We assume that for each base table \( R \) in a relational database we have two update operations: \( \text{insert}(R, t) \) which inserts tuple \( t \) into table \( R \) if \( t \) does not violate any of the constraints declared for \( R \) (fails otherwise), and \( \text{delete}(R, p) \) which deletes all records in \( R \) satisfying predicate \( p \) (and fails if this would violate referential integrity constraints). Update operations are combined in programs to define transactions with ACID guarantees.

Suppose that we have defined a view \( V = Q(R_1, R_2, \ldots, R_n) \), where the \( R_i \) indicate the base tables used in query \( Q \). The designers of a new database system want to allow users to update directly such a view. That is, if we have an update of the form \( U = \text{insert}(V, t) \) or \( U = \text{delete}(V, p) \), then the database system must automatically generate a transaction \( T_U \) over the tables \( R_i \) such that for any database instance \( DB \) this diagram commutes:

\[
\begin{array}{c}
DB \\ \xrightarrow{T_U} \hspace{1cm} DB' \\
\downarrow Q \\
V \\ \xrightarrow{U} \hspace{1cm} V'
\end{array}
\]

In other words, applying the update \( U \) directly to a view (as if it were a base table) produces the same result as applying \( T_U \) to the database and then evaluating the view query.

A major problem with this approach is that there may be multiple distinct solutions for \( T_U \). We explore this now.

\( (a) \) Explain the difference between a database query and a database view. [2 marks]

\( (b) \) Let \( V = \pi_X(R) \) be a view for some base table \( R \) and some subset \( X \) of \( R \)'s attributes \( Y \). How could this be translated into the desired transaction \( T_U \)? Discuss any problems with ambiguity that may arise. [5 marks]

\( (c) \) Let \( V = \sigma_q(R) \) be a view for some base table \( R \) and predicate \( q \). How could this be translated into the desired transaction \( T_U \)? Discuss any problems with ambiguity that may arise. [5 marks]

\( (d) \) In the design of a database schema it was discovered that a relation \( R \) violated Boyce-Codd normal form, and so it was replaced by two base tables \( R_1 \) and \( R_2 \) resulting from the standard decomposition process. Suppose users attempt to reconstruct the original relation using the view \( V = R_1 \bowtie R_2 \). Discuss the problems that might arise now in the construction of transaction \( T_U \) for updates to \( V \). [8 marks]