SHOW ALL CALCULATIONS & USE PROPER SIGNIFICANT FIGURES AND UNITS

Avogadro’s number, \( N_A = 6.02 \times 10^{23} \)
Planck’s constant, \( h = 6.626 \times 10^{-34} \text{ J s} \)
DeBroglie wavelength, \( \lambda = h / mv \)
Photon energy, \( E_n = n h \nu \)
Rydberg constant, \( R_H = 2.181 \times 10^{-18} \text{ J} \)

Multiple Choice Questions: Circle the single best answer. No penalty for guessing.

1. What is the most probable oxidation number on bromine in \( \text{BrF}_3 \)? (4 points)
   A) –1  B) 0  C) +1  D) +3  E) +5

2. How many nodes does a 4d\(_{xy}\) orbit have? (4 points)
   A) 1 radial and 1 angular  B) 3 radial and 2 angular
   C) 2 radial and 1 angular  D) 0 radial and 1 angular
   E) 1 radial and 2 angular

3. Which of the following atoms or ions has the 1s\(^2\) 2s\(^2\) 2p\(^6\) 3s\(^2\) 3p\(^1\) electron configuration? (4 points)
   A) Ca  B) Al  C) Ga  D) B  E) C\(^+\)

4. Which is an example of a chemical change? (4 points)
   A) melting of lead  B) dissolving of sugar in water
   C) tarnishing of silver  D) crushing of stone  E) rain

5. Calculate the grams of \( \text{Al}_2\text{O}_3 \) that could be produced if 2.5 g of aluminum and 2.5 g of oxygen were allowed to react using the chemical equation below. (4 points)
   \[ 4 \text{Al} + 3 \text{O}_2 \rightarrow 2\text{Al}_2\text{O}_3 \]
   A) 9.4 g  B) 7.4 g  C) 5.3 g  D) 4.7 g  E) 2.5 g

6. What is \( \Delta E \) of a system which moves a mass 10 m using a force of 20 kg m/s\(^2\)? (4 points)
   A) -200 J  B) 200 J  C) -20 J  D) 20 J  E) 2 J

7. How many electrons are required to fill all of the 5f orbitals for a single atom? (4 points)
   A) 2  B) 5  C) 8  D) 10  E) 14
8. Which atom has the largest atomic radius? (4 points)  
   A) Sr  
   B) Mg  
   C) Be  
   D) Ag  
   E) Xe

9. How many neutrons does $^{23}\text{Na}$ have? (4 points)  
   A) 34  
   B) 23  
   C) 12  
   D) 11  
   E) 1

10. Which anion forms soluble salts regardless of the cation present? (4 points)  
    A) OH$^-$  
    B) SO$_3^{2-}$  
    C) ClO$^-$  
    D) NO$_2^-$  
    E) NO$_3^-$

11. What is the hybridization of the oxygen atom in H$_2$O? (4 points)  
    A) sp  
    B) sp$^2$  
    C) sp$^3$  
    D) sp$^4$  
    E) sp$^3$d

12. How many bonds does a nitrogen atom normally form in neutral molecules? (4 points)  
    A) 0  
    B) 1  
    C) 2  
    D) 3  
    E) 4

13. Write the formula or name of the following compounds and indicate the solubility. (16 points)  
    CaCO$_3$  
    NaMnO$_4$  
    iron (II) hypobromite  
    potassium hydroxide

14. Given the following data enthalpies of reaction:  
    \[ \text{C (s) + 1/2 O}_2 (g) \rightarrow \text{CO (g)} \] \[ \Delta \text{H} = -110.5 \text{ kJ/mol} \]  
    \[ 2 \text{C (s) + 2 H}_2 (g) \rightarrow \text{C}_2\text{H}_4 (g) \] \[ \Delta \text{H} = 52.3 \text{ kJ/mol} \]  
    \[ \text{1/2 O}_2 (g) + \text{H}_2 (g) \rightarrow \text{H}_2\text{O (g)} \] \[ \Delta \text{H} = -241.8 \text{ kJ/mol} \]  
Calculate the heat released when excess C$_2$H$_4$ (g) reacts with 4.0 moles of O$_2$ to produce H$_2$O (l) and CO (g). (15 points)  
    \[ ___ \text{C}_2\text{H}_4 (g) + ___ \text{O}_2 (g) \rightarrow ___ \text{CO (g)} + ___ \text{H}_2\text{O (l)} \]
15. A compound containing only chromium, Cr, and oxygen was created by burning 25.56 g of Cr in exactly 31.57 g of oxygen. Write the empirical formula for this compound. (10 points)

16. Describe why the first ionization energy of Na is much larger than the second ionization energy of Na using electron configuration and effective charge arguments. (10 points)

17. Suppose you analyze a 1.321 g unknown sample for phosphorus by a precipitation reaction producing 3.811 g of NH₄MgPO₄•6H₂O. What is the percentage of phosphorus in the unknown sample? (6 points)

18. Balance the following two equations and write out a final net ionic equations. (12 points)

\[ \text{平衡方程} \]

\[ \text{FeCl}_2 (aq) + \text{Hg}_2(\text{NO}_3)_2 (aq) \rightarrow \text{NH}_4\text{SCN} (aq) + \text{Ba(OH)}_2 (aq) \rightarrow \text{NH}_3 (g) + \text{H}_2\text{O} (l) \]
19. Draw the molecular orbital energy levels for O$_2^+$ and indicate orbital populations and the overall bond order. (9 points)

20. Write the ground state electron configuration for Be, Ba$^{2+}$ and Sn$^{2+}$. (9 points)

21. Describe the electron density at a node in a 2p atomic orbital (points in space where $\Psi = 0$) using pictures and words. (10 points)

22. Draw the Lewis dot structure (showing resonance structures if appropriate) for SO$_3$, indicating formal charges on each atom in each structure. (10 points)
23. Suppose that mixing 3.51 g of dry ice (solid CO$_2$) causes 100.0 g of H$_2$O to drop from 25.2 °C to 12.1 °C (heat capacity of water, $C_{\text{water}} = 4.184$ J / g K) when mixed and the dry ice evaporates. What is the $\Delta H$ (kJ / mol) for the evaporation of the dry ice (assume that all of the CO$_2$ leaves the mixture as a gas)? (15 points)

24. Describe a neutron and what its role is in the nucleus of an atom such as $^{56}$Fe. (15 points)

25. What is the chloride ion concentration if 0.813 g of NaCl and 0.221 g of FeCl$_2$ is dissolved in 250.0 mL of distilled water. (15 points)