1. (25 points) Let HALT be the Halting language. Show that HALT is \( \mathbf{NP} \)-hard. Is it \( \mathbf{NP} \)-complete?

2. (25 points) Call graphs \( G \) and \( H \) isomorphic if the nodes of \( G \) can be reordered so that the graph \( G \) is identical to \( H \). Let \( \text{ISO} = \{ \langle G, H \rangle | G \text{ and } H \text{ are isomorphic graphs} \} \). Show that \( \text{ISO} \in \mathbf{NP} \).

3. (25 points) Show that, if \( \mathbf{P} = \mathbf{NP} \), then every language \( A \in \mathbf{P} \), except \( A = \emptyset \) and \( A = \Sigma^* \), is \( \mathbf{NP} \)-complete. Here \( \Sigma \) is the alphabet, and you may assume that it is \{0, 1\}.

4. (25 points) Let \( \phi \) be a 3CNF. An \( \neq \)-assignment to the variables of \( \phi \) is one where each clause contains two literals with unequal truth values.

   (a) Show that any \( \neq \)-assignment automatically satisfies \( \phi \), and the negation of any \( \neq \)-assignment to \( \phi \) is also an \( \neq \)-assignment.

   (b) Let \( \neq \text{SAT} \) be the collection of 3CNFs that have an \( \neq \)-assignment. Show that we obtain a polynomial time reduction from 3SAT to \( \neq \text{SAT} \) by replacing each clause

   \[ c_i = (y_1 \lor y_2 \lor y_3) \]

   with the two clauses

   \[ (y_1 \lor y_2 \lor z_i) \text{ and } (\overline{z_i} \lor y_3 \lor b), \]

   where \( z_i \) is a new variable for each clause \( c_i \), and \( b \) is a single additional new variable.

   (c) Conclude that \( \neq \text{SAT} \) is \( \mathbf{NP} \)-complete.