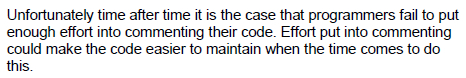
**Q1.**

The extract of text below is to be compressed using a dictionary-based compression method.



(a)  Dictionary-based compression is an example of a lossless encryption method.

Explain the key difference between lossless and lossy compression methods.

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**(1)**

(b)  Explain how the extract of text in the extract above could be compressed using a dictionary-based method.

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**(2)**

(c)  After the text in the extract above has been compressed it is to be transmitted across a computer network.

Explain why dictionary-based compression is not very effective for compressing small amounts of text for transmission.

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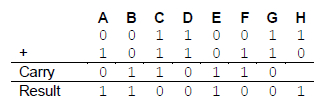
**(1)**

**(Total 4 marks)**

**Q2.**

A student has attempted to add together the binary numbers 00110011 and 10110110, but has made a mistake.

The student’s calculation is shown in the figure below.



Explain what mistake the student has made.

The columns in the addition have been labelled **A** to **H** to help you make your explanation clear.

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**(Total 1 mark)**

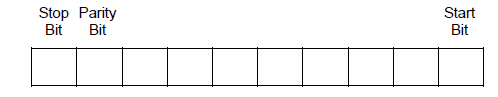
**Q3.**

A data communication system uses asynchronous serial communication.

The ASCII code for the digit '0' is 48 in decimal. In ASCII, other digits follow on from this value in sequence.

The digit '4' is to be transmitted in ASCII using asynchronous serial transmission and **even parity**, with the parity bit stored in the most significant bit of the byte of data containing the ASCII code.

Complete the sequence below to show a valid bit pattern for transmitting the digit '4'

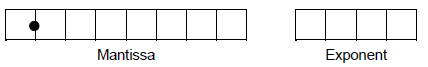


**(Total 3 marks)**

**Q4.**

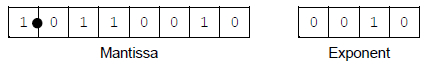
Questions (a), (b), (c) and (d) use a **normalised** floating point representation box with an **8-bit** mantissa and a **4-bit** exponent, both stored using **two’s complement**.

(a)  Write the **smallest positive** number that can be represented by the floating point system in the boxes below.



**(2)**

(b)  The following is a floating point representation of a number:



Calculate the decimal equivalent of the number.

You **must** show your working.

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Answer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(c)  Write the normalised floating point representation of the decimal value 0.15625 (5/32 as a fraction) in the boxes below.

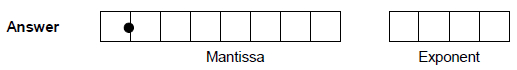
You **must** show your working.

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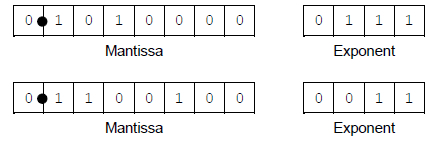
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**(3)**

(d)  The two floating point numbers below are multiplied together.



A problem occurs as a result of the multiplication operation.

Explain what problem has occurred and how the floating point representation could be redesigned to avoid it.

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**(3)**

**(Total 10 marks)**

**Q5.**

Discuss the **advantages** and **disadvantages** of representing an image as a vector graphic instead of as a bitmap.

In your answer, include an example for which it would be most appropriate to use a vector graphic and an example for which it would be most appropriate to use a bitmap.

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**(Total 6 marks)**

**Q6.**

A data communication system uses asynchronous serial communication.

It is proposed that the communication system is modified so that:

•   a majority voting system is used instead of the parity bit

•   Unicode is used to encode the characters to be transmitted instead of ASCII.

Discuss the **improvements** that will occur in the communication system as a result of these changes and any **disadvantages** that will result from them.

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**(Total 4 marks)**

**Q7.**

The ciphertext message "BVP" has been received. The message was encrypted using the Vernam cipher and the key "TIN".

Conversion between letters and their equivalent binary patterns was carried out using a special code called the Baudot-Murray code. A version of the Baudot-Murray codes for each letter is shown in the table below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Letter** | **Encoding** |  | **Letter** | **Encoding** |
| A | 11000 |  | N | 00110 |
| B | 10011 |  | O | 00011 |
| C | 01110 |  | P | 01101 |
| D | 10010 |  | Q | 11101 |
| E | 10000 |  | R | 01010 |
| F | 10110 |  | S | 10100 |
| G | 01011 |  | T | 00001 |
| H | 00101 |  | U | 11100 |
| I | 01100 |  | V | 01111 |
| J | 11010 |  | W | 11001 |
| K | 11110 |  | X | 10111 |
| L | 01001 |  | Y | 10101 |
| M | 00111 |  | Z | 10001 |

Decrypt the ciphertext to work out what the original plaintext message was.

Express the plaintext as letters.

You **must** show your working.

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**Plaintext** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(Total 3 marks)**

**Q8.**

The Vernam cipher can offer perfect security. Most encrypted transmissions that are made by computers use ciphers that are computationally secure but not perfectly secure.

Explain what it means for a cipher to be described as being computationally secure.

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**(Total 1 mark)**

**Q9.**

Cameras within a taxi take still images once every second for security purposes.

The images are compressed using run-length encoding and stored on a flash memory card within the camera.

Describe how a digital image could be captured by a digital camera and compressed using run-length encoding.

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**(Total 6 marks)**

**Q10.**

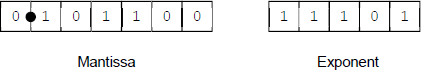
(a)  Shade **one** lozenge to indicate which of the unsigned numbers listed in the table has the largest value.

|  |  |  |
| --- | --- | --- |
| **Number base** | **Number** | **Largest value (shade one)** |
| Binary | 101101001 |  |
| Hexadecimal | 30A |  |
| Decimal | 396 |  |

**(1)**

(b)  This question uses a **normalised** floating point representation with a 7-bit mantissa and a 5-bit exponent, both stored using **two’s complement**.

The following is a floating point representation of a number:



Calculate the decimal equivalent of the number. You **must** show your working.

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Answer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

**(Total 3 marks)**

**Q11.**

This question uses a **normalised** floating point representation with a 7-bit mantissa and a 5-bit exponent, both stored using **two’s complement**.

Write the normalised floating point representation of the decimal value -608 in the boxes below. You **must** show your working.

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**Answer** 

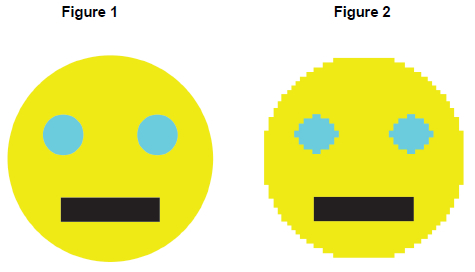
**(Total 3 marks)**

**Q12.**

**Figure 1** shows an image composed of four objects, represented digitally as a vector graphic. **Figure 2** shows the same image, represented digitally as a bitmap graphic.

The bitmap graphic has an image size of 50 × 50 pixels.

Each image uses four colours: white, black, yellow and blue.



(a)  Describe how a vector graphic is represented.

Include an explanation of how the black rectangle in **Figure 1** would be represented in your description.

