AQA

Please write clearly in block capitals.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname ____________________

Forename(s) ____________________

Candidate signature ____________________
I declare this is my own work.

A-level
COMPUTER SCIENCE
Paper 2

Monday 19 June 2023 Morning Time allowed: 2 hours 30 minutes

Materials
For this paper you must have:
- 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 book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 100.

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.

For Examiner's Use	
Question	Mark
1	
2	
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8	
9	
10	
11	
12	
TOTAL	

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Answer **all** questions.

0 1 . 1 A sound is sampled and recorded digitally. The sound is sampled at a rate of 48 000 samples per second (Hz) for 3 minutes using a 16-bit sample resolution.

Calculate the size of the digital recording, giving your answer in mebibytes.

Give your answer rounded to 2 decimal places.

You should show your working.

[2 marks]

Answer ________________ mebibytes

0 1 . 2 The highest frequency component in a different sound is 15 000 Hz.

What is the minimum sampling rate that should be used when recording this sound to ensure that all the frequencies in the original waveform are preserved, so that when the recording is played back the original sound is recreated accurately?

[1 mark]

Answer ________________ Hz

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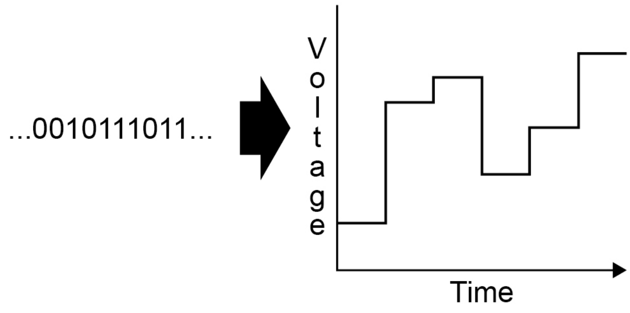
0 1 . 3 **Figure 1** shows part of the process of playing back a sound that has been sampled. The binary sound data is used to generate an electrical waveform.

Figure 1



A hardware component on a sound card carries out the process shown in **Figure 1**.

State the name of this component.

[1 mark]

____

4

Turn over for the next question

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0 2 **Figure 2** shows some of the fields contained in a packet, transmitted on a computer network.

Figure 2

Destination Address	Source Address	Payload (data)	Checksum

0 2 . 1 Name **two** fields typically included in a packet which are **not** shown in **Figure 2**.

[2 marks]

Field 1 ____________________

Field 2 ____________________

0 2 . 2 Explain what the checksum is used for **and** outline how the checksum's value will be determined.

[2 marks]

Explain what the checksum is used for ____________________

Outline how the checksum's value will be determined ____________________

0 2 . 3 Packets of data are transmitted using packet switching.

Describe the role of a router in packet switching.

[2 marks]

6

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0 3 . 1 Encrypt the plaintext SECURITY using the Caesar cipher with a key of 4.

[1 mark]

Plaintext	**Ciphertext**
SECURITY	

The Caesar cipher is an example of a substitution cipher.

A **different** substitution cipher encrypts letters using the method shown in **Figure 3**.

Figure 3

Plaintext	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Ciphertext	C	D	J	R	K	Y	G	S	Q	F	E	P	W	O	H	V	L	I	U	Z	T	B	N	A	X	M

0 3 . 2 State **one** weakness that both the Caesar cipher and the cipher shown in **Figure 3** have which means they can be easily cracked.

[1 mark]

0 3 . 3 State **one** reason why the cipher in **Figure 3** is harder to crack than the Caesar cipher.

[1 mark]

Question 3 continues on the next page

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0 3 . 4 The Vernam cipher, unlike the Caesar cipher, can be perfectly secure.

State **two** conditions that must be met for the Vernam cipher to offer perfect security.

[2 marks]

Condition 1: ____

____

____

Condition 2: ____

____

____

5

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0 4 . 1 Describe how the fetch-execute cycle is used to carry out machine code instructions **and** how the hardware of a computer could be improved so that programs can be executed more quickly.

Your response should include a description of what happens during each stage of the fetch-execute cycle.

[12 marks]

Question 4 continues on the next page

Turn over ►

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0 4 . 2 An interrupt may occur during the fetch-execute cycle.

Describe what an interrupt is **and** explain the purpose of interrupts.

[2 marks]

14

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0 5 A company operates a cinema which has three different screens. Each screen has a capacity determined by the number of seats the screen has.

