Question 1

1) $\pi_{movieID}(\sigma_{name=Leonardo\ DiCaprio}(Actors \bowtie AppearsIn))$

2) *According to the former, we let*

$$Q \leftarrow \pi_{movieID}(\sigma_{name=Leonardo\ DiCaprio}(Actors \bowtie AppearsIn))$$

What is more, $P \leftarrow \pi_{name,movieID}(Actors \bowtie AppearsIn)$*, then the answer is* $P \div Q$.

3) $R \leftarrow \pi_{name}(\sigma_{name=Leonardo\ DiCaprio}(Actors \bowtie AppearsIn))$

$S \leftarrow \pi_{name}(Actors \times \pi_{movieID}(\sigma_{name=Leonardo\ DiCaprio}(Actors \bowtie AppearsIn)) - \sigma_{name=Leonardo\ DiCaprio}(Actors \bowtie AppearsIn))$

$T \leftarrow R - S$

Therefore, the answer is T.

Question 2

1) $F_m = \{E \to D, D \to G, G \to A, A \to H, E \to I, AB \to C, AB \to E, CD \to K\}$.

2) (A, B, J), (B, E, J), (D, B, J), (G, B, J) are candidate keys for R.

3) No, it isn't. We let R_1(A, B, C), R_2(D, E, K, G), R_3(H, I, J), then

	A	B	C	D	E	G	H	I	J	K
R_1	a	a	a							
R_2				a	a	a				a
R_3							a	a	a	

If we can get at least one row in which the distinct variables are all "a"s, then we know this is a lossless decomposition. However, in this case, we cannot add "a"s, therefore, the decomposition is not of R lossless-join.

4) The highest normal form of R is 1NF. The reason for this is it does not satisfy the criteria of 2NF. Definition (*Second Normal Form*): A relation scheme is in second normal form (2NF) if all non-prime attributes are fully functionally dependent on the relation keys. According to this, for example, in F, we have $E \to D$, and E is not a relation key, therefore, the R with respect to F is only in 1NF.

5) In 3NF, all non-primary fields are dependent on the primary key, and base on the criteria and the minimal cover we get in the first question of Question 2, we decompose R into R_1(E, D, I), R_2(D, G), R_3 (G, A), R_4(A, H), R_5(A, B, C, E), R_6(C, D, K), R_7(A, B, J), which are all in 3NF (To keep lossless-join, we add R_7). For instance, regarding R_1, we have FD: $E \rightarrow D$ and $E \rightarrow I$, and we do not have FD: $D \rightarrow I$, therefore E is a primary key for R_1, and R_1 is in 3NF.

6) The answer is R_1(E, D, I), R_2(D, G), R_3 (G, A), R_4(A, H), R_5(A, B, C, E), R_6(C, D, K), R_7(A, B, J), which is the same as the last question. According to 3NF definition,
A relation, R, is in 3NF iff for every nontrivial FD (X->A) satisfied by R at least ONE of the following conditions is true:
(a) X is a super-key for R, or
(b) A is a key attribute for R
BCNF requires only (a), and (b) is not permitted in BCNF, hence, since we have got the decomposition in 3NF, we can just check if some of them are in the condition of (b). Fortunately, all the relations satisfy A and not B, therefore the answer is still R_1(E, D, I), R_2(D, G), R_3 (G, A), R_4(A, H), R_5(A, B, C, E), R_6(C, D, K), R_7(A, B, J).

Question 3

1) Construct a scenario that LRU buffer replacement policy is better than MRU buffer replacement policy.

Data pages: P1, P2, P3, P4

Q1: read P1; Q2: read P2; Q3: read P3; Q4: read P1; Q5: read p2; Q6 read P4;

Buffer:

P1 Q4	P2 Q5	P3

Regarding Q6,

LRU: Replace P3

MRU: Replace P2

Then, if Q7 is coming, and Q7 is to read P2, in this case, LRU buffer replacement policy is better than MRU buffer replacement policy, for the MRU buffer replacement policy has changed P2 into P4, we cannot read it directly, while in the LRU buffer replacement policy case, P2 still exists, we can read it directly.

2) Construct a scenario that LRU buffer replacement policy is better than FIFO.

Data pages: P1, P2, P3, P4

Q1: read P1; Q2: read P2; Q3: read P3; Q4: read P1; Q5: read p2; Q6 read P4;

Buffer:

P1 Q4	P2 Q5	P3

Regarding Q6,

LRU: Replace P3

FIFO: Replace P1

Then, if Q7 is coming, and Q7 is to read P1, in this case, LRU buffer replacement policy is better than FIFO buffer replacement policy, for the FIFO buffer replacement policy has changed P1 into P4, we cannot read it directly, while in the LRU buffer replacement policy case, P1 still exists, we can read it directly.