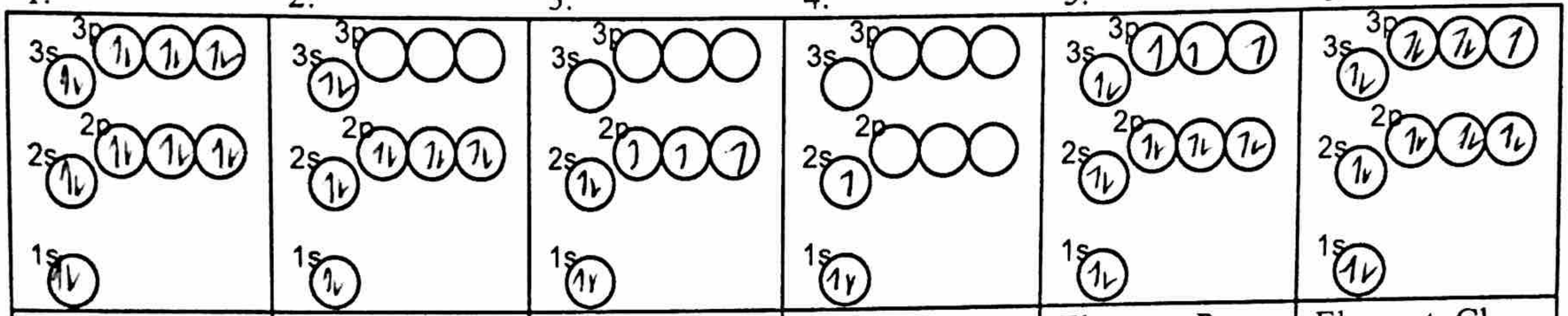
AP Chemistry

Name ____________________
Period ___ Date ___/___/___

7 • Electron Configurations & Periodicity

WRITING ELECTRON CONFIGURATIONS

For each given element, fill in the orbital diagram and then write the electron configuration for the element.



1.	2.	3.	4.	5.	6.
Element: Ar # of e–'s:	Element: Mg # of e–'s:	Element: N # of e–'s:	Element: Li # of e–'s:	Element: P # of e–'s:	Element: Cl # of e–'s:

Write the electron configurations of each of these in **long form** and **short form**:

1. Ar $1s^2 2s^2 2p^6 3s^2 3p^6$
   Ar $[Ne]\ 3s^2 3p^6$

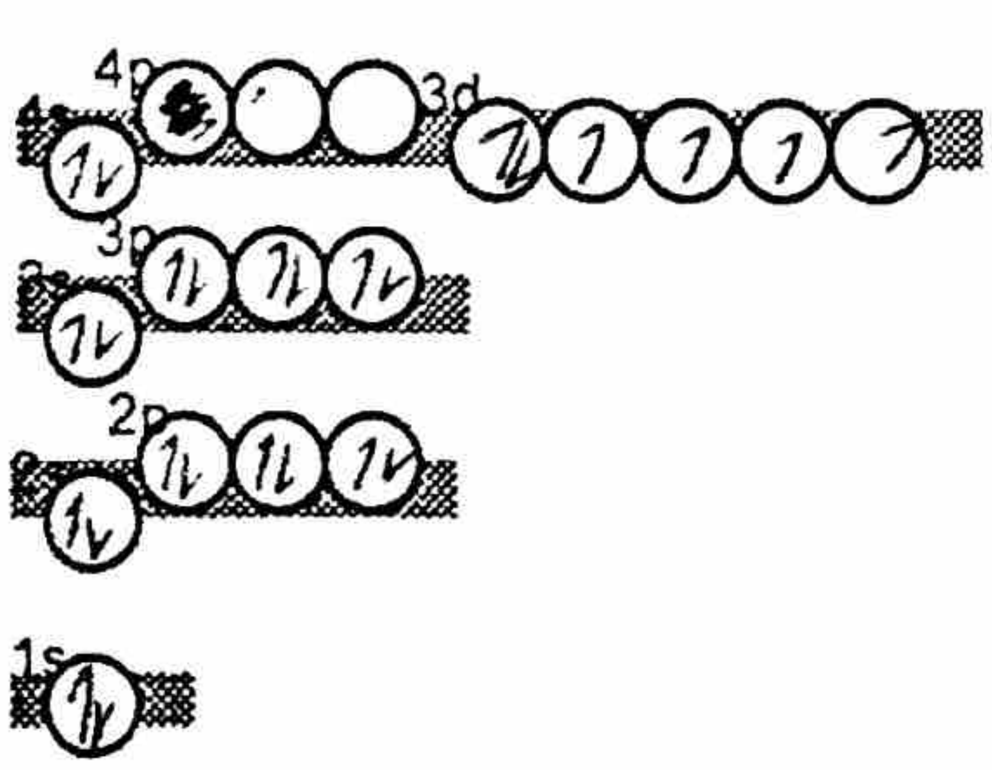
2. Mg $1s^2 2s^2 2p^6 3s^2$
   Mg $[Ne]\ 3s^2$

3. N $1s^2 2s^2 2p^3$
   N $[He]\ 2s^2 2p^3$

4. Li $1s^2 2s^1$
   Li $[He]\ 2s^1$

5. P $1s^2 2s^2 2p^6 3s^2 3p^3$
   P $[Ne]\ 3s^2 3p^3$

6. Cl $1s^2 2s^2 2p^6 3s^2 3p^5$
   Cl $[Ne]\ 3s^2 3p^5$



7. Fill in the orbital diagram for the element, Fe, and write the electron configuration of Fe in the long and short form.

Fe $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

Fe $[Ar]\ 4s^2 3d^6$

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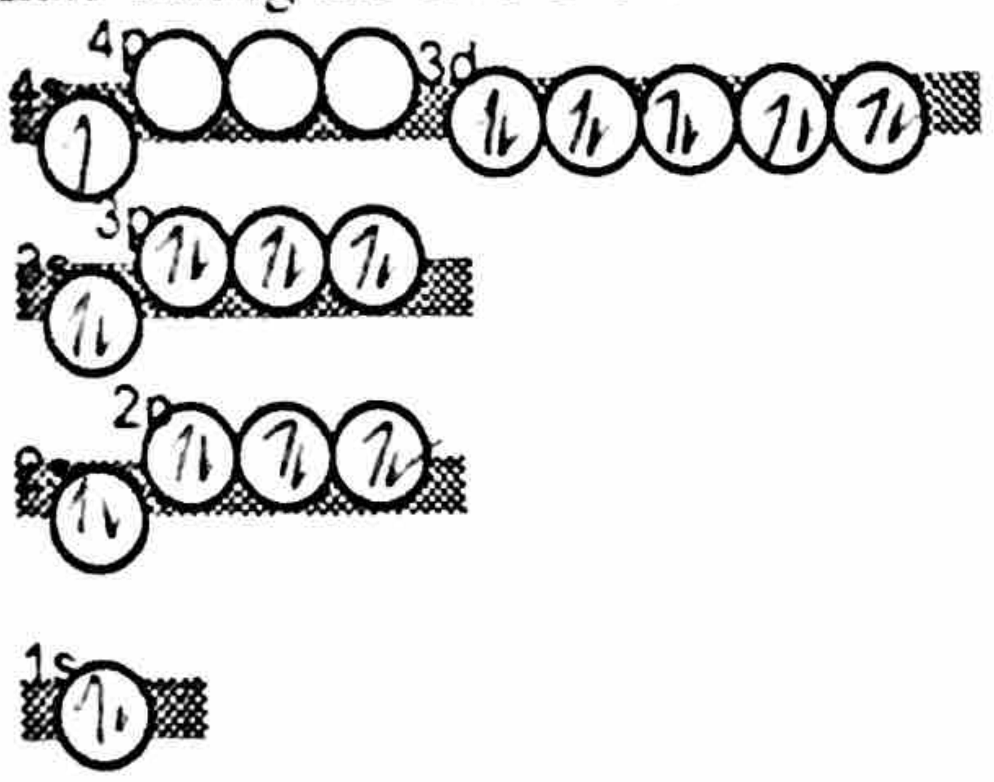
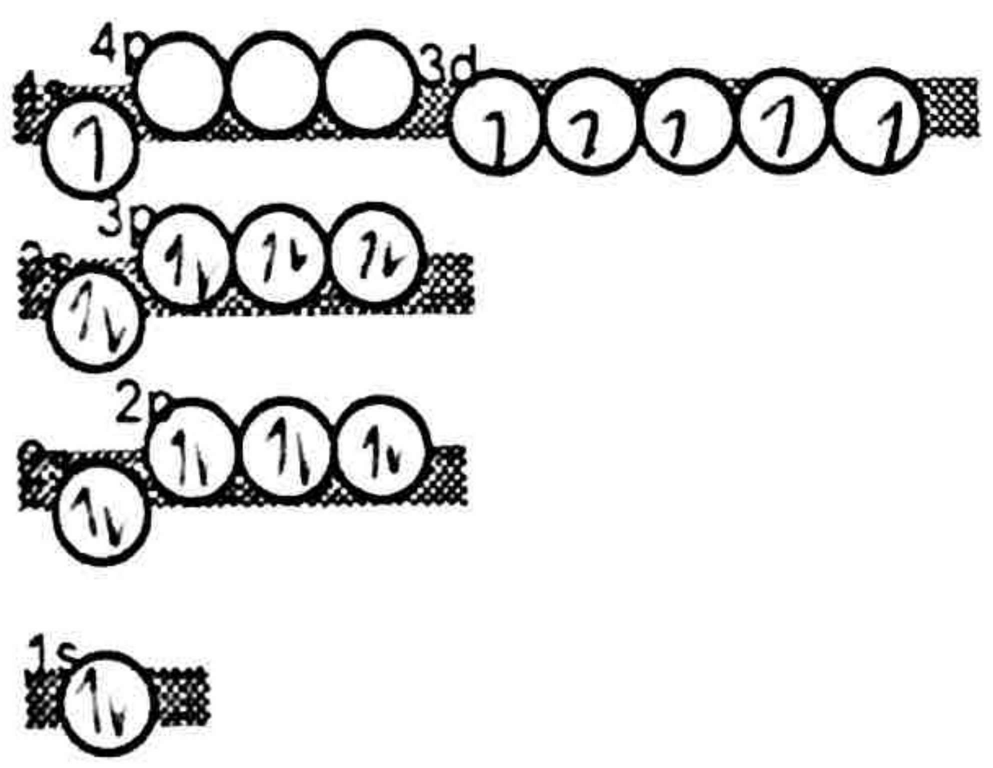
A few elements do not follow the "rules". There is some lowering of the energy of the atom by completely filling or half-filling the five d-orbitals.



