
(D)  $[\text{Ar}]3d^6$  (E)  $[\text{Ar}]3d^7$

8. The Cs-131 nuclide has a half-life of 30 years. After 150 years, about 4 g remain. The original mass of the Cs-131 sample is closest to

- (A) 10 g (B) 110 g (C) 120 g  
(D) 130 g (E) 140 g

9. The number of a certain radioactive nuclide present in a sample decays from 256 to 32 in 18 minutes. What is the half-life of this radioactive species?

- (A) 5 minutes (B) 6 minutes (C) 7 minutes  
(D) 8 minutes (E) 9 minutes

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10. One mole of an ideal gas at 25°C is expanded isothermally from 10.0 L to 20.0 L under such conditions that no work is produced in the surroundings. Which statement is correct?

- (A)  $\Delta S_{\text{gas}} = 0$  (B)  $\Delta S_{\text{gas}} = R \ln 2 / 298$  (C)  $\Delta S_{\text{univ}} = 0$   
 (D)  $\Delta S_{\text{gas}} = \Delta S_{\text{surr}}$  (E)  $\Delta S_{\text{surr}} = 0$

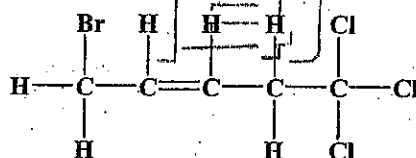
11. The following data were obtained for the reaction of NO with O<sub>2</sub>. Concentrations are in molecules/cm<sup>3</sup> and rates are in molecules/cm<sup>3</sup>·s.

[NO] <sub>0</sub>	[O <sub>2</sub> ] <sub>0</sub>	Initial Rate
2 × 10 <sup>18</sup>	1 × 10 <sup>18</sup>	2.0 × 10 <sup>16</sup>
4 × 10 <sup>18</sup>	1 × 10 <sup>18</sup>	8.0 × 10 <sup>16</sup>
6 × 10 <sup>18</sup>	1 × 10 <sup>18</sup>	18.0 × 10 <sup>16</sup>
2 × 10 <sup>18</sup>	2 × 10 <sup>18</sup>	4.0 × 10 <sup>16</sup>
2 × 10 <sup>18</sup>	3 × 10 <sup>18</sup>	6.0 × 10 <sup>16</sup>

Which of the following is the correct rate law?

- (A) Rate =  $k[\text{NO}]^2$  (B) Rate =  $k[\text{NO}]^2[\text{O}_2]$  (C) Rate =  $k[\text{NO}][\text{O}_2]^2$   
 (D) Rate =  $k[\text{NO}][\text{O}_2]$  (E) Rate =  $k[\text{NO}]^2[\text{O}_2]^2$

12. Please name the following structure:



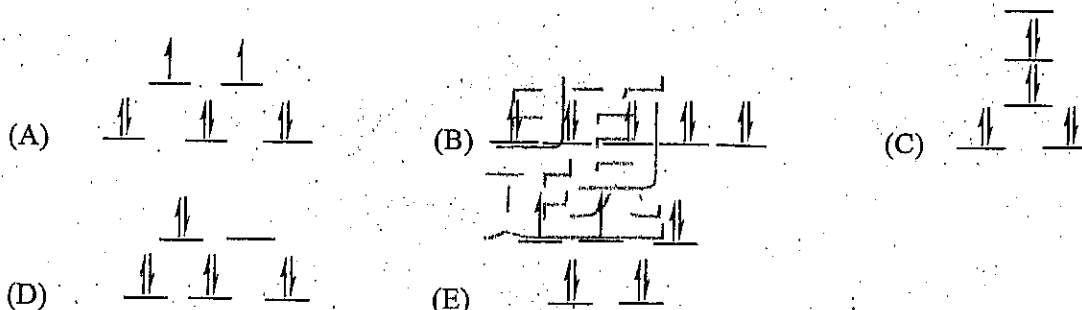
- (A) 1,1,1-trichloro-5-bromo-2-pentene (B) 1,1,1-trichloro-5-bromo-3-pentyne  
 (C) 1,1,1-trichloro-5-bromo-3-pentene (D) 5,5,5-trichloro-1-bromo-2-pentene  
 (E) none of these.

13. Rank the following compounds according to increasing solubility in water.

I. CH<sub>3</sub>-OH; II. CH<sub>3</sub>-CH<sub>2</sub>-OH; III. CH<sub>3</sub>-CH<sub>2</sub>-O-CH<sub>2</sub>-CH<sub>3</sub>; IV. CH<sub>3</sub>-CH<sub>2</sub>-CH<sub>2</sub>-CH<sub>3</sub>

- (A) I < III < IV < II (B) I < II < IV < III (C) IV < III < II < I  
 (D) I < II < III < IV (E) None is correct.

14. A complex ion is a square planar complex. It has a d<sup>8</sup> electron configuration. What is the most reasonable d orbital scheme for this complex?



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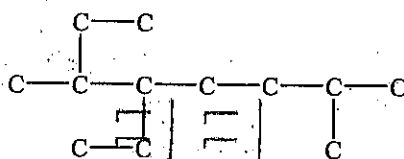
15. How much water must be added to 25.0 mL of a 9.50 M sulfuric acid solution to make a 0.370 M solution? (Assume volumes are additive.)