Each seat is identified by a unique seat number for the screen it is in, but two seats in different screens can have the same number. A specific seat is classified as being of one of two types: standard or deluxe.

On a particular day, there will be several showings of films in each of the screens. A screen might show the same film multiple times or it might show different films at different times of day.

Customers make bookings to go to the cinema. Each booking is for one specific showing of a film. A booking is for one or more seats, and the customer can select the individual seats that they want to book when they make the booking.

When a booking is made, if the customer has not previously made a booking, the customer's first name, last name and telephone number are recorded. If the booking is for more than one seat then only the details of the person who made the booking are recorded – the system does not store the details of who will be sitting in each seat. If a customer has made a booking previously then the details that were stored about them when the previous booking was made are re-used.

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0 5 . 1 Develop a **fully normalised design** for a relational database to store the information required by the cinema. To help you, the Screen, Seat, Film and Showing relations have already been defined in **Figure 4**.

Figure 4

Screen(<u>ScreenNumber</u>, Capacity)

Seat(<u>SeatNumber, ScreenNumber</u>, SeatType)

Film(<u>FilmID</u>, FilmName, Duration, Certificate)

Showing(<u>ShowingID</u>, ScreenNumber, FilmID, ShowTime, ShowDate)

Using the format shown in **Figure 4** list the other **three** relations that will need to be created, together with the attributes that each relation will contain.

Underline the attribute(s) that will form the entity identifier (primary key) in each relation.

[5 marks]

Question 5 continues on the next page

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0 5 . 2 The cinema had to be closed on the 29th March 2023 so that some maintenance could take place.

The SQL query in **Figure 5** was written to delete all of the showings on this date. Some errors were made in the query.

Figure 5

```
DELETE
FROM Showing, Film
WHERE ShowDate = 29/03/2023
```

Describe **two** errors that have been made in the query.

Do **not** refer to the use of semi-colons in your response.

[2 marks]

Error 1 ____

Error 2 ____

0 5 . 3 Describe an issue that could arise in the database if a query to delete all of the showings that had been scheduled to take place on the 29th March 2023 was executed.

[2 marks]

0 5 . 4 The booking system can be accessed through a website which uses CRUD and REST.

Describe what Uniform Resource Locators (URLs) are used for in a RESTful application.

[1 mark]

____

____

____

0 5 . 5 Shade **one** lozenge on the row that correctly shows how REST enables CRUD to be mapped to database functions using SQL.

[1 mark]

A	GET→FETCH, POST→CREATE, DELETE→DELETE, PUT→UPDATE	⬭
B	GET→SELECT, POST→INSERT, DELETE→DELETE, PUT→UPDATE	⬭
C	GET→SELECT, POST→INSERT, DELETE→DELETE, PUT→CREATE	⬭
D	GET→SELECT, POST→UPDATE, DELETE→DELETE, PUT→INSERT	⬭
E	GET→UPDATE, POST→SELECT, DELETE→DELETE, PUT→CREATE	⬭

Question 5 continues on the next page

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0 5 . 6 JSON is used to encode datasets when they are passed between the server and the booking application. **Figure 6** shows an example of how data about some films can be encoded using JSON.

Figure 6

```
{"Films":[
  { "FilmID": 4301,
    "FilmName": "Alien Doomsday",
    "Duration": 106,
    "Certificate": "12A" },
  { "FilmID": 2098,
    "FilmName": "Tom's Amazing Adventure",
    "Duration": 84,
    "Certificate": "U" }
]}
```

State **two** reasons why JSON might have been chosen to encode the data instead of XML, assuming that the software supports both methods.

[2 marks]

Reason 1 ______________________________

____

Reason 2 ______________________________

____

13

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Question parts **06.1** and **06.2** use a **normalised** floating point representation with an **8-bit mantissa** and a **4-bit exponent**, both stored using **two's complement**.

0 6 . 1 **Figure 7** shows a floating point representation of a number:

Figure 7

Mantissa:

0 ●	1	1	0	1	0	0	0

Exponent:

1	1	0	1

Calculate the decimal equivalent of the number in **Figure 7**.

You should show your working.

[2 marks]

Answer ______________________

Question 6 continues on the next page

Turn over ►

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Question parts **06.1** and **06.2** use a **normalised** floating point representation with an **8-bit mantissa** and a **4-bit exponent**, both stored using **two's complement**.

0 6 . 2 Write the normalised floating point representation of the decimal value –23.25 in the boxes below.

You should show your working.