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**(3)**

(b)  Calculate the minimum amount of storage space that is required to store the bitmap image in **Figure 2** excluding metadata. Express your answer in bytes.

You **must** show your working.

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Answer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

**Figure 3** shows an enlarged view of part of one row of pixels from the image in **Figure 2**.



(c)  Describe how a row of pixels, such as that shown in **Figure 3**, could be represented in compressed form by using run length encoding.

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**(2)**

**Figure 4** shows an image of a woodland scene.



(d)  The image in **Figure 2** is compressed using run length encoding. The compressed file is 80% smaller than the original file.

The image in **Figure 4** is compressed using the same technique and the compressed file is approximately the same size as the original file.

Explain why the run length encoding method was not able to compress the image in **Figure 4** as much as it could compress the image in **Figure 2**.

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**(2)**

**(Total 9 marks)**

**Q13.**

The Vernam cipher is a more sophisticated cipher system that, under certain circumstances, offers perfect security.

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

**Condition 1**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Condition 2**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(Total 2 marks)**

**Q14.**

How many different numbers can be represented using 8-bit binary?

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**(Total 1 marks)**

**Q15.**

The table below is a partially complete representation of the rules for adding together two bit values. The first two columns represent the two bit values to add. The first row has been completed and represents the binary addition rule 0 + 0 = 0. Carry occurs when the answer cannot be stored in one bit.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Answer** | **Carry** |
| 0 | 0 | 0 | 0 |
| 0 | 1 |  |  |
| 1 | 0 |  |  |
| 1 | 1 |  |  |

Complete the table to show the **Answer** and **Carry** values for the given binary addition rules by filling in the unshaded cells.

**(Total 3 marks)**

**Q16.**

A particular computer uses a **normalised** floating point representation with a 7-bit mantissa and a 5-bit exponent, both stored using **two’s complement**.

(a)     Four bit patterns that are stored in this computer’s memory are listed in the figure below and are labelled with the letters **A** to **D**. Three of the bit patterns are valid floating point numbers and one is not.



Complete the table below. In the **Correct letter (A–D)** column write the appropriate letter from **A** to **D** to indicate which bit pattern in the figure above matches the description in the **Value description** column.

Do **not** use the same letter more than once.

|  |  |
| --- | --- |
| **Value description** | **Correct letter (A–D)** |
| A normalised negative value. |  |
| The largest positive normalised number of the four values. |  |
| A value that is not valid in the representation because it is not normalised. |  |

**(3)**

(b)     This is a floating point representation of a number:



Calculate the denary equivalent of the number. Show how you have arrived at your answer.

Working \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

Answer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(c)     This is a floating point representation of a number:



Calculate the denary equivalent of the number. Show how you have arrived at your answer.

Working \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

Answer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(d)     Write the normalised floating point representation of the denary value 3008 in the boxes below. Show how you have arrived at your answer.

Working \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

Answer



**(1)**

There can be a loss of precision when a denary number is stored using this floating point system.

The closest possible representation of the denary number 12.83 is shown below:



By converting this bit pattern back into denary it can be seen that the actual number stored is 12.75, not 12.83.

(e)     Calculate the absolute error that has occurred.

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**(1)**

(f)      Calculate the relative error that has occurred.

You must show your working or express your answer as a percentage to four decimal places.

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**(1)**

(g)     In the context of floating point, explain what overflow is and give an example of a situation which might cause overflow to occur.

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**(3)**

**(Total 15 marks)**

**Q17.**

(a)     What is the decimal equivalent of the hexadecimal number D616? Show your working.

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**(2)**

(b)     Represent the decimal value 9.37510 as an unsigned binary fixed point number, with 4 bits before and 4 bits after the binary point.

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**(2)**

(c)     Represent the decimal value -6710 as an **8-bit two’s complement binary integer.**

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**(2)**

(d)     A computer represents numbers using 8-bit two’s complement binary.

Using this representation perform the calculation:

|  |  |
| --- | --- |
|  | 010010002 011000112 + |
| Answer: |  |

**(1)**

(e)     What problem has resulted from performing the calculation using 8-bit two’s complement binary?

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**(1)**

**(Total 8 marks)**

**Q18.**

The ASCII binary code for character a is 11000012

(a)     Explain what is mean by a character code.

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**(1)**

(b)     Complete the table below to show how the word be would be encoded in the binary form of ASCII.

|  |  |
| --- | --- |
| **Character** | **Binary form of ASCII** |
| b |  |
| e |  |

**(2)**

(c)     A program has been developed to convert a string so that all of its characters are in upper case.

The computer does this by taking each character’s ASCII binary code and applying a bitwise AND operation to it, using the mask 10111112.

Convert the lower case character c, ASCII code 11000112, into the upper case character C using the method described above.

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**(1)**

**(Total 4 marks)**

**Q19.**

A well-established use for robots in industry is the spraying of car bodies on a car production line.

A robotics researcher is investigating the feasibility of developing and installing in a car a computer-based control system to take over completely the driving of the car on public highways.

She has identified some of sources of inputs into the control system already:

•        high resolution video camera

•        stereoscopic digital camera

•        long range radar

•        short range radar

•        Global Positioning Satellite receiver.

And some of the outputs:

•        position of steering wheel (in degrees from the vertical)

•        forces on accelerator and brake pedals.

Discuss why automated car control is a harder programming problem to solve than developing programmed control of a robot for spraying car bodies on a car production line, and what processing of input data will be necessary and why to obtain sufficient information to safely and reliably control the driving of the car by computer. Include in your discussion the sources of input that you have used and the information derived from these by processing.

**(Total 9 marks)**

**Q20.**

A flight recorder is an electronic recording device placed in an aircraft for the purpose of facilitating the investigation of aviation accidents and incidents. The image below shows an example of a flight recorder. It is a requirement for every commercial aircraft to have a type of flight recorder called a cockpit voice recorder.



                                                                   © Thinkstock

(a)     Current cockpit voice recorders use solid-state memory chips to store the digital audio data. Alternatively, the data could be stored on a traditional hard disk drive.

Give **two** reasons why cockpit voice recorders store data using solid-state memory instead of using a traditional hard disk drive.

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**(2)**

(b)     Audio from the cockpit is sampled at a rate of 8000 Hz and 16 bits are allocated to each sample.

How many kilobytes would be needed to store 360 seconds of audio?  
Show your working.

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***Answer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_***

**(3)**

(c)     Explain why the highest audio frequency in the sampled audio from the cockpit cannot be greater than 4000 Hz.

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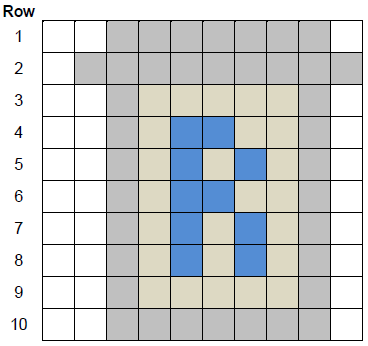
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

**(Total 7 marks)**

**Q21.**

The icon below is represented in a computer's memory as a bitmap image.



Four different colours have been used in the icon.

