ANSWERS TO ATOMIC STRUCTURE PROBLEM SET

1. (a) $\nu = c/\lambda$ =(3.0 x 10^8 m/s)/500 x 10^{-9} m = 6.0 x 10^{14} s^{-1}
(b) $E = h\nu$ = (6.62 x 10^{-34} J-s)(6.0 x $10^{14}s^{-1}$) = 3.97 x 10^{-19} J/photon
(c) E (kJ/mol) = (3.97 x 10^{-19})(6.02 x 10^{23})(1 kJ/1000J) = 239 kJ/mol

2. Wavelength of a photon necessary to produce a photoelectron from this metal is
$\lambda = hc/E$ = (6.62 x 10^{-34})(3 x 10^8)/(6.70 x 10^{-19}) = 2.96 x 10^{-7}m = 296 nm

Therefore the device will not work on this planet because the photons of this wavelength will be absorbed by the atmosphere on this planet.

3. ΔE = (6.62 x 10^{-34})(1.141 x 10^{14}) = 7.553 x 10^{-20} J

ΔE = -2.178 x 10^{-18}[$1/n^2$ - $1/4^2$] = 7.553 x 10^{-20}

Solving for n yields n = 6

4. To calculate the ionization potential of a one-electron system we take the electron from its ground state (n=1) and remove it to its n=∞ orbit. For C^{5+} (Z = 6) and therefore

$\Delta E = E_\infty - E_1$ = -2.178 x 10^{-18}(6^2)[$1/\infty^2$ - $1/1^2$] = +7.841 x 10^{-17} Joule
Therefore the ionization potential of C^{5+} in kJ/mol is simply
7.844 x 10^{-17} x 6.02 x 10^{23}/1000 = 4.72 x 10^4 kJ/mol

5. For the H-atom ΔE = -2.178 x 10^{-18}[$1/2^2$ - $1/1^2$]

For the C^{5+} ion ΔE = -2.178 x 10^{-18}(6^2)[$1/n_o^2$ - $1/n_i^2$]
ΔE must be the same for both species since the transition for both species gives rise to a spectral line at 121.6 nm. Therefore

-2.178 x 10^{-18}[$1/2^2$ - $1/1^2$] = -2.178 x 10^{-18}(6^2)[$1/n_o^2$ - $1/n_i^2$]
1/4 - 1/1 = 6^2[$1/n_o^2$ - $1/n_i^2$]
1/144 - 1/36 = [$1/n_o^2$ -$1/n_i^2$]
Therefore $n_o = \sqrt{144} = 12$ and $n_i = \sqrt{36} = 6$

6. (a) 32 electrons
(b) 25 electrons
(c) 10 electrons
(d) 2 electrons
(e) 0 electrons