

**BCS THE CHARTERED INSTITUTE FOR IT**  
**BCS HIGHER EDUCATION QUALIFICATIONS**  
**BCS Level 5 Diploma in IT**

**DATABASE SYSTEMS**

September 2017

Answer **any** THREE questions out of FIVE. All questions carry equal marks.  
Time: THREE hours

**Answer any Section A questions you attempt in Answer Book A**  
**Answer any Section B questions you attempt in Answer Book B**

The marks given in brackets are **indicative** of the weight given to each part of the question.

Calculators are <b>NOT</b> allowed in this examination.
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**Section A**

**Answer Section A questions in Answer Book A**

**QUESTION A1 (Sept)**

**A1**

A University Library holds a large stock of books that are available for loan to borrowers. The library requires a database to support the processing of these loans.

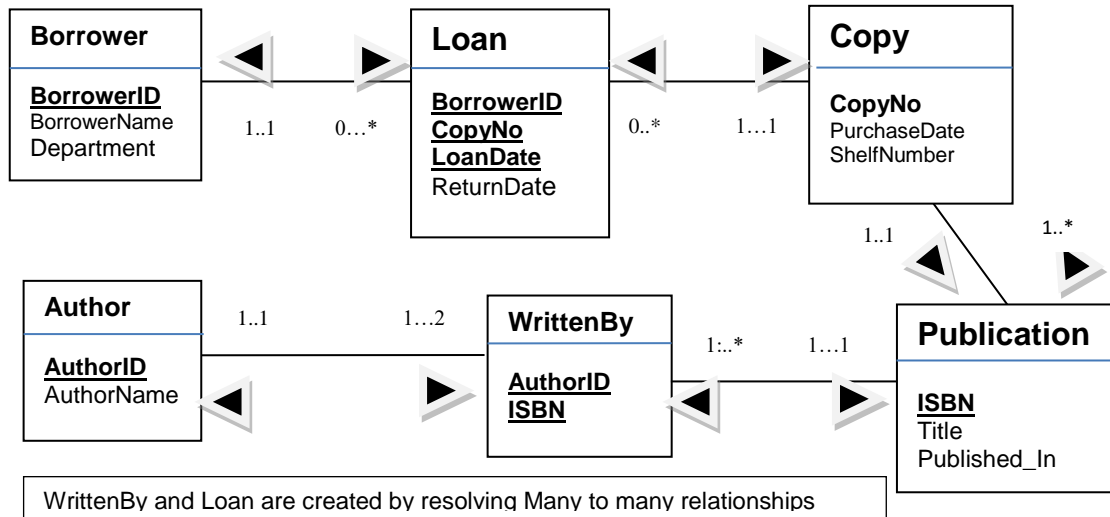
- a) Examine the example records in the Forms (Figure 1) and the assumptions (Figure 2) shown below, then draw an Entity Relationship diagram that includes the following:-
- Entity types assigned with the attributes- (Indicate which attributes represent Primary keys).
  - Relationships between the entity types. (resolve any many to many relationships)
  - Relationship cardinality and optionality constraints.

State the modelling notation you have used and state any necessary assumptions you make.

14 marks

**ANSWER POINTER**

ERD using UML notation



Credit given for

- Understanding of and identification of base Entity Types
- Correct/consistent Relationships between entity types
- Reasonable accuracy of participation constraints and attribute assignment
- Resolution of the many to many relationships.

It should be recognised that the entity that is borrowed from the library is a copy of a book and that copies are related to books in a 1:M relationship.

- b) Draft a set of Tables derived from your ER diagram populated with sample data from Form1 in Figure 1 shown below. You are required to indicate which columns are primary keys and which are foreign keys.

8 marks

**ANSWER POINTER**

Base Tables should be derived from the ERD – primary keys should be shown as above, along with underlined foreign key columns and composite key columns in italics

- Borrower (BorrowerID, BorrowerName, BorrowerDept)
- Loan(BorrowerID, CopyNo, LoanDate ,ReturnDate .....)
- Copy(CopyNo, DateAcquired, ShelfNumber, ISBN)
- Publication(ISBN, Title, Published\_In)
- WrittenBy(AuthorID, ISBN )
- Author(AuthorID, AuthorName.)

