Name_____ **Approximately 10% of the AP exam**

AP Chemistry Exam Practice Part 5: Atomic Theory, Periodicity, Spectroscopy

ZAX

A = mass number Z = atomic number

A = number of protons + neutrons = approximate mass

Z = number of protons

Isotopes = atoms with same # of p+ but different # of nº

Ions = electrons vary

# of p^+(Atomic #) defines the element

1. Consider $3067X^{+2}$

How many protons does this species have? _____

How many neutrons does this species have? _____

How many electrons does this species have? _____

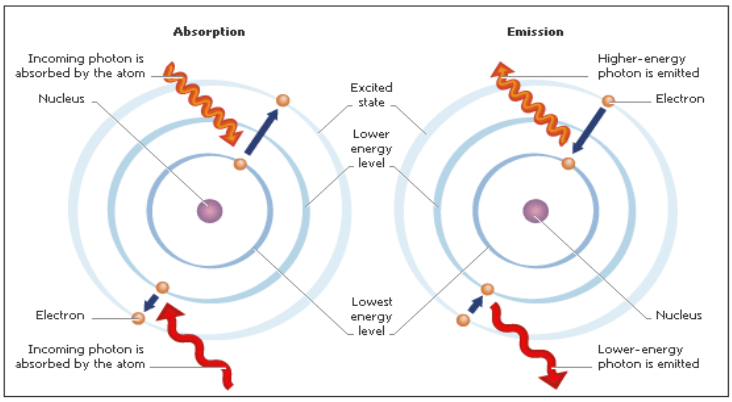
Indeed, this is an _____ (ion? isotope?) of

_____ (what element?)

Excited electrons have absorbed energy and "jumped" to a higher energy level. They possess more energy than before.

They fall back down to a lower energy state and must release energy in the form of ONE quantum/photon, E = hν

Only certain sized photons (lines of frequency/wavelength) are emitted so each element has its own distinct line emission spectrum. This is due to the existence of quantized energy states in atoms.



2. a.) An electron in the hydrogen atom fell from a higher energy level to a lower one and released a photon of light with a wavelength of 97.2nm. What energy was required or released by the electron?

Tip: E=-Rhc/n2 is not used on the AP exam any longer, instead the energy of a given energy level will be provided, or asked as in the question above. No need to memorize this equation either.

b.) The ionization energy of an element is 2,747 kJ/mol. What is the minimum frequency and maximum wavelength required to remove the outermost electron from this element?

Pauli Exclusion Principle	No 2 electrons in the same atom can have the same 4 quantum numbers; thus no 2 electrons can be in the same energy level/sublevel/orbital AND have same spin; 2 electrons in same orbital must have opposite spins
Aufbau Rule	Electrons fill up orbitals from lowest energy to highest energy (this may not be in numerical order! See aufbau box below) 2 is higher than 1; d is higher than p, etc….
Hund's Rule (Bus Rule!)	If 2 equal energy orbitals are available, electrons each go to separate orbitals (with same spin) before pairing up 2p: ____ ↑ ↑

Sublevel	**orbitals within**	**Shape of orbitals**	**3. Draw a picture**	**# of electrons in an orbital**	**# of electrons in sublevel**
s	s	Spherical		2	2
p	p_x, p_y, p_z	Dumbbell shaped		2	6
d	d_{xy}, d_{xz}, d_{yz}, d_{z2}, d_{x2-y2}	4 lobed		2	10
f	7 different f's	8 lobed/too complex	Don't even try	2	14
g	9 different g's	!!!!!	AAAAH!	2	18

Quantum numbers describe where a given electron is in an atom.

1st quantum #	Energy level	1, 2, 3, 4….
2nd quantum #	sublevel	s, p, d, f
3rd quantum #	Orbital/orientation	p_x, p_y, p_z, for example
4th quantum #	spin	

3. Aufbau box: *(add arrows)*

1s

2s 2p

3s 3p 3d

4s 4p 4d 4f

5s 5p 5d 5f 5g

6s 6p 6d 6f 6g 6h

7s 7p 7d 7f 7g 7h 7i

8s 8p 8d…….

Example of **orbital** notation:

C: 

Examples of **electron configuration**:
K: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
Mn: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$
Ag: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1 4d^{10}$

4. a. Give the orbital notation of N^- ion.

b. Give the electron configuration of Pb:

Electron configuration of ions:
- Metals lose their s (and p electrons, if they have them)
- Nonmetals gain enough electrons to fill their outermost p sublevel
- Transition metals ALWAYS lose from the **s** subshell first, then the **d** subshell, even though the **d** subshell was filled last.

5. Mg^{+2}:

Cl^-:

Hg^{+2}:

Ti^{+3}:

Ions or atoms with the same electron configuration are **isoelectronic**.

unpaired electrons = #electrons alone in orbital
C has 2 unpaired electrons
K has 1, Ag has 1, Pb has 2, Mn has 5, Mg has 0

Unpaired electrons make element **paramagnetic**.

Spectroscopy: Radiation can be used to identify parts or arrangements within an atom or molecule.

