Question 1: Let $p$ and $q$ be statements.

(a) Write down the truth table for $\neg(p \lor q)$. [2] marks

(b) Write down the truth table for $(p \lor \neg q) \Rightarrow (p \land q)$. [2] marks

Question 2: Write down the negations of the following propositions

(a) $\forall n \in \mathbb{N} \setminus \{1, 2\}, \forall a, b, c \in \mathbb{N}, a^n + b^n \neq c^n$. [2] marks

(b) $\forall x \in \mathbb{Q}, \exists y \in \mathbb{N}, \forall z \in \mathbb{R}, x + y \geq z$. [2] marks

Question 3: Define what it means for a function $f : A \to B$ NOT to be 1-1. [2] marks

Question 4: Let $A$ be a non-empty set and $f : \emptyset \to A$ a function. Which of the following are true (there may be more than one):

(A) $f$ must be 1-1;
(B) $f$ must be onto;
(C) $f$ is never 1-1;
(D) $f$ is never onto;
(E) whether or not $f$ is 1-1 or onto depends on the choice of $A$ and $f$. [2] marks

Question 5: (a) Find

$$
\begin{pmatrix}
1 & 2 & 3 & 4 & 5 & 6 \\
5 & 4 & 3 & 2 & 1 & 6
\end{pmatrix}
\circ
\begin{pmatrix}
1 & 2 & 3 & 4 & 5 & 6 \\
2 & 6 & 4 & 3 & 1 & 5
\end{pmatrix}.
$$

[1] mark

(b) Express $(18245)(25738)(127)$ as a product of disjoint cycles. [2] mark

(c) Find the inverse of the permutation $(14275)(368)$. [1] mark

PLEASE TURN OVER
**Question 6:** For each of the following statements, write down the contrapositive:

(a) \( \forall x \in \mathbb{Z}, \forall y \in \mathbb{Z}, x + y > 7 \Rightarrow (x > 3 \text{ or } y > 3) \).

(b) \( \forall x \in \mathbb{R}, (\exists y \in \mathbb{Z}, xy \in \mathbb{Z}) \Rightarrow x \in \mathbb{Q} \).

**Question 7:** Define the function \( f : \mathbb{Z} \to \mathbb{Z} \) by \( f(x) = x^3 \). State which of the following is correct:

(A) \( f \) is 1-1 and onto;
(B) \( f \) is 1-1 but not onto;
(C) \( f \) is onto but not 1-1;
(D) \( f \) is neither 1-1 nor onto.

**Question 8:** Let \( A, B \) and \( C \) be sets contained in a universal set \( U \). Which one of the following is equal to \( (A \cap (B^c \cup C))^c \)?

(I) \( A^c \cup (B^c \cap C) \)
(II) \( (A^c \cup B) \cap (A^c \cup C^c) \)
(III) \( A^c \cap (B \cup C^c) \)

**Question 9:** Write \( (\mathbb{Z} \times \{4\}) \setminus \{(x, x) : x \in \mathbb{Z}\} \) in the form \( A \times B \) for sets \( A \) and \( B \).

**Question 10:** Let \( A = \{1, 2\} \) and \( B = \{x\} \). Write down the power set of \( A \times B \).

**Question 11:** Let \( A \) and \( B \) be sets. Give a necessary and sufficient condition for \( A \setminus B = A \).