Exam 3

DO NOT OPEN THE EXAM UNTIL INSTRUCTED

Directions

Please check the exam to make sure there are 10 non-blank pages including the title page. Pages 9&10 contain useful equations, constants and the periodic table. You may remove this page and use for reference or scratch paper. Read all the questions and directions carefully before entering answers!

Sections III - IV allow you to omit a problem. Please read the directions for each section write “OMIT” on the portion you do not want graded. If nothing is marked “OMIT” we will grade the first problems of that section, regardless of what work has been done. We will not attempt to interpret your desire.

When you have completed the exam please place the exam neatly on the front bench.

Pencils and pens down when time is called.

Good Luck!
I. Multiple Choice (30 pts) Please carefully blacken the bubble on the scantron sheet for the answer you have selected for the following multiple choice questions.

1. What color is your exam?
   a. yellow
   b. blue
   c. green

2. How much kinetic energy (KE) does an object with a mass of $5.00 \times 10^2$ g traveling in a straight line with a speed of $5.00 \times 10^1$ m s$^{-1}$ possess? $E = \frac{1}{2} m v^2$
   a. 0.625 kJ
   b. 1.25 kJ
   c. 2.5 kJ
   d. 6.25 kJ
   e. 25 kJ

3. A 500.0 gram sample of aluminum is initially at 25.0 °C. It absorbs 32.60 kJ of heat from its surroundings. What is its final temperature, in °C? (specific heat = 0.9930 J g$^{-1}$ °C$^{-1}$ for aluminum)
   a. 40.4 °C
   b. 64.7 °C
   c. 65.7 °C
   d. 89.7 °C
   e. 90.7 °C

4. An endothermic chemical reaction has just occurred in an insulated isolated system. Which statement below is true?
   a. Work was performed on the surroundings by the system.
   b. Heat was given off to the surroundings by the system.
   c. The potential energy of the system increased.
   d. The potential energy of the system decreased.
   e. The total energy of the system increased.

5. What is the wavelength of electromagnetic radiation which has a frequency of $5.732 \times 10^{14}$ s$^{-1}$. $c = \lambda \nu$, $E = h \nu$, $c = 3.000 \times 10^8$ m/s, $h = 6.626 \times 10^{-34}$ J s
   a. $1.718 \times 10^{23}$ m
   b. $1.912 \times 10^6$ m
   c. $5.234 \times 10^{-7}$ m
   d. 523.0 m
   e. $5.819 \times 10^{-15}$ nm

6. Which one of the following types of radiation has the longest wavelength?
   a. gamma rays
   b. green colored visible light rays
   c. red colored visible light rays
   d. ultraviolet rays
   e. x-rays
7. Based on the position in the periodic table, which one of the following atoms would you expect to have the highest electron affinity?
   a. Cl
   b. Ge
   c. P
   d. Se
   e. Sn

8. Which one of the species below should have the largest radius?
   a. Ca
   b. Ba
   c. Al
   d. Mg
   e. C

9. Bromine tends to form simple ions which have the electronic configuration of a noble gas. What is the electronic configuration of the noble gas which the bromide ion mimics?
   a. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4p^6$
   b. $1s^2 2s^2 2p^6 3s^2 3p^6 4p^6 4d^{10}$
   c. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4p^6$
   d. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$
   e. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10}$

10. Which one of the following is the least electronegative element of the set presented?
    a. F
    b. N
    c. C
    d. O
    e. H

11. The atoms in the oxygen molecule, $O_2$, are held together by
    a. a single covalent bond
    b. a double covalent bond
    c. a triple covalent bond
    d. an ionic bond
    e. a magnetic dipole bond
II. Short answer question (22 pts)

A. (9) Draw complete Lewis structures for the following species: You must show all bonding and non-bonding electrons to receive full credit.

- water

- ClO$_3^-$ anion

B. (6) Draw two resonance structures for sulfur trioxide, the anhydride of sulfuric acid. You must show all bonding and non-bonding electrons to receive full credit.

C. (3) Draw the complete electron configuration of the selenium atom using 1s$^2$2s$^2$ notation.

D. (4) Draw the electron configuration of the sulfide anion, S$^{2-}$, using inert gas core notation.
III. Fill in the Blank (18 pts) Solve any three (3) of the following problems and place your answer in the boxes provided. Note that very little partial credit will be given, so check your answers carefully.

1. A bar of copper with a mass of 750 g changed in temperature from 25.50 to 19.50 °C. How many kilojoules of energy would be required to effect this change? (specific heat of copper = 0.39 \( \frac{J}{g \cdot ^\circ C} \))

2. How many occupied orbitals does gallium have in its ground state?

3. Determine the number of valence electrons in the selenium atom.

4. What would be the enthalpy of reaction for a chemical reaction if it was determined that 0.101 moles of reactant caused a temperature change of 5.01°C when reacted in a calorimeter with a heat capacity of 1001 J/°C?
IV. Thought Questions (30 pts) Answer the questions on any two (2) of the following three pages. Write "OMIT" through the page you wish omitted. Your answers must be clear and complete in order to receive complete credit. SHOW YOUR WORK!

1.

a. Draw the Lewis structure for thionyl chloride, SOCl₂.

b. Give the formal charges for each of the atoms in the molecule.

<table>
<thead>
<tr>
<th>Atom</th>
<th>Formal Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td></td>
</tr>
<tr>
<td>O</td>
<td></td>
</tr>
<tr>
<td>Cl</td>
<td></td>
</tr>
</tbody>
</table>
Two weeks ago you analyzed samples of cereal for their iron content. The analysis involved synthesizing an aqueous Fe$^{2+}$ complex, which had a maximum absorbance wavelength ($\lambda_{\text{max}}$) of 510.0 nm. Please answer the following questions based on this analysis.

a. What is the energy of a photon at $\lambda_{\text{max}}$?

b. The following absorbance vs concentration data was obtained for one of the iron analyses.

![Absorbance vs concentration data](image)

If a 10.00 mL unknown sample with Fe$^{2+}$(aq) had an absorbance of 0.4, how many milligrams of Fe(s) were present in the sample?
3. Calculate the enthalpy of formation of solid Mg(OH)$_2$ from the following thermochemical data:

\[
\begin{align*}
2\text{Mg}(s) + \text{O}_2(g) & \rightarrow 2\text{MgO}(s) \quad \Delta H^\circ = -1203.6 \text{ kJ} \\
\text{Mg(OH)}_2(s) & \rightarrow \text{MgO}(s) + \text{H}_2\text{O}(l) \quad \Delta H^\circ = +37.1 \text{ kJ} \\
2\text{H}_2(g) + \text{O}_2(g) & \rightarrow 2\text{H}_2\text{O}(l) \quad \Delta H^\circ = -571.7 \text{ kJ}
\end{align*}
\]
c (speed of light) = 3.0 x 10^8 m/s
\[ c = \lambda \times \nu \]
\[ h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s} \]
1 J = 1 Kg m^2/s^2
\[ E = h\nu \]
\[ \frac{1}{\lambda} = R_H \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \]
\[ E = -\frac{b}{n_2^2} \quad b = 2.18 \times 10^{-18} \text{ J} \]
\[ R_H = 109678 \text{ cm}^{-1} = \frac{b}{hc} \quad (\text{within 0.05\%}) \]
de Broglie wavelength
\[ \lambda = \frac{h}{mv} \quad ; \quad v = \text{velocity in this equation} \]
\[ q = C(T_f - T_i); \quad C = \text{heat capacity} \]
\[ q = S \cdot m(T_f - T_i); \quad S = \text{specific heat, } m = \text{mass} \]