Atomic Structure & Periodicity –

AP Chemistry Name----------

Free response questions:

$c = \lambda\upsilon$, $E = hc/\lambda$, $E_n = -2.18 \times 10^{-18}$ J / n^2, $\lambda = h/mv$, $E = -13.6ev/n^2$

$c = 2.998 \times 10^8$ m/s $h = 6.626 \times 10^{-34}$ J·s

1) An electron is moving from 3rd level to 2nd level.

   a) Calculate the energy of an electron in the n=2 energy level of hydrogen.

   b) Calculate the energy of an electron in the n=3 energy level.

   c) What is the difference in energy of these two levels?

   d) If a photon of light had this energy, what would its wavelength be?

2) An electron moves from the n=5 to the n=1 quantum level and emits a photon with an energy of 2.093×10^{-18} J.

   a) What is the wavelength of this energy?

3) An electron moves with a velocity of 2.5×10^8 m/s.

   a) What is its wavelength? (The mass of an electron is 9.109×10^{-31} Kg.)

   b) What is the frequency associated with this light?

4) a) Using Bohr's equation for the energy levels of the electron in the hydrogen atom, determine the energy (ev) of an electron in the n = 4 level.

   b)What is the energy in Joules unit?

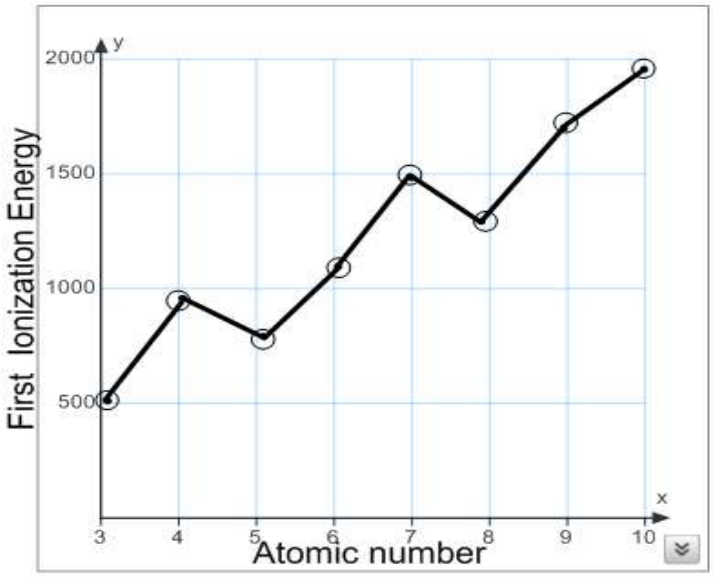
   c) What is the frequency associated with this electron?

   d) What is the wavelength associated with this electron?

5) a) Calculate energy (J) associated with a transition from n = 2 to n = 6 in the Bohr hydrogen atom.

b) Is this transition results in emission or absorption?

c) What is the wavelength of the light in this transition?



6) The first ionization energies of 2nd period elements are given in the above diagram.

Briefly explain each of the following in terms of atomic structure.

a) In general, there is an increase in the first ionization energy from Li to Ne.
b) The first ionization energy of B is lower than that of Be.
c) The first ionization energy of O is lower than that of N.
d) Predict how the first ionization energy of Na compares to those of Li and of Ne. Explain.

7) The green pigment, Chlorophyll found in plants absorbs light with a wavelength of 660 nm.

a) Determine the frequency of the chlorophyll.

b) Calculate the energy of a photon of light with a wavelength of 660nm.

c) In the Balmer series of Hydrogen, one spectral line is associated with the transition of an electron from the fourth energy level to the second energy level. Indicate whether energy is absorbed or emitted as the electron moves from n=4 to n=2. Explain

d) Determine the wavelength of this spectral line.

e) Indicate whether the wavelength calculated in (2) is longer or shorter than the wavelength associated with an electron moving from n=5 to n=2. Explain.

8) The values of the first three ionization energies for Magnesium and Argon are as follows.

	I_1	I_2	I_3 KJ/mol
Mg	735	1443	7730
Ar	1525	2665	3945

a) Give the electronic configuration of Mg and Ar

b) In terms of these configurations, explain why the values of first and second ionization energies of Mg are significantly lower than the values for Ar, where as the third Ionization of Mg is much larger than the third Ionization of Ar.

c) If a sample of Ar in one container and a sample of Mg in another container are each heated and chlorine is passed into each container. What compounds, if any will be formed? Explain in terms of electric configurations given in part (a).

d) Element Q has the following first three ionization energies:

	I_1	I_2	I_3 KJ/mol
Q	496	4568	6920

What is the formula for the most likely compound element Q with chlorine? Explain the choice of formula on the basis of the ionization energies.