- (A) 617 mL (B) 667 mL (C) 642 mL  
(D) 592 mL (E) None of these.

16. Typically, rotational changes are produced by radiation in the \_\_\_\_\_ region of the electromagnetic spectrum.

- (A) IR (B) UV (C) X-ray  
(D) visible (E) microwave

17. Given the compound below is the carbon skeleton (minus any hydrogen atoms) of



I. a compound with 2 isopropyl groups; II. a compound with 3 tertiary carbons;; III. a substituted octane; IV. a compound with 3 secondary carbons; V. a  $C_{12}H_{26}$ ;

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

18. Which of the following statement is correct for the electron pair in a C-F bond:

- (A) centrally located directly between the C and F.  
(B) closer to C because carbon has a lower electronegativity than fluorine.  
(C) closer to F because fluorine has a higher electronegativity than carbon.  
(D) an inadequate model because the bond is ionic.  
(E) closer to C because carbon has a larger radius and thus exerts greater control over the shared electron pair.

19. The Lewis structure for  $H_3BO_3$  is

- (A) (B) (C) (D) (E)

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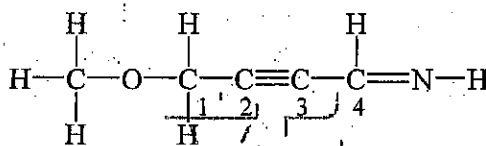
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20. Given the following Lewis structure. (Lone pairs are not drawn in.)



What are the hybridizations of the oxygen atom and of carbon atoms 1, 2, and 4, respectively

(order: O C-1 C-2 C-4)?

- (A)  $sp^3 sp^3 sp sp^2$  (B)  $sp sp^3 sp sp$  (C)  $sp sp^3 sp^2 sp$   
(D)  $sp^2 sp^3 sp^2 sp^3$  (E)  $sp sp^2 sp sp^2$

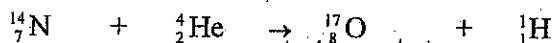
21. For an electron in a 30.0 pm one-dimensional box, calculate the wavelength of electromagnetic radiation to excite the electron from the ground state to the level with  $n = 3$ .

- (A) 0.37 nm (B) 3.7 nm (C) 37 nm  
(D) 3700 nm (E) none of these

22. A coordination compound of  $Cu^{2+}$  can be described as  $Cu(NH_3)_xSO_4$  and is known to contain 24.17%  $NH_3$ . Calculate the value of  $x$ .

- (A) 1 (B) 2 (C) 3  
(D) 4 (E) 5

23. Consider the following process:

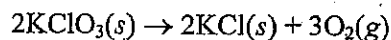


Masses (amu): 14.003074 4.002603 16.999135 1.007825

Which statement describes  $\Delta E$  for the process?

- (A)  $1.15 \times 10^{11}$  J/mol is released. (B)  $1.15 \times 10^{11}$  J/mol is absorbed. (C)  $1.15 \times 10^{18}$  J/mol is absorbed.  
(D)  $1.15 \times 10^{14}$  J/mol is released. (E) none of these

24. A mixture of KCl and  $KClO_3$  weighing 3 g was heated; the dry  $O_2$  generated occupied  $2 \times 10^2$  mL at STP. What percent of the original mixture was  $KClO_3$ ?  $KClO_3$  decomposes as follows:



- (A) 11.2% (B) 24.1% (C) 34.6%  
(D) 57.8% (E) 82.4%

25. The complex ion  $[NiF_4]^{2-}$  is tetrahedral. How many unpaired electrons are there in the complex?

- (A) 1 (B) 2 (C) 3  
(D) 4 (E) 5

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## II. Assays (10% each; total 50%)

1. Consider a solution containing liquids A and B where the mole fraction of B is 0.80. Assuming ideality, calculate the mole fractions of A and B in the vapor at equilibrium with this solution at 25°C. (The vapor pressures of pure liquid A and pure liquid B at 25°C are 250 torr and 480 torr, respectively.) (10%)

2. The table below lists the ionic radii for the cations and anions in three ionic compounds.

Compound	$r_{\text{cation}}$	$r_{\text{anion}}$
$\text{SnO}_2$	71 pm	140. pm
AlP	50 pm	212 pm
BaO	135 pm	140. pm

Each compound has a cubic structure like NaCl, CsCl, or ZnS. Using radius ratios, predict the cubic structure that each compound is most likely to form (that of NaCl, CsCl, or ZnS), the type of holes filled by the cations, and the fraction of holes filled by cations. (10%)

3. Write the balanced molecular equation for the reaction between aqueous solutions of lithium phosphate and sodium hydroxide. (10%)
4. A 1.00-mol sample of an ideal monatomic gas is compressed isothermally and irreversibly in one step from 2.50 atm to 6.50 atm at 300.0 K. Calculate  $w$ ,  $\Delta H$ ,  $\Delta G$ , and  $\Delta S_{\text{surr}}$  for this process. (10%)
5. Write the formula for: (a) sodium dichromate; (b) iron (III) oxide; (c) dinitrogen trioxide; (d) aluminum hydroxide; (e) sulfurous acid. (2% each, 10%)