HOMEWORK 9

PROBLEM 1 (KRANE # 8)

EQUATION 8.1

$$E_2 = (-13.6\,eV)\left(\frac{2^2}{2^2}\right)$$

$$= \boxed{-13.6\,eV}$$

$$E_3 = (-13.6\,eV)\left(\frac{2^2}{3^2}\right) = \boxed{-6.044\,eV}$$

THESE MATCH MEASURED ENERGIES WELL.

PROBLEM 2 (KRANE # 12)

LET $K_\alpha = 0.194\,nm$. THIS IS A TRANSITION FROM $n=1 \Rightarrow n=2$. WITH ENERGY $E = \frac{1240\,nm \cdot eV}{.194\,nm} = 6391.75\,eV$

EQUATION 8.4 GIVES

$$6391.75\,eV = 10.2\,eV(Z-1)^2$$

$$\Rightarrow Z = \sqrt{\frac{6391.75\,eV}{10.2\,eV}} + 1 \cong 26.$$

$\Rightarrow$ $\boxed{\text{THIS IS IRON.}}$

PROBLEM 3

K_α IS $n=1 \to n=2$

K_β IS $n=1 \to n=3$

L_α IS $n=2 \to n=3$

THE ATOMIC NUMBERS

47 FOR SILVER,

74 FOR TUNSTEN

42 FOR MOLYBDENUM.

Eq 8.1.

a.) WITH $Z=47$ $K_\alpha = E_1 - E_2 = (-13.6\,eV)(46)^2\left(-\frac{3}{4}\right)$

$= 21583.2\,eV$

& $K_\beta = E_1 - E_3 = (-13.6\,eV)(46)^2\left(\frac{1}{3^2} - \frac{1}{1^2}\right)$

$= 25580.1\,eV$

$\Rightarrow L_\alpha = K_\beta - K_\alpha = 3996.89\,eV$

$\Rightarrow \lambda_{K_\alpha} = \frac{1240\,eV\,nm}{21583.2\,eV} = .057\ nm$

$\lambda_{K_\beta} = \frac{1240\,eV \cdot nm}{25580.1\,eV} = .048\ nm$

$\lambda_{L_\alpha} = \frac{1240\,eV \cdot nm}{3996.89} = .31\ nm$

Problem 4 (Kane #28)

Let $E(R) = \frac{A}{R^9} - \frac{B}{R}$ be the energy of of a diatomic molecule with distance R with distance, R, between them. This looks like the combination of repulsive and attractive forces which will have a minimum at some R_{eq}. We find that minimum as follows:

$$E'(R) = -9 \cdot \frac{A}{R_{eq}^{10}} + \frac{B}{R_{eq}^2} = 0 \Rightarrow B = \frac{9A}{R_{eq}^8}$$

We also have that, where $R = R_{eq}$,

$$E_0 = \frac{A}{R_{eq}^9} - \frac{B}{R_{eq}}$$

$$\Rightarrow E_0 = \frac{A}{R_{eq}^9} - \frac{1}{R_{eq}}\left(\frac{9A}{R_{eq}^8}\right) = \frac{A}{R_{eq}^9} - \frac{9A}{R_{eq}^9}$$

$$\Rightarrow A = \boxed{-E_0 R_{eq}^9 \left(\frac{1}{8}\right)} \Rightarrow B = \frac{9}{R_{eq}^8}\left(-E_0 R_{eq}^9 \left(\frac{1}{8}\right)\right) = \boxed{\frac{-9 R_{eq} E_0}{8}}.$$

