Communicating Automata and Pi Calculus

Explain briefly the role played by structural congruence in defining the reaction rules of the π-calculus. Give the structural congruence rules which involve restriction, or composition, or both. [7 marks]

A π-calculus term of the form \( \text{new } \vec{z}(M_1|\cdots|M_m|Q_1|\cdots|Q_n) \), where \( m, n \geq 0 \) and each \( M_i \) is a summation, is said to be in standard form. Give an argument (which need not be fully formal) to show that every term of the π-calculus is structurally congruent to a standard form. [6 marks]

Consider the term

\[
P = \overline{a}(b) | \text{new } a (\overline{c} | (a(b).b(c).x(x) + x(y).y(z).z))\,.
\]

Convert \( P \) to standard form by the rules of structural congruence, indicating which rules are used. Hence write down all the possible reactions \( P \rightarrow P' \), and the possible reactions of each resulting \( P' \). For each result which has no further reactions, write down the simplest term to which it is strongly equivalent (\( \sim \)), giving a brief justification. [7 marks]