[3 marks]

Answer

	•						

Mantissa

Exponent

0 6 . 3 On each row of **Table 1**, state the name of the **Type of error** that has occurred in the **Situation** that is described.

[2 marks]

Table 1

Situation	**Type of error**
A calculation is performed and the result of the calculation is so close to zero that the number that is stored is zero.	
A calculation is performed and the result of the calculation is too large to fit in the available number of bits.	
A decimal value is converted to floating point but it cannot be represented exactly in the available number of bits.	

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Question parts **06.1** and **06.2** use a **normalised** floating point representation with an **8-bit mantissa** and a **4-bit exponent**, both stored using **two's complement**.

0 6 . 4 Explain how the floating point representation used in Question parts **06.1** and **06.2** could be modified to represent numbers more precisely, without changing the total number of bits used to represent a number.

[1 mark]

____

____

____

8

Turn over for the next question

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0 7

For question parts **07.1** and **07.2** you should assume that memory locations and registers store **8-bit** values. These question parts use the AQA assembly language instruction set in **Table 3** on **page 23**.

Assembly language instructions can be used to perform masking, which allows the values of individual bits or groups of bits within a number to be isolated or set independently of the values of the other bits in the number.

For example, to isolate the values of the rightmost four bits of an 8-bit number, the number could be ANDed with the binary value `00001111`.

The assembly language instruction `AND R0, R1, #15` performs a bitwise logical AND operation between the value in register `R1` and the number `15` (equivalent to `00001111` in binary), storing the result in register `R0`.

0 7 . 1 In binary, show the result of applying the instruction `AND R0, R1, #15` when register `R1` contains the decimal value 70 which is 46 in hexadecimal.

[1 mark]

R1	0	1	0	0	0	1	1	0
15	0	0	0	0	1	1	1	1
R0								

0 7 . 2 In binary, show the result of applying the instruction `ORR R0, R1, #48` when register `R1` contains the decimal value 6 which is 6 in hexadecimal.

[1 mark]

R1	0	0	0	0	0	1	1	0
48	0	0	1	1	0	0	0	0
R0								

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0 7 . 3 A computer program is required to display the value of the contents of a memory location that stores an 8-bit value. The value should be displayed on the screen of the computer in hexadecimal.

Part of the process required to do this is to convert the value stored in the memory location into the correct ASCII codes for each of the two digits that represent that value in hexadecimal.

For example, if the memory location contained:

1	0	0	1	1	1	1	0

which is `9E` in hexadecimal, then the ASCII codes of the characters that need to be displayed are:

0	0	1	1	1	0	0	1

0	1	0	0	0	1	0	1

The first of these is the ASCII code of the character `9`, the second is the ASCII code of the character `E`.

Write an assembly language program using the AQA assembly language instruction set that will load a value from memory location 100 and store the ASCII code of the first (lefthand) digit of the hexadecimal representation of this value in memory location 101 and the ASCII code of the second (righthand) digit of the hexadecimal representation of this value in memory location 102.

Your program should use masking and/or shifting to complete this task.

The ASCII codes of the hexadecimal digits are shown in **Table 2** and the AQA assembly language instruction set is in **Table 3** on **page 23**.

Table 2

	ASCII Code	
Digit	**Decimal**	**Binary**
0	48	0110000
1	49	0110001
2	50	0110010
3	51	0110011
4	52	0110100
5	53	0110101
6	54	0110110
7	55	0110111

	ASCII Code	
Digit	**Decimal**	**Binary**
8	56	0111000
9	57	0111001
A	65	1000001
B	66	1000010
C	67	1000011
D	68	1000100
E	69	1000101
F	70	1000110

[10 marks]

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12

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This table is included so that you can answer question parts 07.1, 07.2 and 07.3.

Table 3 – Standard AQA assembly language instruction set

`LDR Rd, <memory ref>`	Load the value stored in the memory location specified by `<memory ref>` into register `d`
`STR Rd, <memory ref>`	Store the value that is in register `d` into the memory location specified by `<memory ref>`
`ADD Rd, Rn, <operand2>`	Add the value specified in `<operand2>` to the value in register `n` and store the result in register `d`
`SUB Rd, Rn, <operand2>`	Subtract the value specified by `<operand2>` from the value in register `n` and store the result in register `d`
`MOV Rd, <operand2>`	Copy the value specified by `<operand2>` into register `d`
`CMP Rn, <operand2>`	Compare the value stored in register `n` with the value specified by `<operand2>`
`B <label>`	Always branch to the instruction at position `<label>` in the program.