**Row 1** of the icon is represented in the computer's memory as the bit pattern:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |

(a)     What are the bit patterns that have been used to represent a grey pixel and a white pixel?

|  |  |  |
| --- | --- | --- |
| Grey pixel: \_\_\_\_\_\_\_\_ |  | White pixel: \_\_\_\_\_\_\_\_ |

**(1)**

(b)     State **one** possible 20-bit representation for **Row 4** of the icon.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

**(1)**

(c)     Calculate the number of bytes required to represent all the pixel data in the icon as a bitmap.

Show your working.

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Answer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(d)     When the bitmap is saved as a file, the file size is bigger than the answer to (c). This is because metadata is saved in the file with the pixel data

State **one** item of metadata that would be stored in a bitmap file.

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\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(e)     Run-length encoding (RLE) is an example of a compression method that could be used to reduce the amount of memory required to store the icon.

Describe the principle used by RLE to compress a file and explain why RLE is an appropriate compression method for compressing images such as icons.

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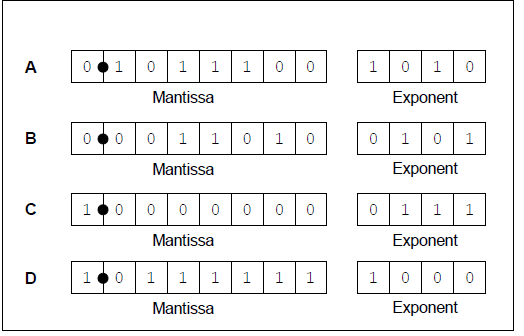
**(3)**

**(Total 8 marks)**

**Q22.**

A particular computer uses a **normalised** floating point representation with an 8-bit mantissa and a 4-bit exponent, both stored using **two’s complement**.

Four bit patterns that are stored in this computer’s memory are listed in the figure below and are labelled **A, B, C, D**. Three of the bit patterns are valid floating point numbers and one is not.



(a)     Complete the table below. In the Correct letter (**A-D**) column shade the appropriate lozenge **A, B, C or D** to indicate which bit pattern from above is an example of the type of value described in the Value description column.

Do **not** use the same letter more than once.

|  |  |
| --- | --- |
| **Value description** | **Correct letter (A-D)** |
| A positive normalised value |  |
| The most negative value that can be represented |  |
| A value that is not valid in the representation because it is not normalised |  |

**(3)**

(b)     The following is a floating point representation of a number:



|  |  |  |
| --- | --- | --- |
| Mantissa |  | Exponent |

Calculate the decimal equivalent of the number. Show how you have arrived at your answer.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Answer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(c)     Write the normalised floating point representation of the negative decimal value -6.75 in the boxes below. Show how you have arrived at your answer.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Answer:



|  |  |  |
| --- | --- | --- |
| Mantissa |  | Exponent |

**(3)**

(d)     An alternative two's complement format representation is proposed. In the alternative representation 6 bits will be used to store the mantissa and 6 bits will be used to store the exponent.

**Existing Representation** (8-bit mantissa, 4-bit exponent):



|  |  |  |
| --- | --- | --- |
| Mantissa |  | Exponent |

**Proposed Alternative Representation** (6-bit mantissa, 6-bit exponent):



|  |  |  |
| --- | --- | --- |
| Mantissa |  | Exponent |

Explain the effects of using the proposed alternative representation instead of the existing representation.

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**(2)**

**(Total 10 marks)**

**Q23.**

A message is to be transmitted from Computer A to Computer B. For security reasons, the message will be encrypted.

(a)     What is encryption?

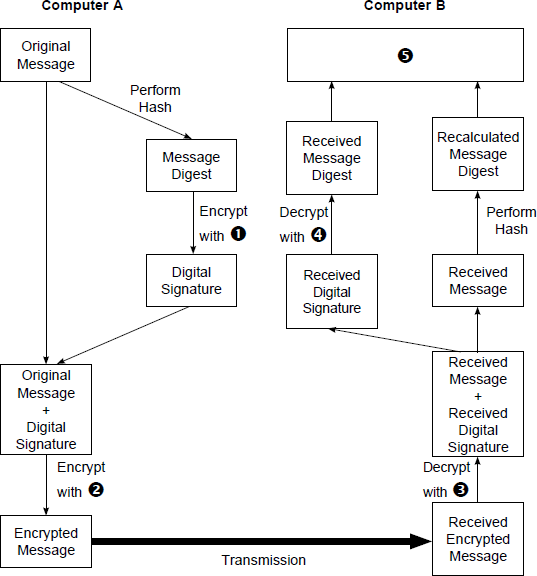
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

The data that are being transmitted will be encrypted and decrypted using public and private keys. The diagram below shows the encryption and decryption processes.

The symbols   to   in the figure represent the names of keys.



(b)     State the names of the keys that are represented by each of the symbols   to  .

|  |  |
| --- | --- |
| **Label** | **Key Name** |
|  |  |
|  |  |
|  |  |
|  |  |

**(2)**

(c)     Describe the process that will take place at the position labelled  .

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

(d)     State **two** purposes of the addition of the digital signature to the message.

Purpose 1 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Purpose 2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

**(Total 6 marks)**

**Q24.**

The image below shows an 8-bit bit pattern.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |

(a)     If the bit pattern above is an **unsigned binary integer**, what is the denary equivalent of this bit pattern?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(b)     If the bit pattern above is a **two’s complement binary integer**, what is the denary equivalent of this bit pattern?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(c)     What is the range of **denary** numbers that can be represented using **8-bit two’s complement binary integers**?

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**(2)**

(d)     If the bit pattern above is an **unsigned binary fixed point** number with 3 bits before and 5 bits after the binary point, what is the denary equivalent of this bit pattern?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(e)     What is the **hexadecimal** equivalent of the bit pattern above?

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**(2)**

(f)     Why are bit patterns often displayed using hexadecimal instead of binary?

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**(1)**

(g)     Describe a method that can, without the use of binary addition, multiply any **unsigned binary integer** by the binary number 10 (the denary number 2).

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**(2)**

**(Total 12 marks)**

**Q25.**

A supermarket uses many hardware devices as part of its daily operations.

A key component at the checkout area is the bar code reader (scanner).

If a product’s bar code cannot be read by the bar code reader the checkout operator will have to enter the bar code manually.

(a)     Name **two** hardware devices that could be used to manually enter a bar code.

Device 1\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Device 2\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(b)     Most supermarket product bar codes follow the International Article Number standard  
which has 13 digits: 12 of these digits are for data and the last one is a check digit.



Describe the principles of operation of a bar code reader **and** how the software in the bar code reader will use the check digit when processing a product.

In your answer you will also be assessed on your ability to use good English, and to organise your answer clearly **in complete sentences**, using specialist vocabulary where appropriate.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(6)**

**(Total 8 marks)**

**Q26.**

The ASCII system uses 7 bits to represent a character. The ASCII code in denary for the numeric character ‘0’ is 48; other numeric characters follow on from this in sequence.

(a)     Using 7 bits, express the ASCII code for the character ‘2’ in binary.

Characters are transmitted using an 8-bit code that includes a single parity bit in the most significant bit. A parity bit is added for error checking during data transmission.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(b)     Using odd parity, what 8-bit code is sent for the numeric character ‘0’?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

Hamming code is an alternative to the use of a single parity bit.

