OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL
COMPUTER SCIENCE

Unit 4 Advanced concepts and principles of computer science

Specimen paper   07:00 GMT   Time allowed: 1 hour 30 minutes

Materials
- You may use a calculator.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this answer book. Cross through any work you do not want to be marked.

Information
- The marks for each question are shown in brackets.
- The maximum mark for this paper is 75.

Advice
- In some questions you are required to indicate your answer by completely shading a lozenge alongside the appropriate answer as shown.
- If you want to change your answer you must cross out your original answer as shown.
- If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

Answer **all** questions in the spaces provided.

0 1 . 1 A data communications system uses parallel data transmission.

Describe how parallel data transmission works.

[2 marks]

0 1 . 2 State **one** advantage of serial data transmission over parallel data transmission.

[1 mark]

0 1 . 3 Shade **one** lozenge to show which of these statements about data communications systems is **false**.

[1 mark]

A For a particular communications channel, the bit rate can be higher than the baud rate. ⬭

B Latency is the rate at which signals on a wire or line can change. ⬭

C The bandwidth of a transmission medium is the range of signal frequencies that the medium can transmit without a significant reduction in signal strength. ⬭

D The greater the bandwidth of a transmission medium the higher the bit rate that can be achieved by a communication system using it. ⬭

0 1 . 4 State the purpose of the **start bit** in asynchronous serial transmission.

[1 mark]

0 1 . 5 State the purpose of the **stop bit** in asynchronous serial transmission.

[1 mark]

____

____

6

Turn over for the next question

0 2 A business with three stores uses a system which keeps details of all of the products that it sells and the sales that it makes. The data that the business keeps is Big Data.

0 2 . 1 Two characteristics of Big Data are that the volume of data means it is too big to fit on a single server and the data comes in a variety of forms.

Describe the third characteristic of Big Data.

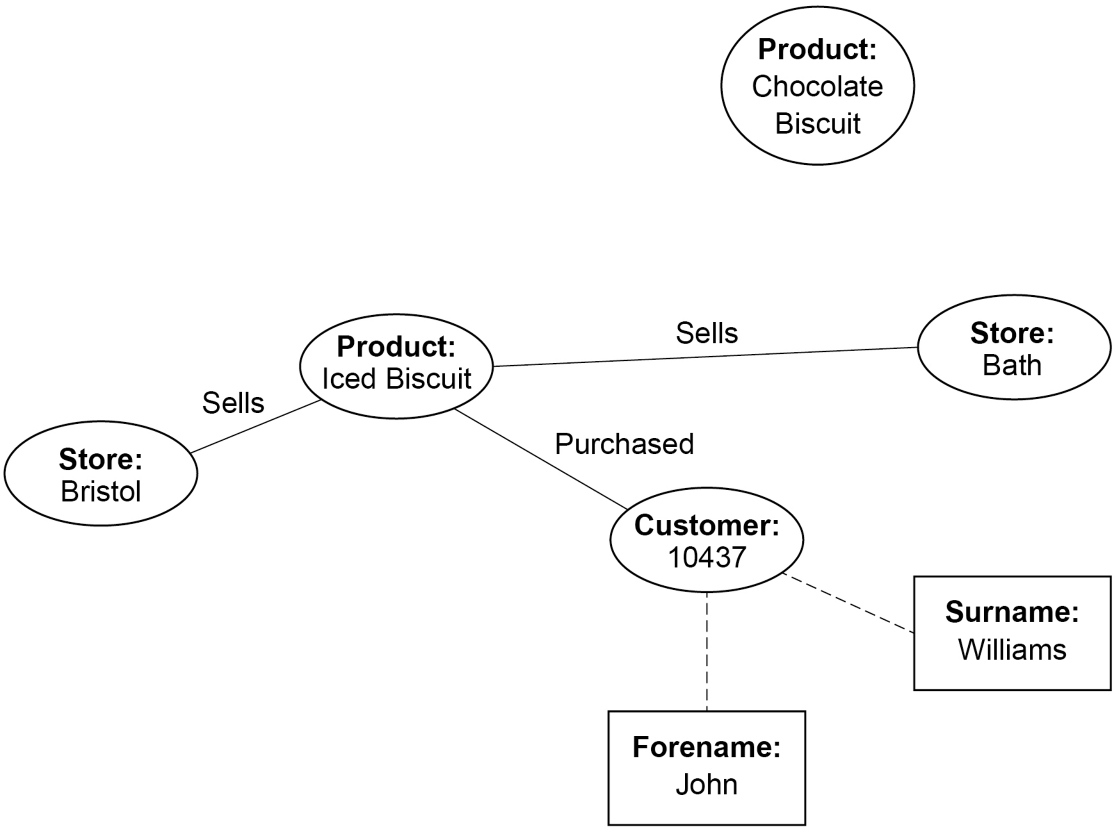
[1 mark]

