Answer the following questions:

Q.1 Choose the correct answer for each of the following items:

(i) One of the following statements is false:
   (a) If $2 < -2$, then $2 = 0$.
   (b) $7$ is an odd number and $7$ is not divisible by $2$.
   (c) $0 \in \mathbb{N}$ or $0 \in \mathbb{Z}$
   (d) $3 > 1$ if and only if $2 = 1 + 1$.

(ii) If $t$ is a tautology, $c$ is a contradiction, and $p$ is any statement, then then
   (a) $t \land p \equiv t$
   (b) $t \lor p \equiv p$
   (c) $c \land p \equiv p$
   (d) $c \lor p \equiv p$.

(iii) If $A = \{R\}$, then
   (a) $A = \mathbb{R}$
   (b) $\mathbb{R} \subseteq A$
   (c) $\mathbb{R} \in A$
   (d) $A \subseteq \mathbb{R}$.

(iv) If $A = \{a_1, a_2, a_3, a_4\}$, then the number of elements in $\wp(A)$ equals
   (a) $16$
   (b) $4$
   (c) $256$
   (d) $8$.

(v) Let $U$ be a universal set and let $A$ and $B$ be subsets of $U$. Then
   (a) $(A \cap B)' = A' \cup B'$
   (b) $A \cup U = A$
   (c) $A \cap U = U$
   (d) $A' = U$. 
Q.2 (a) Use deductive reasoning to prove the tautology \((p \lor q) \land \sim p \equiv q \land \sim p\)

(b) Give a proof of validity for the following argument:
1. \(p \lor (q \rightarrow s)\)
2. \(p \rightarrow r\)
3. \(\sim r \rightarrow (s \rightarrow u)\)
4. \(\sim r / q \rightarrow u\)
Q.3 (a) Use mathematical induction to prove that for all natural numbers $n$,

$$1.2.3 + 2.3.4 + 3.4.5 + \ldots + n(n + 1)(n + 2) = \frac{1}{4}n(n + 1)(n + 2)(n + 3)$$

(b) Prove that for any sets $A$, $B$, and $C$, $A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$
Q.4  (a) Prove that \((A \cap B) \subseteq B\).

(b) Prove that \(A \cup B = A \cup (B - A)\). "\textbf{Hint: } p \lor \sim p \equiv \text{tautology}"