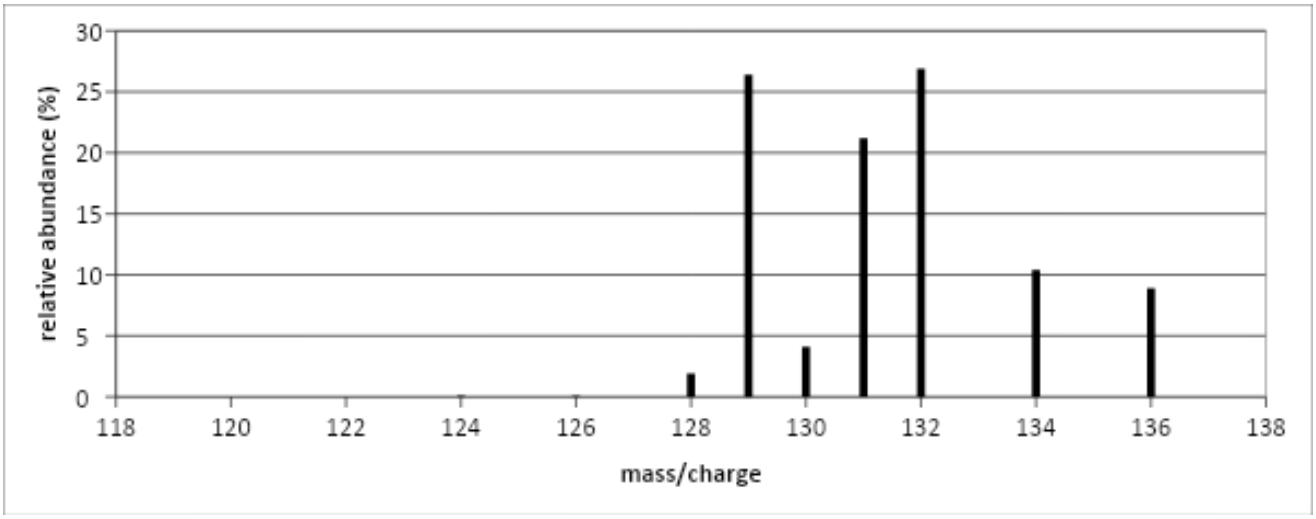
TYPE	USES	TO DETERMINE/Produce	HOW
Mass Spectroscopy	Magnets	Distinguishes isotopes (separates by mass)	The magnet bends heavier isotopes more than lighter ones
Photoelectron Spectroscopy	Beam of X-ray	Binding Energy of electrons in different sublevels within a given atom	"Light" beam (could be other form of ER) gives energy to electrons and removes them from the atom- this energy is measured…takes more energy to remove innermost electrons than outermost electrons
Atomic absorption spectroscopy or Atomic Emission Spectroscopy	Energy to Excited the electrons	Line Emission spectra (or line absorption spectra) which identifies the elements	Energy excites electrons and they absorb a specific wavelength, then when they fall back down, they release a specific wavelength
Visible/UV spectroscopy Infrared Spectroscopy	Visible light or UV light to excite electrons in bonds, Infrared causes bonds to vibrate, Microwaves cause bonds to rotate	Identity of a substance/molecule	Electrons in bonds also have quantized energies and these energies can be used to identify a molecule

Microwave Spectroscopy			

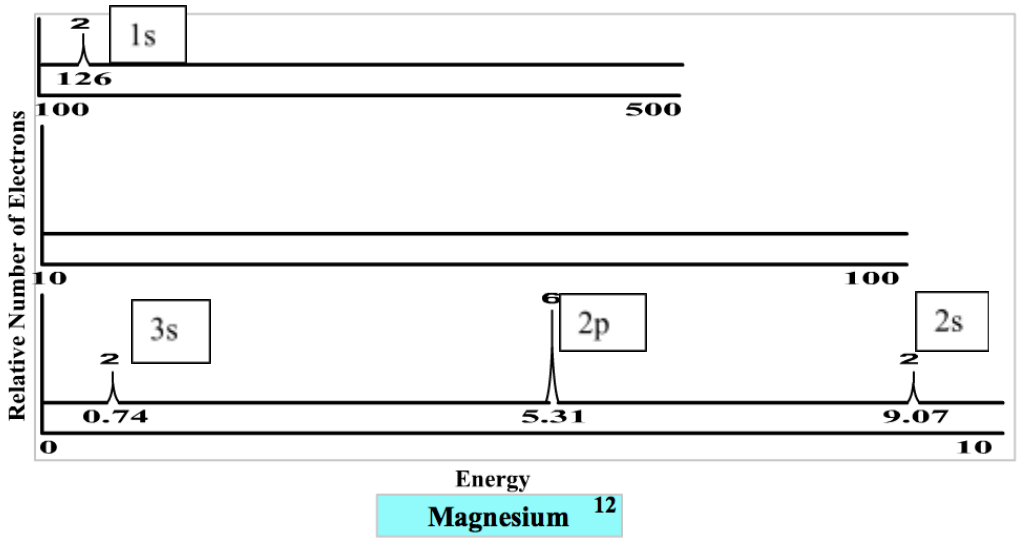
Type of radiation Used	Frequency	Relative Energy	What it does to the atom/molecule	What it tells us about the atom/molecule	Name of Spectroscopy
X-ray	$10^{16} – 10^{19}$ Hz	Quite High	Removes core electrons	How tightly the electrons are held by the nucleus (Measures their binding energy); the identity of an element	Photoelectron spectroscopy (PES)
Ultraviolet	$10^{14} – 10^{16}$ Hz	High	Excites valence electrons	The identity of a molecule or element	UV-Visible Spectroscopy
Visible Light	10^{14} Hz	Medium	Excites valence electrons	The identity or concentration of a molecule	UV-Visible Spectroscopy
Infrared	$10^{11} – 10^{14}$ Hz	Low	Changes the vibrations in the bonds	The types of bonds/atoms/functional groups within a molecule	IR (vibrational) spectroscopy
Microwave	$10^{9} – 10^{11}$ Hz	Quite Low	Changes the rotations of the atoms in the bonds	The locations of hydrogen atoms within a molecule	Microwave (rotational) spectroscopy

Mass Spectrometry Data: …each bar represents the mass and abundance of a given isotope.