____

____

The graph schema in **Figure 1** represents part of a fact-based model of the dataset that the business has built.

Figure 1



0 2 . 2 Modify the graph schema in **Figure 1** to represent the following additional facts.

- The Bath store sells chocolate biscuits.
- There are 20 individual biscuits in a packet of iced biscuits and each packet costs £1.50
- Both chocolate biscuits and iced biscuits are made by the company Delicious Snacks. The company has 75 employees and also makes cake bars.

[3 marks]

4

0 3 A family uses a wireless computer network at home.

0 3 . 1 Describe **two** security measures that the family should put in place to ensure that the wireless access point is secure **and** explain how these security measures will make wireless connections to the access point more secure.

[2 marks]

Measure 1

Measure 2

Question 3 continues on the next page

0 3 . 2 The network uses the CSMA/CA access method with Request to Send/Clear to Send (RTS/CTS).

A computer on the network has data to send to another computer.

Describe how the CSMA/CA access method with RTS/CTS will be used during this transmission.

[6 marks]

8

0 4 Problems can be classified into different categories based upon how efficiently they can be solved, or if they can be solved at all.

Three such classifications are

- Tractable
- Intractable
- Unsolvable

0 4 . 1 Describe what it means for a problem to be described as tractable.

[2 marks]

0 4 . 2 What approach might a programmer take if asked to 'solve' an intractable problem?

[2 marks]

0 4 . 3 Shade **one** lozenge to show which of the problems listed in the table is unsolvable.

[1 mark]

