1. Translate the following expression from KM notation into our original notation, using daggers to denote creation operators and lines to denote contractions.

$$:a^{p^\circ q^\bullet}_{s^\bullet t^{\bullet\bullet}} r^{\bullet\bullet}_{u^\circ}: = ?$$

   Your final expression should be a Φ-normal-ordered string of six operators with three contraction lines.

2. Expand the following as a linear combination of Φ-normal-ordered operators.

$$\tilde{a}^p_q \tilde{a}^{rs}_{tu} = ?$$

3. Evaluate the following matrix element.[1]

$$\langle \Phi_i^a | H_e - E_{\text{ref}} | \Phi_j^b \rangle = ?$$

[1] You may use either of the following equivalent expressions for the Hamiltonian. (I recommend the one on the right!)

$$H_e = h_p^q a_q^p + \tfrac{1}{4} \overline{g}_{pq}^{rs} a_{rs}^{pq} \qquad\qquad H_e = E_{\text{ref}} + f_p^q \tilde{a}_q^p + \tfrac{1}{4} \overline{g}_{pq}^{rs} \tilde{a}_{rs}^{pq}$$