Answer all questions on the Scantron answer sheet by filling in the proper bubble with a number 2 pencil. If you change your answer, please erase the undesired mark thoroughly.

You are not permitted to use a programmable calculator; only non-programmable calculators can be used!

Be sure to fill in the boxes for your SID# and name; then fill in the corresponding bubbles beneath them correctly. You do not need to fill in your section number.

A periodic table with atomic numbers and masses is attached to the back of this exam.

**Useful Information:**
- Avogadro's Number = 6.022 x 10^{23} \text{ mol}^{-1}
- Planck's Constant, \( h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s} \)
- Speed of light = 3.00 x 10^{8} \text{ m/s}
- \( c = \nu \lambda \)
- \( E = h\nu \)
- \( R = 1.097 \times 10^{-7} \text{ nm}^{-1} \)
- \( \frac{1}{\lambda} = R \left( \frac{1}{m^2} - \frac{1}{n^2} \right) \quad n > m \)

**Some Solubility Rules**

<table>
<thead>
<tr>
<th></th>
<th>All compounds containing group 1A cations and the ammonium ion (NH_4^+) are soluble.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>All compounds containing NO_3^-, ClO_4^-, ClO_3^-, and C_2H_3O_2^- anions are soluble.</td>
</tr>
<tr>
<td>3</td>
<td>All chlorides, bromides, and iodides are soluble except those containing Ag^+, Pb^{2+}, or Hg^{2+}.</td>
</tr>
<tr>
<td>4</td>
<td>All sulfates (SO_4^{2-}) are soluble except those containing Hg^{2+}, Pb^{2+}, Sr^{2+}, Ca^{2+}, or Ba^{2+}.</td>
</tr>
</tbody>
</table>
1. When aluminum (Al) reacts with phosphorus (P), the resulting compound has the formula:
   a. $AlP$
   b. $AlP_2$
   c. $Al_2P_2$
   d. $Al_3P_2$
   e. $Al_2P_3$

2. Suppose that a fictitious element, X, has two isotopes: $^{59}X$ (59.015 amu) and $^{62}X$ (62.011 amu). The lighter isotope has an abundance of 63.7%. What is the atomic weight of the element X?
   a. 59.015 amu
   b. 60.103 amu
   c. 60.923 amu
   d. 60.513 amu
   e. 62.011 amu

3. Which species functions as the reducing agent in the following redox reaction?
   \[ ZnO(s) + C(s) \rightarrow Zn(s) + CO(g) \]
   a. $Zn^{2+}(aq)$
   b. $CO(g)$
   c. $Zn(s)$
   d. $ZnO(s)$
   e. $C(s)$

4. What is the final molarity of a nitric acid solution made by combining 12.4 mL of 0.1 M nitric acid and 1.0 mL 4.0 M nitric acid?
   a. 0.00042 M
   b. 0.00524 M
   c. 0.29 M
   d. 0.39 M
   e. 0.42 M

5. What is the concentration of an HCl solution if 313 mL of a 0.100 M KOH solution needed to titrate 415 mL the acid completely?
   a. 0.0313 M
   b. 0.0377 M
   c. 0.0666 M
   d. 0.0754 M
   e. 0.1325 M
6. How many neutrons are in $^{23}\text{Na}$?
   a. $6.0 \times 10^{17}$
   b. $7.2 \times 10^{18}$
   c. $1.4 \times 10^{19}$
   d. $1.4 \times 10^{25}$
   e. $7.2 \times 10^{24}$

7. Which of the following statements about orbitals are true?
   I. No orbital can contain more than two electrons.
   II. All orbitals have at least one node
   III. Electrons in an orbital must be located within the surface of their orbital.
   IV. The number of electrons an orbital holds depends on the principal quantum number of that orbital.
   a. I
   b. II
   c. I and II
   d. II and IV
   e. I and III

8. Which of the following is an allowable quantum number for an electron?
   a. $n=4$, $l=2$, $m_l = -3$
   b. $n=4$, $l= -3$, $m_l = 3$
   c. $n=2$, $l=2$, $m_l = 2$
   d. $n=1$, $l=0$, $m_l = 0$
   e. $n=0$, $l=0$, $m_l = 0$