FROM FIGURE 9.6, $E_0 = -4.52\,eV$ &

$R_{eq} = 0.074\,nm$. Now

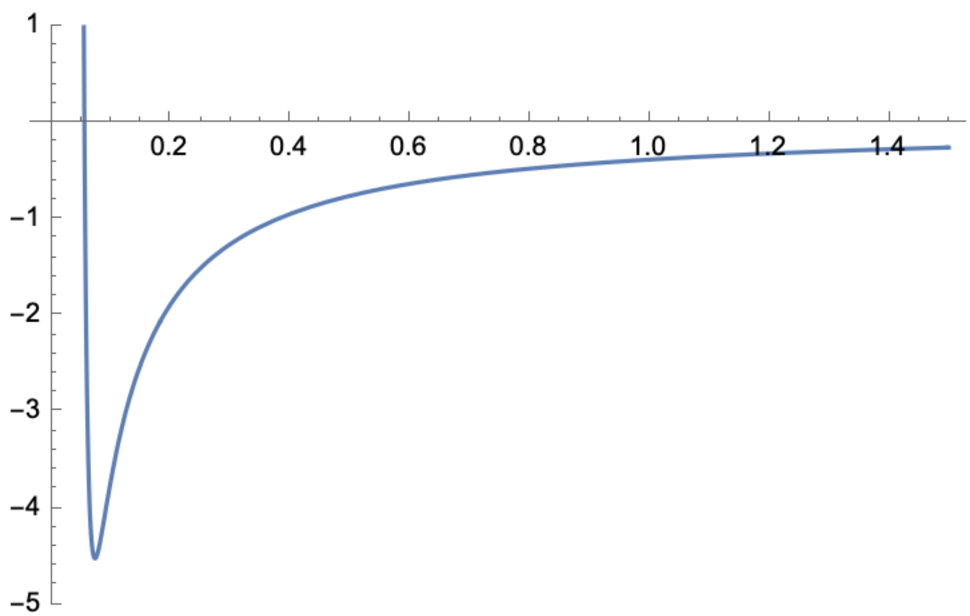
$$E(R) = \frac{A}{R^9} - \frac{B}{R} = \frac{3.76 \cdot 10^{-11}}{R^9} - \frac{0.376}{R}$$

PLOTTED WITH MATHEMATICA.

In[27]:=
```
f[x_] := 3.76*10^-11/x^9 - .376/x
```

In[28]:=
```
Plot[f[x], {x, .05, 1.5}, PlotRange → {-5, 1}]
```

Out[28]=



PROBLEM 5

LET $m=n=1$. IN THE SPIN TRIPLET

$$\psi(x_1, x_2) = \frac{1}{\sqrt{2}}\left[u_n(x_1)u_m(x_2) - u_n(x_2)u_m(x_1)\right]$$

WITH $n=m=1$

$$\psi(x_1, x_2) = \frac{1}{\sqrt{2}}\left[\sqrt{\frac{2}{L}}\sin\left(\frac{\pi x_1}{L}\right)\sqrt{\frac{2}{L}}\sin\left(\frac{\pi x_2}{L}\right) - \sqrt{\frac{2}{L}}\sin\left(\frac{\pi x_2}{L}\right)\sqrt{\frac{2}{L}}\sin\left(\frac{\pi x_1}{L}\right)\right]$$

$$= 0$$

$$\Rightarrow |\psi|^2 = 0 \Rightarrow$$ MUST BE OPPOSITE SPIN.

Problem 6

Let $n=1$ & $m=2$ & $L=1\,nm$. Now

$$\psi(x_1, x_2) = \frac{1}{\sqrt{2}}\left[\frac{2}{L}\sin\left(\frac{\pi x_1}{L}\right)\sin\left(\frac{2\pi x_2}{L}\right) - \frac{2}{L}\sin\left(\frac{\pi x_2}{L}\right)\sin\left(\frac{2\pi x_1}{L}\right)\right]$$

