

## Chapter 1 – Atomic Structure and Periodicity

### Super Problem

Answer the following questions about hydrogen atoms, H, hydrogen molecules, H<sub>2</sub>, and hydrogen compounds.

- (a) An atom of hydrogen emits a discrete wavelength of electromagnetic radiation at 486 nm as the electron transitions from a higher energy level back to the second energy level  $n = 2$ . Calculate the energy change, in joules, associated with this transition.
- (b) A second discrete emission line in an atom of hydrogen has a wavelength of 434 nm as the electron transitions from a higher energy level back to the second energy level ( $n = 2$ ).
- (i) Would the change in energy associated with the 434 nm spectral line be greater than, less than, or equal to, that of the 486 nm spectral line? Justify your answer.
- (ii) Would the energy level ( $n$ ) of the electronic transition responsible for the 434 nm spectral line be at a higher energy level or lower energy level than that of the 486 nm spectral line? Justify your answer.

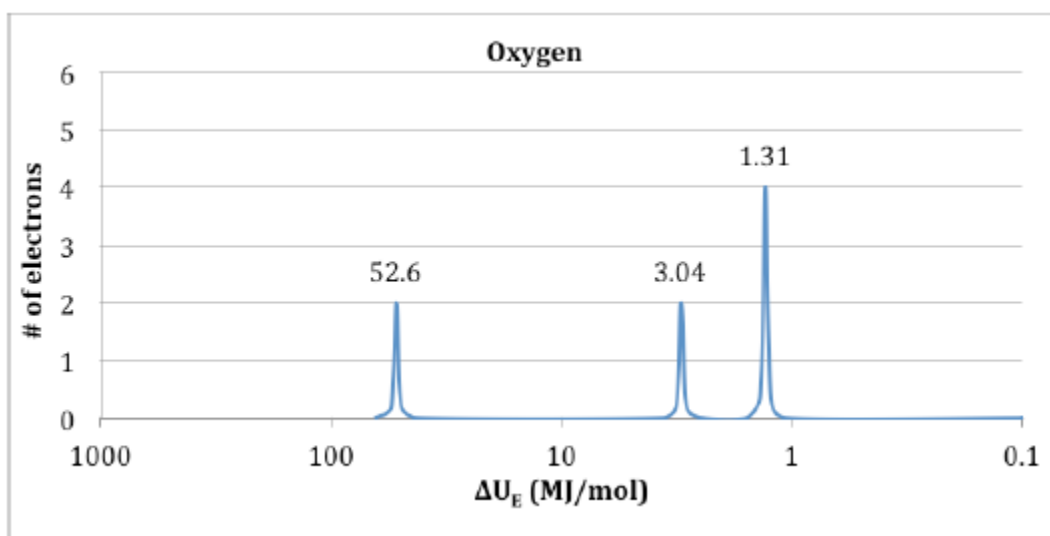
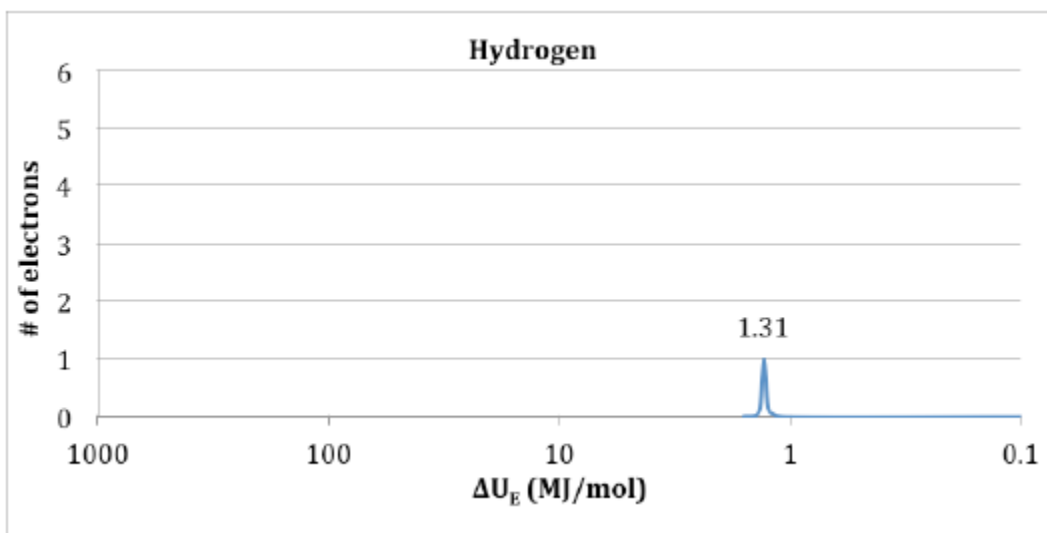
In a separate experiment a molecule of hydrogen,  $\text{H}_2$ , absorbs a photon of electromagnetic radiation with a wavelength of 300 nm. The energy required to break the bond in  $\text{H}_2$  gas is  $432 \text{ kJ mol}^{-1}$ .