(c)     State **one** advantage of using Hamming code instead of a single parity bit.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

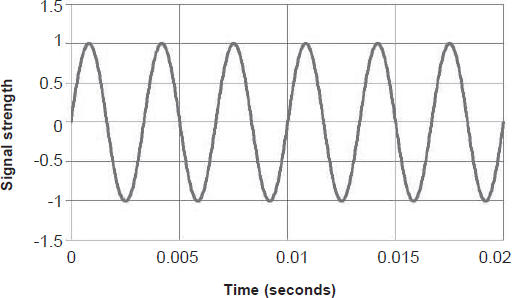
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

**(Total 4 marks)**

**Q27.**

To record sound a computer needs to convert the analogue sound signal into a digital form. During this process samples of the analogue signal are taken. The diagram below shows part (0.02 seconds) of an analogue sound wave.



The **frequency** of an analogue sound wave is determined by how many waves of oscillation occur per second and is measured in Hertz (Hz) – the number of waves of oscillation per second.

(a)     If the part of the analogue sound shown in the diagram above is the highest frequency in the entire sound to be sampled, what is the **minimum sampling rate** (in Hz) that should be used?

*Use the space below. You may get some marks for your working even if your answer is incorrect.*

Answer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

(b)     Describe clearly the steps taken by an ADC (analogue-to-digital converter) in the conversion of an analogue sound wave to an equivalent digital signal.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(3)**

(c)     MIDI is an alternative method for storing sound digitally that does not use sound waves; instead, information about each musical note is stored.

State **one** advantage of using the MIDI representation for storing sound digitally.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

(d)     State an item of data, other than the note itself, that might be stored about a musical note in a MIDI file.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(1)**

**(Total 7 marks)**

Mark schemes

**Q1.**

(a)  **Mark is AO1 (understanding)**

The original data can be fully recovered if lossless compression has been used // lossless data compression can be reversed;

**NE.** no data is lost

**NE.** no loss of quality

The original data cannot be recovered if lossy compression has been used // lossy compression cannot be reversed // the data is degraded by lossy compression;

**A.** redundant / less important data removed

**NE.** data is lost

**NE.** quality is reduced

**Max 1**

**1**

(b)  **All marks AO1 (understanding)**

A dictionary is built that maps sequences of characters/substrings/words/strings in the text onto tokens/values/numbers;

**A.** sequences of characters/substrings/words/strings are stored at known positions in a list/table/array

**TO.** sequences of characters/substrings/words/strings and their frequencies/positions (in the paragraph) are stored

The (sequences of) characters/substrings/words/strings in the text are then replaced by the corresponding tokens/values/numbers/indices in the dictionary;

**A.** shown by example

**If no other marks awarded, award one mark if stated that sequences of characters/substrings/words/strings are assigned tokens/values/numbers, regardless of whether it is clear if this means in the dictionary or paragraph of text.**

**2**

(c)  **All marks AO1 (understanding)**

For small pieces of text there is little repetition (and so the compressed text will be similar in size to the original);

**A.** The dictionary itself will require storage space // will need to be transmitted;

**Max 1**

**1**

**[4]**

**Q2.**

**Mark is AO2 (analysis)**

In column C Result should be 1 / is wrong // column C should be 1 carry 1 /11 // the carry has not been included when adding up the values in column C;

**A.** column C should be 1 not 0

**NE.** column C is wrong

**NE.** column C should be 1

**[1]**

**Q3.**

**All marks AO2 (apply)**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Stop bit | Parity bit |  |  |  |  |  |  |  | Start bit |
| **0** | **1** | **0** | **1** | **1** | **0** | **1** | **0** | **0** | **1** |

**1 mark**: Start bit and stop bit each have the value 1 and 0 and must be different to each other (it does not matter which is 1 or 0).

**1 mark**: Correct bit pattern for character '4': 0110100

**1 mark**: Parity bit is 1 A. parity bit of 0 if this would be correct based upon an incorrect ASCII code used and reject parity bit of 1 if would not be correct for ASCII code used.

**[3]**

**Q4.**

(a)  **All marks AO2 (apply)**

****

**1 mark**: Correct mantissa

**1 mark**: Correct exponent

**2**

(b)



**1 method mark** for either:

•   showing correct value of both mantissa and exponent in decimal

(mantissa = -0.609375 // -39/64 Exponent = 2)

•   showing binary point shifted 2 places to right in binary number

•   indicating that final answer calculated using answer = mantissa x 2exponent

**1 mark** for correct answer

Answer -2.4375 // -39/16 // -2 7/16

**If answer is correct and some working has been shown, award two marks, even if working would not have gained credit on its own.**

**2**

(c)  **All marks AO2 (apply)**

**2 marks** for working:

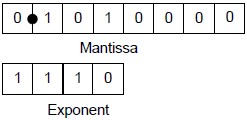
Correct (unsigned) fixed point representation of 0.15625 in binary: 0.00101; **A.** leading 0s and trailing 0s **NE.** this value only shown in final answer mantissa box

Showing the correct value of the exponent in decimal (-2) or binary (1110) // showing the binary point being shifted 2 places right; **A.** if only shown in final answer exponent box

Bit pattern 101 is present somewhere in the final mantissa value and all of the other bits of the mantissa are 0;

**Max 2**

**1 mark** for correct mantissa and exponent together:



**If answer is correct and some working has been shown, award three marks, even if working would not have gained credit on its own.**

**3**

(d)  **1 mark AO2 (analysis) and 2 marks AO1 (understanding)**

**Problem (1 mark AO2 (analysis)):**

Overflow will occur // it will not be possible to store the result/the exponent in the available number of bits;

**Solution (2 marks AO1 (understanding)):**

Mark against *Method 1* or *Method 2*.

*Method 1*

More bits should be added; **TO.** more bits should be added to the mantissa from the exponent **NE.** larger/bigger, must have reference to bits

To the exponent; **TO.** both mantissa and exponent

*Method 2*

Bits could be reallocated from the mantissa to the exponent;

**3**

**[10]**

**Q5.**

**All marks AO1 (understanding)**

**Advantages of vector graphics (max 3 marks):**

Individual objects/components/parts of the image can be manipulated/edited independently; **A.** example of objects **NE.** images are easy to edit

The image/individual objects/components/parts of the image can be enlarged/scaled without loss of quality; **A.** “zoomed in” for enlarged **A.** example of objects **NE.** easy to scale

If an object/component is deleted, the software knows what is behind it // no “hole” is left in the image;

Vector graphics are resolution independent;

Images saved as vector graphics (typically) take up less storage space // can be transmitted more quickly than an (equivalent) bitmap;

**Advantages of bitmaps (max 3 marks)**:

Can represent images with complex textures // lots of variation in colour/tone (which could not be computed); **NE.** high colour depth, complex image

Can represent images that are not composed of regular shapes;

Images captured from nature // digital photos // scanned images are naturally represented as bitmaps (because of the method used to capture them);

*Award marks for advantages of bitmaps which are stated as such or as disadvantages of vector graphics and vice-versa* ***but*** *only award one mark for the same point made both ways eg stating vectors can be enlarged without loss of quality and bitmaps pixelate when enlarged is just one mark.*

**Suitable examples (max 2 marks)**:

•   **Vector (1 mark)**: chart, logo, map, plan, clipart – any example that could be made from regular shapes.