A The Halting problem. ⬭

B The problem of sorting a list into order. ⬭

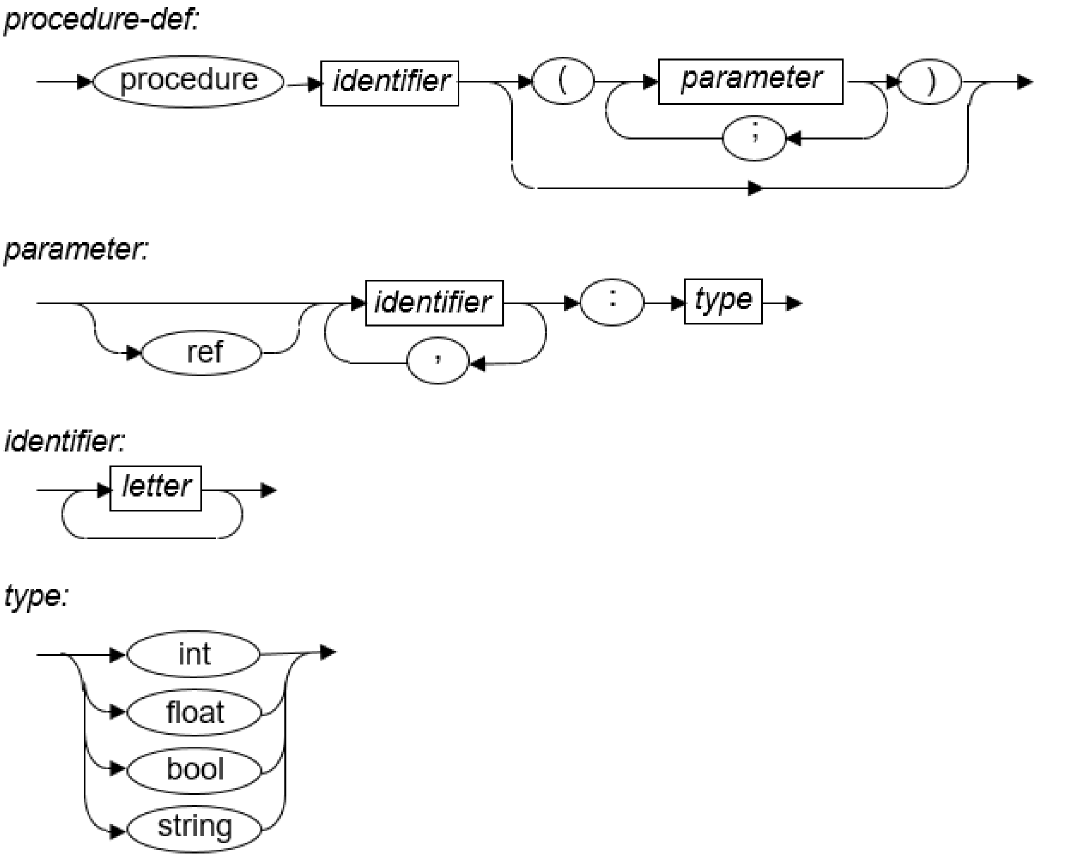
C The problem of traversing a tree. ⬭

D The travelling salesman problem. ⬭

5

0 5 In a particular programming language, the correct syntax for four different constructs is defined by the syntax diagrams in **Figure 2**.

Figure 2



A *letter* is any alphabetic character from "a" to "z" or "A" to "Z".

In this language an example of a valid *identifier* is `loopCount` and an example of a valid *type* is `int`.

0 5 . 1 For each row in the table below, write **Yes** or **No** in the empty column to identify whether or not the **Example** is a valid example of the listed **Construct.**

[2 marks]

Construct	Example	Valid? (Yes/No)
identifier	`Player2name`	
parameter	`x,y:bool`	
procedure-def	`procedure square(s:real)`	
procedure-def	`procedure rect(w:int,h:int)`	

A student has written Backus-Naur Form (BNF) production rules that are supposed to define the same constructs as the syntax diagrams in **Figure 2**. Their BNF rules are shown in **Figure 3**.

Figure 3

```
<procedure-def> ::= procedure <identifier> ( <paramlist> )
<paramlist>     ::= <parameter> | <parameter> ; <paramlist>
<parameter>     ::= <identlist> : <type> |
                    ref <identlist> : <type>
<identlist>     ::= <identifier> | <identifier> , <identlist>
<identifier>    ::= <letter> | <letter> <identifier>
<type>          ::= int | float | bool | char | string
```

A `<letter>` is any alphabetic character from "a" to "z" or "A" to "Z".

0 5 . 2 The BNF production rules in **Figure 3** contain two errors. These errors mean that they do not represent the same statement types as the syntax diagrams in **Figure 2**.

Describe the **two** errors.

[2 marks]

Error 1 ________________________________

Error 2 ________________________________

0 5 . 3 The production rule for a `<paramlist>` is recursive.

Explain why recursion has been used in this production rule.

[1 mark]