8. Fill in the orbital diagram for the element, Cu, and write the electron configuration of Cu in the long and short form.

Cu $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^{10}$

Cu $[Ar]\ 4s^1 3d^{10}$



9. Fill in the orbital diagram for the element, Cr, and write the electron configuration of Cr in the long and short form.

Cr $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$

Cr $[Ar]\ 4s^1 3d^5$

Shade in the six elements that do not follow the Aufbau Principle: ____________________

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd
La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg

Fill in the orbitals that are filled by these elements.

1s		1s
2s		2p
3s		3p
4s	3d	4p
5s	4d	5p
6s	5d	6p
7s	6d	7p

4f
5f

10. Write the orbital occupied by the last electron of each of the following elements:

As	W	Li	U	O	Rn	V
4p	5d	2s	5f	2p	7p	3d

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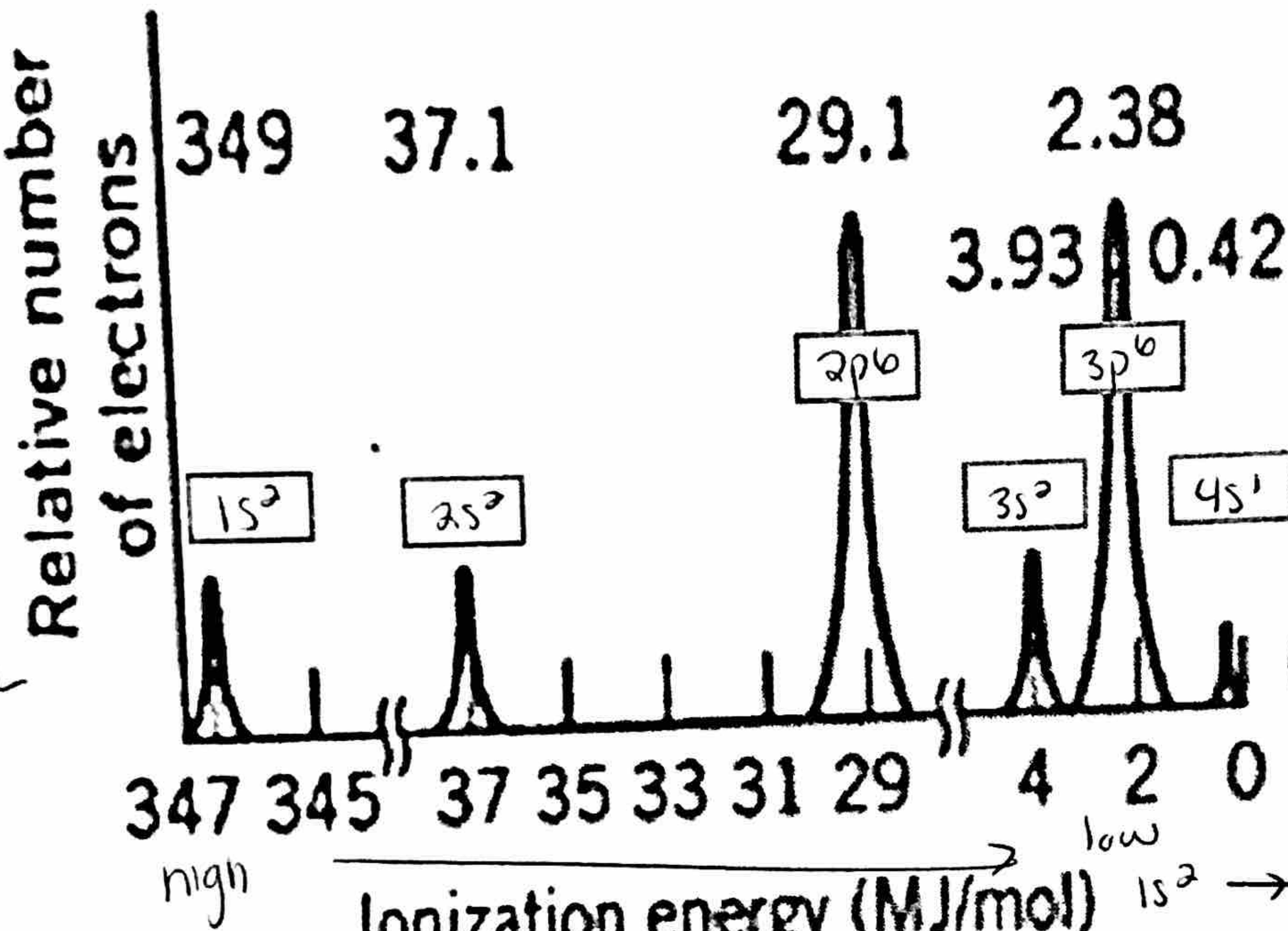
Photoelectron Spectroscopy (PES)

PES is a method used to identify the placement of electrons for a SINGLE atom. Data from PES experiments are displayed as follows: (Note that these are ionization energies for different electrons in the SAME atom)



* size of peak tells us # of electrons in sublevel

polassium

* put in $3p^6 4s^2 3d^{10}$ but come at different

$3p^6 3d^{10} 4s^2 4p$

from https://www.youtube.com/watch?v=NRlqXeY1R_I

Note that the y axis shows the relative number of electrons in each peak. The peak heights therefore show how many electrons would have a given ionization energy relative to another peak. Recall that the closer an electron is to the nucleus, the more energy would be needed to remove that electron from an atom. In the diagram above, the peak at 349 represents electrons CLOSEST to the nucleus, therefore, in the 1st shell. We know from electron configurations that 2 electrons can fit into the 1s sublevel, so we can surmise that the peak at 349 represents two 1s electrons ($1s^2$).

The next peak at 37.1 MJ/mol would represent electrons in the [2nd] shell. Note the height of this peak is the same as the height of the first peak, so the peak should represent [2] electrons. What sublevel should this be? [2s] with a configuration of [$2s^2$] The next peak at 29.1 MJ/mol should be the [6 ($2p^6$)] electrons. Note how large this peak is compared to the prior peak. The peak at 29.1 MJ/mol represents [6 electrons] The peak at 3.93 MJ/mol represents two [3s] electrons. The peak at 2.38 MJ/mol represents [6] electrons (note the height of this peak is the same as the height for the six 2p electrons at 29.1 MJ/mol). The last peak at 0.42 MJ/mol would be for electrons in the [4s] sublevel. Based on the height of this peak, the number of electrons is [1] because the height of the peak is ½ the height of the peaks at 3.93 MJ/mol, 37.1 MJ/mol and 349 MJ/mol.

A few points to note:

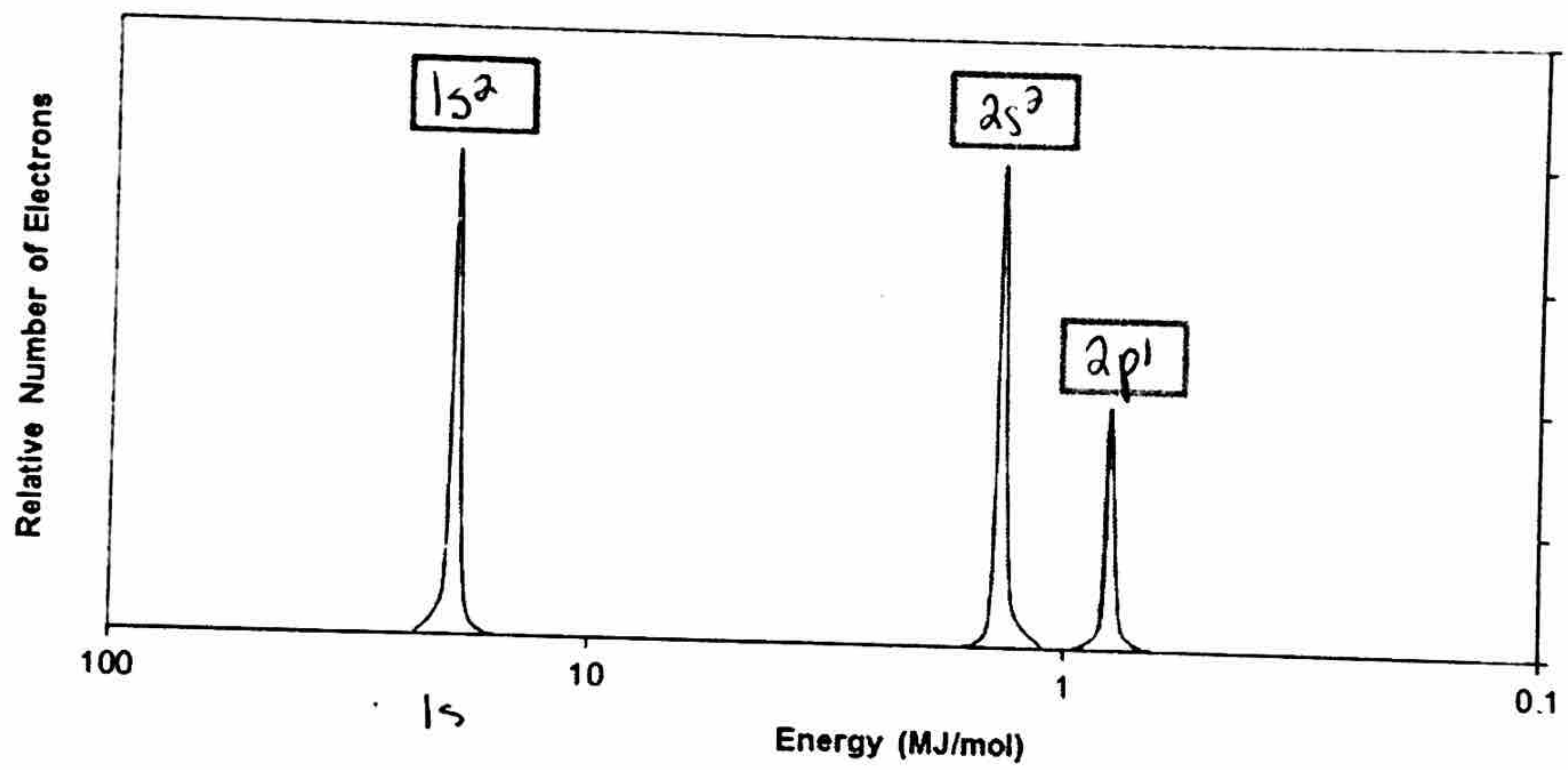
Sometimes the innermost electrons are not shown on a diagram because the scale would be too large.

3d electrons would typically have a higher ionization energy than 4p electrons because 3d electrons are closer to the nucleus and therefore have a stronger Coulombic force holding them than 4p electrons. You can identify whether a peak represents 3d or 4p electrons by viewing the relative height of a peak and noting what the electron configuration for an atom should be.

Your turn:

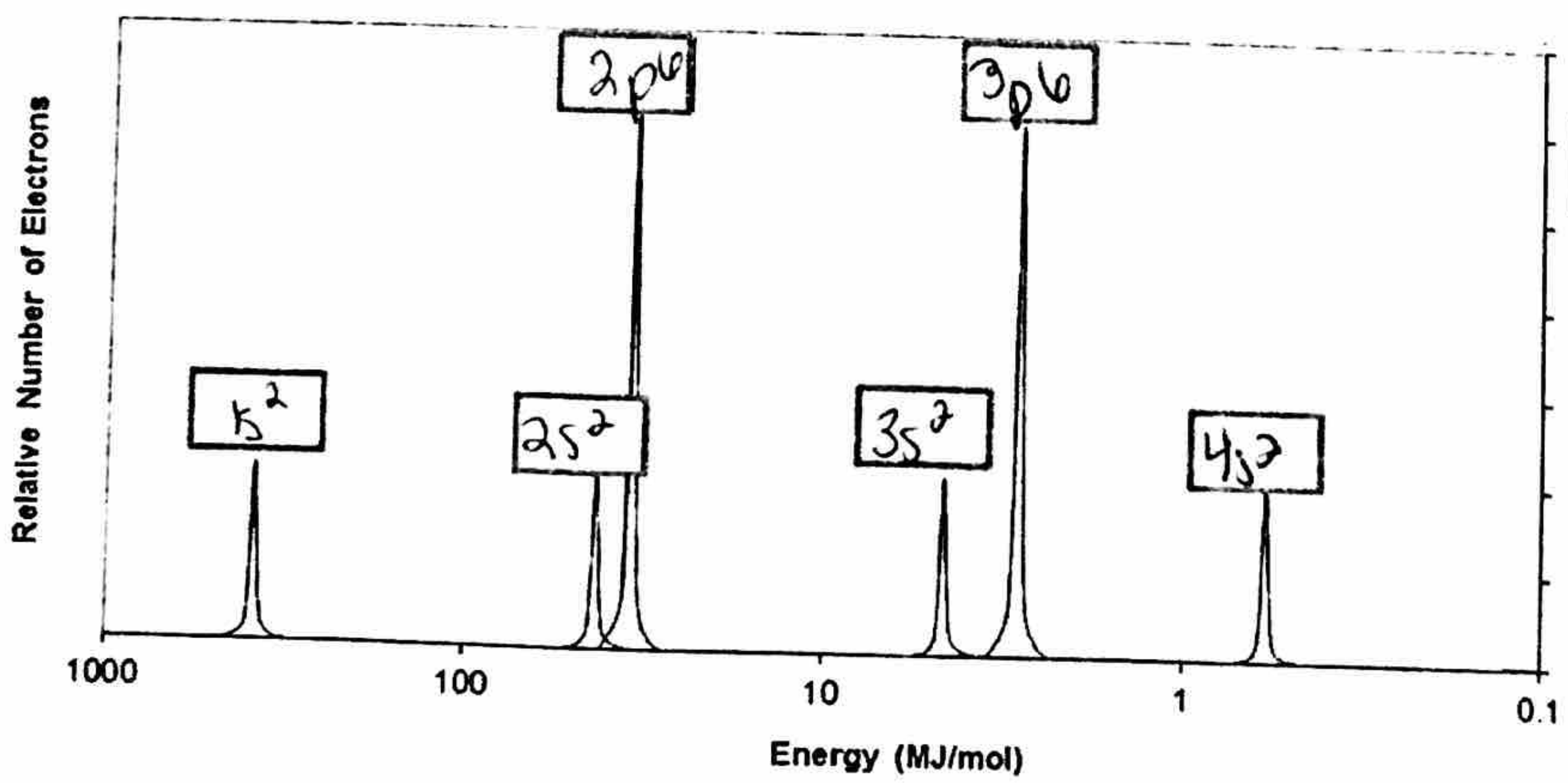
What element is this: Identify the sublevel and number of electrons for each peak.

