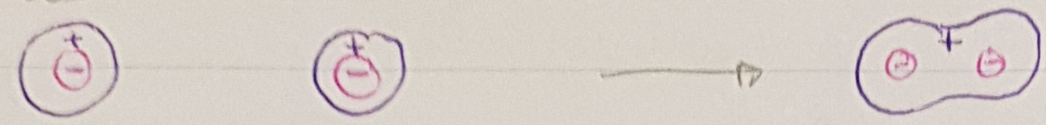
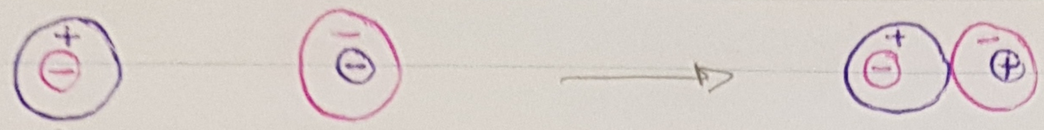
(1) a) $\psi_{2s}^{(l)}(\vec{r}) + \psi_{2s}^{(r)}(\vec{r})$



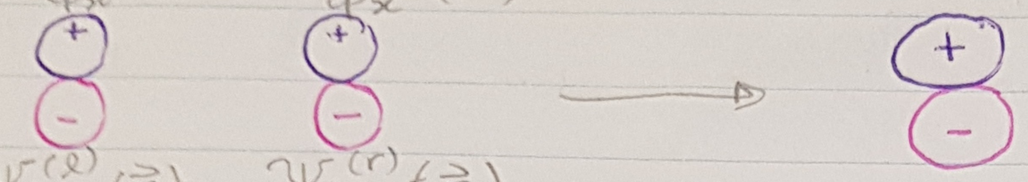
σ_g^+

b) $\psi_{2s}^{(l)}(\vec{r}) - \psi_{2s}^{(r)}(\vec{r})$



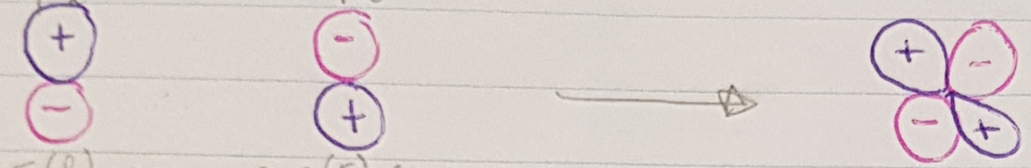
σ_u^+

c) $\psi_{2p_x}^{(l)}(\vec{r}) + \psi_{2p_x}^{(r)}(\vec{r})$



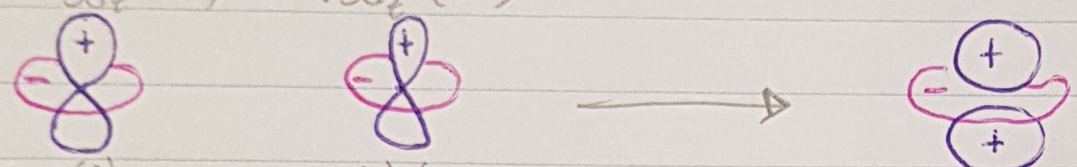
π_u^+

d) $\psi_{2p_x}^{(l)}(\vec{r}) - \psi_{2p_x}^{(r)}(\vec{r})$



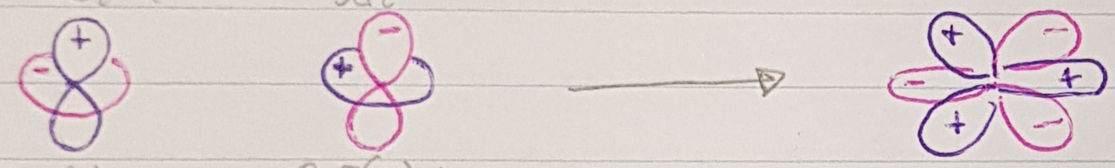
π_g^+

e) $\psi_{3d_{z^2}}^{(l)}(\vec{r}) + \psi_{3d_{z^2}}^{(r)}(\vec{r})$



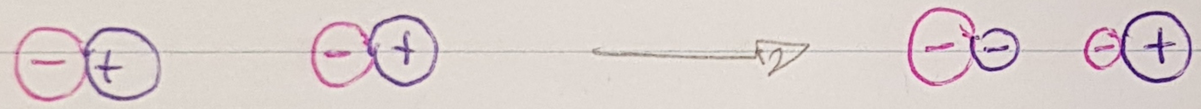
σ_g^+

f) $\psi_{3d_{z^2}}^{(l)}(\vec{r}) - \psi_{3d_{z^2}}^{(r)}(\vec{r})$



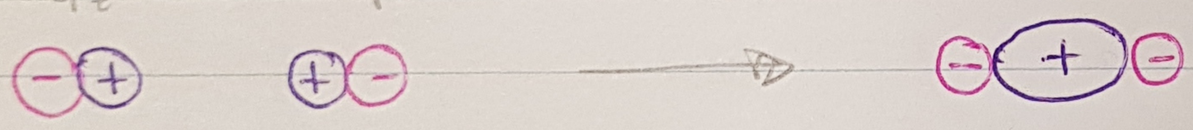
δ_u^+

g) $\psi_{2p_z}^{(l)}(\vec{r}) + \psi_{2p_z}^{(r)}(\vec{r})$



σ_u^+.

