一. 選擇題: 2分/題 (single-choice) (K=39.1; Na=23; Ca=40; g/mole)

1. 2. 3. 4. 5. 6. 7. 8. 9. 10.

1. How many liters are there in a cubic centimeter?
   A) 10⁻⁶    B) 10⁻³    C) 10³    D) 10⁶    E) 10⁹

2. Which one of the following pairs of substances illustrates the Law of Multiple Proportions?
   A) O₃, O₂    B) D₂O, H₂O    C) SiO₂, Sb₂O₃    D) KCl, MgCl₂    E) PCl₃, PCl₅

3. A reaction consumes 5.0 g of A and 6.0 g of B. How many grams of C and D should be obtained?
   1A  +  3B  →  2C  +  4D
   A) 23    B) 11    C) 1    D) 10    E) Not enough information is given to answer this question.

4. Calculate the formula mass of ammonium nitrite.
   A) 64.04    B) 80.04    C) 79.04    D) 63.04    E) 71.847

5. Which of the following is incorrectly labeled?
   A) KCl—strong electrolyte    B) HCl—strong electrolyte
   C) HCOOH—weak electrolyte    D) NH₃—weak electrolyte
   E) HNO₂—strong electrolyte

6. Which of the following species is a weak base in water?
   A) KOH    B) B(OH)₃    C) NH₃    D) CH₃CO₂H    E) Mg(OH)₂

7. The two particles that comprise the nucleus of an atom are
   A) protons and electrons.    B) neutrons and electrons.
   C) alpha particles and neutrons.    D) protons and neutrons.
   E) electrons and gamma rays.

8. Calculate the wavelength, in nanometers, of an x-ray that has frequency of 5.15 × 10⁻¹⁶ s⁻¹.
   A) 5.83    B) 17.2    C) 0.172    D) 1.72 × 10⁸    E) 583

9. An AM radio station operates at a frequency of 1080 kHz. What is the wavelength, in meters, of the radio waves?
   A) 360    B) 278    C) 1080    D) 3.60    E) 2.78

10. In which atom are the 3s and 3p orbitals equal in energy?
    A) H    B) He    C) C    D) O    E) none of the above

11. Select the species below that is not isoelectronic with the Ne atom?
    A) F⁻    B) O²⁻    C) Na⁺    D) Mg²⁺    E) Ar
12. Which one of the following Lewis symbols is incorrect?

A) \( \text{S} \)  
B) \( \text{I} \)  
C) \( \text{Si} \)  
D) \( \text{Ca} \)  
E) \( \text{Se} \)

13. The electron pair geometry around the central iodine in \( \text{I}_3^- \) is

A) linear. B) trigonal bypyramidal. C) tetrahedral. D) octohedral. E) none of these

14. A 1.50 g sample of aniline (\( \text{C}_6\text{H}_5\text{NH}_2 \)) requires 844 J to vaporize.

What is the \( \Delta \text{H}_{\text{vap}} \) for aniline in kJ/mol?

A) 13.6  B) 563  C) 52.3  D) 844  E) 0.52

15. What is the percent by mass of a solution made by dissolving 55.0 g KCl in 125 g water?

A) 30.6  B) 55.0  C) 68.8  D) 56.0  E) 44.0

16. For the gaseous system, \( 2 \text{H}_2\text{S} + 3 \text{O}_2 \leftrightarrow 2 \text{H}_2\text{O} + \text{SO}_2 \),

how is \( K_p \) related to \( K_c \) at a given temperature?

A) less than  B) equal to  C) greater than  D) unrelated to

17. The conjugate acid of \( \text{HPO}_4^{2-} \) is

A) \( \text{PO}_4^{3-} \)  B) \( \text{H}_2\text{PO}_4^{2-} \)  C) \( \text{H}_2\text{PO}_4^- \)  D) \( \text{H}_3\text{PO}_4 \)  E) none of these

18. How many electrons are transferred in the following reaction?

\( 2 \text{Al} (s) + 6 \text{H}^+ (aq) \rightarrow 2 \text{Al}^{3+} (aq) + 3 \text{H}_2 (g) \)

A) 1  B) 2  C) 3  D) 5  E) 6

19. Which of the following species cannot function as an oxidizing agent?

A) \( \text{S(s)} \)  B) \( \text{NO}_3^{-}(aq) \)  C) \( \text{Cr}_2\text{O}_7^{2-}(aq) \)  D) \( \text{I}^- (aq) \)  E) \( \text{MnO}_4^{-}(aq) \)

20. Metals typically have _______ electronegativity values.

A) high  B) low  C) negative  D) no  E) two of these

二．問答與計算：共 60 分

1. (3 分) A star is estimated to have a mass of \( 2 \times 10^{36} \) kg. Assuming it to be a sphere of average radius \( 7.0 \times 10^5 \) km, calculate the average density of the star in units of grams per cubic centimeter.