(c) Calculate the frequency of the photons with a 300 nm wavelength.

(d) Calculate the number of joules required to break the bond in a single molecule of  $\text{H}_2$  gas.

(e) Does the photon have enough energy to break the bond in a molecule of  $\text{H}_2$  gas?  
Mathematically justify your answer.

The photoelectron spectrographs for both hydrogen and oxygen are shown below.

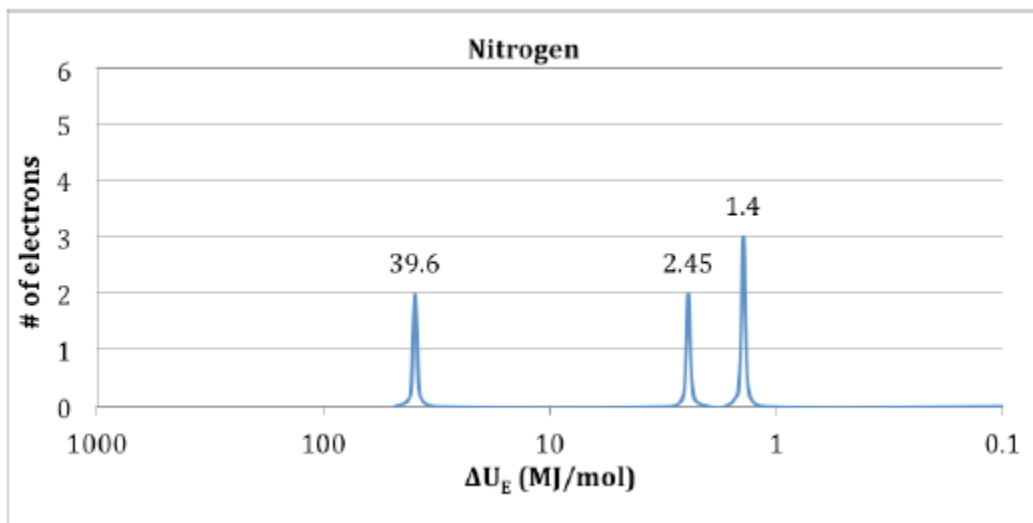


(f) Using evidence from the PES data, explain why two atoms of hydrogen and one atom of oxygen are required to form water,  $H_2O$ .

(g) Look at the photoelectron spectrum for oxygen. Circle the peak that contains the first electron that would be removed from an oxygen atom.

(h) Give the value for the first ionization energy for an atom of oxygen.

- (i) Below is the photoelectron spectrum for nitrogen. Explain why oxygen has a lower first ionization energy than does nitrogen.



- (j) Circle the peak in the photoelectron spectrum for nitrogen that represents the electrons in the  $2s$  subshell.
- (k) When hydrogen and nitrogen react they form ammonia. Write the balanced equation for this reaction.
- (l) Atoms of phosphorus and nitrogen are in the same group, or family, on the periodic table.
- (i) Predict the formula that results when hydrogen atoms form a compound with phosphorus atoms.
- (ii) Atoms of phosphorus are larger than atoms of nitrogen. Explain.