•   **Bitmap (1 mark)**: photograph, scanned image, sprite icon – any example that could not be represented as a vector graphic because it is not composed of regular shapes or is taken from nature.

**Max 5** for question If no valid examples given

**[6]**

**Q6.**

**All marks AO1 (understanding)**

**Improvements (Max 3):**

#Errors can (sometimes) be corrected as well as detected; **A.** the location of an error can be identified

#Multi-bit errors can be detected; **A.** errors that change an even number of bits can be detected

*If neither of the points marked # is awarded then award one mark if the general point that transmissions should be more reliable is made.*

A greater range of characters can now be transmitted; **A.** any response that implies this eg support for multiple languages // languages with large sets of characters, inclusion of specialised symbols in character set

Elimination of problems caused by different versions of ASCII character sets / extended ASCII / use of code pages // eliminates problem of some ASCII codes representing different characters in different countries // Unicode values can be interpreted more consistently than ASCII codes;

**Disadvantages (Max 3):**

\*Each character will require more bits // 8 bits // 16 bits // 32 bits // between 8 and 32 bits;

\*Each bit will be sent multiple times // three or more times // there will be redundancy in the data transmissions; **A.** code, character instead of bit

*If neither of the points marked \* is awarded then award one mark if the general point that more bits are required is made.*

The (effective) rate at which information / (useful) data can be transmitted will be reduced; **A.** transmissions will take longer **R.** references to storage space

**[4]**

**Q7.**

**All marks AO2 (apply)**

**1 mark**: Correct conversion of ciphertext and key to binary.

**1 mark**: The XOR operation is applied to the binary representations of the ciphertext and key to produce the binary representation of the plaintext.

**A.** award this mark if one or both of the binary representations of the ciphertext and key are incorrect but the plaintext binary pattern has been produced by XORing these bit patterns.

**1 mark**: Correct conversion of plaintext from binary to letters.

**A.** award this mark if the binary plaintext is incorrect but the conversion of this to letters is correct for the incorrect bit pattern. If only some bit patterns map to letters (eg 11011 does not) then accept that those which do not are not converted, but reject incorrect conversion.

**I.** Case eg “Dog” is fine.

|  |  |  |  |
| --- | --- | --- | --- |
| Ciphertext in binary: | 10011 | 01111 | 01101 |
| Key in binary: | 00001 | 01100 | 00110 |
| Plaintext in binary: | 10010 | 00011 | 01011 |
| Plaintext as letters: | D | O | G |

**If answer is correct (DOG) and some working has been shown, award three marks, even if working would not have gained credit on its own.**

**[3]**

**Q8.**

**Mark is AO1 (knowledge)**

The cipher cannot be cracked (by any known method **A.** technology) in a reasonable/practical/polynomial/useful amount of time; **NE.** long time

**A.** given enough ciphertext and time the cipher could be cracked (but this is not reasonable)

**R.** responses that suggest the cipher could never be cracked

**NE.** responses about plaintext being deciphered / decrypted /decoded or the cipher solved rather than cracked, unless it is clear that this is being done without the key

**[1]**

**Q9.**

**Marks are for AO1 (understanding)**

**Level of response question**

|  |  |  |
| --- | --- | --- |
| **Level** | **Description** | **Mark Range** |
| 3 | At least five points have been made that shows a very good understanding of both how an image is captured and how run-length encoding is applied. | 5-6 |
| 2 | At least three points have been made that show a good understanding of at least one of how an image is captured and how run-length encoding is applied. | 3-4 |
| 1 | At least one point has been made that shows some understanding of either image-capture or run-length encoding. | 1-2 |

**Guidance:** Indicative Response

**Image Capture**

•   Light enters through / is focussed by the lens; on to (an array of sensors on) the sensor chip **A.** light sensors capture / record light (intensity) **A.** CCD as sensor;

•   Each sensor produces an electrical current / signal;

•   The signal represents a pixel;

•   An (ADC) converts measurement of light intensity into binary / digital data;

•   (Colour) filter is applied to generate separate data values for red, green and blue colour components;

•   The pixels are recorded as a group / array;

**Run-Length Encoding**

•   The image is analysed to identify runs / sequences of the same colour / value **N.E.** patterns;

•   The colours / values and counts of pixels / values / run-lengths are represented / identified / stored **A.** example;

**[6]**

**Q10.**

(a)  **Mark is AO2 (apply);**

30A;

**R.** More than one lozenge shaded

**1**

(b)  **All marks AO2 (apply)**

****

**1 method mark** for either:

•   showing correct value of both mantissa and exponent in decimal (mantissa = 0.6875 // 11/16, Exponent = −3)

•   showing binary point shifted 3 places to left in binary number

•   indicating that final answer calculated using

    answer = mantissa × 2exponent

**1 mark** for correct answer

Answer = 0.0859375 // 11/128

**If answer is correct and some working has been shown, award two marks, even if working would not have gained credit on its own.**

**2**

**[3]**

**Q11.**

**All marks AO2 (apply)**

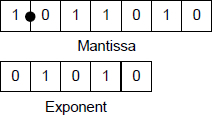
**2 marks** for working:

Correct (unsigned) representation of 608 in binary: 1001100000; **A.** leading 0s Correct representation of -608 in two’s complement binary:10110100000; **A.** leading 1s

Showing the correct value of the exponent in decimal (10) or binary (1010) // showing the binary point being shifted 10 places left;

**Max 2**

**1 mark** for correct mantissa and exponent together:



**If answer is correct and some working has been shown, award three marks, even if working would not have gained credit on its own.**

**Working marks can be awarded for work seen in the final answer eg correct exponent.**

**[3]**

**Q12.**

(a)  **2 marks for AO1 (knowledge) and 1 mark for AO1 (understanding)**

**2 marks AO1 (knowledge):**

Image is represented as / composed of objects;

Properties (of objects) are stored //objects have properties;

**A.** “shapes” or “instructions” for “objects” (this time only)

**N.E.** “formulae” for objects

**A.** “attributes” for “properties”

**1 mark AO1 (understanding):**

A property of the black rectangle is given; e.g.

•   fill colour

•   outline / edge colour

•   x coordinate of a specific point e.g. top right-hand corner

•   y coordinate of a specific point e.g. top right-hand corner

•   outline / edge width

•   width

•   height

**A.** if a property is given without it being directly related to the black rectangle.

**A.** coordinates of a specific point eg top right-hand corner for one mark only if x and y not referenced

**R.** properties that are too vague eg position, colour, coordinates (without further explanation), points (without reference to coordinates)

**Marks should be awarded if student has asserted that rectangle drawn as a wide line.**

**3**

(b)  **All marks AO2 (apply)**

50 × 50 × 2 / 8 = 625 (bytes)

**2 marks** for the correct answer with some working shown

**OR**

**1 mark for one of:**

•   multiplying 50 by 50 in the working // 2500 in the working

•   multiplying by 2 in the working

•   giving the correct solution of 625 (bytes) with no working shown

**2**

(c)  **All marks AO1 (knowledge)**

A run is a sequence / series of pixels of the same colour // the number of consecutive pixels of the same colour would need to be counted;

(Pairs of values would be stored), which would consist of a run length and the colour of the pixels in the run;

Example of how the specific row of pixels would be compressed eg 7 Yellow, 4 Blue, 9 Yellow; **A.** assignment of numeric values to colours

**A.** “row” for “run” as **BOD**

**Max 2**

**2**

(d)  **All marks AO1 (understanding)**

Runs will be of shorter length // the image (in the second figure) contains a lot more different colours; **A.** colour depth is higher in the second image.

