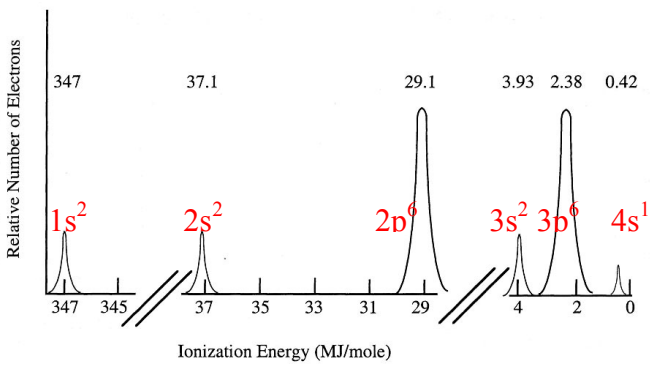
HW Review- AP Chem – Answer Key
Photoelectron Spectroscopy

1) Look at the Photoelectron spectrum at the right and answer the following questions.
   a. What element has this photoelectron spectrum? K
   b. Label each peak with the appropriate energy sublevel and number of electrons.
   c. Why does the last peak (all the way on the right side) have the smallest height? It is a single electron
   d. What is the ionization energy for the 3s electrons for this element? 3.93 MJ/mol



2) The ionization energies in the table at the right were measured using photoelectron spectroscopy.
   a. In the table, you should see that oxygen's ionization energy for a 2s electron is higher than nitrogen's IE for a 2s electron. Explain why.
   O has Z_{eff} = 6+ and N has Z_{eff} = 5+, so O has a stronger coulombic attraction on its electrons.

   b. In the table, you should notice one striking anomaly in the typical patterns of the IE values. That anomaly is that oxygen's IE for its 2p electron is lower than nitrogen's IE for a 2p electron. Explain why.
   The 2p electrons in O experience e^-–e^- repulsion which decreases the electrostatic attraction to the nucleus, indicating higher potential energy and lower ionization energy.

Table 1. Ionization energies (MJ/mole)

Element	1s	2s	2p	3s
H	1.31			
He	2.37			
Li	6.26	0.52		
Be	11.5	0.90		
B	19.3	1.36	0.80	
C	28.6	1.72	1.09	
N	39.6	2.45	1.40	
O	52.6	3.04	1.31	
F	67.2	3.88	1.68	
Ne	84.0	4.68	2.08	
Na	104	6.84	3.67	0.50
Mg	126	9.07	5.31	0.74

3) In Table 8.2, ionization energies were determined by removing electrons in succession from the elements. Let's compare Mg's IE values in this chart to the IE values in the photoelectron spectroscopy Table above (Table 1).
   a. The first IE for Mg in table 8.2 is 738.1 kJ (or 0.7381 MJ). Thus, this is the same value as the IE value of a 3s electron for Mg as stated in Table 1(0.74 MJ). Why are these IE values the same?
   In both cases, the electron is coming out of the same environment, the neutral Mg atom.

TABLE 8.2 The Ionization Energies (kJ/mol) of the First 20 Elements

Z	Element	First	Second	Third	Fourth	Fifth	Sixth
1	H	1,312					
2	He	2,373	5,251				
3	Li	520	7,300	11,815			
4	Be	899	1,757	14,850	21,005		
5	B	801	2,430	3,660	25,000	32,820	
6	C	1,086	2,350	4,620	6,220	38,000	47,261
7	N	1,400	2,860	4,580	7,500	9,400	53,000
8	O	1,314	3,390	5,300	7,470	11,000	13,000
9	F	1,680	3,370	6,050	8,400	11,000	15,200
10	Ne	2,080	3,950	6,120	9,370	12,200	15,000
11	Na	495.9	4,560	6,900	9,540	13,400	16,600
12	Mg	738.1	1,450	7,730	10,500	13,600	18,000

   b. In table 1, both 3s electrons have the same IE value. However, in Table 8.2, when the second 4s electron in Mg is successively removed, the IE is much higher at 1450 kJ (or 1.450MJ). Explain why there is this difference.
   When removing a 2nd electron from Mg, it is coming out of the Mg^+ ion. The remaining 3s electron experiences no e^-–e^- repulsion, so has a stronger coulombic attraction to the nucleus and a higher ionization energy.