List of Basic Logical Laws

These are listed on page 50 of Hammack, except the last two, which I find useful but aren't there.

- Contrapositive Law: $(P \implies Q) = ((\sim Q) \implies (\sim P))$
- DeMorgan's Law I: $\sim (P \wedge Q) = (\sim P) \vee (\sim Q)$
- DeMorgan's Law II: $\sim (P \vee Q) = (\sim P) \wedge (\sim Q)$
- Commutative Law for And: $P \wedge Q = Q \wedge P$
- Commutative Law for Or: $P \vee Q = Q \vee P$
- Distributive Law And over Or: $P \wedge (Q \vee R) = (P \wedge Q) \vee (P \wedge R)$
- Distributive Law Or over And: $P \vee (Q \wedge R) = (P \vee Q) \wedge (P \vee R)$
- Associative Law for And: $P \wedge (Q \wedge R) = (P \wedge Q) \wedge R$
- Associative Law for Or: $P \vee (Q \vee R) = (P \vee Q) \vee R$
- Simplification of Implies: $P \implies Q = (\sim P) \vee Q$
- Negation of Implies: $\sim (P \implies Q) = P \wedge (\sim Q)$

Using the laws above, manipulate the first expression to become the second one. State the laws you use as you use them.

1. $\sim ((P \wedge Q) \vee R)$ is logically equivalent to $((\sim P) \vee (\sim Q)) \wedge (\sim R)$

   Hint: Apply DeMorgan's twice.

2. $(P \vee Q) \implies R$ is logically equivalent to $R \vee ((\sim P) \wedge (\sim Q))$

   Hint: Simplify implies, then apply DeMorgan's and then Commutativity.

3. $\sim ((P \implies Q) \wedge R)$ is logically equivalent to $(P \wedge (\sim Q)) \vee (\sim R)$.

   Hint: Apply DeMorgan's, then Negation of Implies.