Photo Electron Spectra



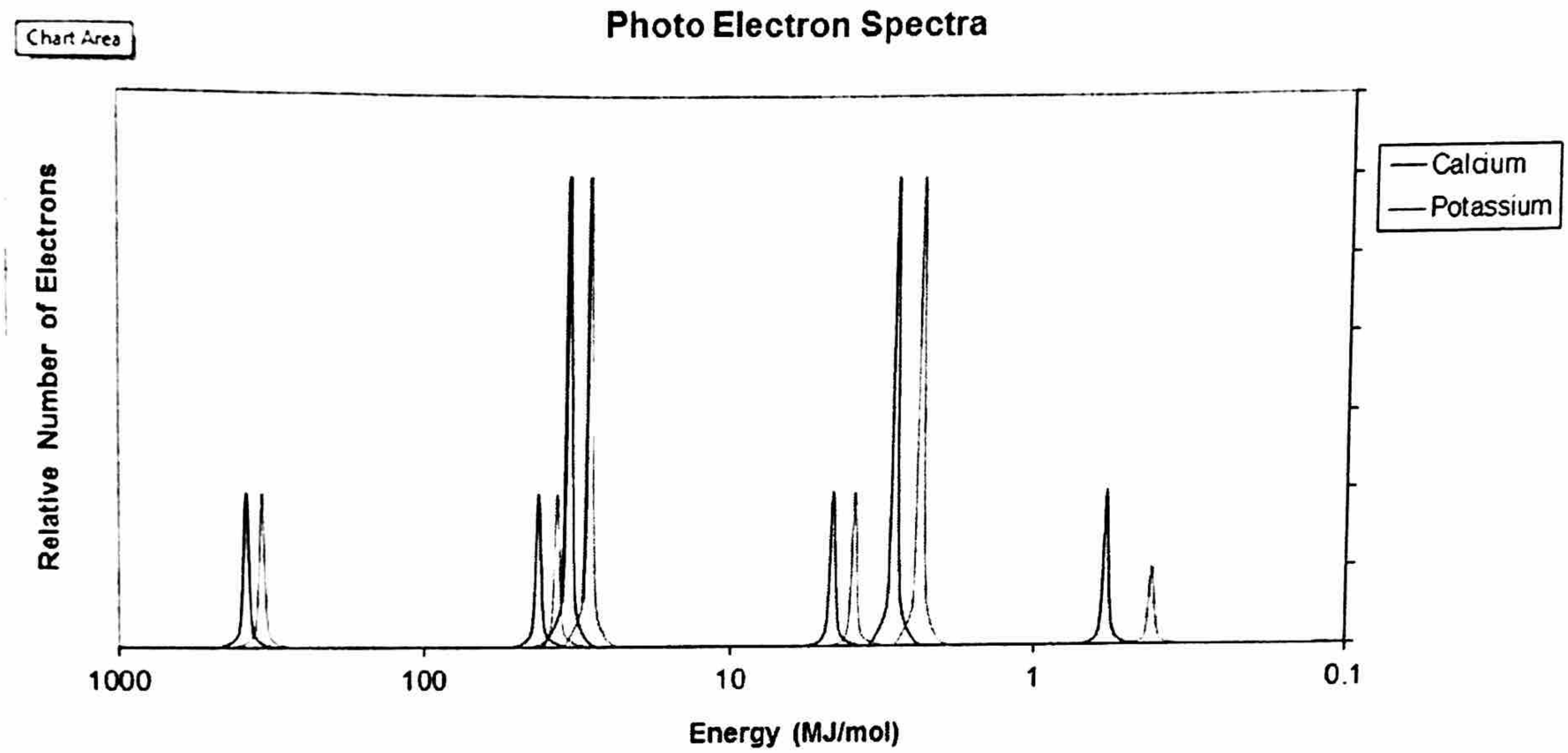
The element is B

Photo Electron Spectra



The element is Ca

Comparing spectra for different elements

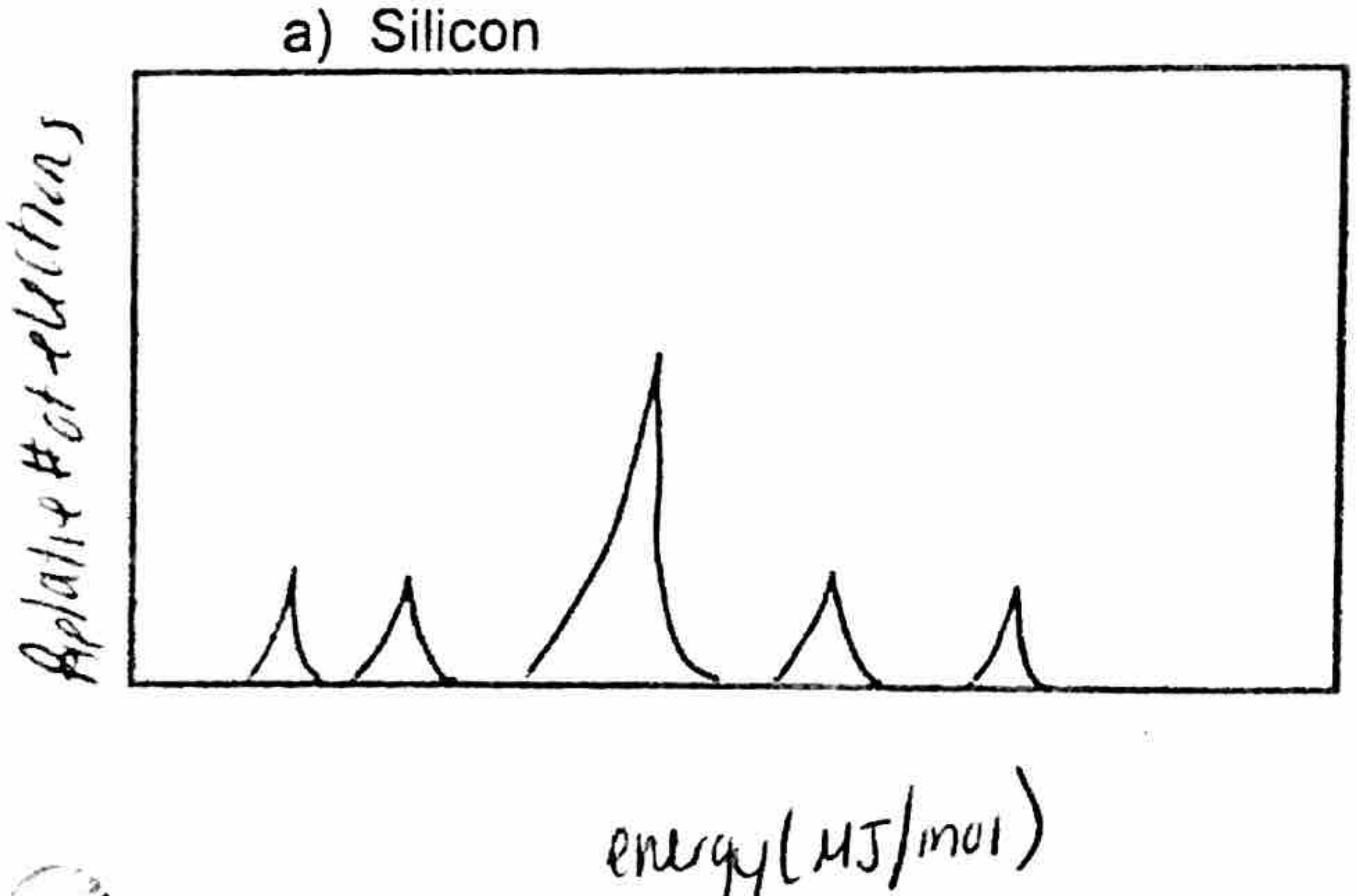


Why are Calcium's peaks slightly higher in energy (x-axis) than potassium's peaks?

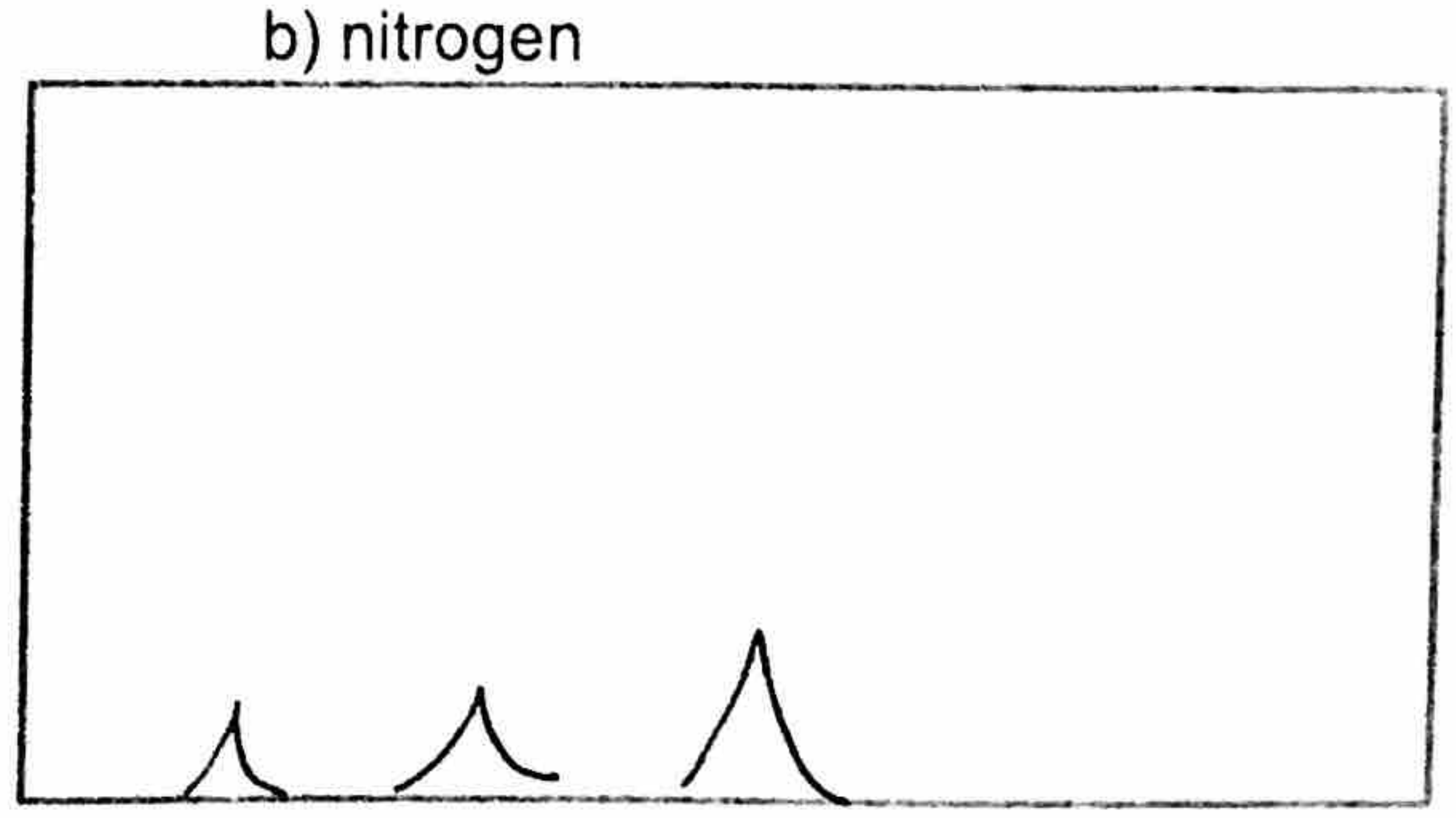
Calcium has a smaller atomic radius due to a greater number of protons in the nucleus creating stronger attractive forces between the nucleus and electrons. This increases the ionization energy b/c it is more difficult to remove electrons.

