Concurrent processes are defined by the syntax

\[ P ::= A(b_1, \ldots, b_n) \mid \Sigma \alpha_i.P_i \mid P_1 | P_2 \mid \text{new } a \ P \]

where each process identifier \( A \) is equipped with a defining equation \( A(a_1, \ldots, a_n) \overset{\text{def}}{=} P_A \). Give the transition rules from which transitions of the form \( P \overset{\alpha}{\rightarrow} P' \) can be inferred, where \( \alpha \) is of the form \( a, \bar{a} \) or \( \tau \). The rules should not use structural congruence (\( \equiv \)). [5 marks]

Enumerate the ways in which a transition of the form \( P|Q \overset{\alpha}{\rightarrow} R \) can be inferred from transitions of \( P \) and/or \( Q \), and indicate the form of \( R \) in each case. [5 marks]

Hence show that if \( P|Q \overset{\alpha}{\rightarrow} R_1 \), then there exists \( R_2 \) such that \( Q|P \overset{\alpha}{\rightarrow} R_2 \) and \( R_1 \equiv R_2 \). [5 marks]

Give an example of \( P \) and \( Q \) for which \( \text{new } a(P|Q) \) has a \( \tau \)-transition but \( P|\text{new } a Q \) has no \( \tau \)-transition. Now suppose that \( \text{new } a(P|Q) \overset{\alpha}{\rightarrow} R_1 \); what syntactic condition on \( P \) ensures that \( P|\text{new } a Q \overset{\alpha}{\rightarrow} R_2 \) for some \( R_2 \) with \( R_1 \equiv R_2 \)? Justify your answer. [5 marks]