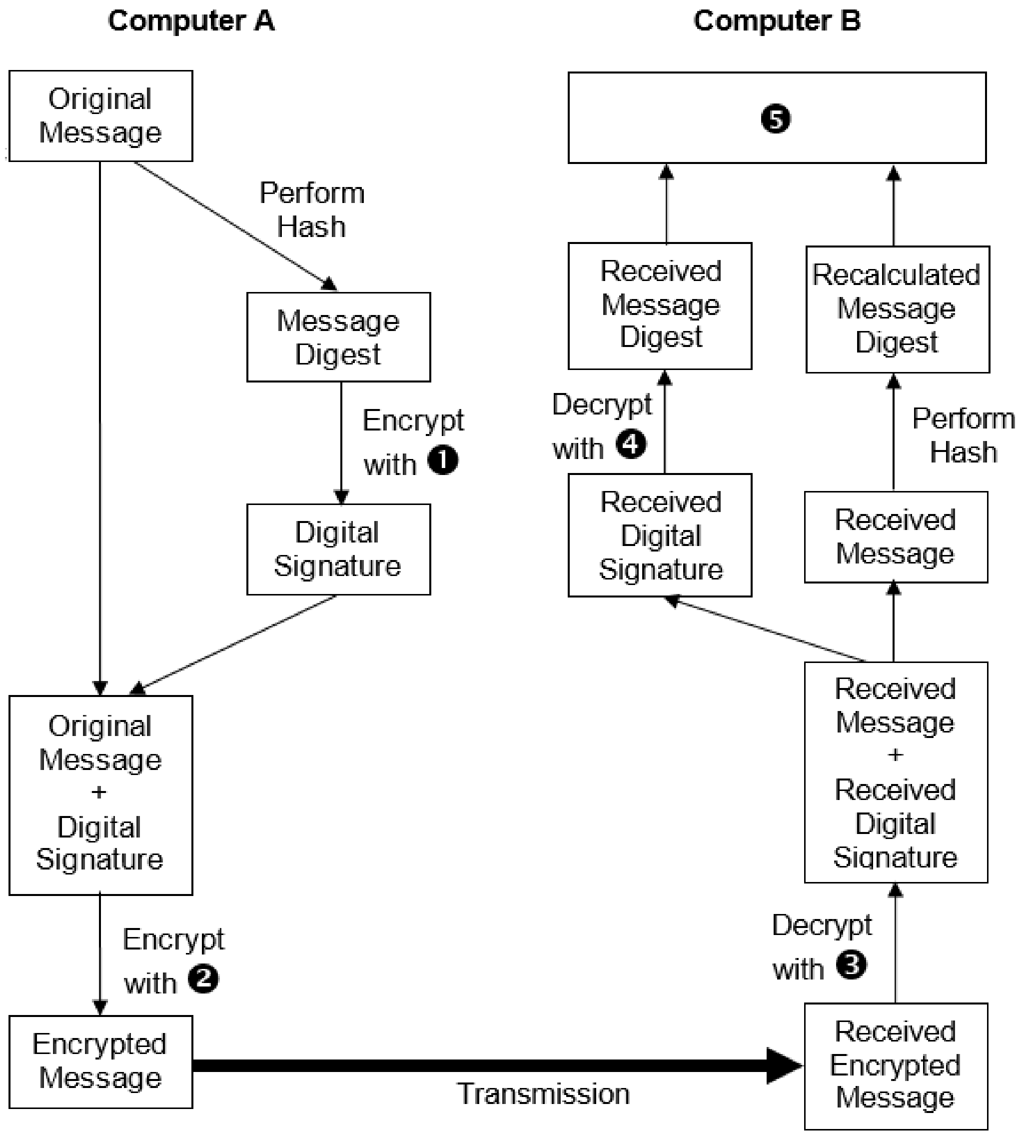
5

0 6 A message is being transmitted from **Computer A** to **Computer B**.

The message will be encrypted and decrypted using public and private keys and a digital signature will also be used.

Figure 4 shows the encryption and decryption processes. The symbols ❶ to ❹ in the figure represent the names of keys.

Figure 4



0 6 . 1 State the names of the keys that are represented by each of the symbols ❶ to ❹.

[2 marks]

Label	Key Name
❶	
❷	
❸	
❹	

0 6 . 2 Describe the process that will take place at the position labelled ❺.

[1 mark]

____

____

0 6 . 3 State **two** purposes of the addition of the digital signature to the message.

[2 marks]

Purpose 1 ____

____

Purpose 2 ____

____

5

Turn over for the next question

0 7 A Turing machine has been designed to recognise palindromic binary numbers, ie numbers such as `101` and `0110` that read the same from left to right as from right to left.

The machine has states S_B, S_0, S_1, S_{C0}, S_{C1}, S_L, S_Y and S_N.

S_B is the start state and S_Y and S_N are the stop states.