`B<condition> <label>`	Branch to the instruction at position `<label>` if the last comparison met the criterion specified by `<condition>`. Possible values for `<condition>` and their meanings are:
	`EQ: equal to` `NE: not equal to`
	`GT: greater than` `LT: less than`

`AND Rd, Rn, <operand2>`	Perform a bitwise logical AND operation between the value in register `n` and the value specified by `<operand2>` and store the result in register `d`
`ORR Rd, Rn, <operand2>`	Perform a bitwise logical OR operation between the value in register `n` and the value specified by `<operand2>` and store the result in register `d`
`EOR Rd, Rn, <operand2>`	Perform a bitwise logical XOR (exclusive or) operation between the value in register `n` and the value specified by `<operand2>` and store the result in register `d`
`MVN Rd, <operand2>`	Perform a bitwise logical NOT operation on the value specified by `<operand2>` and store the result in register `d`
`LSL Rd, Rn, <operand2>`	Logically shift left the value stored in register `n` by the number of bits specified by `<operand2>` and store the result in register `d`
`LSR Rd, Rn, <operand2>`	Logically shift right the value stored in register `n` by the number of bits specified by `<operand2>` and store the result in register `d`
`HALT`	Stops the execution of the program.

Labels: A label is placed in the code by writing an identifier followed by a colon (:). To refer to a label, the identifier of the label is placed after the branch instruction.

Interpretation of `<operand2>`

`<operand2>` can be interpreted in two different ways, depending on whether the first character is a # or an R:

- `#` – use the decimal value specified after the `#`, eg `#25` means use the decimal value 25
- `Rm` – use the value stored in register `m`, eg `R6` means use the value stored in register 6

The available general-purpose registers that the programmer can use are numbered 0–12

Turn over ►

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0 8 A supermarket chain uses a system which stores details of all of the products that it sells and the sales that it makes.

The data that the supermarket stores is Big Data.

0 8 . 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]

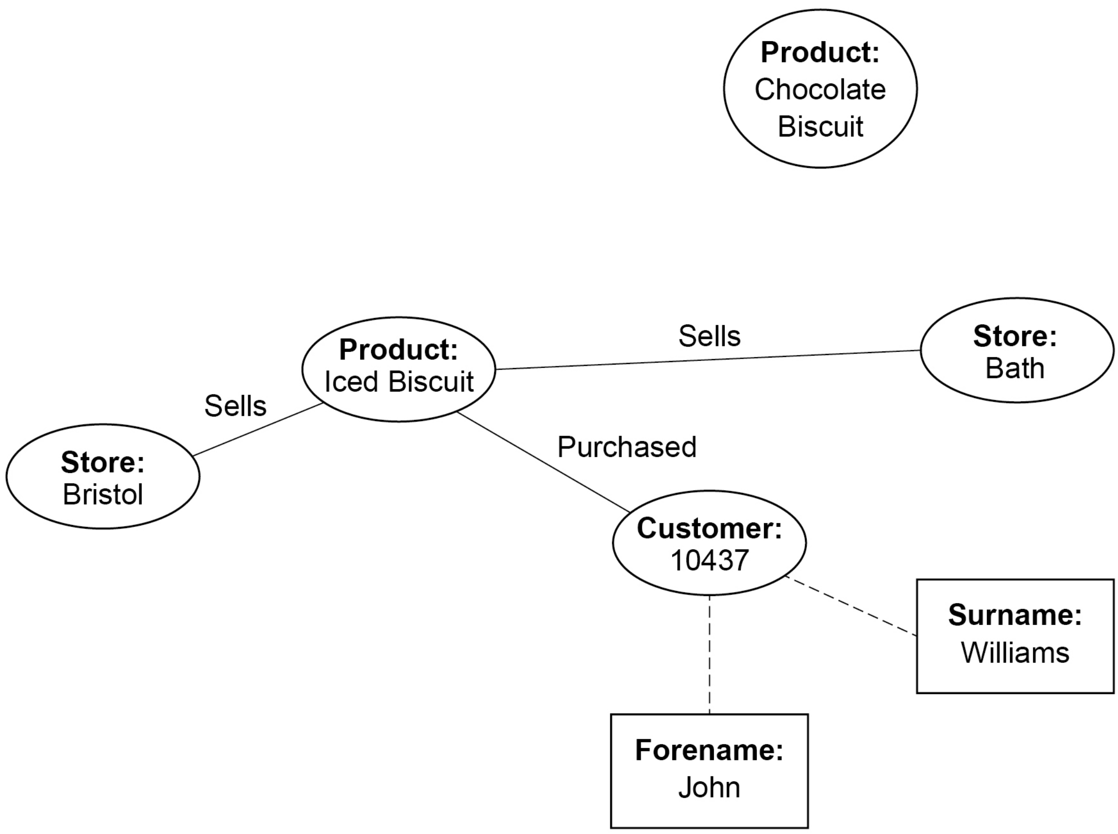
___

___

___

The graph schema in **Figure 8** represents part of a fact-based model of the dataset that the supermarket has built.

