AP Chemistry
1999 Sample Student Responses

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a. i. $c = \lambda \nu$

$3.0 \times 10^8 \frac{m}{sec} = (495 nm) \nu$

$\nu = \frac{3.0 \times 10^8 m\, sec^{-1}}{495 nm} \times \frac{1000000000 nm}{m} = 6.1 \times 10^{14} sec^{-1}$

ii. $E = h \nu$

$= (6.63 \times 10^{-34} J \cdot sec)(6.1 \times 10^{14} sec^{-1})$

$= 4.0 \times 10^{-19} J$

iii. $\frac{4.0 \times 10^{-19} J}{molecule} \times \frac{KJ}{1000 J} \times \frac{6.022 \times 10^{23} molecules}{mol} = \frac{240 KJ}{mol}$

b. i. It emits energy since an electron in n=6 has a higher energy than an electron in n=2. Therefore it must release energy to fall. We know n=6 has higher energy than n=2 since $E_n = \frac{-2.178 \times 10^{-18} J}{n^2}$ and

$$\frac{-2.178 \times 10^{-18} J}{6^2} < \frac{-2.178 \times 10^{-18} J}{2^2}$$

ii. $E_6 - E_2$ = Energy released = ΔE

$\frac{-2.178 \times 10^{-18} J}{6^2} - \frac{-2.178 \times 10^{-18} J}{2^2} = 4.84 \times 10^{-19}$

$\Delta E = h\nu$

$4.84 \times 10^{-19} J = (6.63 \times 10^{-34} J\cdot s)\nu$

$\nu = 7.30 \times 10^{14}$

$c = \lambda\nu$

$3.0 \times 10^8 = \lambda(7.30 \times 10^{14})$

$\lambda = 4.1 \times 10^{-7} m = 410 nm$

iii. Because there are more protons providing attractive forces on the He^+ ion, the energy levels are differently spaced to adjust for this.

(a)

(i) ν = frequency $\quad c = \lambda\nu$

$\nu = \frac{c}{\lambda} = \frac{3\times10^{8}\,m}{s} \Big| \frac{1\,nm}{10^{-9}\,m} \Big| \frac{1}{495\,nm}$

$\boxed{\nu = 6.06\times10^{14}\,s^{-1}}$

(ii) $\Delta E = h\nu \qquad \Delta E = 6.63\times10^{-34} \cdot 6.06\times10^{14} = \boxed{4.02\times10^{-19}\,J}$

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

ν = (from (i)) 6.06×10^{14}

(iii) $E_n = \frac{-2.178\times10^{-18}\,J}{n^2}$ Joules $\quad n=2 \quad$ Cl is in the 2p orbital

$E_2 = \frac{-2.178\times10^{-18}\,J}{2^2} = \frac{-2.178\times10^{-18}\,J}{4} = -5.445\times10^{-19}\,J \Big| \frac{kJ}{1000\,J} = -5.44\times10^{-22}\,kJ$

$\lambda = \frac{h}{m\nu}$

$\lambda m\nu = h$

$m = \frac{h}{\nu\lambda} \qquad m = \frac{6.63\times10^{-34}\,J\,s}{6.06\times10^{14}\,s^{-1}\times495\,nm} \Big| \frac{1\,nm}{10^{-9}\,m} = 2.21\times10^{-60}\,g \Big| \frac{mol}{70.8\,g} = 3.12\times10^{-62}\,mol$

$\frac{-5.44\times10^{-22}\,kJ}{3.12\times10^{-62}\,mol} = \boxed{-1.74\times10^{40}\,kJ/mol}$

b) (i) The H atom emits energy when dropping in energy levels. The higher the energy level, the higher the energy. As an electron drops down energy level, energy is given off.

(ii) $\lambda = ?\,nm$ $c = \lambda\nu$ $E_n = \frac{-2.178 \times 10^{-18} J}{n^2}$

$E_6 = \frac{-2.178 \times 10^{-18} J}{6^2} = -6.05 \times 10^{-20} J$ $E_6 - E_2 = 4.84 \times 10^{-19} = \Delta E$

$E_2 = \frac{-2.178 \times 10^{-18} J}{2^2} = -5.445 \times 10^{-19} J$

$\Delta E = h\nu$ $h = 6.63 \times 10^{-34} Js$

$4.84 \times 10^{-19} J = 6.63 \times 10^{-34} \nu$

$\nu = 7.30 \times 10^{14} s^{-1}$ $c = 3.0 \times 10^8 m/s$

$c = \lambda\nu$ $\lambda = \frac{c}{\nu}$ $\frac{3.0 \times 10^8 ms^{-1}}{7.30 \times 10^{14} s^{-1}} =$

$\lambda = 4.11 \times 10^{-7} m \left| \frac{nm}{10^{-9} m} \right. = 411\,nm$

(iii) These atoms are so close in size that the change in energy is the same. Also, the energy levels stay the same so no factors are changed a)

i) $c = f\lambda$ $f = c/\lambda = (4.95 \times 10^{-7} / 3 \times 10^{8})^{-1} = 6.06 \times 10^{14}\ sec^{-1}$

ii) $E = hf = 6.63 \times 10^{-34} \cdot 6.06 \times 10^{14} = 4.04 \times 10^{-19}\ J$

iii) $4.04 \times 10^{-19} \times 1000 = 4.04 \times 10^{-16}\ kJ$

b) i) The H atom emits energy because to go from a further energy level from the nucleus, $n=6$, where an electron needs much energy to resist the pull of the protons in the nucleus, to a closer level ($n=2$), where not as much energy is needed, one gives up energy.

ii) $E = \frac{-2.178 \times 10^{-18}}{6^2 = 192} = -6.05 \times 10^{-20}$

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iii) It takes more energy to resist the He^+'s proton because its attraction force, Z, is much greater than Hydrogen's proton attraction.