*borrower*

<i><b>BORROWERID (PK)</b></i>	<i><b>BORROWERNAME</b></i>	<i><b>BORROWERDEPT</b></i>
A12	Bloggs	CIS
B34	Greenacre	Business

*loan*

<i><b>COPYNO (FK)</b></i>	<i><b>BORROWERID (FK)</b></i>	<i><b>LOANDATE</b></i>	<i><b>RETURNDATE</b></i>
C1034	A12	02-OCT-16	13-OCT-16
C1034	B34	13-OCT-16	27-OCT-16

*copy*

<i><b>COPYNO</b></i>	<i><b>SHELFNUMBER</b></i>	<i><b>DATEACQUIRED</b></i>	<i><b>ISBN (FK)</b></i>
C1034	C100	12-APR-2014	939757

**publication**

<b>ISBN</b>	<b>TITLE</b>	<b>PUBLISHED_IN</b>
939757	The Joy of E-R Modelling	2013

**writtenby**

<b>AUTHORID (FK)</b>	<b>ISBN (FK)</b>
AU505	939757

**author**

<b>AUTHORID</b>	<b>AUTHORNAME</b>
AU505	Moss

c) Show with the aid of a diagram how your Tables are interlinked. (Related through columns)

3 marks

**ANSWER POINTER**

**borrower**

<b>BORROWERID (PK)</b>	<b>BORROWERNAME</b>	<b>BORROWERDEPT</b>
A12	Bloggs	CIS
B34	Greenacre	Business

**loan**

<b>COPYNO (FK)</b>	<b>BORROWERID (FK)</b>	<b>LOANDATE</b>	<b>RETURNDATE</b>
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**Figure 1: Three sample forms recording loans of copies of books over a period of time**

**Form 1**

<b>Title:</b> The Joy of E-R Modelling	<b>Published_In</b> 2013	<b>ISBN:</b> 939757
<b>Author Id:</b> AU505	<b>Author Name :</b> Moss	
<b>Author Id:</b> -----	<b>Author Name :</b> -----	
<b>CopyNo</b> C1034	<b>Shelf Number</b> C100	<b>DateAcquired:</b> 12-APR-16

Borrower Id	Borrower Name	Borrower Dept	Loan Date	Return Date
A12	Bloggs	CIS	02-OCT-16	13-OCT-16
B34	Greenacre	Business	13-OCT-16	27-OCT-16

### Form 2

<b>Title:</b> Normalisation is Fun and Easy <b>Published_In</b> 2010 <b>ISBN:</b> 549950				
<b>Author Id</b> AU1911		<b>Author Name</b> :Bollinger		
<b>Author Id</b> AU505		<b>Author Name</b> : Moss		
<b>CopyNo</b> C2399		<b>Shelf Number:</b> C101		<b>DateAcquired:</b> 22-APR-2011
Borrower Id	Borrower Name	Borrower Dept	Loan Date	Return Date
B34	Greenacre	Business	04-OCT-16	18-OCT-16
L67	Franks	Leisure	22-OCT-16	29-OCT-16

### Form 3

<b>Title:</b> Normalisation is Fun and Easy <b>Published_In</b> 2010 <b>ISBN:</b> 549950				
<b>Author Id</b> AU1911		<b>Author Name</b> : Bollinger		
<b>Author Id</b> AU505		<b>Author Name</b> : Moss		
<b>CopyNo</b> C2400		<b>Shelf Number:</b> C101		<b>DateAcquired:</b> 25-JUN-2011
Borrower Id	Borrower Name	Borrower Dept	Loan Date	Return Date
A12	Bloggs	CIS	04-OCT-16	25 OCT-16
L67	Franks	Leisure	02-SEP-16	09-SEP-16

### Figure 2: List of Assumptions

- i. The library acquires one or many copies of books, these are physical copies of a particular publication.
- ii. A publication has a unique ISBN (an international code for all published works); a title and the date it was published.
- iii. Each copy has a unique copy number and has a particular shelf number to which it is located.
- iv. A publication is always written by either one or two authors, and an author may write many publications.
- v. Only authors who have written at least one publication will be stored.
- vi. A borrower may have more than one copy on loan at any time.
- vii. A borrower may yet to take out a loan.
- viii. Over time a copy may be out on loan many times or it may never be loaned out.
- ix. A loan is made by a single borrower for one copy of a publication.

### Examiners Comments

This was a fairly popular question with the majority of candidates making an attempt . There was a 50% pass rate and an average mark above 10. There was an improvement in performance of candidates that selected this syllabus topic compared to previous years.

