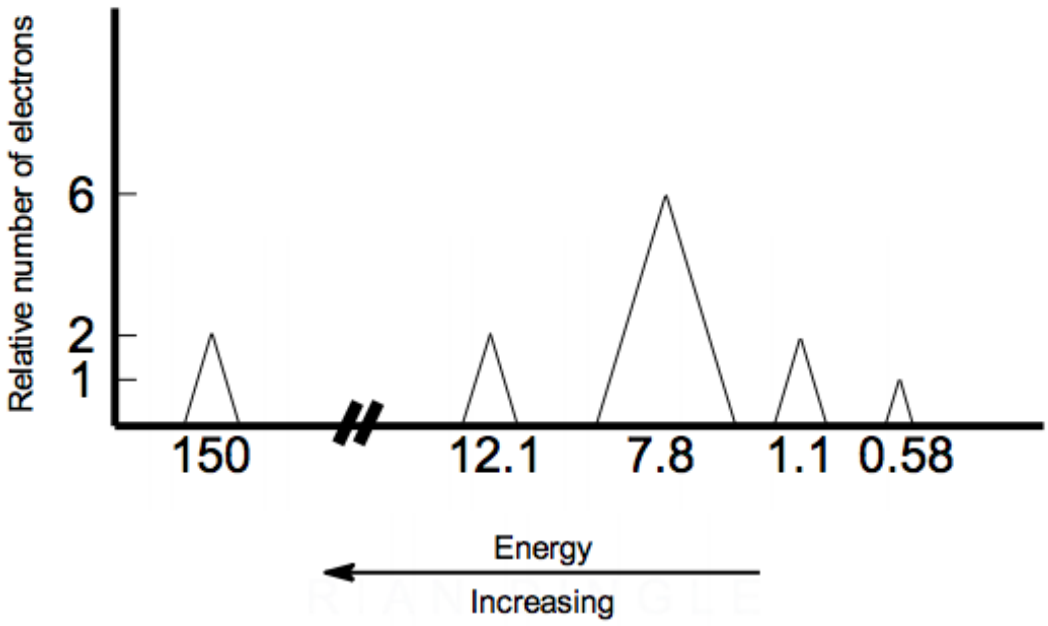
AP Worksheet 1e (Spectroscopy)

Please answer the following questions on a separate sheet of paper.

Part 1: Photoelectron spectroscopy (PES)

1. Consider the simulated PES plot shown below that is produced by the analysis of the atoms of a single element. All peaks in the PES are shown.



   a. Suggest the electron configuration of the element and then identify the element.

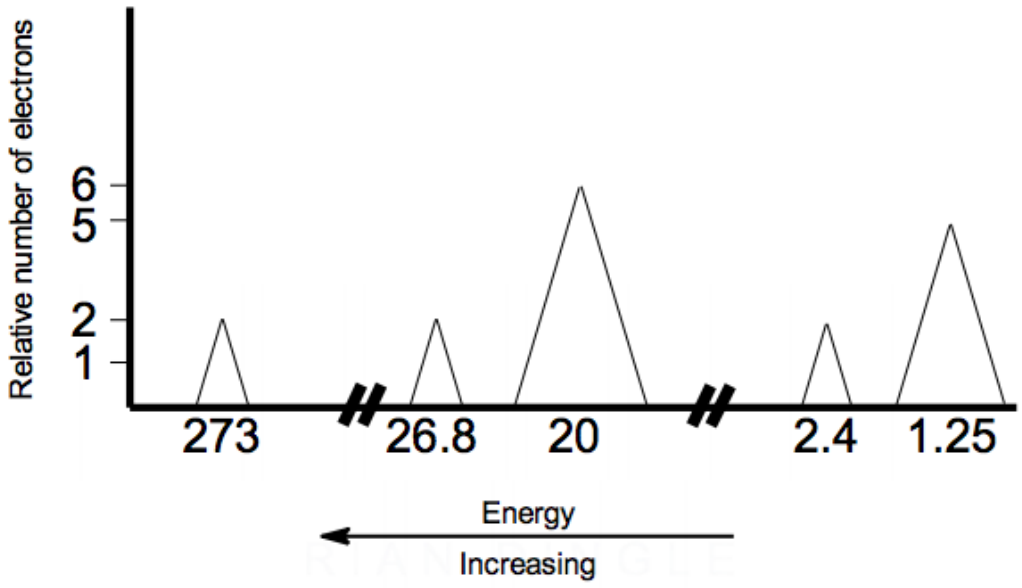
   b. Which two peaks are likely to represent electrons that are removed when this element forms ions? Explain.

   c. Using your answer to (b), identify the most likely charge on an ion of this element. Explain.

   d. Suggest a reason for the jump in energy between the peak at 12.1 and the peak at 150.

   e. Suggest a reason for the x-axis being labeled with increasing values from right to left.