The machine stores data on a single tape which is infinitely long in one direction. The machine's alphabet is 0, 1 and □, where □ is the symbol used to indicate a blank cell on the tape. The machine will enter state S_Y if the value represented on the tape is a palindromic binary number, otherwise it will enter state S_N.

The transition rules for this Turing machine can be expressed as a transition function δ. Rules are written in the form:

δ (Current State, Input Symbol) = (Next State, Output Symbol, Movement)

So, for example, the rule:

$$\delta\,(S_B, 0) = (S_0, \square, \rightarrow)$$

means:

IF the machine is currently in state S_B AND the input symbol read from the tape is 0
THEN the machine should change to state S_0, write a blank symbol (□) to the tape and move the read/write head one cell to the right

The machine's transition function, δ, is defined by:

$\delta\,(S_B, 0) = (S_0, \square, \rightarrow)$
$\delta\,(S_B, 1) = (S_1, \square, \rightarrow)$
$\delta\,(S_B, \square) = (S_Y, \square, \rightarrow)$

$\delta\,(S_0, 0) = (S_0, 0, \rightarrow)$
$\delta\,(S_0, 1) = (S_0, 1, \rightarrow)$
$\delta\,(S_0, \square) = (S_{C0}, \square, \leftarrow)$

$\delta\,(S_1, 0) = (S_1, 0, \rightarrow)$
$\delta\,(S_1, 1) = (S_1, 1, \rightarrow)$
$\delta\,(S_1, \square) = (S_{C1}, \square, \leftarrow)$

$\delta\,(S_{C0}, 0) = (S_L, \square, \leftarrow)$
$\delta\,(S_{C0}, 1) = (S_N, 1, \leftarrow)$
$\delta\,(S_{C0}, \square) = (S_Y, \square, \rightarrow)$

$\delta\,(S_{C1}, 0) = (S_N, 0, \leftarrow)$
$\delta\,(S_{C1}, 1) = (S_L, \square, \leftarrow)$
$\delta\,(S_{C1}, \square) = (S_Y, \square, \rightarrow)$

$\delta\,(S_L, 0) = (S_L, 0, \leftarrow)$
$\delta\,(S_L, 1) = (S_L, 1, \leftarrow)$
$\delta\,(S_L, \square) = (S_B, \square, \rightarrow)$

0 7 . 1 This Turing machine is carrying out a computation. The machine starts in state S_B with the string 101 on the tape. All other cells contain the blank symbol, ☐ (not shown). The read/write head is located at the lefthand symbol of the string and is indicated with an upward arrow.

Trace the computation of the Turing machine, using the transition function δ.

Show the contents of the tape, the current position of the read/write head and the current state as the input symbols are processed.

The initial configuration of the machine has been completed for you in step 1.

[5 marks]

Step								State
1.	1	0	1				...	S_B
2.							...	
3.							...	
4.							...	
5.							...	
6.							...	
7.							...	
8.							...	
9.							...	
10.							...	
11.							...	

0 7 . 2 The three rules shown below are part of the machine's transition function.

Explain what effect these three rules, taken together, have on the tape, the read/write head and the state of the Turing machine:

$$\delta\ (S_0, 0) = (S_0, 0, \rightarrow)$$
$$\delta\ (S_0, 1) = (S_0, 1, \rightarrow)$$
$$\delta\ (S_0, \square) = (S_{C0}, \square, \leftarrow)$$

[2 marks]

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0 7 . 3 A universal Turing machine (UTM) is a special type of Turing machine that can be considered to act like an interpreter.

Explain why a UTM can be considered to be an interpreter.

[2 marks]

9

0 8 A computer network makes use of the DHCP system.

When a device wishes to join the network, it communicates with a DHCP server.

Describe:

- the purpose of the DHCP system
- why the DHCP system is used
- what will happen during this communication.

[4 marks]

4

Turn over for the next question

0 9 A garage services and repairs cars. It uses a relational database to keep track of the jobs that customers have booked for it to carry out. The database includes jobs that have been completed and jobs that are waiting to be done.

The details of the jobs that the garage does, together with the parts that it stocks and uses are stored in the database using the four relations shown in **Figure 5**.