2. (6 分) Adipic acid is an organic compound composed of 49.31% C, 43.79% O, and the rest hydrogen. If the molar mass of adipic acid is 146.1 g/mole, what are the empirical and molecular formulas for adipic acid?

3. (6 分) Write the formula for each of the following compounds:

   (a) copper(Ⅱ) nitrate
   (b) sodium peroxide
   (c) magnesium fluoride
(d) potassium dihydrogen phosphate
(e) lithium sulfite

4. (6分) Balance equation for the following reaction

\[ MnO_4^- + Fe^{2+} \xrightleftharpoons[acid]{\text{acid}} Fe^{3+} + Mn^{2+} \]

5. (3分) A reaction rate constant is 0.001 min\(^{-1}\). How long will it take for the reaction to go to 38.5\% completion?

6. (6分) Titanium metal has a body-centered cubic unit cell. The density of titanium is 4.5 g/cm\(^3\).

   Calculate a) the edge length of the unit cell and b) a value for the atomic radius of titanium. (Ti=47.88 g/mole, unit=pm)

7. (18分) Predict the hybridization of each molecules or ions, and describe the molecular structure and polar molecular

   (a) CO\(_2\)  (b) NH\(_4^+\)  (c) XeF\(_4\)  (d) ICl\(_2^-\)  (e) I\(_3^-\)  (f) BCl\(_3\)  (g) SO\(_2\)

   (h) AlCl\(_6^-\)  (i) N\(_2O\)  (j) H\(_2O\)

8. (3分) How many bond angle are there in PCl\(_4^-\)?

9. (9分) One of the emission spectral lines for Be\(^{3+}\) has a wavelength of 253.4 nm for an electronic transition that begins in the state with \(n=5\). What is the principal quantum number of the lower-energy state corresponding to this emission?
答案


二．問答與計算:

二. 開放式問題

1. \( \frac{m}{V} = \frac{2 \times 10^{39} \text{g}}{1.4 \times 10^{33} \text{cm}^3} = 1.4 \times 10^6 \text{g/cm}^3 \)

2. \( \frac{C}{12.01} = \frac{49.31}{12.01} = 4.1 \)
   \( \frac{H}{1.008} = \frac{6.9}{1.008} = 6.85 \)
   \( \frac{O}{16.01} = \frac{43.79}{16.01} = 2.74 \)
   \( \frac{C}{O} = \frac{4.1}{2.74} = 1.5; \frac{O}{H} = \frac{2.74}{6.85} = 0.4 \)
   \( \text{C}_3 \text{H}_5 \text{O}_2 \) 的摩爾質量：146.1

3. \( \text{Cu(NO}_3\text{)}_2, \text{Na}_2\text{O}_2, \text{MgF}_2, \text{KH}_2\text{PO}_4, \text{Li}_2\text{SO}_3 \)

4. \( 2\text{H}_2\text{O} + 4\text{Ag(s)} + 8\text{CN}^-\text{(aq)} + \text{O}_2 \text{ basic} \rightarrow 4\text{Ag(CN)}_2^-\text{(aq)} + 4\text{OH}^- \)

5. 480秒

6. a. 单元晶胞的邊長 = 328ppm
   b. 氫化鈦的原子半徑 = 142ppm

7. (a) sp，直線，無極性
   (b) sp³，四面體，無極性
   (c) sp³d²，平行四邊形，無極性
   (d) sp³，T字型，無極性
   (e) sp，直線，無極性
   (f) sp²，平面三角形，無極性
   (g) sp²，角形，有極性
   (h) sp³d²，八面體，無極性
   (i) sp，直線，有極性
   (j) sp³，角形，有極性

8. 90、120、180 度

9. \( E = 6.625 \times 10^{-34} \times 3 \times 10^8 / 253.4 \times 10^{-9} = 7.8 \times 10^{-19} \)

10. 根據公式 \( n = \frac{42}{2} - \frac{4}{5} \)
    n = 4