

**AP Chemistry Problem Set Chapter 7**

Name \_\_\_\_\_

Due: Monday, December 11<sup>th</sup>, 2006

30 points – 5 points for completion, 3 random essay problems will be graded, each worth 5 points. Each multiple choice must be answered (1 point each). Staple this sheet to the front of your essay responses.

**Multiple Choice.** Please indicate your multiple choice answers below.

1. \_\_\_\_\_ 2. \_\_\_\_\_ 3. \_\_\_\_\_ 4. \_\_\_\_\_ 5. \_\_\_\_\_

6. \_\_\_\_\_ 7. \_\_\_\_\_ 8. \_\_\_\_\_ 9. \_\_\_\_\_ 10. \_\_\_\_\_

(A) 1s _____ 2s $\uparrow$
(B) 1s $\downarrow\uparrow$ 2s $\downarrow\uparrow$
(C) 1s $\downarrow\uparrow$ 2s $\downarrow\uparrow$ 2p $\uparrow$ $\uparrow$ _____
(D) 1s $\downarrow\uparrow$ 2s $\downarrow\uparrow$ 2p $\downarrow\uparrow$ $\downarrow\uparrow$ $\downarrow\uparrow$
(E) [Ar] 4s $\downarrow\uparrow$ 3d $\downarrow\uparrow$ $\uparrow$ $\uparrow$ $\uparrow$ $\uparrow$

1. Represents an atom that is chemically unreactive.
2. Represents an atom in an excited state.
3. Represents an atom that has four valence electrons.
4. Represents an atom of a transition metal.
5. Represents a common ion of an alkaline earth element.

6. Which of the following represents the ground state electron configuration for the  $Mn^{3+}$  ion?
- (A)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4$       (B)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$       (C)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$   
 (D)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$       (E)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^1$

7. One of the outermost electrons in a strontium atom in the ground state can be described by which of the following sets of four quantum numbers?
- (A) 5, 2, 0,  $\frac{1}{2}$       (B) 5, 1, 1,  $\frac{1}{2}$       (C) 5, 1, 0,  $\frac{1}{2}$       (D) 5, 0, 1,  $\frac{1}{2}$       (E) 5, 0, 0,  $\frac{1}{2}$

Ionization Energies for element X ( $\text{kJ mol}^{-1}$ )				
First	Second	Third	Fourth	Five
580	1815	2740	11600	14800

8. The ionization energies for element X are listed in the table above. On the basis of the data, element X is most likely to be:
- (A) Na      (B) Mg      (C) Al      (D) Si      (E) P
9. In the periodic table, as the atomic number increases from 11 to 17, what happens to the atomic radius?
- (A) It remains constant.      (B) It increases only.      (C) It increases, then decreases.  
 (D) It decreases only.      (E) It decreases, then increases.
10. The electron configuration:  $1s^2 2s^2 2p^6 3s^2 3p^6$  corresponds to the electron configuration of:
- (A)  $S^{2-}$       (B)  $Ca^{2+}$       (C) Cl<sup>-</sup>      (D)  $K^+$       (E) all of these

## Essays:

### 1. (1999 - #2)

Answer the following questions regarding light and its interactions with molecules, atoms, and ions.

- The longest wavelength of light with enough energy to break the Cl-Cl bond in  $\text{Cl}_2(g)$  is 495 nm.
  - Calculate the frequency, in  $\text{s}^{-1}$ , of the light.
  - Calculate the energy, in J, of a photon of the light.
  - Calculate the minimum energy, in  $\text{kJ mol}^{-1}$ , of the Cl-Cl bond.
- A certain line in the spectrum of atomic hydrogen is associated with the electronic transition in the H atom from the sixth energy level ( $n = 6$ ) to the second energy level ( $n = 2$ ).
  - Indicate whether the H atom emits energy or whether it absorbs energy during the transition. Justify your answer.
  - Calculate the wavelength, in nm, of the radiation associated with the spectral line.
  - Account for the observation that the amount of energy associated with the same electronic transition ( $n = 6$  to  $n = 2$ ) in the  $\text{He}^+$  ion is greater than that associated with the corresponding transition in the H atom.

### 2. (1993 - #6 a & b; 2006B - #7 b, c & d)

Account for each of the following in terms of principles of atomic structure, including the number, properties, and arrangements of subatomic particles.

- The second ionization energy of sodium is about three times greater than the second ionization energy of magnesium.
- The difference between the atomic radii of Na and K is relatively large compared to the difference between the atomic radii of Rb and Cs.
- Atomic size decreases from Na to Cl in the periodic table.
- The first ionization energy of K is less than that of Na.
- Each element displays a unique gas-phase emission spectrum.

### 3. (2000 - #7 a, b & c; 2005 - #7 c)

Answer the following questions about the element selenium, Se (atomic number 34).

- Samples of natural selenium contain six stable isotopes. In terms of atomic structure, explain what these isotopes have in common, and how they differ.
- Write the complete electron configuration (e.g.,  $1s^2 2s^2 \dots$  etc.) for a selenium atom in the ground state. Indicate the number of unpaired electrons in the ground-state atom, and explain your reasoning.
- In terms of atomic structure, explain why the first ionization energy of selenium is
  - less than that of bromine (atomic number 35), and
  - greater than that of tellurium (atomic number 52).
- As shown in the table below, the first ionization energies of Si, P, and Cl show a trend.

Element	First Ionization Energy ( $\text{kJ mol}^{-1}$ )
Si	786
P	1,012
Cl	1,251

- For each of the three elements, identify the quantum level (e.g.,  $n = 1$ ,  $n = 2$ , etc.) of the valence electrons in the atom.
- Explain the reasons for the trend in first ionization energies.

4. (2002 - #6 a & b; 2003B - #7 b, c & d)

Account for the following observations using principles of atomic structure and/or chemical bonding. In each part, your answer must include specific information about both substances.

- (a) The atomic radius of Li is larger than that of Be.
- (b) The second ionization energy of K is greater than the second ionization energy of Ca.
- (c) Carbon and lead are in the same group of elements, but carbon is classified as a nonmetal and lead is classified as a metal.
- (d) Compounds containing Kr have been synthesized, but there are no known compounds that contain He.
- (e) The first ionization energy of Be is  $900 \text{ kJ mol}^{-1}$ , but the first ionization energy of B is  $800 \text{ kJ mol}^{-1}$ .

5. (2006 - #8)

Suppose that a stable element with atomic number 119, symbol Q, has been discovered.

- (a) Write the ground-state electron configuration for Q, showing only the valence-shell electrons.
- (b) Would Q be a metal or a nonmetal? Explain in terms of electron configuration.
- (c) On the basis of periodic trends, would Q have the largest atomic radius in its group or would it have the smallest? Explain in terms of electronic structure.
- (d) What would be the most likely charge of the Q ion in stable ionic compounds?
- (e) Write a balanced equation that would represent the reaction of Q with water.
- (f) Assume that Q reacts to form a carbonate compound.
  - (i) Write the formula for the compound formed between Q and the carbonate ion,  $\text{CO}_3^{2-}$ .
  - (ii) Predict whether or not the compound would be soluble in water. Explain your reasoning.