h) $\psi_{2p_z}^{(l)}(\vec{r}) - \psi_{2p_z}^{(r)}(\vec{r})$



σ_g^+.

(2) $Li_2^{2+} : (1\sigma_g^+)^2 (1\sigma_u^+)^2 \rightarrow |\phi_{1\sigma_g^+}\alpha\, \phi_{1\sigma_g^+}\beta\, \phi_{1\sigma_u^+}\alpha\, \phi_{1\sigma_u^+}\beta|$

$$= \frac{1}{\sqrt{4!}} \begin{bmatrix} \phi_{1\sigma_g^+}(\vec{r}_1)\alpha(1) & \phi_{1\sigma_g^+}(\vec{r}_1)\beta(1) & \phi_{1\sigma_u^+}(\vec{r}_1)\alpha(1) & \phi_{1\sigma_u^+}(\vec{r}_1)\beta(1) \\ \phi_{1\sigma_g^+}(\vec{r}_2)\alpha(2) & \phi_{1\sigma_g^+}(\vec{r}_2)\beta(2) & \phi_{1\sigma_u^+}(\vec{r}_2)\alpha(2) & \phi_{1\sigma_u^+}(\vec{r}_2)\beta(2) \\ \phi_{1\sigma_g^+}(\vec{r}_3)\alpha(3) & \phi_{1\sigma_g^+}(\vec{r}_3)\beta(3) & \phi_{1\sigma_u^+}(\vec{r}_3)\alpha(3) & \phi_{1\sigma_u^+}(\vec{r}_3)\beta(3) \\ \phi_{1\sigma_g^+}(\vec{r}_4)\alpha(4) & \phi_{1\sigma_g^+}(\vec{r}_4)\beta(4) & \phi_{1\sigma_u^+}(\vec{r}_4)\alpha(4) & \phi_{1\sigma_u^+}(\vec{r}_4)\beta(4) \end{bmatrix}$$

(3) $\psi_{Li^{2+}}(\vec{r}) = -\left(\frac{1}{3}\right)^{1/2} R_{4,2}(r) Y_{2,-1}(\theta,\phi) + \left(\frac{2i}{3}\right) R_{3,2}(r) Y_{2,1}(\theta,\phi) - \left(\frac{2}{9}\right)^{1/2} R_{1,0}(r) Y_{0,0}(\theta,\phi)$.

a) $E = \{E_4, E_3, E_1\} = \left\{-\frac{3^2}{2(4)^2}, -\frac{3^2}{2(3)^2}, -\frac{3^2}{2(1)^2}\right\} = \left\{-\frac{9}{32}, -\frac{1}{2}, -\frac{9}{2}\right\}$

b) $P(E_4) = \left|\left\langle -\left(\frac{1}{3}\right)^{1/2} R_{4,2} Y_{2,-1} \middle| \psi_{Li^{2+}} \right\rangle\right| = \left|\left(-\left(\frac{1}{3}\right)^{1/2}\right)^2\right| = \frac{1}{3}$

$P(E_3) = \left|\left\langle \left(\frac{2i}{3}\right) R_{3,2} Y_{2,1} \middle| \psi_{Li^{2+}} \right\rangle\right| = \left|\left(\frac{2i}{3}\right)^2\right| = \frac{4}{9}$

$P(E_1) = \left|\left\langle -\left(\frac{2}{9}\right)^{1/3} R_{1,0} Y_{0,0} \middle| \psi_{Li^{2+}} \right\rangle\right| = \left|\left(-\left(\frac{2}{9}\right)^{1/2}\right)^2\right| = \frac{2}{9}$

$\langle E \rangle = \frac{3}{9}\left(-\frac{9}{32}\right) + \frac{4}{9}\left(-\frac{1}{2}\right) + \frac{2}{9}\left(-\frac{9}{2}\right) = \frac{-27-64-288}{288} = -1.316$ //

c) $L^2 = \{\hbar^2(2)(2+1), \hbar^2(2)(2+1), \hbar^2(0)(0+1)\} = \{6\hbar^2, 6\hbar^2, 0\hbar^2\}$

d) $P(6\hbar^2) = \left(\left(\frac{1}{3}\right)^{1/2}\right)^2 + \left|\left(\frac{2i}{3}\right)^2\right| = \frac{3}{9}$ //