Question 1. [6 MARKS]

Consider the following database:

P

A	B
1	5
4	6
2	8
3	4
7	12
8	3
9	1

Q

A	B
2	5
2	2
8	12
1	5
9	13
4	12
3	18
1	18

R

B	D
12	95
2	98
5	94
8	98
18	96
13	90

Give the result of following queries, using the same tabular format as above; do **not** describe the result in English. Assume the set semantics (not bag semantics) for Relational Algebra.

Part (a) [2 MARKS]

$Temp(B) := \Pi_{Q.B}(\sigma_{P.A=Q.A \wedge P.B>5}(P \times Q))$

$Answer := \Pi_D((\Pi_B Q - Temp) \bowtie R)$

Solution:

D
90
96

Part (b) [2 MARKS]

$[\Pi_B R] - [\rho_{X(B)} \Pi_{R1.B}(\sigma_{R1.B \neq R2.B \wedge R1.D<R2.D}(\rho_{R1} R \times \rho_{R2} R))]$

Solution:

B
2
8

Part (c) [2 MARKS]

$[\Pi_{Q.A}(\sigma_{P.B<10 \wedge P.B=Q.A}(P \times Q))] \cap [\Pi_{Q.A}(\sigma_{P.A=Q.A \wedge Q.B=R.B \wedge R.D>95}(P \times Q \times R))]$

Solution:

Q.A
3
1

Question 2. [8 MARKS]

Consider the following schema, which you used in recent tutorials:

Suppliers(sID, sName, address)

Parts(pID, pName, colour)

Catalog(sID, pID, price)

Catalog[sID] $\subseteq$ Suppliers[sID]

Catalog[pID] $\subseteq$ Parts[pID]

Part (a) [1 MARK]

Give a small example that violates the key constraint of relation Suppliers. Show the necessary relation(s) as tables with column headings and actual data in the rows. Annotate your example to show the violation.

Solution:

Any instance of Suppliers where the same SID occurs twice violates the key constraint of relation Suppliers. Example:

sID	sName	address
9172	"Barney's Part Supply"	"123 Tree Lane"
9172	"AAA Parts"	"91 West Main"

Part (b) [1 MARK]

Give a small example that violates the foreign key constraint on attribute *pID* of relation Catalog. Annotate your example to show the violation.

Solution:

Any instance of Catalog and Parts where there is a value for pID in Catalog that does not occur as a pID in Catalog. Example:

Catalog

sID	pID	price
9124	21	0.29

Parts

pID	pName	colour
11	"size 0.3cm ratchet"	"silver"
45	"standard washer"	"bronze"

Part (c) [6 MARKS]

Which of the following statements are enforced by the schema? Circle one answer for each. If the statement is enforced, say what part of the schema enforces it. If it is not enforced, write an integrity constraint that would enforce it (using one of the two forms defined in the texbook).

1. A part must not have two part names.

   [Enforced] This part of the schema enforces it:

   pID is a key for Parts, so the same part cannot occur twice in the Parts table. This means it has no chance to get two different part names.

   Not enforced This new integrity constraint would enforce it:

2. The same address cannot occur twice in the Suppliers relation.

   Enforced This part of the schema enforces it:

   [Not enforced] This new integrity constraint would enforce it:

   $\sigma_{S1.address=S2.address \wedge S1.pID \neq S2.pID}(\rho_{S1}Suppliers \times \rho_{S2}Suppliers) = \varnothing$

3. A supplier cannot supply a part at two different prices.

   [Enforced] This part of the schema enforces it:

   sID and pID are together the key for Catalog, so the same supplier and part cannot occur twice in Catalog. This means they have no chance to occur with two different prices.

   Not enforced This new integrity constraint would enforce it:

Question 3. [12 MARKS]

This question assumes the schema from Assignment 1, repeated here:

Relations

- Ret(ID, name, address, city, country)
- Store(ID, retailer, address, city, country, phone)
- Mem(memNum, name, phone, address, city, country)
- Card(cardNum, memNum, limit)
- Supp(cardNum, memNum, pLimit)
- Trans(cardNum, memNum, date, time, store, type, amount)
- Pmt(cardNum, memNum, date, time, amount)

Integrity constraints

- Store[retailer] $\subseteq$ Ret[ID]
- Card[memNum] $\subseteq$ Mem[memNum]
- Supp[cardNum] $\subseteq$ Card[cardNum]
- Supp[memNum] $\subseteq$ Mem[memNum]
- Trans[cardNum] $\subseteq$ Card[cardNum]
- Trans[memNum] $\subseteq$ Mem[memNum]
- Trans[store] $\subseteq$ Store[ID]
- Pmt[cardNum] $\subseteq$ Card[cardNum]
- Pmt[memNum] $\subseteq$ Mem[memNum]

Write the following queries using only the basic Relational Algebra operators $\Pi, \sigma, \bowtie, \times, \cap, \cup, -, \rho$. Assume the set semantics (not bag semantics) for Relational Algebra.

1. Report the name of every retailer that has a store in every country in the database (whether the country is a location of a retailer's head office, is a location of a store, or is where a member lives).

   Solution:

   $Countries := (\Pi_{country} Ret) \cup (\Pi_{country} Store) \cup (\Pi_{country} Mem)$
   $Should(rID, country) := (\Pi_{ID} Ret) \times Countries$
   $Do(rID, country) := \Pi_{retailer,country} Store$
   $DoNot(ID) := \Pi_{rID}(Should - Do)$
   $Answer := \Pi_{name}((\Pi_{ID} Ret - DoNot) \bowtie Ret)$

2. Find every member who is the primary cardholder for exactly one credit card. Report the ID of every store in the US where they have done any transaction. (Don't include any information about members — just the store IDs.)

   Solution:

   $OnePlus(memNum) := \Pi_{memNum} Card$
   $TwoPlus(memNum) := \Pi_{C1.memNum}(\sigma_{C1.memNum=C2.memNum \wedge C1.cardNum \neq C2.cardNum}(\rho_{C1} Card \times \rho_{C2} Card)$
   $ExactlyOne := OnePlus - TwoPlus$
   $Answer := \Pi_{Store}(\sigma_{store=ID \wedge country="US"}((ExactlyOne \bowtie Trans) \times Store))$

Question 4. [4 MARKS]

Part (a) [2 MARKS]

Suppose relation R contains the following:

A	B	C
1	5	1
4	6	5
2	8	1
3	4	NULL
1	2	3
3	3	2

Show the result of the following SQL query:

```
SELECT A, B
FROM R
WHERE C < 5;
```

Solution:

A	B
1	5
2	8
1	2
3	3

Part (b) [2 MARKS]

Suppose that

- X has the value NULL
- Y has the value 13

Fill in the table below to show the value of each of the expressions.

Solution:

`(NOT(X > 5)) OR (Y < 20)`	True
`(X < 10) OR (X = 10) OR (X > 10)`	Unknown