(1) Write out the truth table for \( \neg P \& Q \& \neg R \), and show that it is the same as the truth table for \( \neg[P \lor (Q \Rightarrow R)] \).

(2) (a) Write out the truth table for both \( P \Rightarrow Q \) and \( \neg Q \Rightarrow \neg P \) to double check that the contrapositive of \( P \Rightarrow Q \) is logically equivalent to \( P \Rightarrow Q \).

(b) Now write out the truth table for \( Q \Rightarrow P \). When does this truth table not match the truth table of \( P \Rightarrow Q \)?

(3) Explain why for a given set \( A \):

(a) \( \forall x \in A \ P(x) \) is false iff \( \exists x \in A \neg P(x) \) is true;

(b) \( \exists x \in A \ P(x) \) is false iff \( \forall x \in A \neg P(x) \) is true.
(4) Let $A$ be a set of real numbers. Express each of the following properties in abbreviated form, using the abbreviations $\Rightarrow$, $\iff$, $\land$, $\lor$, $\exists$, $\forall$, other common math symbols, and the names $\mathbb{N}$, $\mathbb{Q}$, and $\mathbb{R}$.

(a) $A$ has no smallest member.

(b) Between any two distinct members of $A$ there is an integer.

(c) There are two distinct members of $A$ with no member of $A$ in between.

(d) $\pi$ is the only irrational member of $A$.

(e) If there is a positive number in $A$, then $A$ contains no rational numbers.

(5) For each of the parts of the previous problem, write out the negation of the statements in abbreviated form. Then simplify the statement by moving the negation symbol 'inside' as far as possible.