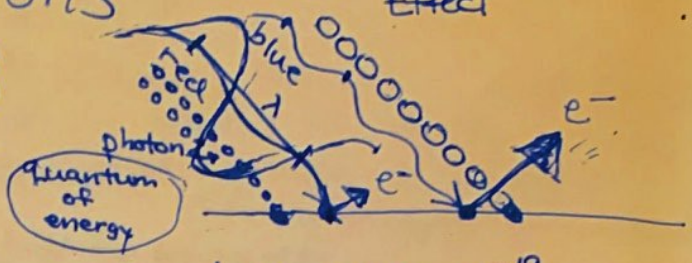
PES Questions

$C = \lambda\nu$
$E = h\nu$
$E = \frac{hc}{\lambda}$

Photoelectric Effect

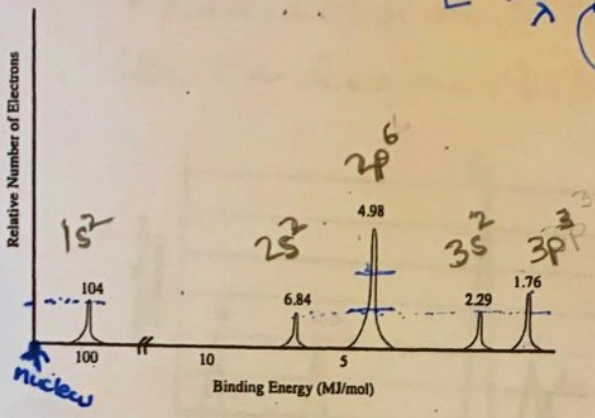


$1 eV = 1.60 \times 10^{-19} J$
↳ usually used when talking ~ the E of a single e⁻

$E = h\nu$ → photons

Multiple-Choice Questions

Use the PES spectra below to answer questions 1-4.



Ioniz. E

Incoming Radiation Energy = Binding Energy + Kinetic Energy (of ejected electron)

1. What element does this spectra represent?
   (A) Boron
   (B) Nitrogen
   (C) Aluminum
   (D) Phosphorus

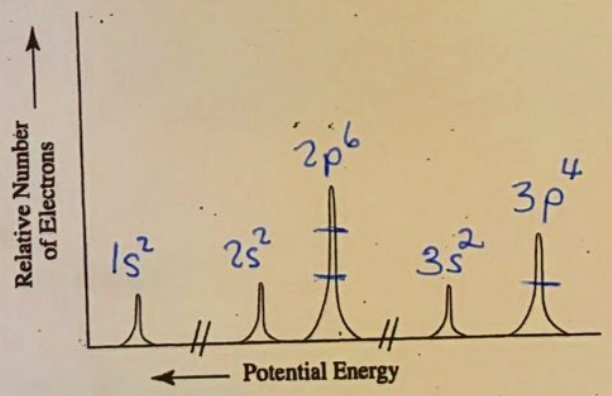
2. Which peak represents the 2*s* subshell?
   (A) The peak at 104 MJ/mol
   (B) The peak at 6.84 MJ/mol
   (C) The peak at 2.29 MJ/mol
   (D) The peak at 1.76 MJ/mol

3. An electron from which peak would have the greatest velocity after ejection?
   (A) The peak at 104 MJ/mol
   (B) The peak at 6.84 MJ/mol
   (C) The peak at 4.98 MJ/mol
   (D) The peak at 1.76 MJ/mol

4. How many valence electrons does this atom have?
   (A) 2
   (B) 3
   (C) 4
   (D) 5

PES gives info about...
- Studying PES showed scientists that not all electrons in an EL have the same energy
- Orbitals can hold a certain # of e's max. Max # of e's per orbital.

5. The photoelectron spectrum of an element is given below:



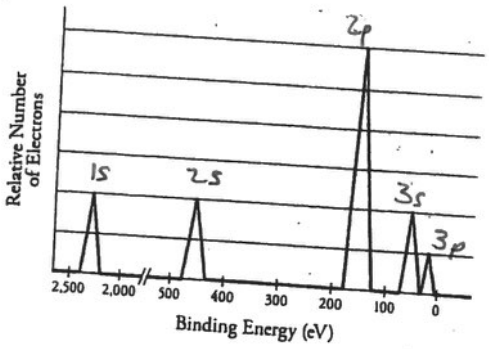
(a) Identify the element this spectra most likely belongs to and write out its full electron configuration. $1s^2 2s^2 2p^6 3s^2 3p^4$ Sulfur

(b) Using your knowledge of atomic structure, explain the following:
   (i) The reason for the three discrete areas of ionization energies → 3 ELs
   (ii) The justification for there being a total of five peaks → 5 sublevels (sets of orbitals)
   (iii) The relative heights of the peaks when compared to one another

- s orbitals can hold up to 2 e's
- p orbitals can hold up to 6 e's

- Usually it takes EMR in the visible or UV range to cause electron emission.
- Radiation in IR is used to study bonds
- Radiation in Microwave range is used to study shape of molecules

Use the diagram below to answer questions 8-10.