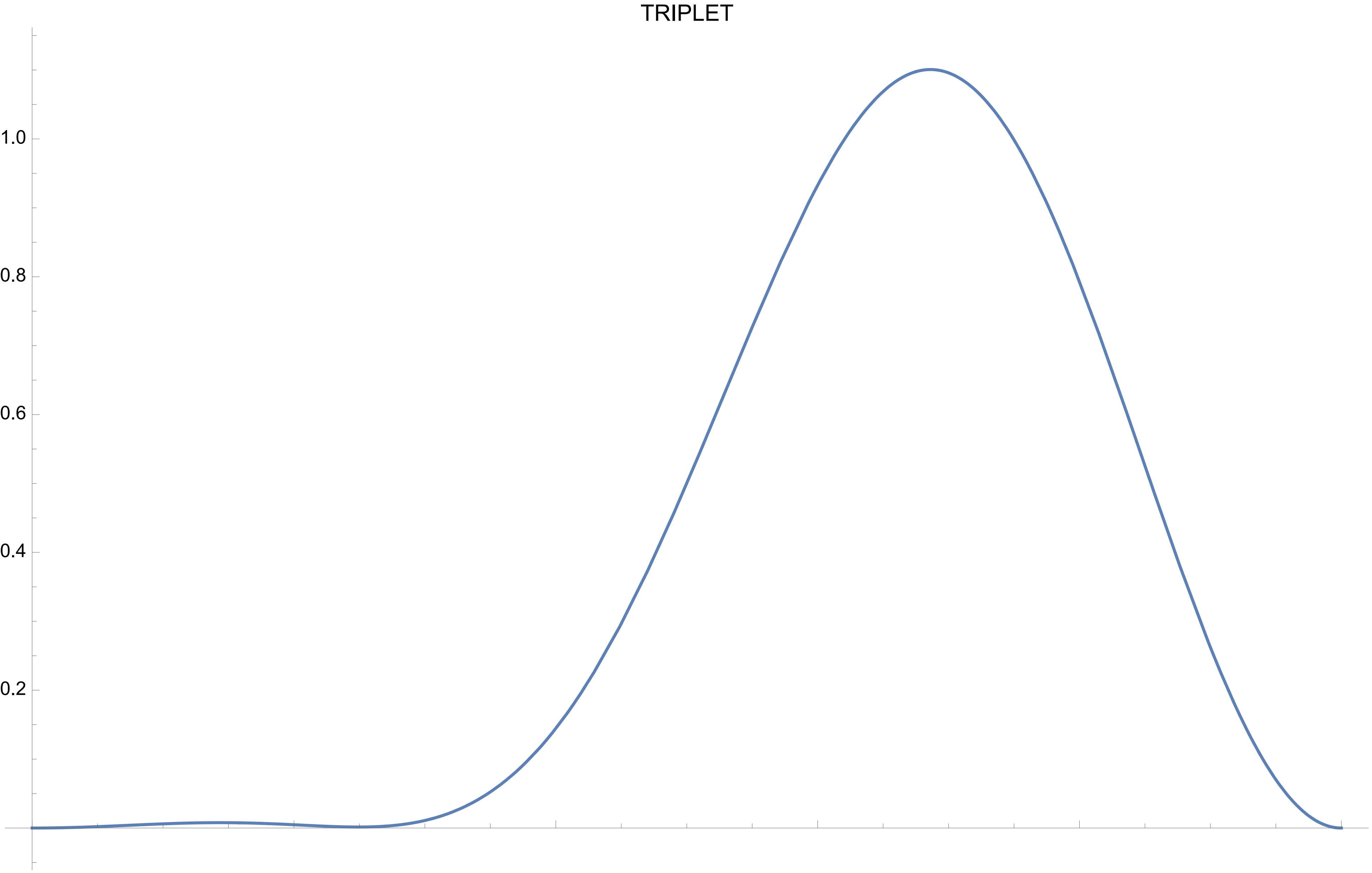
$$\Rightarrow \psi\left(x_1, \frac{L}{4}\right) = \frac{1}{\sqrt{2}}\left[\frac{2}{L}\sin\left(\frac{\pi x_1}{L}\right)\sin\left(\frac{2\pi}{4}\right) - \frac{2}{L}\sin\left(\frac{2\pi}{4}\right)\sin\left(\frac{2\pi x_1}{L}\right)\right]$$