6. What element is this? _____Use the graph below, calculate the average atomic mass. (Show your work) What is the molar mass?


relative abundance (%)
30
25
20
15
10
5
0
118
120
122
124
126
128
130
132
134
136
138
mass/charge

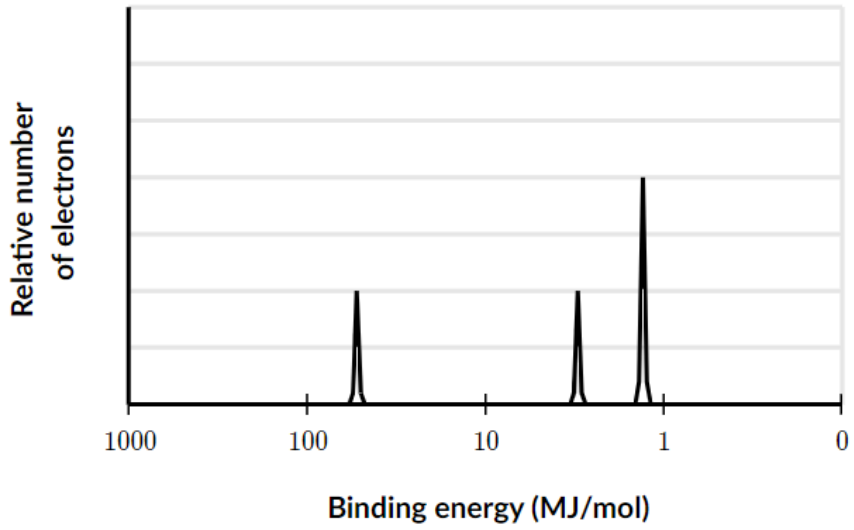
PES data: (photoelectron spectroscopy)…each bar represents the abundance AND energy to remove each of the electrons from an atom **(binding energy!)**. The **outermost** (valence) electrons take the **least** amount of energy to remove.



Be careful! *Sometimes x axis goes from highest to lowest!*

7. What element's photoelectron spectrum is shown below? _____

Based on the PES below, what is the approximate 1st ionization energy of this element?



Coulomb's Law can be used to explain atomic radius, ionization energy, electronegativity, and electron affinity.

$$F = \frac{kq_1q_2}{d^2}$$

where q_1 and q_2 are charges on the nucleus and a given electron, and d is the distance between them.

(for discussing repulsive forces between electrons, then q_1 and q_2 are the charges on 2 electrons)

Beer's Law: $A = \varepsilon bc$

A = absorbance
C = Concentration of the absorbing species

ε = Molar absorptivity or molar extinction coefficient (constant for a particular species)

b = Cell thickness (solution thickness)

PLAIN ENGLISH: The amount of light at a given wavelength that is absorbed by a solution depends on the concentration of the solution, the thickness (diameter) of the solution, and a constant.

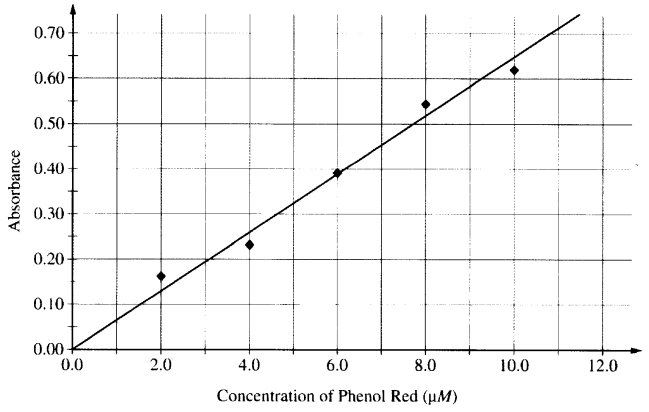
OR, if the thickness of the container used and the identity of the solution used don't change, the concentration of the solution is directly proportional to the absorbance.

8. A student is given a solution of phenol red of unknown concentration. Solutions of phenol red are bright pink under basic conditions.

a. The student uses a pH probe and determines that the pH of the solution is 11.20. Calculate the hydrogen ion concentration, $[H^+]$, in the solution of phenol red.

The student analyzes a sample of the solution using a spectrophotometer set at a wavelength of 559 nm, the wavelength of maximum absorbance for phenol red. The measured absorbance of the phenol red solution of 559 nm is 0.35.

b. Based on the calibration curve shown below, what is the concentration of the solution in micromoles per liter (μM)?



c. If the student mixed 10 mL of distilled water with 10 mL of the sample, would this diluted solution have an absorbance greater than, less than, or equal to the absorbance of the original solution? Justify your answer.

d. If the student measured the absorbance of the solution at a wavelength of 650 nm, would the absorbance be greater than, less than, or equal to the absorbance of the solution at 559 nm? Justify your answer.

e. Place a dot on the graph for a sample of phenol red with a concentration of 3.0 micromolar and a fingerprint in the way of the light on the cuvette.

