Question 1 (7 points) You are hired to set up a relational database for a small community hospital. The first thing you do is to go to the hospital and find out the attributes that need to be stored, and their inter-relationships. Here are your findings:

- Every room has a unique room number (integer).
- Every room has one designated usage (char [40]), but different rooms may have the same usage.
- Every patient is assigned a room, but many patients may be assigned to the same room.
- Every patient has a unique patient number (integer)
- Every patient has a name (char[40]) which is not necessarily unique.
- A patient may be treated by more than one doctor, and a doctor may attend to more than one patient.
- Every doctor has a unique doctor number (integer) and a unique phone (char[10]).

a) (3 points) Draw an entity-relationship diagram to represent the information described above.

b) (4 points) Suppose every entity set and every relationship set is to be represented by a different relation. Give the SQL data definition (i.e., create table statements) for those relations representing relationship sets.
Question 2 (6 points) Consider the following create table statement:

```sql
CREATE TABLE r1
(a1 INTEGER, a2 INTEGER, a3 INTEGER, a4 INTEGER, a5 INTEGER,
 PRIMARY KEY (a1, a2),
 UNIQUE (a3,a4),
 FOREIGN KEY (a5) REFERENCES r2(a5))
```

a) (2 points) List all the non-trivial functional dependencies pertaining to the attributes of r1 that can be inferred from the create table statement.

b) (2 points) Is r1 in BCNF? Give a brief explanation.

c) (2 points) Is r1 in 3NF? Give a brief explanation.

Question 3 (3 points) Consider the following relation instance:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>John</td>
<td>1</td>
<td>Van</td>
</tr>
<tr>
<td>2</td>
<td>John</td>
<td>2</td>
<td>Rmd</td>
</tr>
<tr>
<td>3</td>
<td>Jane</td>
<td>3</td>
<td>Rmd</td>
</tr>
<tr>
<td>3</td>
<td>Jane</td>
<td>3</td>
<td>Rmd</td>
</tr>
<tr>
<td>4</td>
<td>Jill</td>
<td>4</td>
<td>Bby</td>
</tr>
<tr>
<td>5</td>
<td>Jill</td>
<td>5</td>
<td>Cql</td>
</tr>
</tbody>
</table>

Observe that $B \rightarrow A$ appears to hold with respect to the given instance. Check to see if all of the following dependencies hold with respect to the instance and explain why:

a) $A \rightarrow B$

b) $B \rightarrow C$

c) $C \rightarrow A$
**Question 4 (4 points)** Use the following three axioms:

- (reflexivity) if \( \beta \subseteq \alpha \), then \( \alpha \rightarrow \beta \)
- (augmentation) if \( \alpha \rightarrow \beta \), then \( \alpha \gamma \rightarrow \beta \gamma \)
- (transitivity) if \( \alpha \rightarrow \beta \) and \( \beta \rightarrow \gamma \), then \( \alpha \rightarrow \gamma \)

to determine if the following two statements are true or false. If you think it is true, give a proof; otherwise, give a counter-example.

(a) (2 points) if \( \alpha \rightarrow \beta \gamma \), then \( \alpha \rightarrow \beta \)

(b) (2 points) if \( \alpha \rightarrow \beta \) and \( \beta \gamma \rightarrow \delta \), then \( \alpha \gamma \rightarrow \delta \)

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