Figure 5

Job (<u>JobID</u>, CarRegNo, JobDate, InGarage, JobDuration)

Car (<u>CarRegNo</u>, Make, Model, OwnerName, OwnerEmail, OwnerTelNo)

Part (<u>PartID</u>, Description, Price, QuantityInStock)

PartUsedForJob (<u>JobID, PartID</u>, QuantityUsed)

- Each car has a unique CarRegNo. This is the unique registration number or license plate that identifies the car.
- A type of car can be uniquely identified by the combination of its Make and Model. Different Makes may use the same Model name and a particular manufacturer (Make) will produce several different car Models.
- A booking made for a car on a particular date counts as one job, regardless of how many different tasks are completed upon it.
- A job might require the use of any number of parts, including zero.
- Some of the details are stored in the database as soon as a booking is made and others are only added when a job has been completed.

The attribute JobID is the Entity Identifier (Primary Key) of the Job relation.

0 9 . 1 If the JobID attribute were not included in the Job relation, which other attribute or attributes that are currently in the relation could probably be used as an Entity Identifier (Primary Key) instead?

[1 mark]

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It has been suggested that the owner details (OwnerName, OwnerEmail, OwnerTelNo) should not be stored in the Car relation and that a new relation should be created to store owner details separately from car details.

0 9 . 2 Explain why storing the owner details separately would improve the design of the database.

[2 marks]

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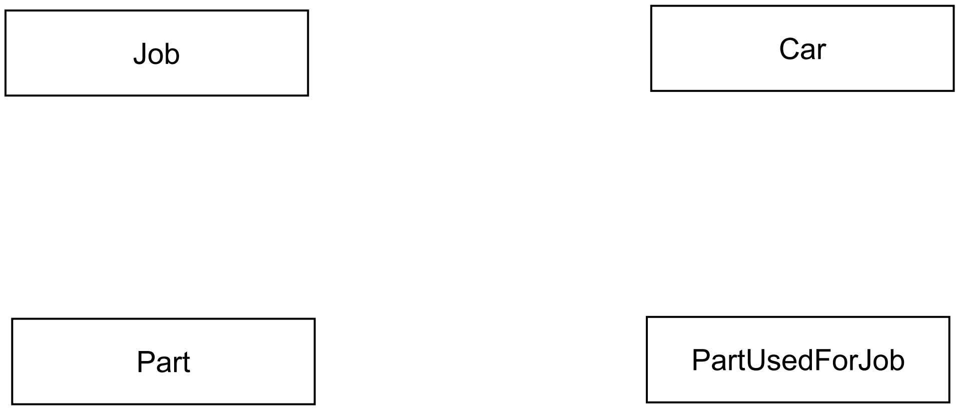
0 9 . 3 On the incomplete Entity-Relationship diagram below show the degree of any **three** relationships that exist between the entities.

[2 marks]



When an appointment is made for a job, this is represented in the Job relation. At the time of booking:

- the InGarage attribute is set to False, and
- the JobDuration attribute is set to 0:00

When the car arrives at the garage the value of the InGarage attribute is changed to True.

When the job is finished:

- the value of the JobDuration attribute is updated to indicate how long the job took, and
- details of the parts used are recorded in the database.

The Job with JobID 206 has been completed. The job took 1 hour 30 minutes (1:30) and used two of the parts with PartID 12.

0 9 . 4 Write the SQL commands that are required to record the amount of time that the job took in the database.

[3 marks]

Figure 5 is repeated below.

Figure 5 (repeated)

Job (<u>JobID</u>, CarRegNo, JobDate, InGarage, JobDuration)

Car (<u>CarRegNo</u>, Make, Model, OwnerName, OwnerEmail, OwnerTelNo)

Part (<u>PartID</u>, Description, Price, QuantityInStock)

PartUsedForJob (<u>JobID, PartID</u>, QuantityUsed)

0 9 . 5 Write the SQL commands that are required to record in the database the fact that two of the parts with PartID 12 were used.

[2 marks]

A mechanic needs to produce a list of all of the parts used on the job with JobID 93 for a customer.