+1

H
+1/-1

+2

S block

Alkaline earth metals

9. Increasing nuclear charge explains ***everything***: increasing ability to attract electrons, _____ AR, _____ EN, _____ IE, which both explain _____ reactivity across metals, _____ reactivity among nonmetals

-4 | -3 | -2 | -1

No ions formed usually

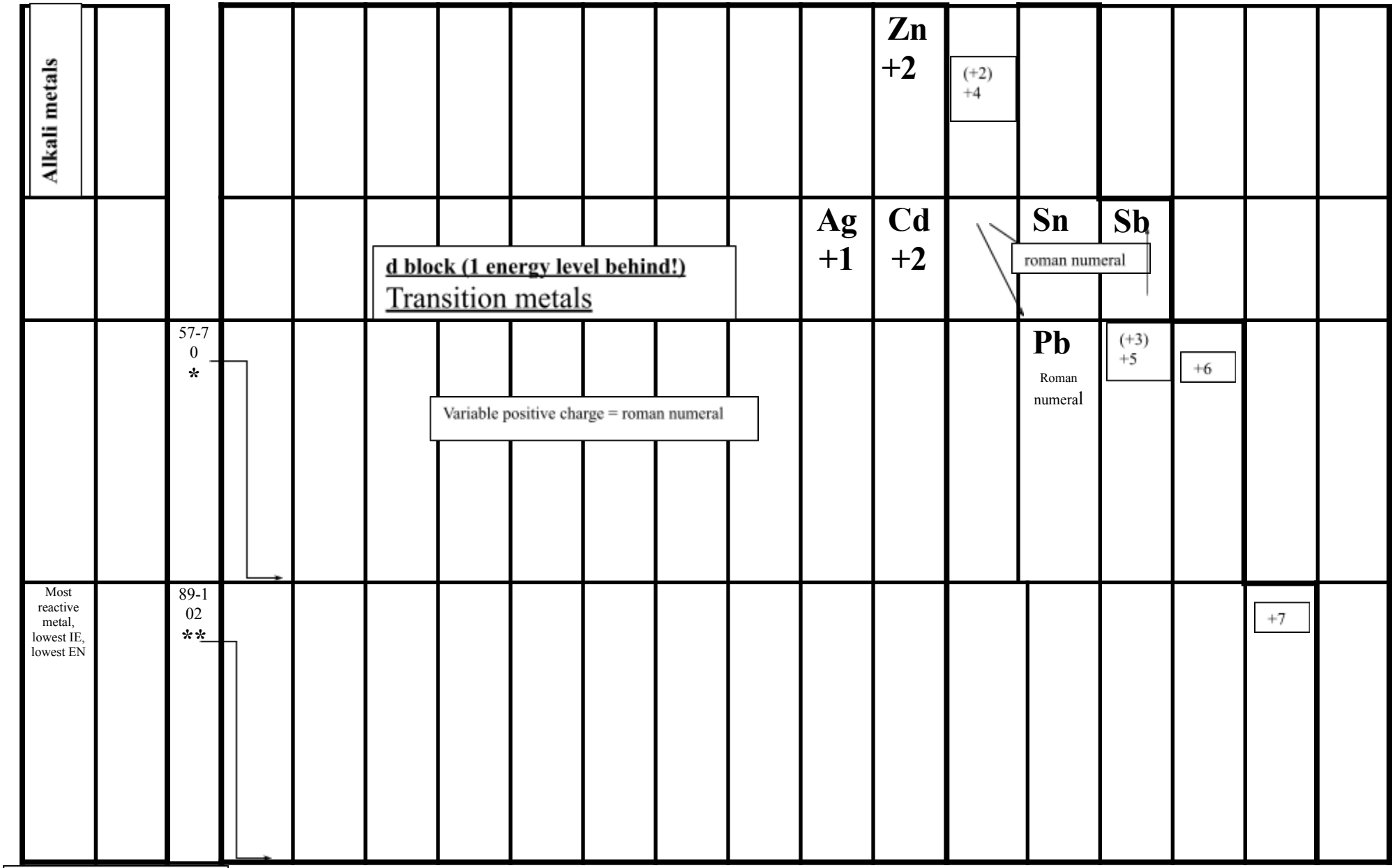
Highest IE

Most reactive nonmetal, highest EN

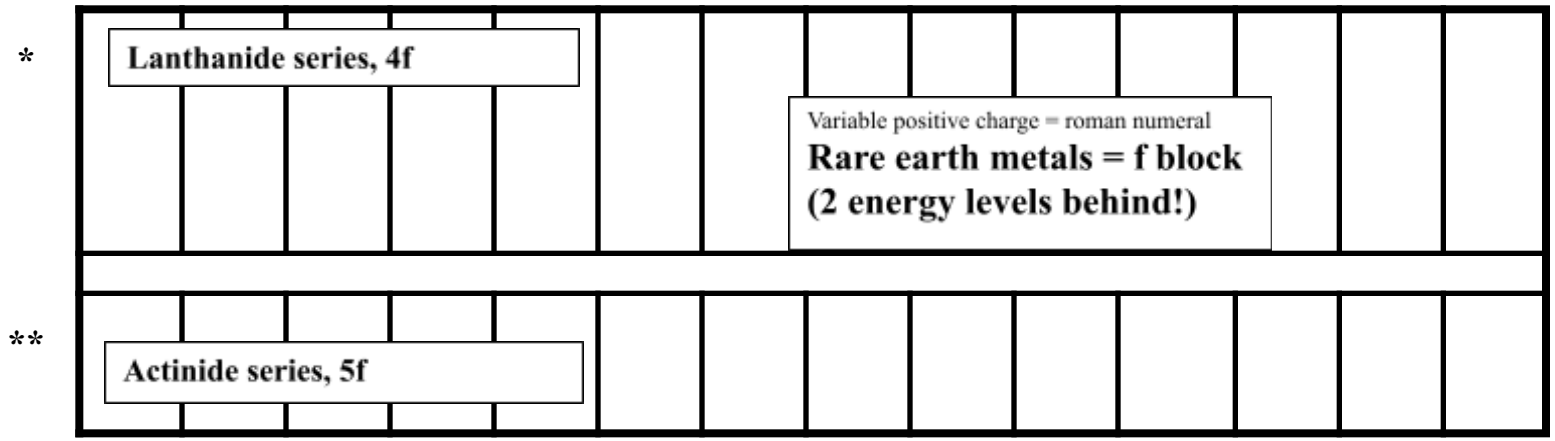
No measurable EN (too low), high IE, INERT!

+3

p block



y levels (and thus
us!) explains
act electrons,
EN
reactivity
reactivity


*
Lanthanide series, 4f
Variable positive charge = roman numeral
Rare earth metals = f block
(2 energy levels behind!)
**
Actinide series, 5f

11. Answer the following using appropriate chemical principles and specific information about each species. What element has the larger radius and why?

a.) calcium or barium

b.) calcium or magnesium

c.) Ca^{2+} or S^{2-}

12. Answer the following using appropriate chemical principles and specific information about each species.

a.) Which element has the largest ionization energy and why? Calcium or Barium?

b.) Which element has the highest electronegativity and why? Sulfur, Chlorine, or Argon?

c.) There is a large jump between the 2^{nd} and 3^{rd} ionization energy for calcium. Explain.

Optional Multiple choice practice: 2012

Questions 11 – 13

(A) Cs
(B) Ag
(C) Pb
(D) Br
(E) Se

11. Has the highest electronegativity
12. Has the lowest first ionization energy
13. Has the largest atomic radius.

23. Which of the following statements about atoms is NOT correct?

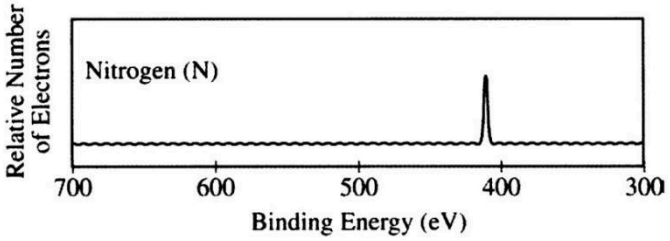