Draw an approximate sketch (just showing relative sizes of peaks and whether they are high or low ionization energy for:

a) Silicon



b) nitrogen



Explain whether each of the following is true or false.

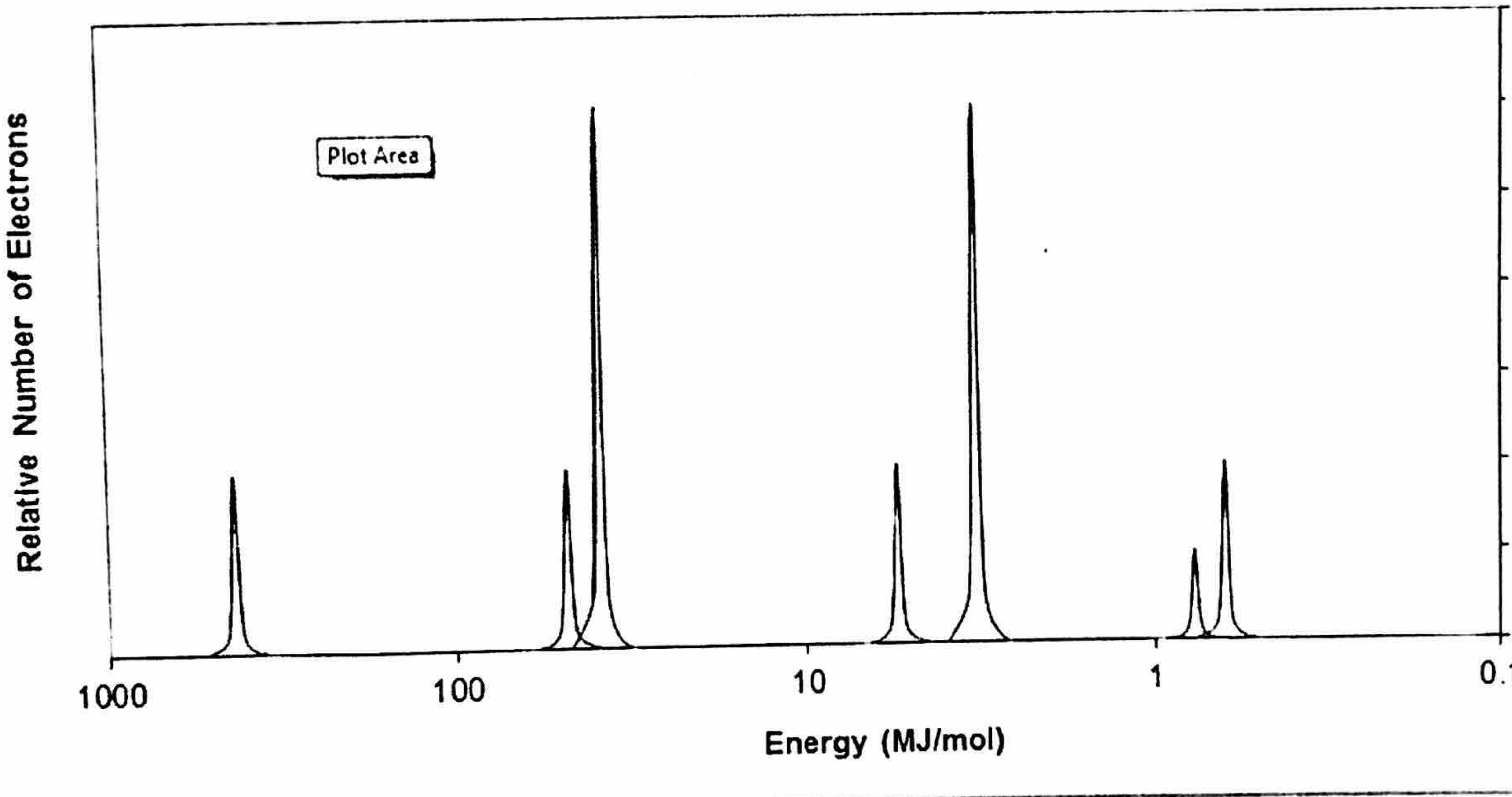
1) The photoelectron spectrum of Ca^{2+} and Ar should be the same.

False. Although they have the same # of electrons Ca^{+2} has more protons holding the valence electrons/and all electrons, more tightly.

2) The photoelectron spectrum of ^{16}O and ^{18}O should be the same.

true, neutrons do not have a charge so it will not alter the ionization energy

The photoelectron spectrum of Scandium is below. Explain why the peak just to the right of 1.0 is assigned to the 3d orbital and not the ~~4p~~ 4s orbital.



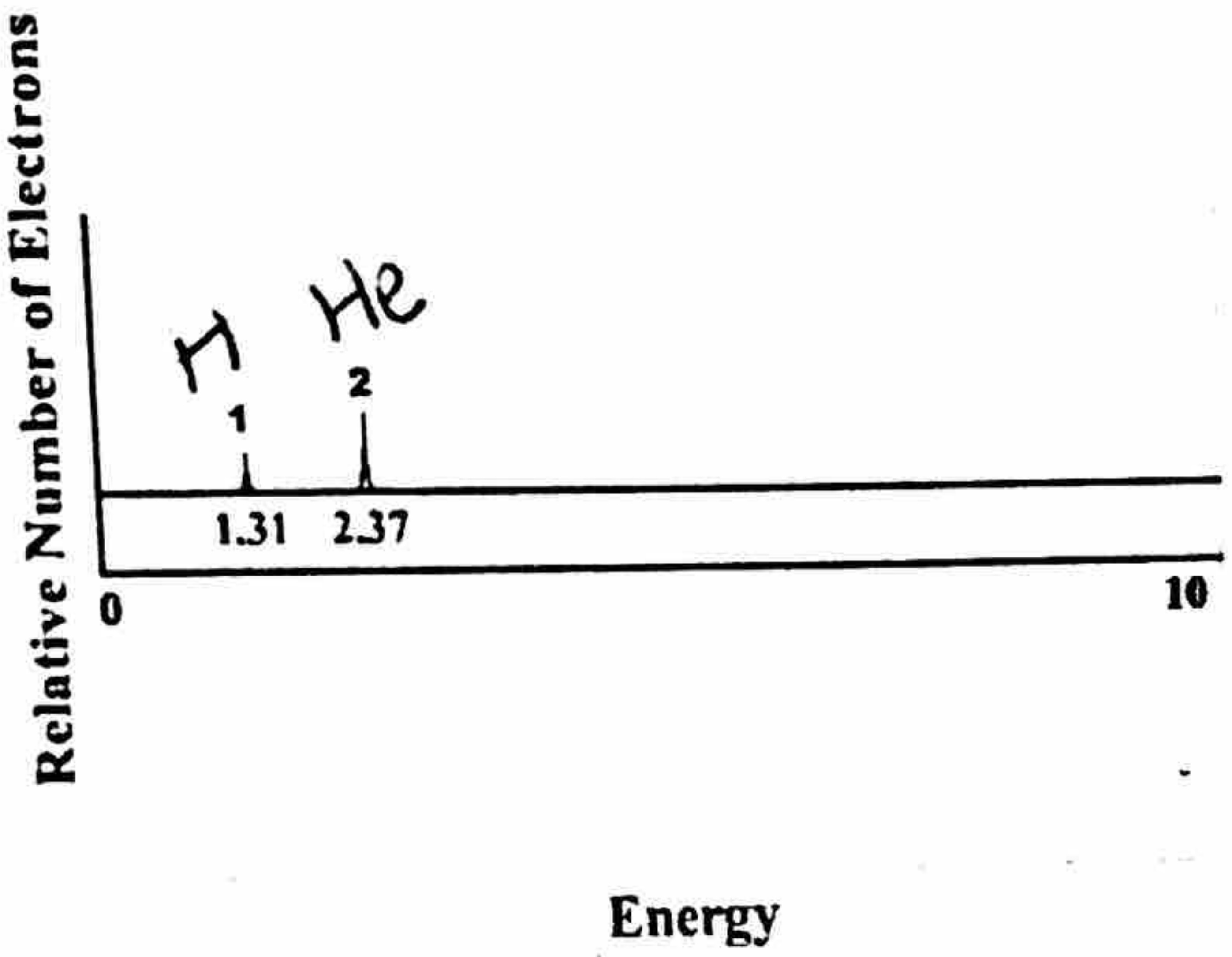
Because the electrons are removed from the highest energy level first and 4 is higher (further) than 3