This list must include the PartID, Description, Price (each) and QuantityUsed of each part, and no other details. The parts in the list should be ordered by PartID with the parts with the lowest PartIDs nearest to the top of the list.

0 9 . 6 Write an SQL query to produce the list.

[5 marks]

Figure 5 is repeated below.

Figure 5 (repeated)

Job (<u>JobID</u>, CarRegNo, JobDate, InGarage, JobDuration)

Car (<u>CarRegNo</u>, Make, Model, OwnerName, OwnerEmail, OwnerTelNo)

Part (<u>PartID</u>, Description, Price, QuantityInStock)

PartUsedForJob (<u>JobID, PartID</u>, QuantityUsed)

There are restrictions on which parts can be fitted to which cars. For example:

- The driver's door mirror with PartID 104 can only be fitted to one particular make and model of car.
- The ignition switch with PartID 27 can be fitted to any model of car for one particular make as the maker uses the same ignition switch in all models.
- The tyre with PartID 97 can be fitted to a wide range of cars of different makes and models as it is a standard size.

If the information about which parts could be fitted to which makes and models of cars were represented in the database, it could be used to help a mechanic identify the correct parts to use for a job.

0 9 . 7 Describe how the database design could be modified to represent which makes and models of car a part can be fitted to.

[3 marks]

18

1 0 In a functional programming language, four functions named `fw`, `fx`, `fy` and `fz` and a list named `sales` are defined as shown in **Figure 6**.

Figure 6

```
fw [a,b] = a * b
fx c = map fw c
fy d = fold (+) 0 d
fz e = fy (fx e)
sales = [[10,2], [2,25], [4,8]]
```

The `sales` list represents all of the sales made in a shop in one day. It is composed of sublists.

The values in each sublist indicate the price of a product and the quantity of the product that was sold. For example, `[10,2]` indicates that 10 units of a product priced at £2 were sold.

1 0 . 1 Shade **one** lozenge to show how many of the four functions (`fw`, `fx`, `fy`, `fz`) in **Figure 6** directly include a higher-order function in their definitions.

[1 mark]

1	⬭	**2**	⬭	**3**	⬭	**4**	⬭

1 0 . 2 Calculate the results of making the function calls listed in **Table 2**, using the functions and lists in **Figure 6** as appropriate.

[3 marks]

Table 2

Function Call	Result
`fw [4,3]`	
`fx sales`	
`fz sales`	

1 0 . 3 Describe what the result of the function call `fz sales` represents to the shop.

[1 mark]

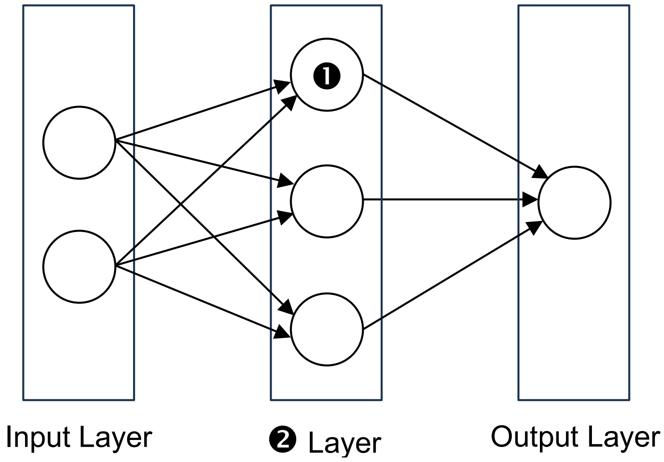
____

____

5

1 1 . 1 **Figure 7** shows a simple neural network.

Figure 7



State the names of components ❶ and ❷ in the network shown in **Figure 7**.

[2 marks]

❶ ______________________________

❷ ______________________________

1 1 . 2 State how the neural network in a deep learning system would differ from a simple neural network.

[1 mark]

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1 1 . 3 State **three** potential benefits of using artificial intelligence.

[3 marks]

Benefit 1 ______________________________

____

Benefit 2 ______________________________

____

Benefit 3 ______________________________

____

6

END OF QUESTIONS