Question 1 (a).

Since ABC ∩ CD = C and C is a superkey of R 2 (due to the FD C → D), the decomposition is lossless.

Question 1 (b).

Since AC ∩ ABD = A and A is a superkey of R 1 (due to the FD A → BCD), the decomposition is lossless.

Question 1 (c).

A decomposition is lossless join if there exists a sequence of binary lossless-join decompositions that generates that decomposition. It turns out that there is one such decomposition. First, decompose R into R3(A,C,D) and R4(A,B,C,E). This is lossless because R3 ∩ R4 = AC, and AC is a superkey of R 3 . Next, decompose R4 into R1(A,B,C) and R2(A,B,E). This is also lossless because R1 ∩ R2 = AB, and AB is a superkey of R1. Therefore, {R1(A,B,C), R2(A,B,E), R3 (A,C,D)} is a lossless-join decomposition.

Question 2 (a).

R is not in BCNF because A → E violates BCNF: A is not a superkey of R as {A}+ = ABDE.

Question 2 (b).

The decomposition is lossless-join because R1∩R2 = {E} and E→BDE.

Question 2 (c).

Note that {A}+=ABDE. Therefore, on R2, we have {A}+=AE. This indicates that R2 is not in BCNF.

Question 2 (d).

1. {E}+ = {EDB}, which indicates that R is not in BCNF. Accordingly, we decompose R into R1(E, B, D) and R2(E, A, C).
2. The only non-trivial FD on R1 is E→DB, and E is a key of R1. Thus, R1 is in BCNF.
3. {A}+={AEDB}, and hence, we have {A}+={AE} on R2. This indicates that R2 is not in BCNF. Accordingly, we decompose R2 into R3(A, E) and R4(A, C).
4. R3 and R4 are in BCNF since each of them contains only two attributes.
5. Therefore, { R1(E, D, B), R3(A, E), R4(A, C) } is a BCNF decomposition of R.

Question 3.

1. {B}+=BCDE, which indicates that R is not in BCNF. Accordingly, we decompose R into R1(B, C, D, E) and R2(B, A).
2. Since R2 has only two attributes, it is in BCNF.
3. For R1, let's examine the closure of each attribute subset:
    - {B}+={BCDE}, which indicates that B is a key of R1.
    - {C}+={BCDE}, which indicates that C is a key of R1.
    - {D}+={D}
    - {E}+={E}
    - {DE}+={DE}
    - All other attribute subsets are superkeys since they are supersets of either B or C.

    Therefore, R1 is in BCNF.
4. As a consequence, {R1(B, C, D, E), R2(A, B)} is a BCNF decomposition of R.