## 2001 Paper 5 Question 11

## Logic and Proof

(a) Explain the meaning of the notation $A \models B$, where $A$ and $B$ denote formulae of (i) propositional logic and (ii) S4 modal logic.
(b) For each of the following equivalences, state whether it holds or not, justifying each answer rigorously.

$$
\begin{aligned}
(P \wedge(Q \rightarrow R)) \rightarrow S & \simeq(\neg P \vee \neg Q \vee S) \wedge(\neg P \vee \neg R \vee S) \\
(P \rightarrow Q) \rightarrow(Q \rightarrow P) & \simeq(Q \rightarrow P) \\
\forall x y(P(x) \vee \neg P(y)) & \simeq \quad \forall x y(P(x) \leftrightarrow P(y))
\end{aligned}
$$