(A) Atoms are electrically neutral because they have the same number of protons and electrons.
(B) All atoms of a given element must have the same number of protons, neutrons, and electrons.
(C) Most of the volume of an atom contains only electrons.
(D) The nucleus is positively charged.
(E) Almost all of the mass of an atom is in the nucleus.

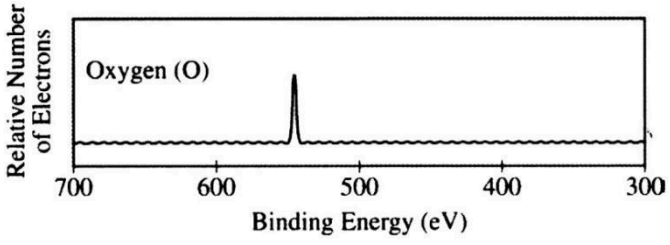
2013

41. N_2 molecules absorb ultraviolet light but not visible light. I_2 molecules absorb both visible and ultraviolet light. Which of the following statements explains the observations?

a. More energy is required to make N_2 molecules vibrate than is required to make I_2 molecules vibrate.
b. More energy is required to remove an electron from an I_2 molecule than is required to remove an electron from an N_2 molecule.
c. Visible light does not produce transitions between electronic energy levels in the N_2 molecule but does produce transitions in the I_2 molecule.
d. The molecular mass of I_2 is greater than the molecular mass of N_2.

43.





The photoelectron spectra above show the energy required to remove a 1*s* electron from a nitrogen atom and from an oxygen atom. Which of the following statements best accounts for the peak in the upper spectrum being to the right of the peak in the lower spectrum?

a. nitrogen atoms have a half-filled *p* subshell.
b. There are more electron-electron repulsions in oxygen atoms than in nitrogen atoms.
c. Electrons in the *p* subshell of oxygen atoms provide more shielding than electrons in the *p* subshell of nitrogen atoms.
d. Nitrogen atoms have a smaller nuclear charge than oxygen atoms.

58.