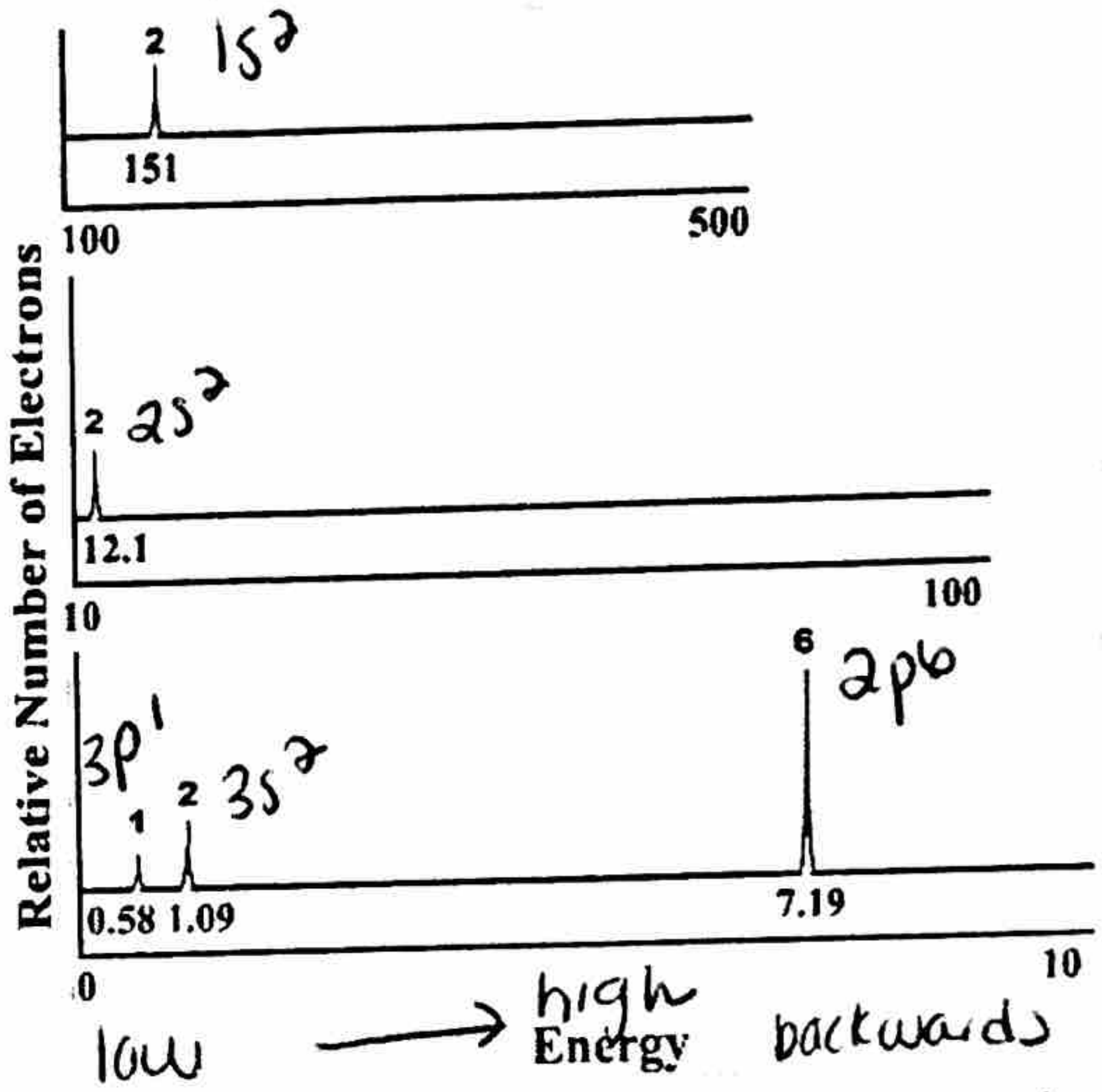
Practice Set: Photoelectron Spectroscopy (PES)

AP Chemistry

Chemist: ______________________ Date: __________

Refer to the PES spectra below. For the spectrum on the left, the integration peak with 1 electron is that of Hydrogen, whereas the other peak reflecting two electrons represents Helium.





For the left hand spectrum, what do the relative energies associated with the electrons suggest about the following. Provide sound reasoning and cite evidence from the spectrum to support your claims:

1) The strength of attraction between protons and electrons as their amounts increase.

   higher energy electrons are closer to the nucleus

2) The amount of energy required to create ions for elements that have full orbitals vs. those that have unfilled orbitals.

   it would require more energy to create ions for elements that have full orbitals b/c more electrons would need to be removed

For the right hand spectrum:

3) Which energy value is associated with the 1s electrons? 151

4) What element is represented by the right hand spectrum? aluminum

5) What do the relative energies and locations associated with the electrons suggest about the following. Provide sound reasoning and cite evidence from the spectrum to support your claims:

   a) The amount of energy required to remove valence electrons compared to the energy required to remove inner shell electrons. it requires less energy to remove a valence electron than an inner shell electron b/c they are further from the nucleus

   b) The height of the integration peaks.

   #of electrons = height of the peaks

Refer to the PES spectra below. Identify the elements for each and then proceed to the prompts.