Peak 1	Peak 2	Peak 3	Peak 4	Peak 5
2300 eV	450 eV	150 eV	30 eV	5.0 eV

The photoelectron spectrum for a neutral aluminum atom is located above.

8. The amount of energy necessary to remove an electron from the 2*p* subshell is closest to which value?

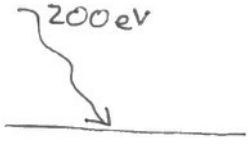
(A) 450 eV
(B) 150 eV
(C) 30 eV
(D) 5.0 eV

9. On a spectrum of an aluminum ion: +3

(A) All peaks would be identical.
(B) The peak furthest to the right be twice as tall.
(C) The two peaks furthest to the right would be missing.
(D) All peaks would be half as tall.

10. A different aluminum atom is exposed to incoming radiation with an energy of 200 eV. Ejected electrons that were originally in which orbital would have the lowest kinetic energy?

(A) 1*s*
(B) 2*s*
(C) 2*p*
(D) 3*p*



6. The table below gives data on four different elements, in no particular order:

2 EL 3 EL

Carbon, Oxygen, Phosphorus, and Chlorine

	Atomic radius (pm)	First Ionization Energy (kJ/mol^{-1})
Element 1	170 C	1086.5 C
Element 2	180 P	1011.8 P
Element 3	175 Cl	1251.2 Cl
Element 4	152 O	1313.9 O

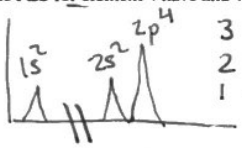
(a) Which element is number 3? Justify your answer using both properties.

Cl (• 3 EL → bigger than O + C
• 17p → smaller than P
Cl (• has greater IE than P due to greater nuclear charge

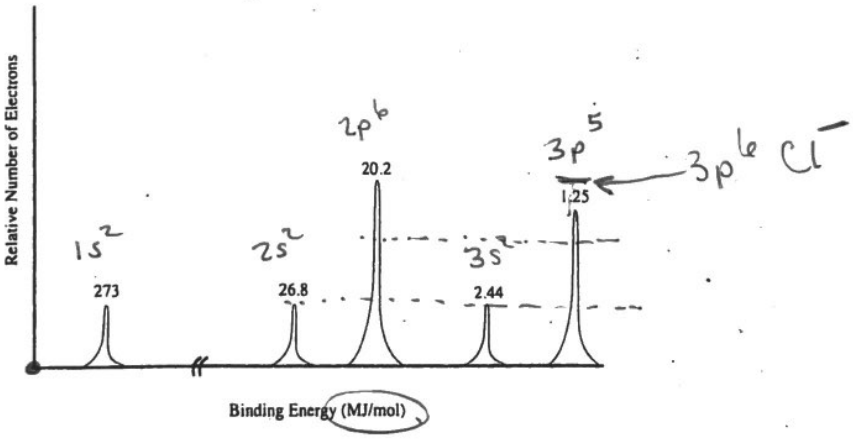
(b) What is the outermost energy level that has electrons in element 2? How many valence electrons does element 2 have? EL 3 is outermost, contains 5 e's

(c) Which element would you expect to have the highest electronegativity? Why? Element 4, has highest IE so has greatest attraction for electrons.

(d) How many peaks would the PES for element 4 have and what would the relative heights of those peaks be to each other?



3 peaks
2 same height
1 twice as high



7. The above PES belongs to a neutral chlorine atom.

(a) What wavelength of light would be required to eject a 3s electron from chlorine?

(b) For the PES of a chloride ion, how would the following variables compare to the peaks on the PES above? Justify your answers.

(i) Number of peaks Same

(ii) Height of the peaks The peak on the far right would be higher. The 3p orbitals would contain 6 e's in the ion and only 5 in the atom.

$E = h\nu$

$c = \lambda\nu$

$E_{photon} = \frac{hc}{\lambda}$

$\lambda = \frac{hc}{E}$

$$\lambda = \frac{(6.626\times10^{-34}\ J\cdot s)(2.998\times10^{8}\ m\cdot s^{-1})}{\frac{2.44\ MJ}{1\ mol}\left(\frac{10^6\ J}{1\ MJ}\right)\left(\frac{1\ mol}{6.022\times10^{23}\ photons}\right)}$$

$= 4.90\times10^{-8}\ m$