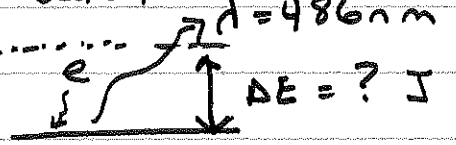
APChem - Unit 5 - NMSI SuperProblem

A) Given:

Hydrogen Atom $n = 2$



Soln:

$E = h\nu$

$c = \lambda\nu \Rightarrow \nu = \frac{c}{\lambda}$

$= \frac{hc}{\lambda} = \frac{(6.63\times10^{-34}\ J\cdot s)(3.00\times10^{17}\ \frac{nm}{s})}{486\ nm}$

$E = 4.09\times10^{-19}\ J$

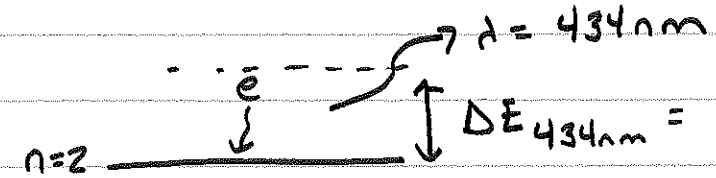
Constants

$h = 6.63\times10^{-34}\ J\cdot s$

$c = 3.00\times10^{8}\ m/s$ or $3.00\times10^{17}\ \frac{nm}{s}$

1 point for correct substitution
1 point for the correct number of joules (or kJ); unit must be shown to receive credit

B) Given:



i) $\Delta E = \frac{hc}{\lambda}$ if λ is smaller then the $\Delta E \uparrow$

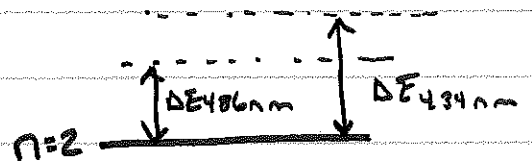
Since ΔE & λ are inversely related

∴ The ΔE for 434nm Emission will be greater than that of 486nm

1 point for correct answer with justification

ii) $\Delta E_{434nm} > \Delta E_{486nm}$

If $\Delta E_{434nm} > \Delta E_{486nm}$ then the electron must be at a higher initial energy level since both return to $n=2$



1 point for correct answer with justification

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c) Given: ∞ H_2 molecule ← photon absorbed $\lambda = 300\,nm$

Energy required to Break H_2 Bond is $432\ \frac{KJ}{mol}$

$\upsilon = ?$

Soln:

$c = \lambda \upsilon$

$\upsilon = \frac{c}{\lambda} = \frac{3.00 \times 10^{17}\ nm/s}{300\,nm}$

$\upsilon = 1.00 \times 10^{15}\ 1/s$

1 point for correct calculation

d) E = ? Joules to Break Bond in Single molecule of H_2 GAS

$432\ \frac{KJ}{mole}$ ← is for 1 mole not Single molecule

$$\left(\frac{432\ KJ}{mole\ H_2}\right)\left(\frac{1000\ J}{1\ KJ}\right)\left(\frac{1\ mole\ H_2}{6.02 \times 10^{23}\ molecules\ H_2}\right) = 7.18 \times 10^{-19}\ J/molecule\ H_2$$

1 point for the correct answer

e) Does photon (300nm) have enough E to Break H_2 Bond

$E = h\upsilon$ $\upsilon = 1 \times 10^{15}\ 1/s$

$E = (6.63 \times 10^{-34}\ J \cdot s)(1.00 \times 10^{15}\ 1/s)$

$E = 6.63 \times 10^{-19}\ J$

$6.63 \times 10^{-19}\ J < 7.18 \times 10^{-19}\ J$

↑ Energy in Photon

↑ Energy needed to Break Bond in Single H_2 Bond

∴ The photon does not have enough energy to Break the Bond

1 point for calculating the energy of the photon

1 point for comparing the energy of the photon to the energy of the single molecule of H_2 and stating the correct answer

