Please print:

Last name: _____

First name:_____

Chem 1061 Exam 4

Fall 2004

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Tuesday, December 7, 2004

Instructions:

Time: You have 85 minutes to complete this exam.

Equations and constants:

$c = \nu\lambda \quad c = 2.998 \times 10^{8}$ m/s

$E = h\nu \quad h = 6.626 \times 10^{-34}$ J · s

$E_{\text{emitted photon}} = h\nu = E_i - E_f$

Contents:

I, _____ have read and understand the directions given above, and pledge that I will follow all regulations with regard to Academic Dishonesty as outlined by this college when taking this exam.

Signature _____ Date and Time _____

I. Multiple choice

Choose the best answer from the choices given, and mark your choice on the provided Scantron sheet with a #2 pencil. *(3 pts each)*

1. What is the energy associated with a single photon of light with a frequency of 7.00×10^{14} s^{-1}?

   a. 1.75×10^{-48} J
   b. 4.64×10^{-19} J
   c. 2.63×10^{5} J
   d. 4.38×10^{13} J
   e. 6.02×10^{23} J

2. Which quantum number distinguishes the different shapes of the orbitals?

   a. n
   b. l
   c. m_s
   d. m_l
   e. all of these

3. All of the following statements about the quantum numbers are true ***except***

   a. n has integer values from 1 to ∞
   b. l has values from 1 to $n - 1$
   c. m_l has $2l + 1$ values
   d. m_l has values of –1 to +1, including zero
   e. m_s has values of $+\frac{1}{2}$ and $-\frac{1}{2}$

4. Which of the following sets of quantum numbers refers to an electron in a 3d orbital?

   a. $n = 2$, $l = 2$, $m_l = 2$, $m_s = +1/2$
   b. $n = 3$, $l = 2$, $m_l = 2$, $m_s = +1/2$
   c. $n = 4$, $l = 2$, $m_l = 2$, $m_s = -1/2$
   d. $n = 4$, $l = 3$, $m_l = 3$, $m_s = -1/2$
   e. $n = 5$, $l = 4$, $m_l = 3$, $m_s = +1/2$

5. The maximum number of electrons that can be accommodated in a p subshell is

   a. 2
   b. 4
   c. 6
   d. 8
   e. 10

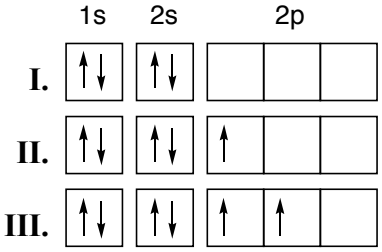
6. The Pauli exclusion principle requires that

   a. both the position of an electron and its momentum cannot be known simultaneously very accurately
   b. the energy and frequency of a photon are related by $E = h\nu$
   c. the wavelength of a photon of light times its frequency is equal to the speed of light
   d. no two electrons in the same atom can have the same set of four quantum numbers
   e. an electron has both particle-like and wave-like properties

7. Which of the following might be an electron configuration of an uncharged transition metal?

   a. $1s^2, 2s^2, 2p^2$
   b. $1s^2, 2s^2, 2p^6, 3s^2, 3p^5$
   c. $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2$
   d. $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^5$
   e. $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6$

8. Which of the following orbital diagrams represents a paramagnetic atom?



   a. **I** only
   b. **II** only
   c. **III** only
   d. **I** and **II** only
   e. **II** and **III** only

9. How many total electrons does a stable aluminum ion have?

   a. 27
   b. 24
   c. 18
   d. 13
   e. 10

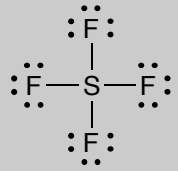
10. What is the electron configuration of Fe^{3+}?

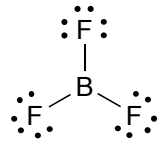
   a. [Ar] $3d^6$, $4s^2$
   b. [Ar] $3d^3$, $4s^2$
   c. [Ar] $3d^4$, $4s^1$
   d. [Ar] $3d^5$
   e. [Ar] $3d^6$

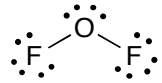
11. Which of the following contains an exception of the octet rule?

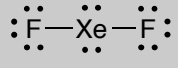
   a. PF_3
   b. SiF_4
   c. OF_2
   d. ClF_3
   e. ClF

12. Which of the following is an incorrect Lewis structure?

   a. 

   b. 

   c. 

   d. 

   e. 