One area in which candidates often went wrong was the failure to recognise that the entity that is borrowed from the library is a copy of a book and that copies are related to books in a 1:M relationship.

The other issues were:

Some candidates produced excellent answers, but were careless and lost marks because they didn't follow instructions, such as; remembering to state the ERD modelling notation; forgetting to populate the tables with sample data; not pointing out primary/foreign keys;

In section (c) It was surprising to find candidates that produced a good answer to section (b) often failed to make an attempt at this section.

## A2

Refer to the following set of SQL statements and the sample tables for this question.

```
CREATE TABLE tickets(
    ticketno NUMBER
    ,purchasedate DATE
    ,custid NUMBER
    ,fixtureid NUMBER
    ,seatid VARCHAR(5));

CREATE TABLE fixtures(
    fixtureid NUMBER
    ,fixturedate DATE
    ,opposition VARCHAR(4));

CREATE TABLE customer(custid NUMBER
    ,custname VARCHAR(20)
    ,address VARCHAR(20));

CREATE TABLE seats(
    seatid VARCHAR(5)
    ,seatingarea VARCHAR(20)
    ,seat_type VARCHAR(20));
```

### Sample tables

Table: seats

SEATID	SEATINGAREA	SEATTYPE
C11	West Stand	Reserved
C12	West Stand	
C13	West Stand	
MM3	West Upper	
MM4	West Upper	Reserved
MM59	West Upper	
H105	South Stand	Family
H106	South Stand	Family
H107	South Stand	
G2	East Stand	Away
G3	East Stand	Away
K4	North Stand	Disabled

Table: tickets

TICKETNO	PURCHASEDATE	CUSTID	FIXTUREID	SEATID
107823	13-Dec-2016	10032	8320	MM59
959235	13-Dec-2016	10032	8321	K4
309998	15-Dec-2016	13420	8322	MM3
306298	08-Mar-2017	13420	9767	MM3
736228	15-Oct-2016	13420	9770	C11
736229	15-Oct-2016	13420	8320	G2
736230	15-Oct-2016	17243	8320	C12
107922	13-Dec-2016	10035	8320	H105
107923	13-Dec-2016	10035	8320	H106

Table: fixtures

FIXTUREID	FIXTUREDATE	AWAYTEAM
8320	02-Jan-2017	CHEL
8321	23-Jan-2017	MANC
8322	18-Dec-2016	SUND
9767	15-Mar-2017	BORO
9770	16-Oct-2016	WATF
9889	05-Apr-2017	MANC

Table: customer

CUSTID	CUSTNAME	ADDRESS
10032	R. Sayers	Tess Ilkley Moor
17243	P. Smith	'Homeblest', Preston Capes
10035	V. Singh	23 Belle Vue St, Odiham
13420	P. Smith	Dove Cottage, Stratford

a) Write SQL statements that populate the fixture table with the first 2 rows of data.

3 marks

**ANSWER POINTER**

```
INSERT INTO fixtures VALUES(8320, '2-Jan-2017', 'CHEL');  
INSERT INTO fixtures VALUES(8321, '23-Jan-2017', 'MANC');
```

c) The CREATE TABLE statements are missing important constraints that could impact on the integrity of data in the tables. .

i) List **three types** of data integrity constraints that are absent in the script.

3 marks

**ANSWER POINTER**

Entity,,referential and check (Domain/Column range) constraints

ii) Write three SQL ALTER statements (one for each type of data integrity constraint) that show how these data integrity constraints would be added to the script.

9 marks

**ANSWER POINTER**

Imprecise syntax is allowed as long as the code is recognisable. The use of an ALTER statement is preferable to the use of a new CREATE table and gains more marks.

Entity Integrity should be established for the seats table

```
ALTER TABLE seats  
ADD CONSTRAINT PK_seats PRIMARY KEY (seatID);
```

On the seats table add CHECK constraint

```
ALTER TABLE seats  
ADD CONSTRAINT chk_Seat_type  
CHECK (Seat_Type IN ('Reserved', 'Disabled', 'Away', 'Family'))
```

On the `ticket` table, add referential integrity constraints (all 3 should be specified)

```
ALTER TABLE tickets
ADD CONSTRAINT fk_PerSeat FOREIGN KEY (seatid)
REFERENCES seats(seatid);
```

```
ALTER TABLE tickets
ADD CONSTRAINT fk_percustomer FOREIGN KEY (custid)
REFERENCES Customers(CustId);
```

```
ALTER TABLE tickets
ADD CONSTRAINT fk_perfixture FOREIGN KEY (fixtureid)
REFERENCES fixtures(fixtureid);
```

- d) Assume the script has been updated to include data integrity constraints. Why would an error occur if an attempt is made to run the script again? What extra SQL code is required to avoid this error occurring so that the script can run repeatedly?

