BCS THE CHARTERED INSTITUTE FOR IT

BCS HIGHER EDUCATION QUALIFICATIONS
BCS Level 6 Professional Graduate Diploma in IT

ADVANCED DATABASE MANAGEMENT SYSTEMS

Tuesday 18th April 2023 - Afternoon

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 **NOT** allowed in this examination.

Section A
Answer Section A questions in Answer Book A

A1.

This question relates to the theoretical foundations of the Relational model and the emergence of alternative database models and supporting technology.

a) Compare and contrast the main features of Relational Calculus with those of Relational Algebra.

(6 marks)

b) Explain the main differences between **each** of the following data models:

i) Relational;

(4 marks)

ii) Object-Oriented;

(4 marks)

iii) Document Oriented.

(4 marks)

Your answer should cover differences in data representation, data definition languages, data manipulation, and data access/query languages.

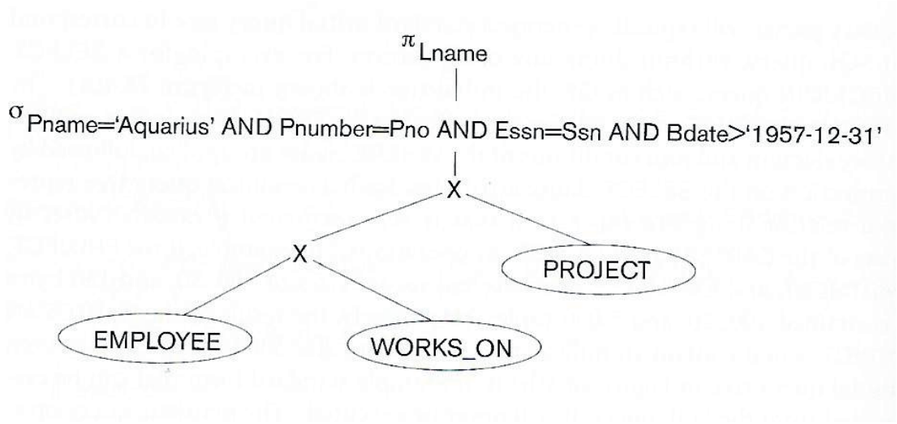
c) Define the term “Data Persistence” and explain why it is important in a Database Management System (DBMS).

(7 marks)

A2.

Consider the following initial query tree (Fig A2.1) that operates on Tables `EMPLOYEE` (Fig A.2.2) `WORKS_ON` (Fig A2.3) and `PROJECT` (Fig A2.4).

Fig A.2.1 Query Tree



c) A database audit has shown that a staff member who changed division in a company has been able to access data that should not be accessed from their new division. Explain the concepts of authentication and authorisation, describe what they are and their relevance to the prevention of the incident.

(6 marks)

d) A database security administrator has many responsibilities, ranging from establishing abstract security policies to implementing security privileges for users. Consider the following tools available to a database security administrator and describe what they do:

i) SQL statement
```
GRANT SELECT ON Payroll TO John
```
(2 marks)

ii) SQL statement
```
REVOKE INSERT FROM HR_staff
```
(2 marks)

iii) SQL statement
```
GRANT UPDATE ON product TO Amy WITH GRANT OPTION
```
(2 marks)

iv) Views.

(2 marks)

END OF EXAMINATION

Section B
Answer Section B questions in Answer Book B

B4.

a) The ACID properties of transactions are a standard set that ensures that database transactions are processed reliably.

i) State the name of **each** of the four properties and explain what it ensures.
(4 marks)

ii) Provide an example showing how simple transactions can lead to an undesirable outcome without adhering to the concept of atomicity.
(4 marks)

b) Consider transaction schedules:

i) Explain the concepts of serial and serialisability when applied to transaction schedules.
(2 marks)

ii) Provide an example of a set of database instructions (operations) performed by different processes that are not serialisable.
(8 marks)

c) When processing transactions in distributed relational database systems, additional effort is required. Describe the two-phase commit protocol on the example of a transaction involving 3 RDBMSs on different servers by discussing the case where one RDBMS needs to abort its changes to local data. You may wish to use a diagram.
(7 marks)

B5.