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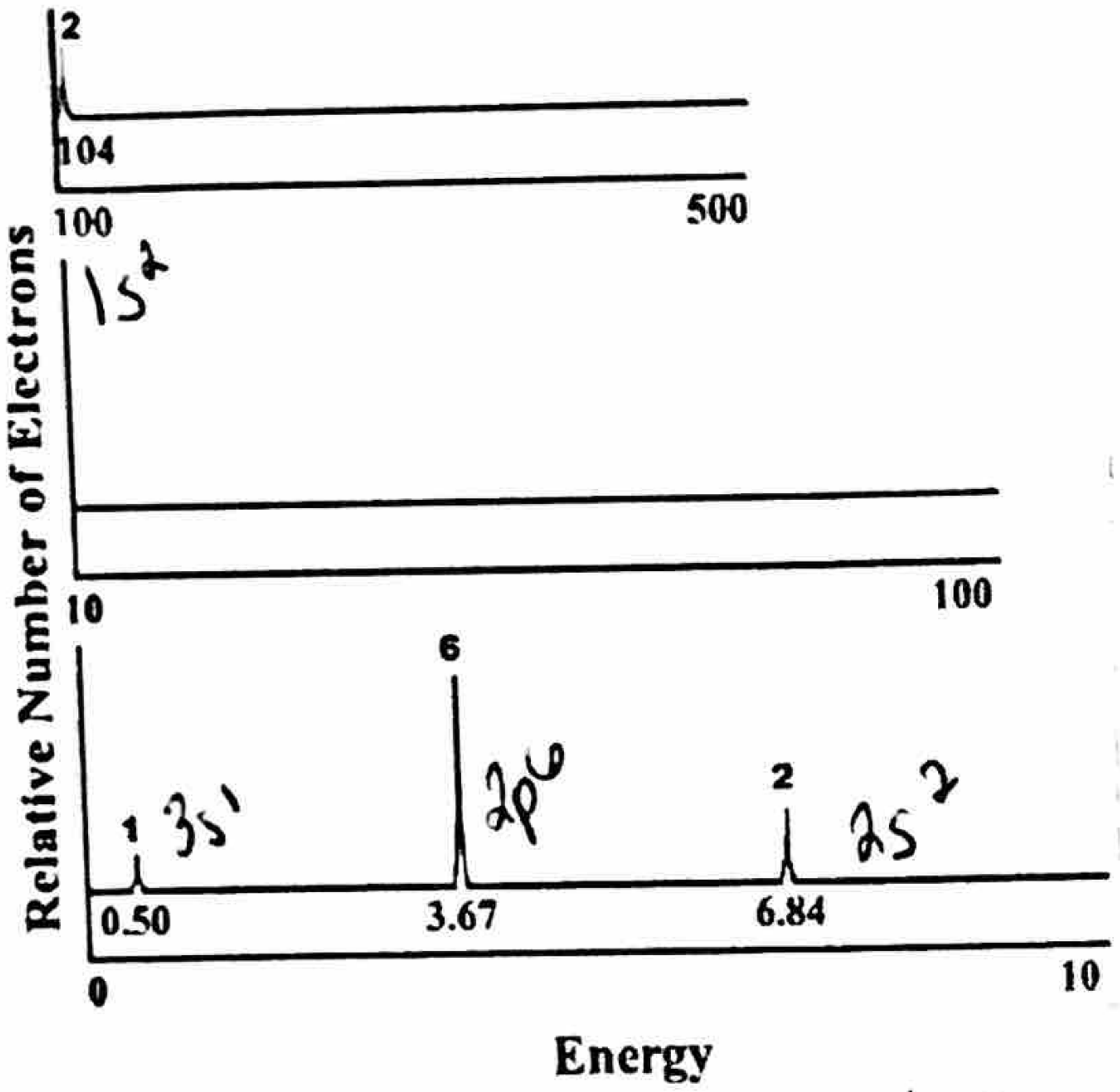
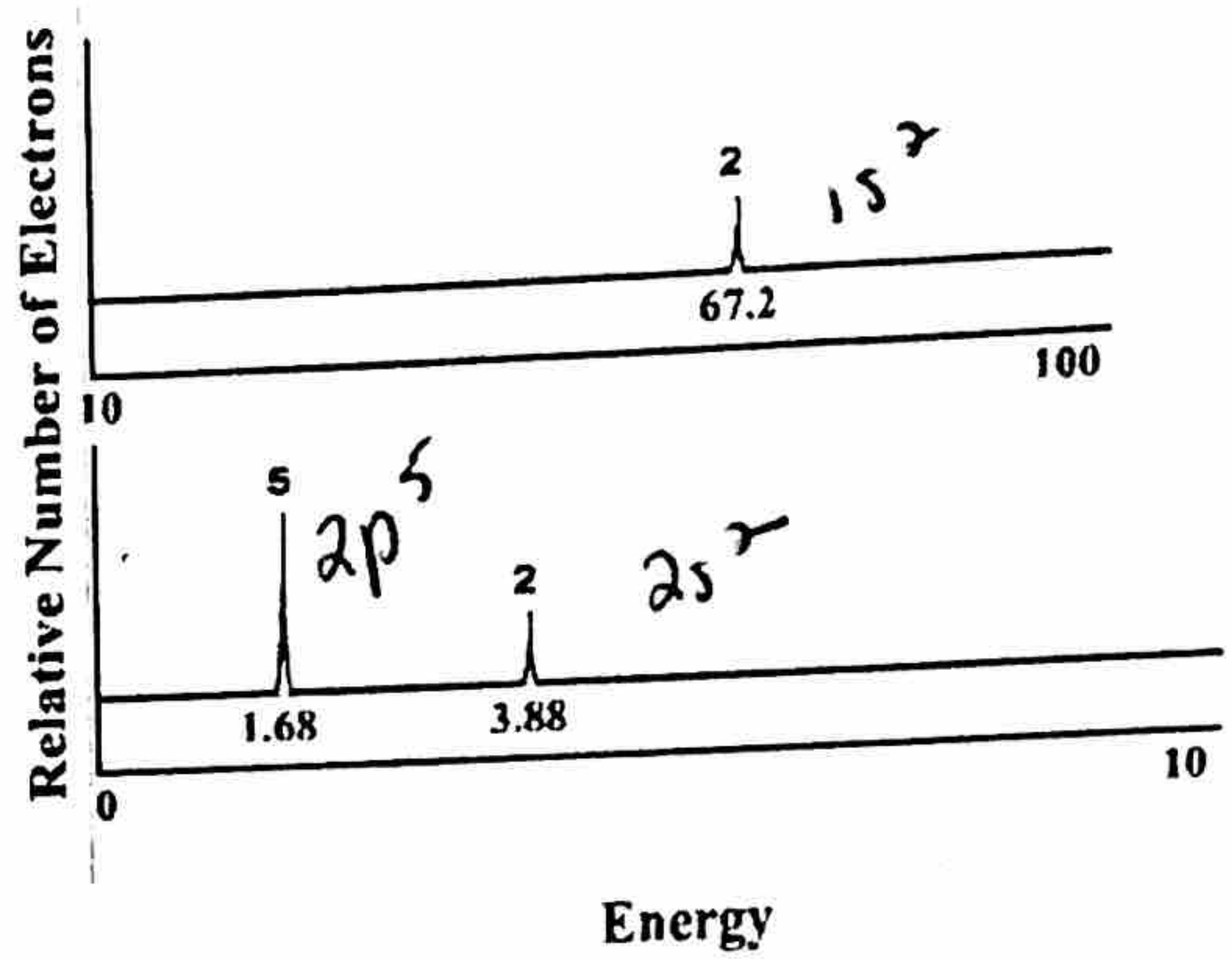
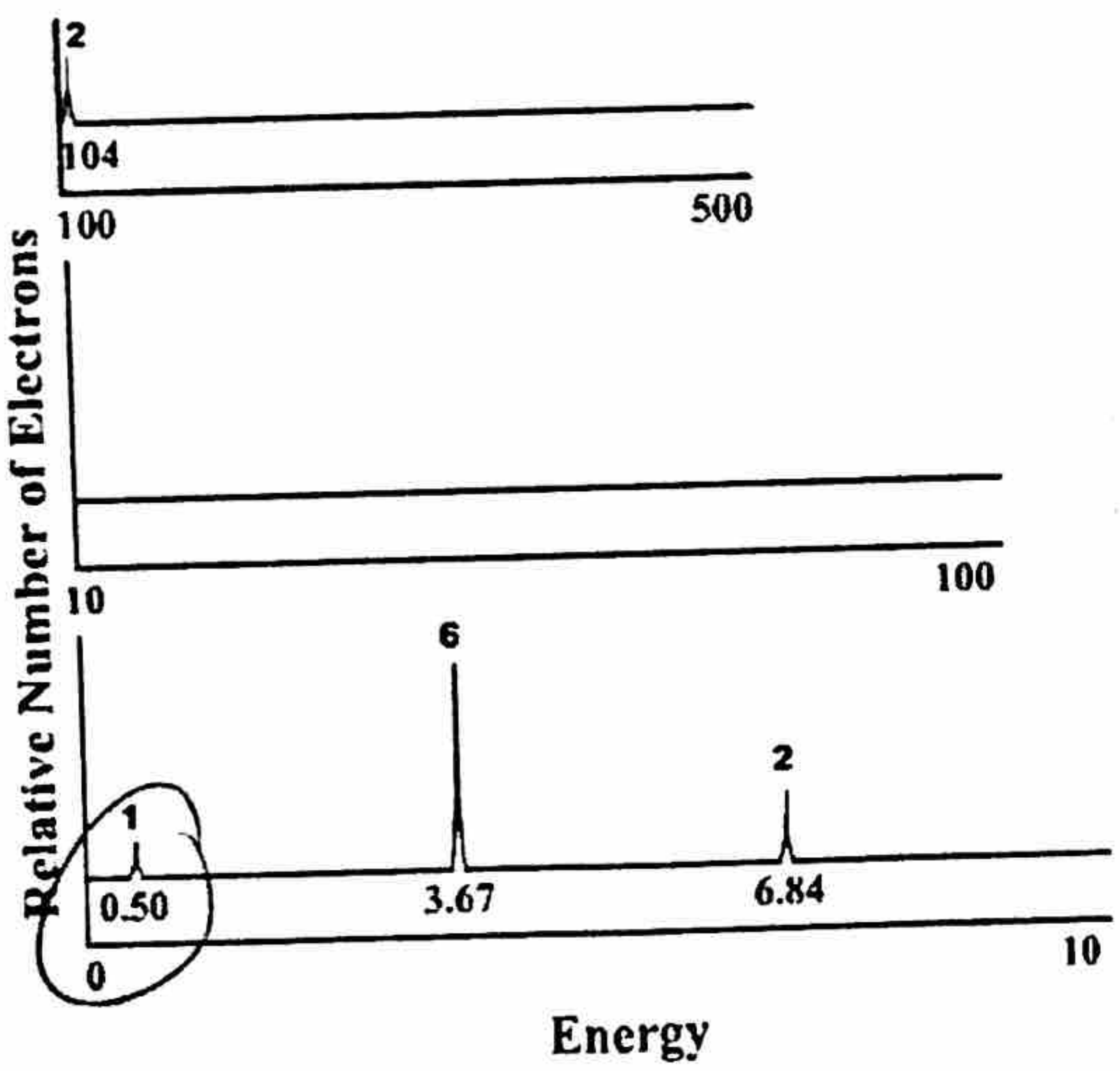


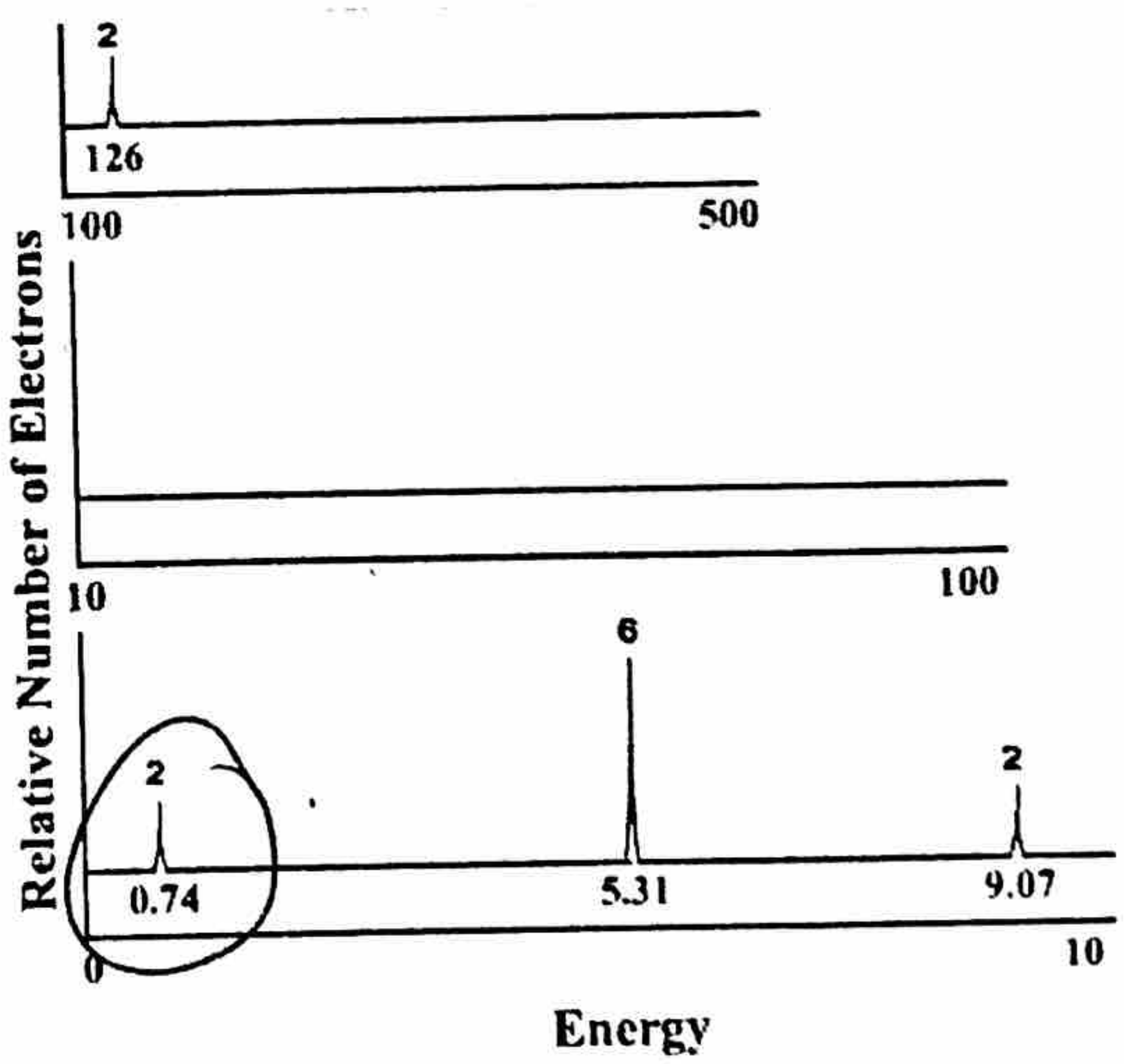


6) Based on the above spectra, discuss why the left hand spectrum is better suited for forming a positive ion (cation), whereas the right hand is better suited for forming a negative ion (anion).