5 marks

### ANSWER POINTER

The first `CREATE` table would `FAIL` because the `ticket` table already exists.

Some DBMS's allow `IF <table> EXISTS` statements prior to each `CREATE TABLE` statement. If the tables have been populated the order of `DROPS` are important to protect referential integrity

The following sequence of `DROP` statements will work as all foreign key references will be dropped if the `tickets` table is dropped first

```
DROP TABLE tickets;
DROP TABLE passholder;
DROP TABLE seats;
DROP TABLE fixture;
```

Alternatively a more general solution is to first drop all the references (referential integrity) constraints for example

```
ALTER TABLE ticket DROP constraint fk_percustomer;
```

then `DROP` statements can be applied in any order. (aside Oracle uses an option `CASCADE` applied to each `DROP` statement as follows `DROP TABLE seats CASCADE CONSTRAINTS;`

- e) Write a query that counts the number of seats sold in each `seatingarea` for a fixture with `fixtureid = 8320`.

The query should return :-

SEATINGAREA	COUNT OF SEATS
West Stand	1
West Upper	1
South Stand	2
East Stand	1

5 marks

### ANSWER POINTER

```
SELECT seatingarea
```

```

        ,COUNT(seatid) AS count_of_seats
FROM seats s
        ,tickets t
WHERE s.seatid = t.seatid
AND fixtureid = 8320
GROUP BY seatingarea;

```

### Examiners Comments

This was a popular question with well over half of the candidates making an attempt. There was a 40% pass rate and an average mark below 10. The performance of those candidates that selected this question was comparable to the performance on similar questions in previous years.

In general candidates are now familiar with SQL scripts and could answer most parts to the question. More importantly and still quite a concern, is the apparent lack of practical knowledge of SQL, which was crucial in successfully answering this question.

In part a). More than half of candidates produced 2 correct INSERT statements. The remaining candidates did not gain any marks if they used a SELECT statement that only queried the table instead of populating it.

In part b) there were some very good attempts at identifying the missing constraints and reasonable attempts at implementing them in SQL. The syntax of the ALTER table statement was not particularly important, but the definition of the constraint had to be clear and precise enough to demonstrate that candidates understood the concepts.

In part c), answers were generally poor, with few successful attempts. Many candidates did not seem to be aware of the potential problem that can occur when using scripts. A range of answers looked for operations such as UPDATE and ROLLBACK rather than devising the required update to the script.

In part d) a wide range of answers were produced. This seemed to reflect the range of ability and knowledge of SQL. Writing SQL must be concise. Missing out the JOIN, COUNT and/or GROUP BY was common from the query. This was more a case of candidates being careless. However, marks were awarded for partially correct answers

A3

### Examiner's General Comment

This was a very popular question with almost all students attempting it (96%). The question's pass rate was, however, disappointing at below 50% (much lower than previous years),

- (a) A company uses the table below to record details of its projects. Each project is attached to a department and runs for a certain duration (in months). The primary key for this table is (projnbr, deptnbr):

<u>PROJNBR</u>	<u>DEPTNBR</u>	PROJNAME	DEPTNAME	DURATION
P01	D03	Web Portal	HR Dept	10
P01	D07	Web Portal	Sales Dept	10
P02	D07	Data warehouse	Sales Dept	7
P02	D03	Data warehouse	HR Dept	7

- (i) Give an example of an "Update Anomaly" that may occur in this table.

2 marks

- (ii) Explain what is meant by "partial dependency" in a table.

1 mark

- (iii) Identify any partial dependencies in the above table.



.3 marks

- (iv) Remove any partial dependencies from the above table by performing a normalisation process and show skeletal designs of the resultant tables.

3 marks

- (b) The following table keeps record of medical consultations conducted in a medical practice. Each consultation takes place in a room and is conducted by a doctor on a patient. A patient cannot have two consultations on the same day. Identify **three candidate keys** for this table.