2. Consider the simulated PES plot shown below that is produced by the analysis of the atoms of a single element. All peaks in the PES are shown.



a. Write the electron configuration and identify the element.

b. The plot is divided into three separate areas on the x-axis. Why is the axis divided in this manner?

c. What would be the charge on an ion formed from this atom? Justify your answer.

d. What is the significance of three of the peaks having the same height?

e. The peaks at 1.25 and 2.44, as well as the peaks at 20.2 and 26.8, are relatively close to one another but have different energies. Explain why they are of the same magnitude but slightly different.

3. Consider a PES plot for carbon atoms.

a. How many peaks would you expect in the PES for carbon? Explain.

b. What would be the relative heights of the peaks that you have identified in (a)? Explain your answer carefully.

c. How would you expect the height of the 2p peak in carbon's PES to compare to the height of the 2p peak in nitrogen's PES? Explain.

Part 2: Isotopes and Mass Spectroscopy and Isotopes

4. Many elements have a number of isotopes.

   a. Define the term isotope.

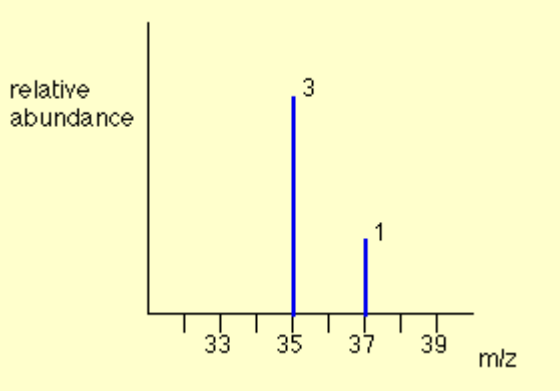
   b. Complete the following table.

Row	Isotope symbol	Atomic #	# Protons	# Neutrons	Mass #
1	$^{13}_{6}C$				
2		17		18	
3			26		56
4			17		37

   c. Consider the 2nd and 4th rows in the table. What three things do they have in common?

   d. Consider the 2nd and 4th rows in the table. Give two differences.

5. The results taken from a mass spectrum of chlorine gas show peaks at *m/z* 35.00 and *m/z* 37.00. (The *m/z* peaks on a mass spectrum identify the different isotopes of an element that are present in the sample.)



   a. Given that the relative abundances of Cl 35.00 and Cl 37.00 are 77.50% and 22.50% respectively, calculate the average relative atomic mass of chlorine atoms.

   b. Suggest the possible masses of Cl_2 **molecules** that are made when two chlorine atoms bond together.

   c. Which of the molecules you suggested in (b) will be the most abundant? Explain.

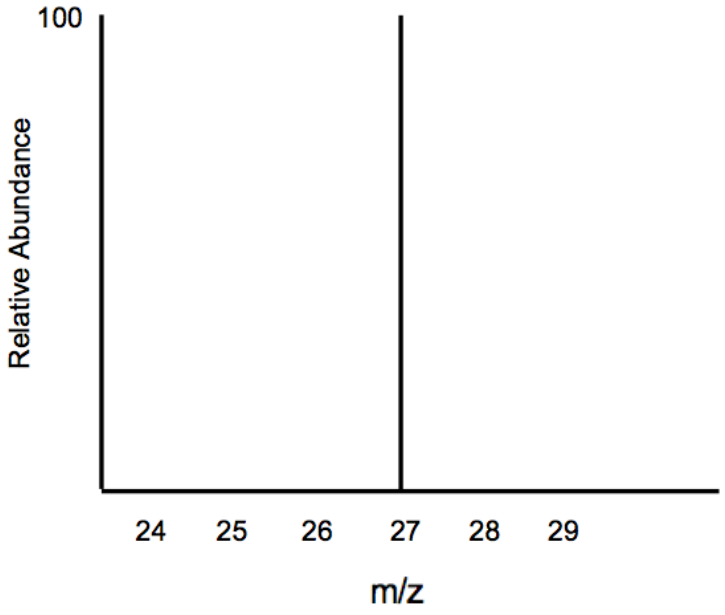
6. An unknown element 'Z' is analyzed in a mass spectrometer and is found to have the following isotopes with the corresponding relative abundances.

Isotope	Z^{50}	Z^{52}	Z^{53}	Z^{54}
Relative abundance	4.34	83.79	9.50	2.37

   a. Sketch the expected mass spectrum that these data would provide. Label the axes and pay attention to the sizes of any lines that you draw.

   b. Calculate the average atomic mass of Z and identify the element.

7. Consider the following mass spectrum that was generated from the analysis of an element.



   a. What does the existence of only a single peak in the spectrum suggest about the element?

   b. Identify the element.

8. Copper has an atomic mass of 63.5456 amu has two stable isotopes. Copper-63 has a mass of 62.9296 amu and copper-65 has a mass of 64.9278 amu.

   a. Calculate the percent abundance of each isotope of copper.

   b. Sketch the expected mass spectrum of copper.