Element	Atomic Radius	First Ionization Energy
Calcium	194 pm	590 kJ / mol
Potassium		

Based on periodic trends and the data in the table above, which of the following are the most probable values of the atomic radius and the first ionization energy for potassium, respectively?

a. 242 pm, 633 kJ / mol
b. 242 pm, 419 kJ / mol
c. 120 pm, 633 kJ / mol
d. 120 pm, 419 kJ / mol

From the 1984 AP Exam

19. Which of the following represents a pair of isotopes?

		Atomic Number	Mass Number
(A)	I.	6	14
	II.	7	14
(B)	I.	6	7
	II.	14	14
(C)	I.	6	14
	II.	14	28
(D)	I.	7	13
	II.	7	14
(E)	I.	8	10
	II.	16	20

22. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

Atoms of an element, X, have the electronic configuration shown above. The compound most likely formed with magnesium, Mg, is

(A) MgX (C) MgX_2 (E) Mg_3X_2
(B) Mg_2X (D) MgX_3

24. The formula for potassium hexacyanoferrate (II) is

(A) $K_4[Fe(CN)_6]$ (C) $K_2[Pt(CN)_4]$
(D) $K_2[Pt(CN)_6]$ (B) $K_3[Fe(CN)_6]$ (E) KCN

43. The elements in which of the following have most nearly the same atomic radius?

(A) Be, B, C, N (D) C, P, Se, I
(B) Ne, Ar, Kr, Xe (E) Cr, Mn, Fe, Co
(C) Mg, Ca, Sr, Ba

58. Which of the following represents the ground state electron configuration for the Mn^{3+} ion? (Atomic number Mn = 25)

(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) $1s^2\ 2s^2 2p^6\ 3s^2 3p^6 3d^3\ 4s^1$

From the 1989 AP Exam:

Questions 1–3

a. O c. Rb e. N
b. La d. Mg

1. What is the most electronegative element?
2. Which element exhibits the greatest number of different oxidation states?
3. Which of the elements above has the smallest ionic radius for its most commonly found ion?

Questions 4–7

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

4. An impossible electronic configuration
5. The ground–state configuration for the atoms of a transition element
6. The ground–state configuration of a negative ion of a halogen
7. The ground–state configuration of a common ion of an alkaline earth element

33. Which of the following conclusions can be drawn from J. J. Thomson's cathode ray experiments?

a. Atoms contain electrons.
b. Practically all the mass of an atom is contained in its nucleus.
c. Atoms contain protons, neutrons, and electrons.
d. Atoms have a positively charged nucleus surrounded by an electron cloud.
e. No two electrons in one atom can have the same four quantum numbers.

From the 1994 AP Exam

Questions 1–4

(A) Heisenberg uncertainty principle
(B) Pauli exclusion principle
(C) Hund's rule (principle of maximum multiplicity)
(D) Shielding effect
(E) Wave nature of matter

1. Can be used to predict that a gaseous carbon atom in its ground state is paramagnetic
2. Explains the experimental phenomenon of electron diffraction
3. Indicates that an atomic orbital can hold no more than two electrons
4. Predicts that it is impossible to determine simultaneously the exact position and the exact velocity of an electron

54. All of the following statements concerning the characteristics of the halogens are true EXCEPT:

(A) The first ionization energies (potentials) decrease as the atomic numbers of the halogens increase.
(B) Fluorine is the best oxidizing agent.
(C) Fluorine atoms have the smallest radii.
(D) Iodine liberates free bromine from a solution of bromide ion.
(E) Fluorine is the most electronegative of the halogens.

From the 1999 AP Exam

Questions 1-4 refer to the following types of energy.

(A) Activation energy
(B) Free energy
(C) Ionization energy
(D) Kinetic energy
(E) Lattice energy

1. The energy required to convert a ground-state atom in the gas phase to a gaseous positive ion
2. The energy change that occurs in the conversion of an ionic solid to widely separated gaseous ions
3. The energy in a chemical or physical change that is available to do useful work
4. The energy required to form the transition state in a chemical reaction

Question 5-8 refer to atoms for which the occupied atomic orbitals shown below.

(A) 1s ___ 2s ↑
(B) 1s ↑↓ 2s ↑↓
(C) 1s ↑↓ 2s ↑↓ 2p ↑ ↑ ___
(D) 1s ↑↓ 2s ↑↓ 2p ↑↓ ↑↓ ↑↓
(E) [Ar] 4s ↑↓ 3d ↑↓ ↑ ↑ ↑ ↑

5. Represents an atom that is chemically unreactive
6. Represents an atom in an excited state
7. Represents an atom that has four valence electrons.
8. Represents an atom of a transition metal.

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

37. 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

50. 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.

51. Which of the following is a correct interpretation of the results of Rutherford's experiments in which gold atoms were bombarded with alpha particles?
(A) Atoms have equal numbers of positive and negative charges.
(B) Electrons in atoms are arranged in shells.
(C) Neutrons are at the center of an atom.
(D) Neutrons and protons in atoms have nearly equal mass.
(E) The positive charge of an atom is concentrated in a small region.

From the 2002 AP Exam

Questions 1-2: Consider atoms of the following elements. Assume that the atoms are in the ground state.

(A) S (B) Ca (C) Ga (D) Sb (E) Br

1. The atom that contains exactly two unpaired electrons

2. The atom that contains only one electron in the highest occupied energy sublevel.

17. In which of the following groups are the three species isoelectronic; i.e., have the same number of electrons?
(A) S^{2-}, K^{+}, Ca^{2+}
(B) Sc, Ti, V^{2+}
(C) O^{2-}, S^{2-}, Cl^{-}
(D) Mg^{2+}, Ca^{2+}, Sr^{2+}
(E) Cs, Ba^{2+}, La^{3+}

43. The atomic mass of copper is 63.55. Given that there are only two naturally occurring isotopes of copper, ^{63}Cu and ^{65}Cu, the natural abundance of the ^{65}Cu isotope must be approximately
(A) 90 %
(B) 70 %
(C) 50 %
(D) 25 %
(E) 10 %

44. Which of the following properties generally decreases across the periodic table from sodium to chlorine?
(A) First ionization energy
(B) Atomic mass
(C) Electronegativity
(D) Maximum value of the oxidation number
(E) Atomic radius

46. The effective nuclear charge experienced by the outermost electron of Na is different than the effective nuclear charge experienced by the outermost electron of Ne. This difference best accounts for which of the following?