PATIENTNBR	CONSULTATIONDATE	CONSULTATIONTIME	DOCTORNBR	ROOMNBR
P01	17-Aug-17	09:30	D01	R01
P01	20-Aug-17	14:00	D02	R02
P02	17-Aug-17	11:00	D01	R01
P03	17-Aug-17	11:00	D02	R02
P04	23-Aug-17	09:30	D01	R02

8 marks

- (c) The following table has attributes A, B, C and D:

A	B	C	D
a1	b1	c1	d1
a2	b1	c2	d1
a1	b2	c1	d1
a2	b2	c2	d1
a1	b3	c1	d2
a2	b3	c2	d2

- (i) Explain what is meant by “**functional dependency**” in a table.
- (ii) Identify **three** functional dependencies from the above table.

2 marks

6 marks

## ANSWER POINTER

(a)

(i) Update Anomaly: If we wish to change the name of a project, this will need to be done for all occurrences of that project which can lead to an anomaly if those changes are not consistent. (The same problem exists for updates of department name and duration)

(ii) Partial Dependency: The dependency of a non-key attribute on only a subset of the attributes involved in a composite key

(iii)  $\text{projnbr} \rightarrow \text{projname}$   
 $\text{projnbr} \rightarrow \text{duration}$   
 $\text{deptnbr} \rightarrow \text{deptname}$

(iv)  $\text{project}(\underline{\text{projnbr}}, \text{projname}, \text{duration})$   
 $\text{department}(\underline{\text{deptnbr}}, \text{deptname})$   
 $\text{projdept}(\underline{\text{projnbr}^*}, \underline{\text{deptnbr}^*})$

## Examiner's Comment

Most candidates managed to correctly identify the partial dependencies related to projName and deptName, but very few saw that duration is dependent only on projNbr. As a result, most candidates created a table in which duration was placed alongside projNbr and deptNbr. Also, a lot of candidates failed to use the arrow of the functional dependency correctly.

(b)

Three candidate keys:

(patientNbr, consultationDate)  
(doctorNbr, consultationDate, consultationTime)  
(roomNbr, consultationDate, consultationTime)

### Examiner's Comment

Most candidates failed to correctly identify the candidate keys. In general, the presence of date and time attributes provide a good hint for such keys, and candidates should look out for such attributes.

(c)

(i)

Functional dependency is a feature that exists when one attribute uniquely determines another attribute. One value of the first attribute will always correspond to the same value of the second attribute

(ii)

$A \rightarrow C$

$C \rightarrow A$

$B \rightarrow D$

### Examiner's Comment

Although most candidates are able to provide an example of a functional dependency (such as student name depends on student number), almost all failed to provide a meaningful definition of this concept. This underlines a lack of deep understanding of the nature of functional dependencies.

As a result, when presented with data such as the one in the question (not using familiar names for the attributes), students struggle to identify the functional dependencies.

## Section B

### Answer Section B questions in Answer Book B

#### B4

Using your own simple examples and suitable diagrams, discuss the following Relational Algebra operators. For full marks, you must then supply an example SQL statement of how that concept is implemented.

(a) PROJECTION

5 marks

(b) JOIN

5 marks

(c) INTERSECT

5 marks

(d) SELECTION

5 marks

(e) UNION

- (a) A vertical slice through a relation that extracts all rows but only for specific named attributes (columns). A suitable diagram is required to illustrate this concept.

SQL statement:

```
:
SELECT id
       ,name
       ,email
FROM student;
```

- (b) A process that combines data from two or more relations. A mention of the different types: INNER, NATURAL, OUTER would gain credit. A suitable diagram is required to illustrate this concept.

SQL statement:

```
SELECT *
FROM student s
     ,tutor t
WHERE s.supervisor = t.id;
```

- (c) The 'overlap' between two sets. Returns only those values that are present in both sets – with any duplicates removed. An appropriate Venn diagram would gain credit here. For example, show individuals on a university campus who are both tutors and students.

SQL statement :

```
:
SELECT id, name FROM staff
INTERSECT
SELECT id, name FROM student;
```

- (d) A horizontal slice through a relation that extracts all columns but only for those rows that satisfy particular criteria. A suitable diagram is required to illustrate this concept.

SQL statement:

```
SELECT *
FROM student
WHERE Course = 'Computer Science';
```

- (e) Returns all values found in either set – with duplicates removed. The UNION ALL operator does not eliminate duplicates. A Venn diagram would gain credit in this answer.. For example, return those students who are either Computing or Mathematics students.