Figure 8



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0 8 . 2 Modify the graph schema in **Figure 8** 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]

0 8 . 3 One approach to dealing with Big Data is to write code that can be distributed to run across more than one server.

State **two** features of functional programming languages that make it easier to write code that can be distributed to run across more than one server.

[2 marks]

Feature 1 ______________________________

____

____

Feature 2 ______________________________

____

____

6

Turn over for the next question

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0 9 The truth table in **Table 4** represents the operation of a logic system.

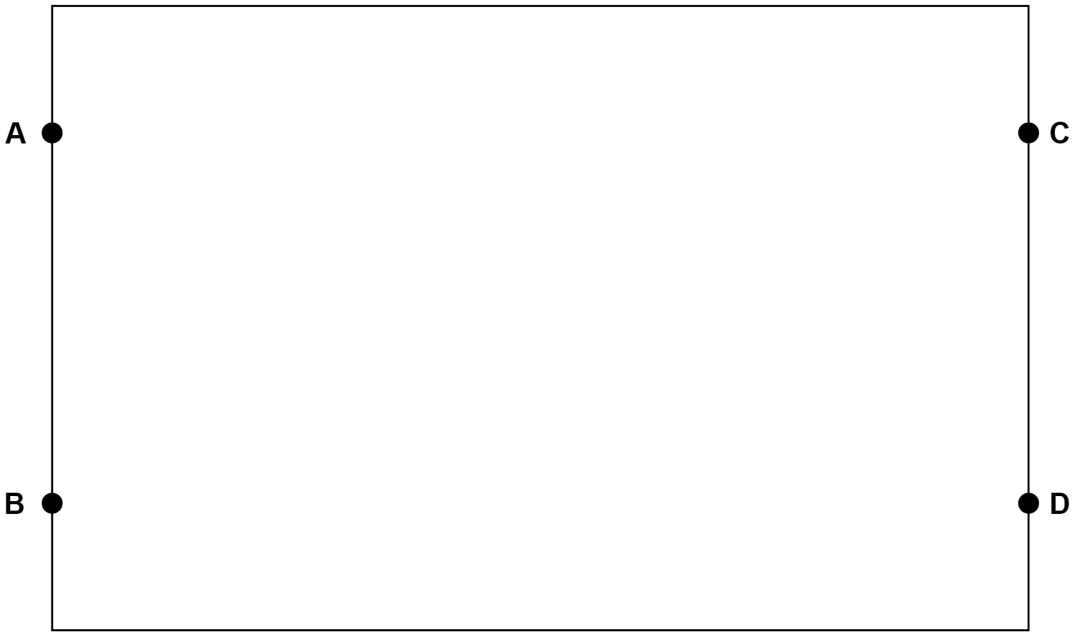
Table 4

Inputs		Outputs	
A	**B**	**C**	**D**
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

0 9 . 1 In the space below, draw a logic circuit that would produce the outputs shown in **Table 4** for the given inputs.

To achieve full marks for your response, your circuit should use **exactly two gates**.

[3 marks]



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0 9 . 2 Explain the purpose of the circuit that you have drawn that produces the outputs given in **Table 4**.

[1 mark]

0 9 . 3 Using the rules of Boolean algebra, simplify the following Boolean expression.

$$A \cdot \overline{B} + B \cdot \left(\overline{\overline{A} + (\overline{B} \cdot C)}\right)$$

You **must** show your working.

[4 marks]

Working

Answer

8

Turn over ►

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1 0 . 1 A data communication system uses **asynchronous** data transmission with even parity to send character codes that are encoded using 7-bit ASCII.

Figure 9 shows five binary patterns.

