Question 1

a) Define the following terms: *data*, *database* and *database management systems* (DBMS).

[3 marks]

	Do not write in this column
	3 marks

b) Define the following terms in a Relational model and give an example of each: 1) *relation,* 2) *foreign key*.

[4 marks]

	Do not write in this column
	4 marks

c) The following tables form part of a Library database held in a relational database management system:

```
Book        (ISBN, title, edition, year)
BookCopy    (copyNo, ISBN, available)
Borrower    (borrowerNo, borrowerName, borrowerAddress, allowance)
BookLoan    (copyNo, dateOut, dateDue, borrowerNo)
```

where `Book` contains details of book titles in the library and the `ISBN` is the key.

`BookCopy` contains details of the individual copies of books in the library and copyNo is the key. `ISBN` is a foreign key identifying the book title. Attribute `available` has values of either "Y" or "N".

`Borrower` contains details of library members who can borrow books and `borrowerNo` is the key. `allowance` gives the total number of book copies one can borrow.

`BookLoan` contains details of the book copies that are borrowed by library members and `copyNo/dateOut` forms the key. `borrowerNo` is a foreign key identifying the borrower.

Formulate the following queries in **relational algebra**. **[12 marks]**

	Do not write in this column
i) Produce a relation of all the information for all books. **(1 mark)**	
ii) List the titles of all the books published in the year 2017. **(2 marks)**	
iii) List the copy numbers of the book "Lord of the Rings" that are available for borrowing. **(3 marks)**	

iv) Give the borrowerNo of borrowers who have borrowed all the books that borrower 123 borrowed between 2nd Feb 2017 and 4th May 2017. (Note: only consider dateOut, no need to consider due date.) **(6 marks)**

12 marks

d) Answer the following questions on Normalization.

[11 marks]

i) Table 1 below lists sample dentist/patient appointment data. A patient is given an appointment at a specific time and date with a dentist located at particular surgery. The table is susceptible to various anomalies. Provide examples of *deletion* and *modification* anomalies.

Table 1

denNo	denName	patNo	patName	apptDate	apptTime	surgeryNo
D1011	Tony Smith	P100	Gillian White	20/5/2016	10:00	S15
D1011	Tony Smith	P105	Jill Bell	20/5/2016	12:00	S15
D1024	Helen Park	P108	Tom Ford	20/5/2016	10:00	S10
D1024	Helen Park	P108	Tom Ford	17/6/2016	14:00	S10
D1032	Robin Hood	P105	Jill Bell	17/6/2016	16:30	S10
D1032	Robin Hood	P110	John Walker	24/6/2016	17:00	S13

(4 marks)

Do not write in this column

4 marks

ii) Relation R(A, B, C, D, E, F, G, H) has functional dependencies of

fd1: A → BCGH,

fd2: D → E,

fd3: AF → D and

fd4: G → H.

Which normal form is relation R in? Describe and illustrate the process of normalization by converting R to Third Normal Form (3NF) relations. (Note: primary keys must be identified for each step.) **(7 marks)**

	Do not write in this column
	7 marks

Question marking: $\frac{}{3} + \frac{}{4} + \frac{}{12} + \frac{}{4} + \frac{}{7} = \frac{}{30}$

Question 2

You are asked to design a relational database for an online DVD rental company, and the following information is given by your client:

- There are a number of registered customers, and the database needs to store their account number (which uniquely identifies a customer), name, address, date of birth and some other personal information.
- There are a number of DVDs for the customers to rent. For each DVD the company needs to record information like the serial number (which uniquely identifies a DVD), title, year of publication, type of DVD, price to rent a DVD, etc.
- For each DVD there are a number of copies available. The customers rent copies of a DVD.
- A customer can rent a number of DVDs at a time. The database should record the date of rent and due date of the DVD copy.
- When a certain DVD is not available, the customer wanting to rent the DVD can be added to a waiting list for the DVDs. Once a copy of the DVD has become available, the customers on the waiting list of the DVD will be notified on a first come first served basis.

Answer the following questions:

a) Briefly explain the four steps to design/implement a relational database.

[4 marks]

	Do not write in this column
	4 marks

b) Draw an ER diagram for the online DVD rental database. State any *assumptions* you make about the data if any. Your ER diagram must include details of the entities, attributes and relationships.

[16 marks]

	Do not write in this column
	16 marks

Question marking: $\frac{}{4} + \frac{}{16} = \frac{}{20}$

Question 3

a) Mark "True" or "False" for each of the following statements on **database transaction management**:

i) The ACID properties of transaction are *Atomicity, Consistency, Isolation* and *Sequentiality*.

ii) *Concurrency* does not cause problems in ensuring ACID properties.

iii) *Dirty read* occurs when transaction reads several values but the second transaction updates some of them during execution of the first one.

iv) Two basic concurrency control techniques are *locking* and *rolling back.*

[4 Marks]

	Do not write in this column
	4 marks

b) A bank's DBMS performs two transactions A and B in a short period of time and the bank updates a client's account as shown below in Figure 1:

Time	A	B
t_1	begin_transaction	
t_2	read(account)	
t_3	account = account +100	
t_4	write(account)	begin_transaction
t_5	…	read(account)
t_6	rollback	account = account -10
t_7		write(account)
t_8		commit

Figure 1

Answer the following questions for the scheduling of the two transactions A and B.

[13 marks]

i) What is the name of the problem that updating like this would cause? Explain it. **(3 marks)**

ii) Name a solution to this problem, and rewrite the transactions A and B in Figure 1 using your named solution. **(6 marks)**

iii) What is a deadlock? **(1 mark)**

iv) Name and explain two techniques that can be used to solve deadlock problems. **(3 marks)**

	Do not write in this column
	13 marks

c) Describe and illustrate the elements of a *three-tier client/server architecture*. **(8 marks)**

	Do not write in this column
	8 marks

Question marking: $\frac{}{4} + \frac{}{13} + \frac{}{8} = \frac{}{25}$

Question 4

b) Answer the following questions about Data Warehouse and Data Mining. **[13 marks]**

i) What does the acronyms *OLTP* and *OLAP* stand for? **(2 marks)**

ii) What is a *data warehouse*? **(5 marks)**

iii) Discuss the difference of OLTP systems and Data Warehousing systems in terms of their *main purposes, data age* and *target users*. **(6 marks)**

	Do not write in this column
	13 marks

b) What is XML? Discuss the difference between XML and the relational model in terms of *structure, schema, queries, ordering* and *implementation*.

[12 marks]

	Do not write in this column
	12 marks

Question marking: $\frac{}{13} + \frac{}{12} = \frac{}{25}$