a) Consider data masking, data redaction and encryption:

i) Describe data masking.
(2 marks)

ii) Describe data redaction.
(2 marks)

iii) Explain how data masking can be more beneficial for developers than encryption during the testing phase of the development of new applications.
(4 marks)

b) Database auditing has recently gained importance due to legislation such as GDPR (General Data Protection Regulation). What is database auditing, and how may it be conducted?
(3 marks)

Fig A2.2 **EMPLOYEE**

SSN	Lname	Bdate
12329	Rogers	1957-12-31
13453	Ahmed	1978-03-04
15463	Bohm	1956-06-03

Fig A2.3 **WORKS_ON**

ESSN	Pnumber	HrsWorked
12329	49	450
13453	43	200
15463	46	19

Fig A2.4 **PROJECT**

Pno	Pname	Pstartdate
43	Aquarius	2021-02-03
44	Markets	2020-12-11
46	Hospitality	2020-12-24

a) Express the equivalent SQL statement represented in the above query tree**.**
(7 marks)

b)

i) Explain why the query tree (Fig A2.1) represents an inefficient method to process the SQL query.

ii) Describe how the query tree could be transformed to optimise the query to run efficiently.
(8 marks)

c) Describe the following query optimisation techniques and discuss their relative benefits and drawbacks:

i) Cost-based query optimisation.
(5 marks)

ii) Rule-based query optimisation.
(5 marks)

[Turn Over]

A3.

a) Describe each of the following approaches to distribution of data in a distributed database and comment on the benefits and drawbacks of each approach compared with storing data in a centralised database:

i) Data Fragmentation; **(4 marks)**
ii) Replication. **(4 marks)**

b) Company XYZ has three departments at different sites. Department 1 is located at Hull, department 2 is located at Manchester and department 3 is located at Boston.

The following Tables show sample data contained in the XYZ centralised database.

The database holds data on departments, employees and the assignments of employees to projects.

Fig A3.1 `EMPLOYEE` (sample data)

EmployeeID	EmpName	Birthdate	Salary	Gender	Contact	DeptID
12329	Rogers	1957-12-31	23430	M	12231	1
13453	Ahmed	1978-03-04	34000	F	13299	3
15463	Bohm	1956-06-03	29000	M	055456	3
16721	Collins	1959-04-23	45000	F	454433	2
16722	Sakar	1979-05-07	49000	M	563476	2
16779	Mehmet	1969-03-04	55000	F	073037	1

Fig A3.2 `ASSIGNMENT` (sample data)

EmployeeID	ProjectID	TotalHrsWorked
13453	43	200
15463	46	19
16721	47	22
16722	47	22
16779	49	200
12329	49	450

Fig A3.3 `PROJECT` (sample data)

ProjectID	ProjectName	Projectstarted	DeptID
43	Aquarius	2021-02-03	3
44	Markets	2020-12-11	3
46	Hospitality	2020-12-24	3
47	Networks	2016-11-21	2
49	Catering	2015-04-06	1
50	Maintenance	2020-12-24	2

Fig A3.4 `DEPARTMENT`(sample data)

DeptID	DeptName	Manager	DepartmentLocation
3	R&D	16722	Boston
2	Admin	16721	Manchester
1	HQ	16779	Hull

Users and applications in the Boston and Manchester departments require fast access to each of the four tables to process information only for the department that is located at that site. The attributes they actually use from the `EMPLOYEE` data are `Empname`, `EmployeeID`, `Salary` and `DeptID`.

The company headquarters are located in the department at Hull and users at that site access all information about employees, departments, assignments and projects frequently.

With reference to the scenario and the sample tables, produce an appropriate fragment allocation design. Justify your answer.

(8 marks)

c) Over recent years, mobile computing devices (e.g., smartphones, wearable devices and PDAs) have been widely used to store and share data captured on a mobile device connected over a mobile network to a centralised database. Mobile devices use a "lightweight" database embedded in the mobile device, and numerous apps provide an interface for user access to that data.

Describe a simple mobile application you are familiar with and briefly explain the key issues of data distribution and how data consistency is maintained, for example, when communication with the central database fails.

(9 marks)

[Turn Over]