(For short runs) the additional run length data may (largely) cancel out (or even outweigh) the reduction in storage of pixel colour data;

**A.** responses given in reverse ie why first figure was compressed more effectively

**2**

**[9]**

**Q13.**

**All marks AO1 (knowledge)**

The key must be (at least) as long as the data to be encrypted/plaintext;

The key must not be reused // key must only be used once;

The key must be (truly) random;

The key must be kept securely / not revealed / only known by user(s);

**Max 2**

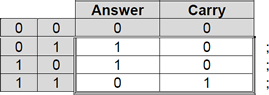
**[2]**

**Q14.**

256 // 28;

**[1]**

**Q15.**

****

**[3]**

**Q16.**

(a)  **1 mark** per correct answer:

|  |  |
| --- | --- |
| **Value description** | **Correct letter (A-D)** |
| A negative value. | A; |
| The largest positive number of the four values. | C; |
| A value that is not valid in the representation because it is not normalised. | B; |

If a letter is used more than once then mark as correct in the position that it is correct (if any).

**3**

(b)



**1 method mark** for either:

•   showing correct value of both mantissa and exponent in denary (Mantissa = 0.703125 // 45/64, Exponent = 4)

•   showing binary point shifted 4 places to right in binary number

•   indicating that final answer calculated using answer = mantissa x 2exponent

**1 mark** for correct answer

Answer = 11 1/4 // 11.25 // 45/4

*If answer is correct and some working has been shown, award two marks, even if working would not have gained credit on its own.*

**2**

(c)



**1 method mark** for either:

•   showing correct value of both mantissa and exponent in denary (Mantissa = 0.65625 // 21/32, Exponent = −3)

•   showing binary point shifted 3 places to left in binary number

•   indicating that final answer calculated using answer = mantissa x 2exponent

**1 mark** for correct answer

Answer = 21/256, 0.08203125 **A**. Rounded to at least 2dp

*If answer is correct and some working has been shown, award two marks, even if working would not have gained credit on its own.*

**2**

(d)  **2 marks** for working:

Correct representation of 3008 in fixed point binary: 101111000000;

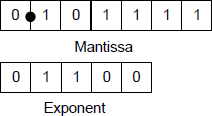
**A**. leading 0s.

Showing the correct value of the exponent in denary (12) or binary (1100) // showing the binary point being shifted 12 places;

Showing the correct value of the mantissa in binary: 0.101111; **A**. leading and trailing 0s.

**MAX 2**

**1 mark** for correct mantissa and exponent together:



*If answer is correct and some working has been shown, award three marks, even if working would not have gained credit on its own.*

*Working marks can be awarded for work seen in the final answer eg correct exponent.*

**3**

(e)  0.08 // 12.83 - 12.75 // 2/25

**R**. −0.08

**A**. Award **BOD** mark if correct method has been shown i.e. 12.83 − 12.75 but candidate has then made an error performing the subtraction operation

**1**

(f)  0.6235%

**A**. 0.006235 // 0.0062 // 0.08 ÷ 12.83

**A**. Follow-through of incorrect answer to part (e)

**A**. Award **BOD** mark if correct method has been shown but candidate has then made an error performing the division operation

**1**

(g)  **Definition (2 marks):**

The result of a calculation is too large to store/represent // a number is too large to store/represent;

In the available number of bits / storage space (allow example eg data type, byte, word, example of a data type); **R**. Space **NE**

**Example (1 mark):**

Multiplying two numbers together;

Dividing a number by a number less than one / small number;

**R**. Zero

**A**. Adding two numbers (of same sign)

**A**. When number converted from one type to another that does not have suitable range/enough bits/enough storage space to represent it

**A**. Answers by example

**MAX 1**

**3**

**[15]**

**Q17.**

(a)     **All marks AO2 (apply)**

**1 mark for working:** conversion of D to 13 or multiplication of a number (even if not 13) by 16 and adding 6 to the result;  
**1 mark for answer:** 214;

**2**

(b)     **All marks AO2 (apply)**

1001; 0110;

**1 mark:** correct first four bits

**1 mark:** correct bits in position 5 – 8

**2**

(c)     **All marks AO2 (apply)**

1;0111101;

**2 marks:** Correct answer only

**2**

(d)     **Mark is for AO2 (apply)**

10101011;

**1**

(e)     **Mark is for AO1 (understanding)**

The result is too large to be represented;

(it causes) overflow;

The result represents a negative value;

**Max 1 mark**

**1**

**[8]**

**Q18.**

(a)     **Mark is for AO1 (knowledge)**

A character code uses a unique number / code to represent each different character;

**1**

(b)     **Marks are for AO1 (understanding)**

**1 mark:**b = 1100010;  
**1 mark:**e = 1100101;

**2**

(c)     **Mark is for AO2 (apply)**

1000011

**1**

**[4]**

**Q19.**

**Marks are for AO2 (apply)**

**Mark Scheme**

|  |  |  |
| --- | --- | --- |
| **Level** | **Description** | **Mark Range** |
| 3 | A line of reasoning has been followed to produce a coherent, relevant, substantiated and logically structured response. The response covers both the comparison of car control and painting (see Guidance Table 1) and the use of data for car control (see Guidance Table 2).  At least two points from each column of Table 1 have been made and substantiated and at least three sources of input, its processing, the derived information and why it is needed must have been addressed successfully. | 7-9 |
| 2 | There is some evidence that a line of reasoning has been followed. The response is relevant and most but not all points made are substantiated. The response covers both the comparison of car control and painting (see Guidance Table 1) and the use of data for car control (see Guidance Table 2) but one of these two may be covered at a fairly superficial level.  EITHER:  At least two points from each column of Table 1 have been made and substantiated and at least one source of input, its processing, the derived information and why it is needed must have been addressed successfully  OR:  At least one point from each column of Table 1 has been made and substantiated and at least two sources of input, its processing, the derived information and why it is needed must have been addressed successfully | 4-6 |
| 1 | There is little or no evidence that a line of reasoning has been followed. Some relevant points have been made but these may only cover one of the comparison of car control and painting (see Guidance Table 1) or the use of data for car control (see Guidance Table 2). If both have been covered, the coverage is superficial and the points made are not successfully substantiated. | 1-3 |

