Question 1 (10 marks)

Consider a relation $R(A,B,C,D,E,G,H,I,J,K)$ and its FD set $F = \{A \rightarrow BC, E \rightarrow AD, BD \rightarrow E, CE \rightarrow DH, H \rightarrow G, EI \rightarrow J\}$.

1) No.

2) Find a minimal cover F_m for F.

   One of the possible solutions:

   $F_m = \{A \rightarrow B, A \rightarrow C, BD \rightarrow E, E \rightarrow A, E \rightarrow D, E \rightarrow H, H \rightarrow \mathrm{G}, EI \rightarrow J\}$.

3) Is the decomposition $\{ABCDE, EGH, EIJK\}$ (with the same FD set F) of R lossless-join? Please justify your answer.

   Yes.

   Step 1 – Initialize a matrix S:

Decomposition	A	B	C	D	E	G	H	I	J	K
$R_1(A,B,C,D,E)$	a	a	a	a	a	b	b	b	b	b
$R_2(E,G,H)$	b	b	b	b	a	a	a	b	b	b
$R_3(E,I,J,K)$	b	b	b	b	a	b	b	a	a	a

   Step 2 – Rows 1, 2 and 3 of S agree on {E}:

Decomposition	A	B	C	D	E	G	H	I	J	K
$R_1(A,B,C,D,E)$	a	a	a	a	**a**	b	a	b	b	b
$R_2(E,G,H)$	a	b	b	a	**a**	a	a	b	b	b
$R_3(E,I,J,K)$	a	b	b	a	**a**	b	a	a	a	a

   Step 3 – Rows 1, 2 and 3 of S agree on {A}:

Decomposition	A	B	C	D	E	G	H	I	J	K
$R_1(A,B,C,D,E)$	**a**	a	a	a	a	b	a	b	b	b
$R_2(E,G,H)$	**a**	a	a	a	a	a	a	b	b	b

$R_3(E, I, J, K)$	a	a	a	a	a	b	a	a	a	a

Step 4 – Rows 1, 2 and 3 of S agree on {H}:

Decomposition	A	B	C	D	E	G	H	I	J	K
$R_1(A, B, C, D, E)$	a	a	a	a	a	a	a	b	b	b
$R_2(E, G, H)$	a	a	a	a	a	a	a	b	b	b
$R_3(E, I, J, K)$	a	a	a	a	a	a	a	a	a	a

Row 3 is entirely made up by "a" values, so the decomposition is lossless.

4) Candidate keys: EIK, ADIK, and BDIK.

5 possible super keys: AEIK, EIJK, BEIK, EHIK, DEIK.

5) Is it possible to decompose R into a collection of BCNF relations and ensure the decomposition is dependency-preserving and lossless-join? Please justify your answers.

Yes.

$F_m = \{A \to B, A \to C, BD \to E, E \to A, E \to D, E \to H, H \to G, EI \to J\}$.

Based on F_m, we can decompose R into a lossless-joining BCNF decomposition that preserves dependencies:

$R_0 = \{E, I, K\}$, $R_1 = \{A, B, C\}$, $R_2 = \{H, G\}$,

$R_3 = \{E, A, D, H\}$, $R_4 = \{E, I, J\}$, $R_5 = \{B, D, E\}$.

Question 2 (6 marks)

1) T1: undo T2: redo T3: undo.

Because T1, T3 are not committed, T2 is committed.

2) T1: undo T3: undo.

Because T1, T3 are not committed, T2 is committed before the checkpoint.

Question 3 (4 marks)

1) Consider the capacity of the buffer pool is 4 and the request frame sequence is 1,2,3,4,5,4,5,4...

2) Consider the capacity of the buffer pool is 4 and the request frame sequence is 1,2,3,4,1,2,3,5,4…