Figure 9

Pattern 1:	1	0	1	1	1	0	1	1	0	1
Pattern 2:	1	1	0	1	1	1	1	0	0	0
Pattern 3:	0	1	0	0	0	0	1	1	1	0
Pattern 4:	1	0	1	1	1	1	0	0	0	0
Pattern 5:	1	1	0	0	0	0	0	1	0	0

How many of the binary patterns in **Figure 9** could represent valid transmissions of a single character in this data communication system?

[1 mark]

1 0 . 2 An alternative data communication system uses **synchronous** data transmission.

Describe what synchronous data transmission is.

[1 mark]

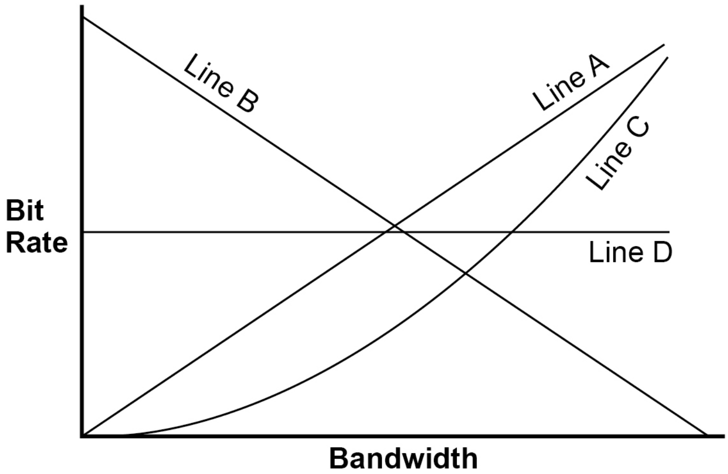
1 0 . 3 Describe **one** limitation of the use of parity bits for managing errors.

[1 mark]

1 0 . 4 Shade **one** lozenge to indicate which of the lines on the graph in **Figure 10** shows the correct relationship between the bandwidth and the bit rate of a communications medium.

[1 mark]

Figure 10



A Line A ⬭

B Line B ⬭

C Line C ⬭

D Line D ⬭

4

Turn over for the next question

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1 1 An email is being sent from User A on Computer A to User B on Computer B.

1 1 . 1 Describe the role that will be played by the transport layer of the TCP/IP stack in the transmission of the email from Computer A to an email server.

[3 marks]

1 1 . 2 Whilst being transported across the Internet, the email data passes through a number of routers and one gateway.

Describe the additional functionality of a gateway, beyond that of a router.

[1 mark]

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1 1 . 3 State the name and purpose of **two** application layer protocols that will be used to transfer the email from Computer A to Computer B.

Each protocol must have a different purpose.

[4 marks]

Protocol 1 name ______________________________

Protocol 1 purpose ______________________________

____

____

Protocol 2 name ______________________________

Protocol 2 purpose ______________________________

____

____

1 1 . 4 The email servers involved in the transmission of the email use well-known ports.

Explain what a well-known port is **and** why an email server must use one.

[2 marks]

What a well-known port is ______________________________

____

____

____

Why an email server uses a well-known port ______________________________

____

____

____

Question 11 continues on the next page

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1 1 . 5 The email message needs to be sent securely as it contains confidential information.

The message will be encrypted using asymmetric encryption. To enable Computer B to authenticate that the message was sent by Computer A, a digital signature will also be sent with the message.

Describe how:
- Computer A will encrypt the message and create the digital signature
- Computer B will decrypt the message and verify that it was sent by Computer A.

In your response you should refer to the specific keys that will be used in this process.

[6 marks]

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16

Turn over for the next question

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1 2 **Figure 11** shows a function, `FunctionZ`, written in a functional programming language.

Figure 11

```
FunctionZ [] = 0
FunctionZ (x:xs) = x + 2 * FunctionZ (xs)
```

- `[]` is the empty list.
- `(x:xs)` as the argument to a function splits a list into two parts, the head `x` and tail `xs`.

1 2 . 1 Complete **Table 5** by writing the value of the argument passed to each call of `FunctionZ` and the value returned by each call, when `FunctionZ [4, 2, 5, 3]` is evaluated.

[3 marks]

Table 5

Call number	Argument	Value returned
1	[4, 2, 5, 3]	
2		
3		
4		
5		

1 2 . 2 All of the values in lists passed to `FunctionZ` as the argument are members of the set of integers.

Shade **one** lozenge to indicate the co-domain of the function.

[1 mark]

A The set of integers ⬭

B The set of irrational numbers ⬭

C The set of natural numbers ⬭

D The set of rational numbers ⬭

E The set of real numbers ⬭

4

END OF QUESTIONS

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