9. In the following reversible acid-base reaction, which compound or compounds are acting as an acid?
   $$\text{HP}O_4^{2-} + \text{NH}_4^+ \leftrightarrow \text{H}_2\text{PO}_4^- + \text{NH}_3$$
   a. $\text{HP}O_4^{2-}$ only
   b. $\text{NH}_4^+$ only
   c. $\text{NH}_4^+$ and $\text{NH}_3$
   d. $\text{NH}_4^+$ and $\text{H}_2\text{PO}_4^-$
   e. $\text{HP}O_4^{2-}$ and $\text{NH}_3$

10. The number of electrons occupying all d orbitals in 1.0g of Kr is
    a. $7.2 \times 10^{22}$
    b. $7.2 \times 10^{21}$
    c. $1.4 \times 10^{22}$
11. What is the oxidation number of the sulfur atom in $K_2SO_4$?
   a. -2
   b. 0
   c. +2
   d. +4
   e. +6

12. The mixing of which pair of reactants will result in a precipitation reaction?
   a. $CsI(aq) + NaOH(aq)$
   b. $NH_4Br(aq) + NaI(aq)$
   c. $HCl(aq) + Ca(OH)_2(aq)$
   d. $K_2SO_4(aq) + Ba(NO_3)_2(aq)$
   e. $NaNO_3(aq) + NH_4Cl(aq)$

13. $HCl$, $HI$, $H_2SO_4$, $LiCl$, and $KI$ are all classified as:
   a. Acids
   b. Nonelectrolytes
   c. Strong electrolytes
   d. Weak electrolytes
   e. Both a and c

14. When calcium carbonate ($CaCO_3$) is added to hydrochloric acid (HCl) then calcium chloride ($CaCl_2$), carbon dioxide, and water are produced. How many grams of calcium chloride will be produced when 11.0g of calcium carbonate are combined with 5.00g of hydrochloric acid, assuming the reaction goes to the maximum theoretical yield?
   a. 7.61g
   b. 12.2g
   c. 15.2g
   d. 16.0g
   e. 24.4g

15. Which of the following are the correct ground state electron configurations of Cu and $Cu^{2+}$ respectively?
   a. $[Ar]4s^23d^9$ and $[Ar]4s^23d^{10}4p^1$
   b. $[Ar]4s^23d^9$ and $[Ar]3d^6$
   c. $[Ar]4s^23d^9$ and $[Ar]4s^13d^8$
   d. $[Ar]4s^13d^{10}$ and $[Ar]4s^23d^7$
   e. $[Ar]4s^13d^{10}$ and $[Ar]3d^9$
16. Cryolite, \( Na_3AlF_6 \), an ore used in the production of aluminum, can be synthesized by reacting aluminum oxide \( Al_2O_3 \), sodium hydroxide \( NaOH \), and hydrogen fluoride \( HF \), producing cryolite and water. If 2480 kg of aluminum oxide, 1088 kg of sodium hydroxide and 950 kg of hydrogen fluoride react, which will be the limiting reagent?
   a. Aluminum oxide
   b. Sodium hydroxide
   c. Hydrogen fluoride
   d. Cryolite
   e. Water

17. What are the coefficients in front of \( NO_3^- (aq) \) and \( Cu(s) \) when the following redox equation is balanced in acidic solution:
   \[
   _____NO_3^- (aq) + _____Cu(s) \rightarrow _____NO(g) + _____Cu^{2+}(aq)
   \]
   a. 1,1
   b. 2,6
   c. 3,4
   d. 3,6
   e. 2,3

18. What is the longest wavelength of light possibly emitted when an electron moves from the \( n=5 \) shell in hydrogen to a different shell?
   a. 95 nm
   b. 608 nm
   c. 2278 nm
   d. 4050 nm
   e. 7456 nm

19. What is the stoichiometric coefficient on carbon monoxide (CO) when the following equation is balanced using the lowest whole-number coefficients?
   \[
   _____Ca_3(PO_4)_2 + _____SiO_2 + _____C \rightarrow _____CaSiO_3 + _____P_4 + _____CO
   \]
   a. 1
   b. 2
   c. 3
   d. 6
   e. 10

20. Prior to their phase out in the 1980s, chemicals containing lead were commonly added to gasoline as anti-knocking agents. A 0.837g sample of one such additive containing only lead, carbon, and hydrogen was burned in an excess of oxygen to completion. The combustion produced 0.911g of \( CO_2 \) and 0.466g of \( H_2O \). What is the chemical formula of this additive?
   a. \( CHP \)
b. $C_2H_3Pb$

c. $C_3HPb_{10}$

d. $C_6H_9Pb$

e. $C_8H_{20}Pb$