1.

Consider the sub-relation $R1(A,B,C,D,E)$. The dependencies over the relation $ABCDEFGHI$ are $A \to B, C \to D$.

(a) The relation *R1* is in 1NF with respect to the above functional dependencies. The primary key cannot be identified from the above functional dependencies. So, 2NF is not guaranteed.

Therefore, the strongest normal form of the relation *R1* is 1NF.

(b) The relation is not in BCNF because the relation is not in 2NF. To normalize the relation into BCNF, first normalize the table into 2NF and then 3NF. The relation is said to be in BCNF, if the relation is in 3NF and for each functional dependency $(X \to Y)$, X should be the super key.

In 2NF, there should not be any partial dependency. To decompose the relation into 2NF, decompose the relation into *AB*, *CD* and *ACE* with respect to the functional dependencies. Now, the decomposed relations are $AB, CD \text{ and } ACE$. These relations are in BCNF because the relation is in 3NF and super key exist for each functional dependency.

Therefore, the relations after decomposition are $AB, CD \text{ and } ACE$.

2.

Consider the sub-relation $R2(A,B,F)$. The dependencies over the relation $ABCDEFGHI$ are $AC \to E, B \to F$.

(a) The relation *R2* is in 1NF with respect to the above functional dependencies. The primary key cannot be identified from the above functional dependencies. So, 2NF is not guaranteed.

Therefore, the strongest normal form of the relation *R2* is 1NF.

(b) The relation is not in BCNF because the relation is not in 2NF. To normalize the relation into BCNF, first normalize the table into 2NF and then 3NF. The relation is said to be in BCNF, if the relation is in 3NF and for each functional dependency $(X \to Y)$, X should be the super key.

In 2NF, there should not be any partial dependency. To decompose the relation into 2NF, decompose the relation into *AB* and *BF* with respect to the functional dependencies. The dependency $AC \to E$ need not be considered because the attributes *C* and *E* are not present in the relation. Now, the decomposed relations are $AB \text{ and } BF$. These relations are in BCNF because the relation is in 3NF and super key exist for each functional dependency.

Therefore, the relations after decomposition are $AB \text{ and } BF$.

3.

Consider the sub-relation $R3(A,D)$. The dependencies over the relation $ABCDEFGHI$ are $D \to G, G \to H$.

(a) The above functional dependencies cannot be applied on the relation *R3*. The relation cannot be decomposed with respect to the above functional dependencies because the attributes *D*, *G* and *H* (the attributes that are present in the functional dependencies) are not present in the relation *R3*.

Therefore, the strongest normal form of the relation *R3* is BCNF.

(b) **The relation *R3* is in BCNF. No need to decompose the relation.**

4.

Consider the sub-relation $R4(D,C,H,G)$. The dependencies over the relation $ABCDEFGHI$ are $A \to I, I \to A$.

(a) The above functional dependencies cannot be applied on the relation *R4*. The relation cannot be decomposed with respect to the above functional dependencies because the attributes *I* and *A* (the attributes that are present in the functional dependencies) are not present in the relation *R4*.

Therefore, the strongest normal form of the relation *R4* is BCNF.

(b) **The relation *R4* is in BCNF. No need to decompose the relation.**

5.

Consider the sub-relation $R5(A,I,C,E)$. The dependencies over the relation $ABCDEFGHI$ are not given.

(a) The functional dependencies are not given.

Therefore, the relation *R5* is in BCNF.

(b) **The relation *R5* is in BCNF. No need to decompose the relation.**