SQL statement::

```
SELECT id
       ,name
FROM Student
WHERE Department = 'Computing'
UNION
SELECT id
```

```
        , name
FROM Student
WHERE Department = 'Mathematics';
```

### Examiner's Comments

All five sections were generally well done – in a descriptive sense - although many candidates failed to provide a good example. Still, many did well on this very popular question.

### B5

Using your own simple examples and suitable diagrams, discuss the following data management concepts.

- |  |         |
|--|---------|
| (a) Database-level data validation and its implementation    | 5 marks |
| (b) User-interface data security and its implementation      | 5 marks |
| (c) Database-level redundancy, its problems and minimization | 5 marks |
| (d) User-interface data validation and its implementation    | 5 marks |
| (e) Database-level data security and its implementation      | 5 marks |

Discussions should include the following

- (a) Primary keys, foreign keys, NOT NULL, CHECK, UNIQUE, DEFAULT
- (b) CAPCHA, usernames & passwords, PIN numbers, secret questions, biometrics.
- (c) Insert/update/delete anomalies, the role of normalization and its stages
- (d) Dropdown lists, radio buttons, check boxes, date pickers, double entry of passwords.
- (e) Usernames & passwords, system and object-level privileges, profiles, roles, views.

### Examiner's Comments

Answers were less focused than those for question 4 with often long and rambling responses. Still, many candidates did provide a wide range of valid suggestions and were suitably rewarded.

### B6

#### Examiner's General Comment

Over half of the candidates attempted this question. The pass rate was a disappointing 30%

- a) Database recovery is one of the main services provided by database management systems.
- (i) Describe five types of failure that may occur in a database environment. 5 marks
  - (ii) Discuss how the log file is a fundamental feature in any recovery mechanism by describing:
    - the contents of the log file
    - the write-ahead log protocol
    - how the log file is used in forward and backward recovery
    - how checkpoints affect the recovery protocol.8 marks

b) A Database can be defined as a self-describing collection of integrated records. Explain the meaning and the importance of the term “self-describing”.

4 marks

c) A company wants to move its current file-based system to a database system. In many ways, this can be seen as a good decision. Identify and describe four disadvantages in adopting a database approach.

8 marks

## B6

(a)

(i) Types of failures include:

- System crashes due to hardware or software errors, resulting in loss of main memory
- Media failures, such as head crashes or unreadable media, resulting in the loss of parts of secondary storage
- Application software errors, such as logical errors in the program accessing the database, that cause one or more transactions to fail
- Natural physical disasters, such as fires, floods, or power failures;
- Intentional and unintentional destruction of data or facilities by users.

(ii)

- The log file contains: transaction records (transaction id, type of operation, id of data being accessed, before and after-images of updates/inserts/deletes to the database) and checkpoint records. (2 marks)
- Write-ahead log protocol ensures that log records are written before the corresponding write to the database. Thus, if the system fails before the write occurs after the log record has been written but before the write to the database, the system can recover using the information in the log file. (2 marks)
- Before images can be used to undo changes to the database (i.e. perform backward recovery); after images can be used to redo changes (i.e. perform forward recovery). (2 marks)
- Log file contains a checkpoint record (point of synchronisation between the database and the log file when all buffers are written into the secondary storage), which can speed up the time for recovery following a failure (e.g., avoid redoing transactions that have been safely written to the database). (2 marks)

### Examiner's Comment

Answers to part (i) were generally fine, however answers to part (ii) showed a lack of understanding of how database recovery works. Many candidates confused the use of log files with the use of a database backup.

b) Self-describing refers to the fact that a database holds data about its data (meta-data, or data dictionary). (2 marks) The self-describing nature of a database is what provides program-data independence (the definition of data is separated from the programs using that data).

### Examiner's Comment

Answers were disappointing, with only a few candidates managing to link the self-describing feature of databases to the data dictionary (meta-data).

c) Disadvantages may include

Cost of software: depending on the number of users, the cost of a DBMS can be quite steep  
Cost of hardware: the company needs to invest in new servers to host the DBMS and database

Cost of conversion: the legacy system needs to be converted into a database and its supporting applications need to be developed. This also includes the cost of training staff to use the new system

Cost of running and maintenance including the cost of IT staff (database administration)

### **Examiner's Comment**

Most candidates managed to identify a few disadvantages (mainly cost). However, a lot of candidates struggled to think of any. It seems that candidates are more practised at merely listing the advantages of database systems when compared to file-based systems.