Key

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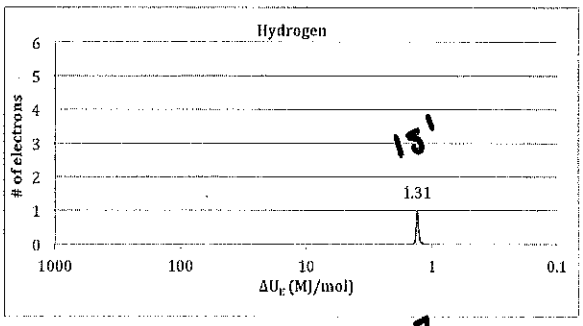
e. Does the photon have enough energy to break the bond in a molecule of H_2 gas? Mathematically justify your answer.

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



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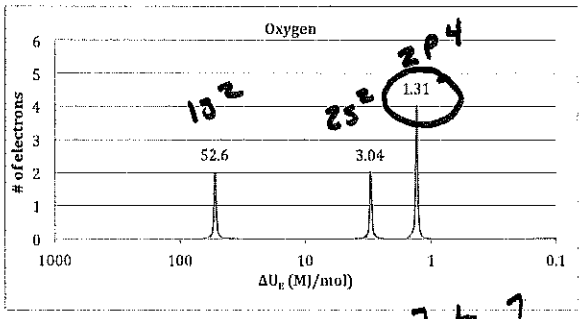

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f. Using evidence from the PES data, explain why two atoms of hydrogen and one atom of oxygen are required to form water, H_2O.

The PES data shows that H has 1 electron in its valence shell & O has 4, So it can form 2 single bonds, one with each of the 2 atoms of H

1 point for the correct answer referencing the data provided

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

The peak labeled 1.31 (far most to the Right) should Be Circled as one of those 4e's would Be Removed 1st.

1 point for correct peak

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

1.31 MJ/mol

1 point for the correct first ionization energy

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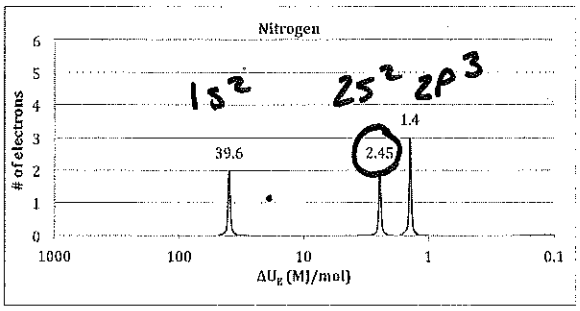
i. Below is the photoelectron spectrum for nitrogen. Explain why oxygen has a lower first ionization energy than does nitrogen.



1 point for the correct explanation

N $2p^3$ vs O $2p^4$

O has a higher Z_{eff} (more positive nuclear charge) than N, oxygen has 2e's paired in its p orbital. N has all 3 p electrons unpaired. O paired e's causes an increased e-e repulsion which decreases the electrostatic PE of those paired electrons ∴ it takes less energy to remove the 1st one of them.

j. Circle the peak in the photoelectron spectrum for nitrogen that represents the electrons in the 2*s* subshell.

Peak 2.45 circled

1 point for the correct peak

k. When hydrogen and nitrogen react they form ammonia. Write the balanced equation for this reaction.

$$N_2 + 3H_2 \rightarrow 2NH_3$$

1 point for the balanced equation

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.

Since in same family similar properties

PH_3

1 point for the correct formula

ii. Atoms of phosphorus are larger than atoms of nitrogen. Explain.

Atoms of P have valence e's in 3rd shell + Atoms of N have valence e's in 2nd shell. The more shells, the less attracted the electrons are to the nucleus the further away they are from nucleus

P $1s^2 2s^2 2p^6 3s^2 3p^3$

N $1s^2 2s^2 2p^3$

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1 point for the correct answer with justification