**Guidance**

|  |  |
| --- | --- |
| **Guidance Table 1: Automated car control vs programmed control of a robot for spraying car bodies** | |
| **Robot for spraying car bodies** | **Automated car control** |
| Exactly same operation performed over and over again by programmed robot sprayer  Position of car bodies predetermined / / car bodies in known precise positions all the time / / Robot sprayer does not need to deviate from pre-programmed position at any time / / a strictly controlled environment  Actions to be performed known in advance for programmed robot sprayer.  Programmed robot sprayer requires only limited sensing of environment if any / / fewer inputs to monitor  Robot sprayer does limited processing.  Robot sprayer has a relatively simple program which is numerically controlled | The environment in which the car operates is not predictable / / is more complex / / has greater uncertainty  Car system needs to know at all times exactly where it is  Car system needs to recognise what it sees  Car system will need a range of sensors  Car system has to analyse / react to an input very quickly (and then adjust one or more of the three given outputs to alter car motion)  Car system has to continuously monitor many external variables  Car system has to perform very complex processing  Car system will need very powerful processors |

|  |
| --- |
| **Guidance Table 2: Processing, why, sources of input data, derived information** |
| **Source of data: Radar:  Processing:**  (long range) radar returns / signals              Processed to obtain location information of every             object over a 360 degree view              Plotted on a two dimensional map (for further             processing)              Changes in position processed              Trajectories of moving objects calculated  (long range) radar returns / signals              Processed to obtain speed of moving objects              Speed of the car subtracted from the speed of object  **Derived information:**              Precise fix on the location of every object              Distance from objects              Speed information from changes in position and time              Speed information from (speed) radar              Direction information from changes in position              Trajectories of moving objects  **Why?**              To keep car at safe distance from other objects / / to             steer car safely              To negotiate roundabouts / junctions  **Processing:**              Radar return / signal processed to obtain speed             information of objects              Speed of the car subtracted from the speed of object.  **Derived information:**              A zero result indicates a stationary object, a non-zero             result indicates a moving object  **Why?**              The car must be able to distinguish moving objects from             stationary objects, e.g. pedestrian from fence             post  **Processing:**  (short-range) radar returns / signals              Separation distance between car and object              Closing speed on object  **Why?**              To avoid collision by applying brakes automatically              To maintain safe separation distance from objects at sides             of car  **Source of data: Stereoscopic Camera (at front of car):  Processing:**              Separate images processed to construct view of             surrounding area in 3D              Machine intelligence processing used to extract             important features  **Derived information:**              Depth information              Road edge              Road centre              Lane edges  **Why?**              To predict car's trajectory              Keep car within its lane              Keep car on safe overtaking course  **Source of data: High resolution video camera (at front of car):  Processing:**              Video frames processed and matched by comparison              with a database of road signs  **Derived information:**              Particular road sign  **Why?**              Needed to observe highway code              Needed to be aware of junctions, etc.  **Source of data: Global Positioning Satellite receiver:  Processing:**              Satellite signals processed to obtain location and time             information              Comparison made with a stored representation of road             system  **Derived information:**              Position of car relative to junctions, etc              Speed of car  **Why?**              Needed to observe highway code              Needed to be aware of junctions, etc |

**[9]**

**Q20.**

(a)     **Marks are for AO1 (understanding)**

Solid-state memory chips are more robust;

No reliance on mechanical parts that could fail;

No corruption of data due to magnetic fields;

Faster write speed so more data could be recorded;

**Max 2**

**MAX 2**

(b)     **Marks are for AO2 (apply)**

**1 mark:** 8000 \* 2 \* 360 ;

**1 mark:** / 1000 ;

**1 mark:** Final answer: 5760 (KB) ;

**OR**

**Alternative method:**

**1 mark:** 8000 \* 16 \* 360 ;

**1 mark:** / 8

**1 mark:** / 1000;

**3**

(c)     **Marks are for AO1 (understanding)**

**1 mark:** Nyquist's theorem / / sample rate should be twice the highest frequency to be stored;

**1 mark:** With a sample rate of 8000 Hz any audio frequency over 4000 Hz would not be properly measured;

**2**

**[7]**

**Q21.**

(a)     **Mark is for AO2 (apply)**

Grey Pixel: 00

White Pixel: 11;

**Must have both correct to achieve mark**

**1**

(b)     **Mark is for AO2 (apply)**

**1 mark** for either:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |

or:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |

**1**

(c)     **All marks AO2 (apply)**

**Working 1 mark:**

20\*10 / / 2\*10\*10 / / 200;

Division of a number of bits by 8 to convert to bytes (even if number is not 200);

**1 mark:**

25 (bytes);

**2**

(d)     **Mark is for AO1 (understanding)**

**1 mark (Max)** for any of the items in this list, or a description of any of them:

•        image width

•        image height

•        colour (bit) depth / / bits per pixel

•        number of colour planes

•        colour table / palette

•        number of colours in palette

•        number of important colours

•        colour channel bitmasks

•        colour channel gamma correction

•        file size

•        image size

•        type of compression used

•        pixel density / / pixels per metre (**A** any other measurement unit)

•        offset to pixel data within file.

**A** Any other valid answer (there are many possibilities)

**1**

(e)     **2 marks for AO1 (knowledge) and 1 mark for AO1 (understanding)**

**AO1 (Knowledge): How it works (2 marks):**

**1 mark:** Identifies sequences of identical data values / colour pixels;

**1 mark:** Represents these as one data value / pixel colour together with a count of how many such values are in the sequence;

**AO1 (Understanding): Why suitable for icons (Max 1 mark):**

Images / icons often contain sequences of pixels that are the same colour;

RLE is a lossless compression method, so the quality of the image will not be affected (which is important for icons);

**3**

**[8]**

**Q22.**

(a)     **All marks AO1 (understanding)**

**1 mark** per correct response:

|  |  |
| --- | --- |
| **Value description** | **Correct letter (A-D)** |
| A positive normalised value. | A |
| The most negative value that can be represented. | C |
| A value that is not valid in the representation because it is not normalised. | B |

If a letter is used more than once then mark as correct in the position where it is correct (if any).

**3**

(b)     **All marks AO2 (apply)**

****

|  |  |
| --- | --- |
| Mantissa | Exponent |

**1 method mark** for either:

•        showing correct value of both mantissa and exponent in denary (Mantissa = 0.6875 / / 11 / 16, Exponent = 5)

•        showing binary point shifted 5 places to right in binary number

•        indicating that final answer calculated using answer = mantissa x 2exponent

**1 mark** for correct answer

Answer = 22

**If answer is correct and some working has been shown, award two marks, even if working would not have gained credit on its own.**

**2**

(c)     **All marks AO2 (apply)**

**2 marks** for working:

Correct representation of 6.75 in fixed point binary:

110.11; **A** leading 0s.

Correct representation of -6.75 in two's complement fixed point binary: 1001.01; **A** leading 1s.

Showing the correct value of the exponent in denary (3) or binary (11) / / showing the binary point being shifted 3 places;

**Max 2**

**1 mark** for correct mantissa and exponent together:



              Mantissa



        Exponent

**If answer is correct and some working has been shown, award three marks, even if working would not have gained credit on its own.**

**Working marks can be awarded for work seen in the final answer eg correct exponent.**

**3**

(d)     **All marks AO1 (understanding)**

**1 mark:** Reduced precision;

**1 mark:** Increased range; **A** can represent larger / smaller numbers

**2**

**[10]**

**Q23.**

(a)     (Using an algorithm) to convert a message into a form that is not understandable (without the key to decrypt it);

(Using an algorithm) to convert a message into a form that is only understandable by the intended parties // can only be read with the correct key;  
(Using an algorithm) to convert a message into cipher text;  
**NE** Scrambling unless further explanation is provided  
**NE** Coding  
**A** “Unreadable” for “understandable”  
**A** “Data” for “a message”  
**R** Responses that do not make clear that encryption is a process  
**MAX 1**

**1**

(b)     **1 mark** for two or three keys correctly named.  
**2 marks** for all four keys correctly named.

|  |  |
| --- | --- |
| **Label** | **Key Name** |
|  | A's Private Key |
|  | B's Public Key |
|  | B's Private Key |
|  | A's Public Key |

**A** “Sender” for “A” and “Recipient” for “B” (or similar role descriptions)  
Allow use of same key name more than once and mark correct in the position it is correct (if any).