(A) Na has a greater density at standard conditions than Ne.
(B) Na has a lower first ionization energy than Ne.
(C) Na has a higher melting point than Ne.
(D) Na has a higher neutron-to-proton ratio than Ne.
(E) Na has fewer naturally occurring isotopes than Ne.

2008

19. Which of the following ions is isoelectronic with Br^{-}?
(A) Ca^{2+}
(B) K^{+}
(C) Sr^{2+}
(D) I^{-}
(E) Cl^{-}

21. Of the following electron configurations of neutral atoms, which represents an atom in an excited state?
(A) $1s^2 2s^2 2p^5$
(B) $1s^2 2s^2 2p^5 3s^2$
(C) $1s^2 2s^2 2p^6 3s^1$
(D) $1s^2 2s^2 2p^6 3s^2 3p^2$
(E) $1s^2 2s^2 2p^6 3s^2 3p^5$

63. Which of the following best helps to account for the fact that the F^{-} ion is smaller than the O^{2-} ion?
(A) F^{-} has a larger nuclear mass than O^{2-} has
(B) F^{-} has a larger nuclear charge than O^{2-} has
(C) F^{-} has more electrons than O^{2-} has
(D) F^{-} is more electronegative than O^{2-} is
(E) F^{-} is more polarizable than O^{2-} is

24. Which of the following shows the correct number of protons, neutrons, and electrons in a neutral cesium-134 atom?

	Protons	Neutrons	Electrons
(A)	55	55	55
(B)	55	79	55
(C)	55	79	79
(D)	79	55	79
(E) `	134	55	134

From the 2014 AP Exam

3. Which of the following correctly identifies which has the higher first ionization energy, Cl or Ar, and supplies the best justification?
a. Cl, because of its higher electronegativity
b. Cl, because of its higher electron affinity
c. Ar, because of its completely filled valence shell
d. Ar, because of its higher effective nuclear charge

Element	First Ionization Energy (kJ / mol)	Atomic radius (pm)
B	801	85
C	1086	77
N	1400	75
O	1314	73
F	1680	72
Ne	2080	70

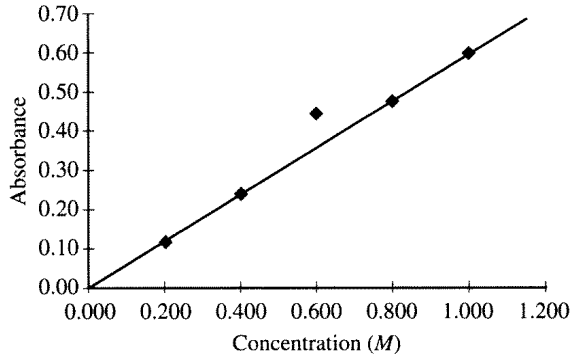
12. The table above shows the first ionization energy and atomic radius of several elements. Which of the following best helps to explain the deviation of the first ionization energy of oxygen from the overall trend?

a. The atomic radius of oxygen is greater than the atomic radius of fluorine.

b. The atomic radius of oxygen is less than the atomic radius of nitrogen.

c. There is repulsion between paired electrons in oxygen's 2*p* orbitals.

d. There is attraction between paired electrons in oxygen's 2*p* orbitals.



27. A student prepared five solutions of $CuSO_4$ with different concentrations, and then filled five cuvettes, each containing one of the solutions. The cuvettes were placed in a spectrophotometer set to the appropriate wavelength for maximum absorbance. The absorbance of each solution was measured and recorded. The student plotted absorbance versus concentration, as shown in the figure above. Which of the following is the most likely explanation for the variance of the data point for the 0.600 M $CuSO_4$ solution?

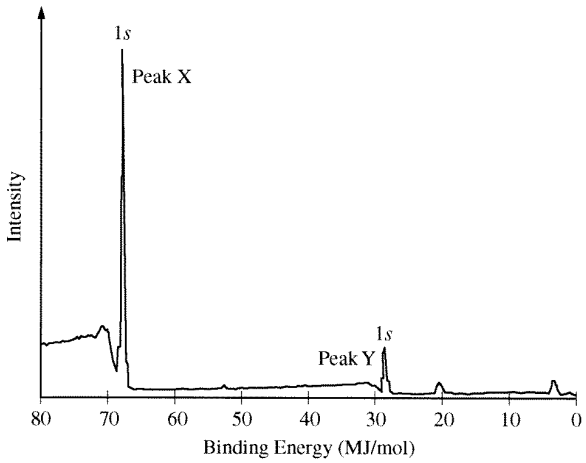
a. The cuvette into which the 0.600 M solution was placed had some water droplets inside.

b. The cuvette into which the 0.600 M solution was placed was filled slightly more than the other cuvettes.

c. The wavelength setting was accidentally moved away from than of maximum absorbance.

d. The cuvette used for the 0.600 M solution had not been wiped clean before being put in the spectrophotometer.