- the one on the left only has one electron in the valence shell, which is easy to get rid of compared to gaining 7 electrons (.50) less energy
- the one on the right has 7 valence electrons only needing one more electron to create a full valence electron. (1.68)

Refer to the PES spectra below. Identify the elements for each and then proceed to the prompts.

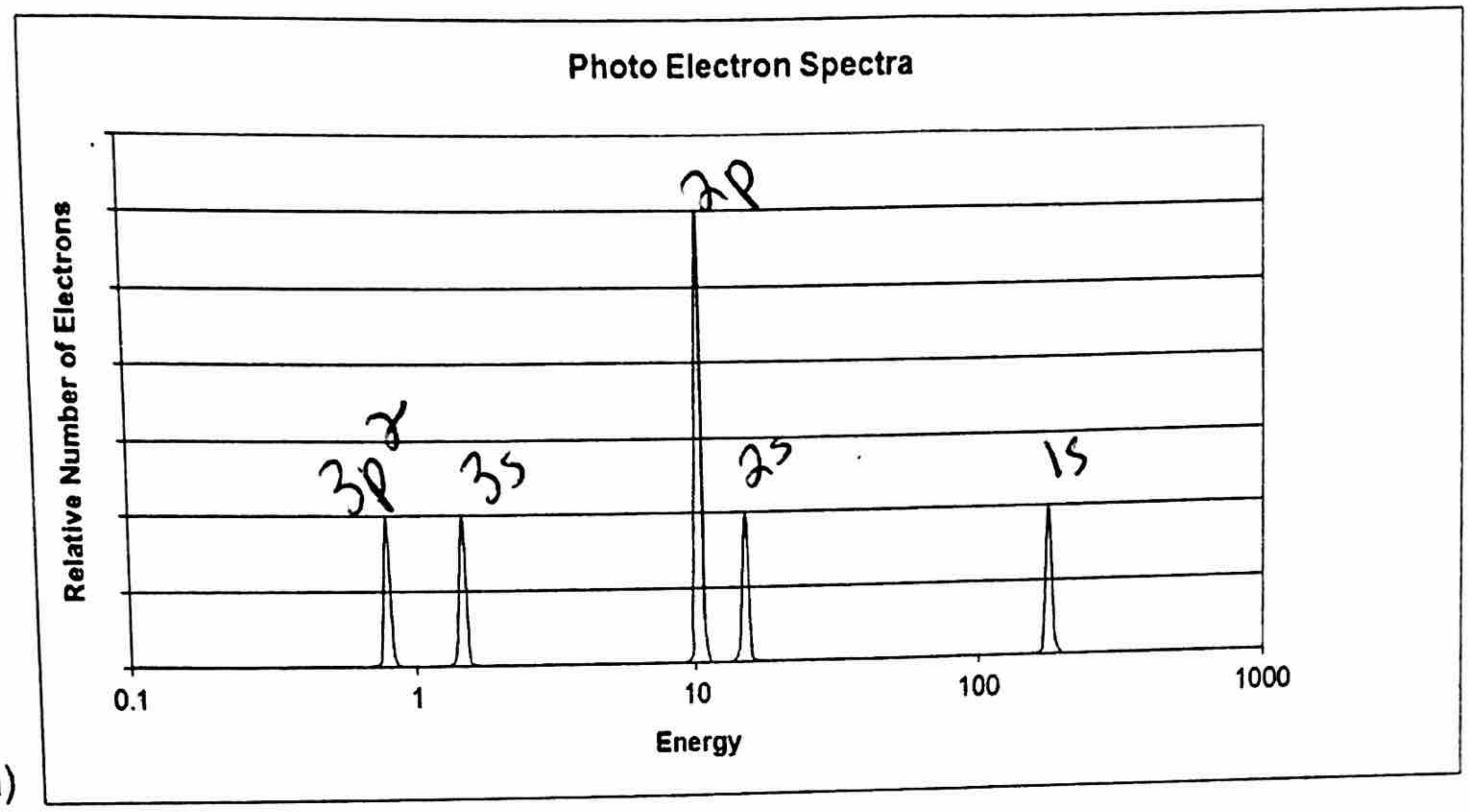




7) Based on the above spectra, discuss which element has an easier time forming a cation.

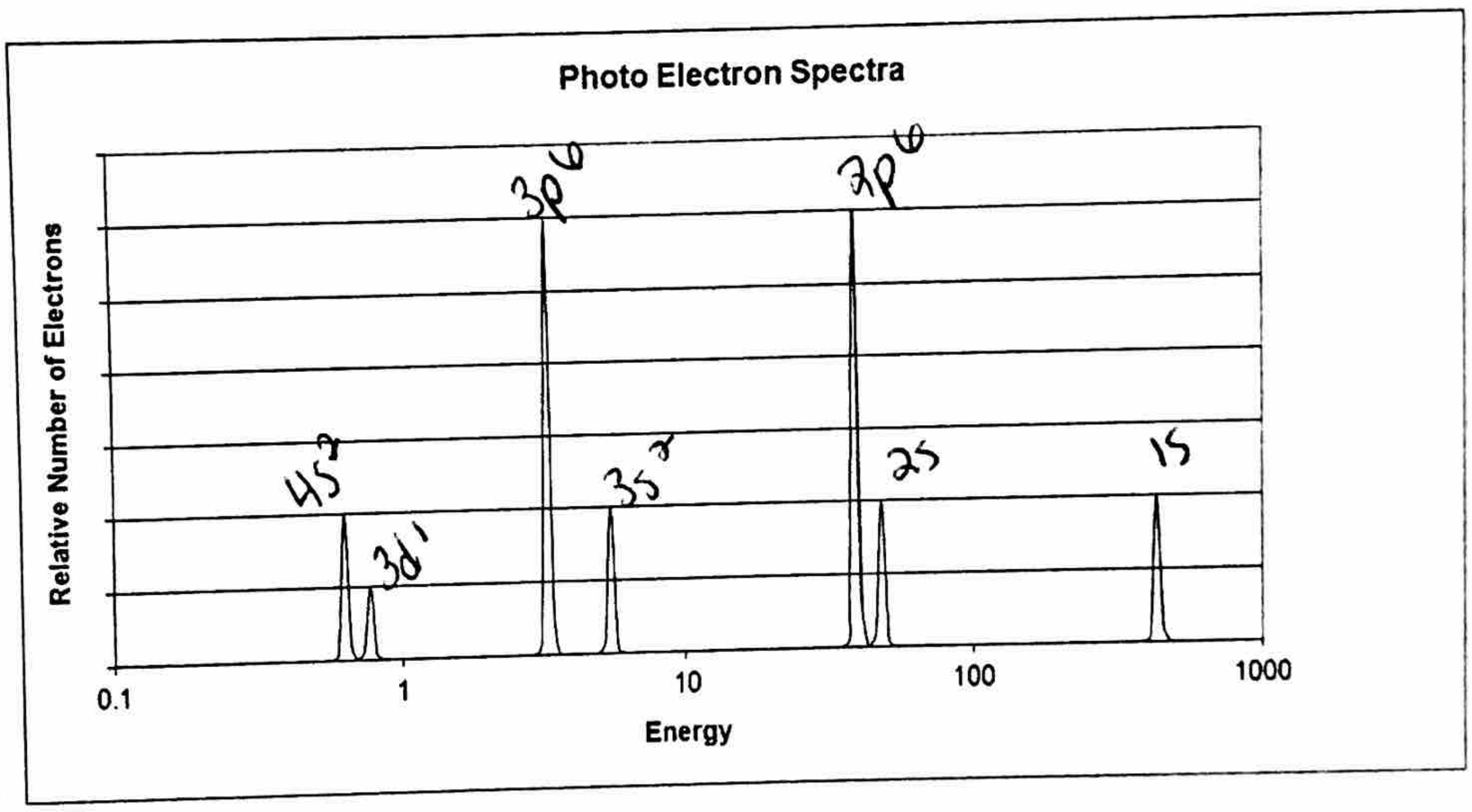
The one on the left because it has less energy that is required to remove an electron

8) Identify the following elements based on their PES data:



a)

The element is silicon



b)

The element is Scandium