2) $|\psi_\ell\rangle = \frac{1}{2}\sum_{i=1}^{4}(-1)^{f_\ell(i)}|i\rangle$

$$|\psi_1\rangle = \frac{1}{2}\left(-|1\rangle + |2\rangle + |3\rangle + |4\rangle\right)$$

$$|\psi_2\rangle = \frac{1}{2}\left(|1\rangle - |2\rangle + |3\rangle + |4\rangle\right)$$

$$|\psi_3\rangle = \frac{1}{2}\left(|1\rangle + |2\rangle - |3\rangle + |4\rangle\right)$$

$$|\psi_4\rangle = \frac{1}{2}\left(|1\rangle + |2\rangle + |3\rangle - |4\rangle\right)$$

2Bi) $\langle\psi_1|\psi_2\rangle = \frac{1}{4}(-1 - 1 + 1 + 1) = 0$

$\langle\psi_1|\psi_3\rangle = \frac{1}{4}(-1 + 1 - 1 + 1) = 0$

$\langle\psi_1|\psi_4\rangle = \frac{1}{4}(-1 + 1 + 1 - 1) = 0$

etc. $\langle\psi_\ell|\psi_{\ell'}\rangle = \delta_{\ell\ell'}$