**2**

(c)     Two (message) digests are compared // received and recalculated digests compared;  
**A** “They” for the two message digests  
**A** “Hash” for “digest”  
**R** Two messages are compared

**1**

(d)     To authenticate / confirm identity of sender // to confirm that message was sent by A;  
**A** Ensures person is who they say they are  
**NE** Identify the sender (must be clear that the signature confirms this identity), know who the sender is

To detect if message has been tampered with / changed;  
**NE** Prevent the message being tampered with

**Award marks in part (d) for valid responses to part (d) that are made in part (c).**

**2**

**[6]**

**Q24.**

(a)     182;

**1**

(b)     -;74;

**2**

(c)     -128; to (+)127;

**Mark as follows:**Lowest value identified correctly;  
Highest value identified correctly;

**2**

(d)     5 11 / 16 / /

5.6875;;

**A** 91 ÷ 16;;

**Mark as follows:**

Correct whole number part (5);  
Correct fractional / decimal part (11 / 16 or 0.6875);

**2**

(e)     B;6;

**2**

(f)      Easier for people to read / understand;  
**R** If implication is it easier for a computer to read / understand  
Can be displayed using fewer digits;  
More compact when printed / displayed;  
**NE** Takes up less space  
**NE** More compact

**MAX 1**

(g)     Shift all the bits one place to the left; and add a zero / /  
Add an extra 0; to the RHS of the bit pattern; / /

**A** Arithmetic left shift applied once / by one place;;

**2**

**[12]**

**Q25.**

(a)     Keyboard / / keypad / / concept keyboard / / numberpad;

Touch-screen;

**R** mouse

**2**

(b)     A light source / laser is shone at bar code / / a bar code is illuminated; **NE** beam / photons

(moving) mirror / prism moves light beam across bar code / / user moves reader across bar code / / user moves the bar code across the reader;

**NE** beam

Light reflected back;

Black / white bands reflect different amounts of light / / black reflects less light / / white reflects more light;

Light sensor / photodiode / CCD (measures amount of reflected light);

Light reflected converted into an electrical signal;

**A** convert reflection to (binary) numbers / characters / ASCII

**Check Digit:**

The (12) data digits are passed through a function to calculate a check digit;

The result is compared against the check digit read in / / check digit compared to rest of bar code;

If they do not match an error is indicated;

If they match the bar code is accepted and processed;

**Mark Bands and Description**

*To achieve a mark in this band, candidates must meet the subject criterion (SUB) and all 5 of the quality of language criteria (QWCx)*.

|  |  |
| --- | --- |
| *SUB* | Candidate has made at least five subject-related points. Candidate has made valid points about both scanning **and the check digit** in their answer. |
| *QWC1* | Text is legible. |
| *QWC2* | There are few, if any, errors of spelling, punctuation and grammar. Meaning is clear. |
| *QWC3* | The candidate has selected and used a form and style of writing appropriate to the purpose and has expressed ideas clearly and fluently. |
| *QWC4* | Sentences (and paragraphs) follow on from one another clearly and coherently. |
| *QWC5* | Appropriate specialist vocabulary has been used. |

**5-6**

*To achieve a mark in this band, candidates must meet the subject criterion (SUB) and 4 of the 5 quality of language criteria (QWCx)*.

|  |  |
| --- | --- |
| *SUB* | Candidate has made at least three subject-related points. |
| *QWC1* | Text is legible. |
| *QWC2* | There may be occasional errors of spelling, punctuation and grammar. Meaning is clear. |
| *QWC3* | The candidate has, in the main, used a form and style of writing appropriate to the purpose, with occasional lapses. The candidate has expressed ideas clearly and reasonably fluently. |
| *QWC4* | The candidate has used well-linked sentences (and paragraphs). |
| *QWC5* | Appropriate specialist vocabulary has been used. |

**3-4**

*To achieve a mark in this band, candidates must meet the subject criterion (SUB) and 4 of the 5 quality of language criteria (QWCx)*.

|  |  |
| --- | --- |
| *SUB* | Candidate has made at least one subject-related point. |
| *QWC1* | Most of the text is legible. |
| *QWC2* | There may be some errors of spelling, punctuation and grammar but it should still be possible to understand most of the response. |
| *QWC3* | The candidate has used a form and style of writing which has many deficiencies. Ideas are not always clearly expressed. |
| *QWC4* | Sentences (and paragraphs) may not always be well-connected. |
| *QWC5* | Specialist vocabulary has been used inappropriately or not at all. |

**1-2**

Candidate has made no relevant points.

**0**

**Note:** Even if English is perfect, candidates can only get marks for the points made at the top of the mark scheme for this question.

If a candidate meets the subject criterion in a band but does not meet the quality of language criteria then drop mark by one band, providing that at least 4 of the quality of language criteria are met in the lower band. If 4 criteria are not met then drop by two bands.

**MAX 6**

**[8]**

**Q26.**

(a)     011 0010;

**R** If not 7 bits

**1**

(b)     1011 0000

**Mark as follows:**Correct data bits;  
Correct parity bit for the candidate’s data bits;  
**R** If not 8 bits

**2**

(c)     Error correction (not just error detection) (for single errors);  
Can detect when two errors have occurred in data transmission;  
Reduces the need for the retransmission of data;  
Decreases the likelihood of an undetected error // improved error detection;  
Can locate an error (not just detect that an error has occurred);

**Max 1**

**[4]**

**Q27.**

(a)     300; \* 2;  
//  
600;;

*Note: award 1 mark for doubling an incorrectly calculated highest frequency*

**2**

(b)     Regular samples are taken (of the analogue signal);  
Samples are quantised // the height of each sample is approximated to an integer value // height of samples measured // amplitude/volume measured;  
Each integer value is encoded as a binary value // measurements are coded in a fixed number of bits;  
output the binary numbers as digital signals / voltage levels;

**Max 3**

(c)     Can (easily) synthesise musical notation from it;  
Can be played on different instruments;  
Can be (easily) transposed to a different key/pitch;  
Produces (relatively) small files;  
Easy to manipulate (the data);  
Allows for easy interface with electronic musical instruments;  
No data lost about a musical note;

**Max 1**

(d)     Length/duration (of note) // Note-on and Note–off;  
Instrument;  
Velocity//Speed;  
Volume//Amplitude;  
Timbre;  
Pedal effects;  
Channel;  
Instructions about how to recreate a sound;  
Aftertouch;  
Pitch bend;  
Note envelope;

**R** Note/key/pitch/frequency;  
**A** Other sensible answers;

**Max 1**

**[7]**