31.



A sample containing atoms of C and F was analyzed using x-ray photoelectron spectroscopy. The portion of the spectrum showing the 1*s* peaks for atoms of the two elements is shown above. Which of the following correctly identifies the 1*s* peak for the F atoms and provides an appropriate explanation?

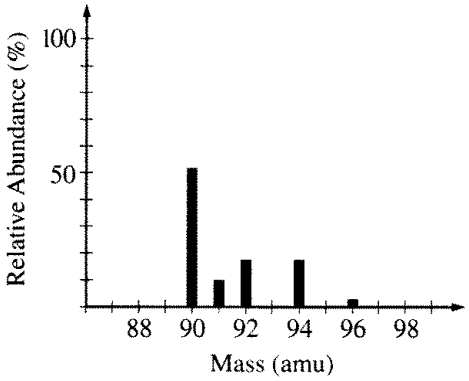
a. Peak X, because F has a smaller first ionization energy than C has.

b. Peak X, because F has a greater nuclear charge than C has.

c. Peak Y, because F is more electronegative than C is.

d. Peak Y, because F has a smaller atomic radius than C has.

From the 2015 AP Exam



3. The mass spectrum of element X is presented in the diagram above. Based on the spectrum, which of the following can be concluded about element X?

a. X is a transition metal, and each peak represent an oxidation state of the metal.

b. X contains five electron sublevels.

c. The atomic mass of X is 90.

d. The atomic mass of X is between 90 and 92.

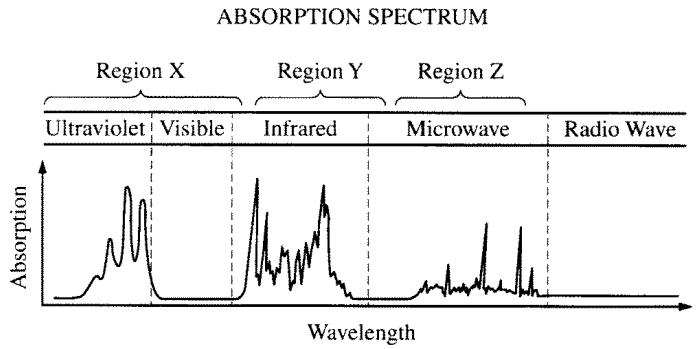
12.

	Ionization Energy (kJ / mol)
First	801
Second	2,430
Third	3,660
Fourth	25,000
Fifth	32,820

The first five ionization energies of a second period element are listed in the table above. Which of the following correctly identifies the element and best explains the data in the table?

a. B, because it has five core electrons
b. B, because it has three valence electrons
c. N, because it has five valence electrons
d. N, because it has three electrons in the p sublevel.

50.



The diagram above represents the absorption spectrum for a pure molecular substance. Which of the following correctly indicates the type of transition observed for the substance in each of the regions of the absorption spectrum?

	Region X	Region Y	Region Z
A	Molecular vibration	Molecular rotation	Electronic transition
b.	Electronic transition	Molecular rotation	Molecular vibration
c.	Molecular rotation	Molecular vibration	Electronic transition
d.	Electronic transition	Molecular vibration	Molecular rotation

Answers:

FRQ:

1. 30, 37, 28, ion, zinc **2.** (a) 2.04 x 10^{-18}J(b) 6.88 x 10^{15} Hz, 43.9 nm

4. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^2$

5. Mg^{+2}:$1s^2 2s^2 2p^6$, Cl^-:$1s^2 2s^2 2p^6 3s^2 3p^6$, Hg^{+2}:$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 4f^{14} 5d^{10}$, Ti^{+3}:$1s^2 2s^2 2p^6 3s^2 3p^6 3d^1$ **6.** Xe, 131.30g/mol **7.** Oxygen

8. (a) 6.3 x 10^{-12}M (b) 5.5 μM (c)less than, dilution lowers the concentration (d) less than **9.** decreasing, increasing, increasing, low, high **10.** increasing, decreasing, decreasing, high, low **11.** (a) Barium; Barium has 6 energy levels, calcium has 4 energy levels (b) S^{-2}; Sulfur has 16 protons, calcium has 20 protons (c) Calcium; calcium has 4 energy levels, magnesium has 3 **12.** (a) Calcium; calcium has 4 energy levels, while Barium has 6, which allows the electrons in calcium to have a stronger coulombic attraction to the protons in the nucleus, making it harder to remove the outermost electron (b) Chlorine; argon is a noble gas, so it is unreactive, chlorine has 7 valence electrons and sulfur has 6 valence electrons, thus making it easier for chlorine to gain a full shell over sulfur (c) It take more energy to remove an electron from a full shell over the valence shell

MCQ:

2012: 11 D 12A 13 A 23 B
2013: 41 C 43D 58 B
1984: 19 D 22 E 24 A 43 E 58 A
1989: 1 A 2 E 3 D 4 C 5 E 6 B 7 B 33 A
1994: 1 C 2 E 3 B 4 A 54 D
1999: 1 C 2E 3B 4A 5D 6A 7C 8E 37 C 50 D 51 E
2002: 1 A 2 C 17 A 43 D 44E 46 B
2008: 19 C 21 B 63 B 24 B
2014: 3D 12C 27D 31 B
2015: 3D 12 B 50 D