II. Short answer

Briefly define and/or give an example of the following terms: (*3 pts each*)

13. photon
    - a discrete packet of energy
    - the particle-like form of electromagnetic radiation (light)
    - energy released when an electron makes a downward energy level transition
14. electromagnetic radiation
    - the form of energy that travels at *c* and is in the form of waves
    - *e.g.* gamma rays, X-rays, ultraviolet, visible, infrared light, microwaves, radio waves
15. valence electrons
    - s & p electrons in outermost electron shell
16. ionization energy
    - energy required to remove an electron from an atom
    - $X \rightarrow X^+ + e^-$; ΔH = ionization energy
17. polar covalent bond
    - a covalent bond in which the electrons are shared unevenly
    - due to a difference in electronegativities of atoms involved in bond
18. formal charge
    - hypothetical charge assigned to an atom in a molecule
    - formal charge = valence # – ½ shared e^- – unshared e^-

Write the abbreviated electron configurations (with the noble gas core in brackets) for the following atoms or ions. Atomic numbers are given in parentheses to help you quickly locate the elements. (*3 pts each*)

19. Ta (Z = 73)

    [Xe] $6s^2$, $4f^{14}$, $5d^3$
20. Ti^{2+} (Z = 22)

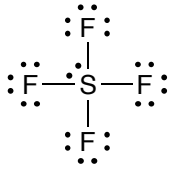
    [Ar] $3d^2$
21. Sn^{2+} (Z = 50)

    [Kr] $5s^2$, $4d^{10}$
22. Al^{3+} (Z = 13)

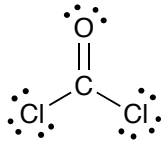
    [Ne]

The following molecules all have Lewis structures where no atom carries a formal charge. Draw these Lewis structures. (*5 pts each)*

23. SF_4 (34 valence e^-)

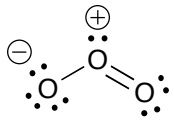


24. $COCl_2$ (C is central atom) (24 valence e^-)

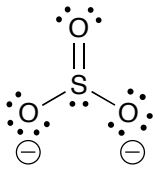


The following molecules have Lewis structures in which an atom or atoms carry a formal charge. Draw the best Lewis structure for each compound and indicate all formal charges near the appropriate atoms. (*5 pts each*)

25. O_3 (18 valence e^-)



26. SO_3^{2-} (26 valence e^-)



III. Problems

Show all your work and draw a box around your final answer.

27. In a hydrogen atom, the energy of the $n = 5$ level is -8.716×10^{-20} J and the energy of the $n = 2$ level is -5.448×10^{-19} J. What is the wavelength of light (in nm) corresponding with the photon that has been emitted by a transition from the $n = 5$ energy level to the $n = 2$ energy level? If this is visible light, what color is it? (*10 pts*)

Color	Wavelength
Ultraviolet	10-400 nm
Purple	400-450 nm
Blue	450-500 nm
Green	500-575 nm
Yellow	575-625 nm
Orange	625-675 nm
Red	675-740 nm
Infrared	740-10,000 nm

$$E_{\text{photon}} = E_i - E_f$$
$$= {}^{-}8.716 \times 10^{-20}\ \text{J} - {}^{-}5.448 \times 10^{-19}\ \text{J}$$
$$= 4.57\underline{6}4 \times 10^{-19}\ \text{J}$$
$$= h\nu$$
$$\nu = \frac{4.57\underline{6}4 \times 10^{-19}\ \text{J}}{6.626 \times 10^{-34}\ \text{J} \cdot \text{s}} = 6.90\underline{6}7 \times 10^{14}\ \text{s}^{-1}$$
$$\lambda = \frac{c}{\nu} = \frac{2.998 \times 10^{8}\ \text{m/s}}{6.90\underline{6}7 \times 10^{14}\ \text{s}^{-1}} = 4.34\underline{0}7 \times 10^{-7}\ \text{m}$$
$$= 434.1\ \text{nm (purple light)}$$

28. Under what circumstances could the consequence of the above energy level transition be directly observed by a chemistry student? What equipment is necessary and what specific observation would that energy level transition correspond to? (*4 pts*)

If a glass tube filled with hydrogen gas is subjected to a high voltage (as in an atomic emission lamp), the tube will glow brightly as photons descend from high to lower energy levels. If this light is viewed through a prism or diffraction grating, discrete bands of light will be visible. The specific energy level transition above produces purple light, and as such it's result will be directly visible in the form of the purple band visible through the diffraction grating, as part of the atomic line spectrum.