9) Use principles of atomic structure and/or chemical bonding to answer each of the following.

a) The radius of the Ca atom is 0.197 nanometer; the radius of the Ca^{2+} ion is 0.099 nanometer. Account for this difference.

b) The lattice energy of $CaO(s)$ is -3,460 kilojoules per mole; the lattice energy for $K_2O(s)$ is -2,240 kilojoules per mole. Account for this difference.

	Ionization energy kJ/m	
	1st	2nd
K	419	3050
Ca	590	1140

c) Explain the difference between Ca and K in regard to

(i) their first ionization energies,

(ii) their second ionization energies.

d) The first ionization energy of Mg is 738 kilojoules per mole and that of Al is 578 kilojoules per mole. Account for this difference.

10) Use principles of atomic structure and/or chemical bonding to answer each of the following.

a) Write the ground state electron configuration for an arsenic atom, showing the number of electrons in each subshell

b) Give one permissible set of four quantum numbers for each of the outermost electrons in a single As atom when it is in its ground state.

c) Is an isolated arsenic atom in the ground state paramagnetic or diamagnetic? Explain briefly.

d) Explain how the electron configuration of the arsenic atom in the ground state is consistent with the existence of the following known compounds: Na_3As, $AsCl_3$, and AsF_5.

11) Use the details of modern atomic theory to explain each of the following experimental observations.

a) Within a family such as the alkali metals, the ionic radius increases as the atomic number increases.

b) The radius of the chlorine atom is smaller than the radius of the chloride ion, Cl^-. (Radii : Cl atom = 0.99Å; Cl^- ion = 1.81 Å)

c) The first ionization energy of aluminum is lower than the first ionization energy of magnesium. (First ionization energies: $_{12}Mg$ = 7.6 ev; $_{13}Al$ = 6.0 ev)

d) For magnesium, the difference between the second and third ionization energies is much larger than the difference between the first and second ionization energies. (Ionization energies for Mg: 1st = 7.6 ev; 2nd = 14 ev; 3rd = 80 ev)

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

a) The second ionization energy of sodium is about three times greater than the second ionization energy of magnesium.

b) 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.

c) A sample of nickel chloride is attracted into a magnetic field, whereas a sample of solid zinc chloride is not.

d) Phosphorus forms the fluorides PF_3 and PF_5, whereas nitrogen forms only NF_3.

13) Explain each of the following observations using principles of atomic structure and/or bonding.

a) Potassium has a lower first-ionization energy than lithium.

b) The ionic radius of N^{3-} is larger than that of O^{2-}.

c) A calcium atom is larger than a zinc atom.

d) Boron has a lower first-ionization energy than beryllium.

14) a) The first ionization energy of Li is larger than that of Be

b) The second IE of K is greater than the second IE of Ca

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

a) Samples of natural selenium contain six stable isotopes. In terms of atomic structure, explain what these isotopes have in common, and how they differ.

b) Write the complete electron configuration (e.g. 1s2, 2s2, … etc.) for a selenium atom in the ground state. Indicate the number of unpaired electrons in the ground-state atom, and explain your reasoning.

c) In terms of atomic structure, explain why the first ionization energy of selenium is:

(i) less than that of bromine (atomic number 35), and

(ii) greater than that of tellurium (atomic number 52).

15)

a) The Ca^{2+} and Cl^- ions are isoelectronic, but their radii are not the same. Which ion has the larger radius? Explain.

b) Carbon and lead are in the same group of elements, but carbon is classified as a nonmetal and lead is classified as a metal.

c) Compounds containing Kr have been synthesized, but there are no known compounds that contain He.

d) The first ionization energy of Be is 900 kJ mol -1, but the first ionization energy of B is 800 kJ mol -1.

Answer:

1)
a) $E_2 = -5.45 \times 10^{-19}$ J
b) $E_3 = -2.42 \times 10^{-19}$ J
c) $\Delta E = 3.03 \times 10^{-19}$ J
d) $\lambda = hc/E = 6.6 \times 10^{-7}$ m

2) E5-E1
$\Delta E = 2.09 \times 10^{-18}$
$\lambda = hc / \Delta E = 9.50 \times 10^{-8}$ J

3) a) 2.909×10^{-12} m
b) 1.03×10^{20}hz

4)
a) -0.85ev
b) 1.361×10^{-19} J
c) 2.054×10^{14} hz
d) 1.461×10^{-6} m

5)
a) 4.84×10^{-19} J
b) absorption
c) 4.107×10^{-6} m

7)
a) Frequency $\nu = c/\lambda$

b) $E = h \nu =$
$= 3.01 \times 10^{-19}$ J

c) Energy will be emitted when electron moves from a higher energy 4th level to low energy 2nd level. The energy will be emitted in the form of a photon.

d) $E = -2.18 \times 10^{-18} / n^2$

Change in $E = -2.18 \times 10^{-18} (1/4^2 - 1/2^2) = 4.08 \times 10^{-19}$ J

$E = hc/\lambda$

$= 4.60 \times 10^{-7}$m or 460 nm