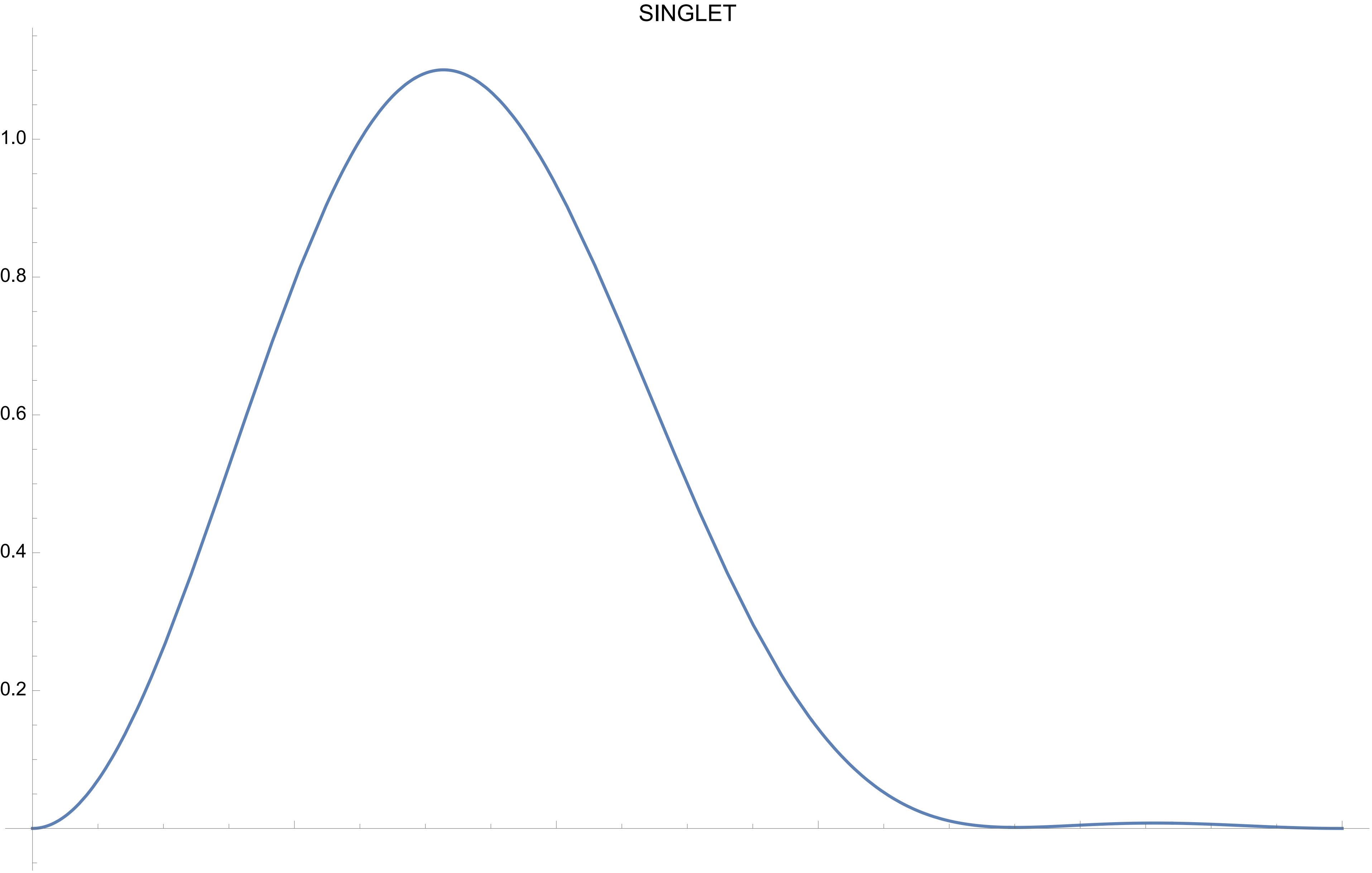
$$= \frac{1}{\sqrt{2}}\left[\frac{2}{L}\sin\left(\frac{\pi x_1}{L}\right) - \frac{2}{L}\sin\left(\frac{2\pi x_1}{L}\right)\right]$$

$$= \frac{2}{L\sqrt{2}}\left[\sin\left(\frac{\pi x_1}{L}\right) - \sin\left(\frac{2\pi x_1}{L}\right)\right]$$

$$\Rightarrow \left|\psi\left(x_1, \frac{L}{4}\right)\right|^2 = \frac{4}{L^2 2}\left[\sin^2\left(\frac{\pi x_1}{L}\right) - 2\sin\left(\frac{\pi x_1}{L}\right)\sin\left(\frac{2\pi x_1}{L}\right) + \sin^2\left(\frac{2\pi x_1}{L}\right)\right]$$

For the spin singet we would add instead of subtract the middle term. Plotted with Wolfram, if x_1 is at $\frac{1}{4}$, the opposite spin state (singlet) allows for a higher probility of x_2 near $\frac{1}{4}$.


TRIPLET
1.0
0.8
0.6
0.4
0.2


SINGLET
1.0
0.8
0.6
0.4
0.2