1	**1**	**Marks are for AO1 (understanding)** **1 mark** for identifying that analogue is <u>continuous</u> data **1 mark** for identifying that digital has <u>discrete</u> values / stored as <u>binary</u> values **A.** consists of 1s and 0s.	**2**
1	**2**	**Marks are for AO1 (understanding)** More compact representation; Easy to modify / edit notes // easy to change values eg octave for entire score; Easy to change instruments; Simple method to compose algorithmically; Musical score can be generated directly from a MIDI file; No data lost about musical notes // no data lost through sampling; **A**. "better quality" but only if it there is some explanation of this eg "no error introduced during sampling", "no background noise recorded" The MIDI file can be directly output to control a device; MIDI records the musician's inputs rather than the sound produced; **Max 2**	**2**

2	**1**	**Marks are for AO1 (understanding)** **Level of response question** (see table below) **Guidance** – Indicative Response **Image Capture** - Light enters through/is focussed by the <u>lens</u>; 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 **NE.** patterns; - The colours/values and counts of pixels/values/run-lengths are represented/identified/stored **A.** example;	**6**

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

3	**1**	**Marks are for AO2 (apply)** **1 mark** for calculating number of pixels (8x10 // 80) **1 mark** for multiplying number of pixels by correct colour depth (80 x 3) **1 mark** for correctly converting to bytes (240 / 8 // 30 bytes) **A.** Follow through errors	**3**
3	**2**	**Mark is for AO1 (understanding)** 5; **R**. More than one lozenge shaded	**1**

04	1	**Marks are for AO2 (apply)** 768;	1
04	2	**Marks are for AO2 (apply)** Identification of length (200s / 3 * 60 + 20), sample resolution (16 bit) and sample rate (44,100 Hz) in working; **A**. 44.1 (kHz) for sample rate Showing the correct calculation ((3 * 60+20) * 16 * 44,100 // 200 * 16 * 44,100) or showing correct intermediary value (141,120,000 (bits) / 17,640,000 (Bytes)); **I**. Conversion. **A**. Allow follow through as long as it is clear the student is attempting to multiply length, sample rate and sample resolution. Conversion of answer in bits to megabytes (17.64MB); **I**. Incorrect value for number of bits. **A**. rounded up to fewer significant places as long as correct method can be seen in working. **Max 2** if final answer is incorrect **Award** 3 marks if final answer 17.64MB	3

5	1	**3 marks are for AO1 (understanding)** (Analogue signal) sampled at fixed/regular time intervals; **R.** Amplitude/Voltage of signal/wave (at each sample point) measured; Measurement coded into a fixed number of bits // coded in binary;	3
5	2	**2 marks for AO2 (apply)** 48 000 (Hz) // 34.56 * 1000 * 1000 * 8 / 16 / 360;; **A.** 48 kHz;; **NE.** 48 If final answer is incorrect then award 1 mark for working for one of: • calculating recording size in bits: 34.56 * 1000 * 1000 * 8 • showing recording size in bits: 276 480 000 • dividing **(A.** incorrect) recording size in bits by 16 and 360 **Note**: Award 2 marks if correct answer given regardless of working. **Max 1** if final answer is incorrect.	2
5	3	**2 marks for AO1 (knowledge)** You must sample at a rate that is at least double; the highest frequency (component) in the original sound;	2

6		**2 marks are for AO2 (analyse)** The student has used the number of colours (4) instead of the colour depth/number of bits per pixel (2); The correct minimum file size is 40 bytes;	2

07	1	**4 marks for AO3 (programming)**
		
		Example 1:
		`LDR R0, 100`
		`LDR R1, 101`
		`ADD R2, R0, R1`
		`CMP R2, #26`
		`BLT store`
		`SUB R2, R2, #26`
		`store: STR R2, 102`
		
		Example 2:
		`LDR R0, 100`
		`LDR R1, 101`
		`ADD R2, R0, R1`
		`CMP R2, #25`
		`BGT adjust`
		`STR R2, 102`
		`HALT`
		`adjust: SUB R2, R2, #26`
		`STR R2, 102`
		
		Example 3:
		`LDR R0, 100`
		`LDR R1, 101`
		`ADD R2, R0, R1`
		`CMP R2, #25`
		`BGT adjust`
		`B end`
		`adjust: SUB R2, R2, #26`
		`end: STR R2, 102`
		
		A. Use of alternative registers
		A. Any label name in place of store / adjust
		
		DPT. Use of invalid register name eg Rd
		DPT. Use of incorrect addressing mode
		DPT. Inclusion of invalid symbols in commands
		
		Programming Marks:
		1 Mark for `LDR R0, 100`, `LDR R1, 101` and `STR R2, 102`
		1 Mark for `ADD R2, R0, R1`
		1 Mark for `SUB R2, R2, #26`
		1 Mark for either:
		
		• `CMP R2, #26`, `BLT store` and `store:` aligned to a `STR` instruction **or**
		• `CMP R2, #25`, `BGT adjust` and `adjust:` aligned to a `SUB` instruction
		
		Max 3 if any errors.
			4

07	2	**Mark is for AO1 (understanding)** Frequency/statistical/syntactical analysis cannot provide clues to the plaintext // nothing can be learnt about the plaintext from the ciphertext;	1

8	1	**Mark is for AO1 (knowledge)** Takes up less storage space; Faster transmission times; To fit within certain system restrictions (eg e-mail attachment restrictions); **Max 1**	1
8	2	**Mark is for AO1 (understanding)** The file can be reproduced exactly as it was originally; **A.** The quality of an image/sound/video would not be reduced. 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 **Max 1**	1
8	3	**3 marks are for AO1 (understanding)** (Variable) length strings of symbols/substrings of original data are represented by single tokens; A table/dictionary is formed using the tokens as the keys/index; The strings of symbols are used as the entries; **Alternative answer for LZ77** A sliding window of previous data is maintained; A length-distance pair is formed where each of the next *length* characters; is equal to the characters exactly *distance* behind it; in the uncompressed stream.	3

Qu	Pt	Marking Guidance	Marks
9	1	**Marks are for AO1 (understanding)** Analogue data is continuous // analogue data can take any value in a given range // between any two analogue values there is another value; Digital data has discrete values // can be stored as binary values / 1s and 0s; **A.** Has jumps / gaps between each value.	2

Qu	Pt	Marking Guidance	Marks
9	2	**Marks are for AO1 (understanding)** The ADC takes samples of the (analogue / continuous electrical) signal / voltage / wave at regular intervals; **R.** Sound wave for signal. The samples are quantised // the amplitude (**A.** height) of each sample is approximated to an integer value // the amplitude (**A.** height) of samples are measured; **A.** Voltage for amplitude. **A.** Digital / number / value for integer value. **A.** Explanation of how the signal is quantised. Each sample is assigned a binary value / encoded as a binary value; **A.** Stored / converted so long as sample is stated previously. **R.** Digital value for binary value.	3

<table>
<tr><th>Qu</th><th>Pt</th><th>Marking Guidance</th><th>Marks</th></tr>
<tr><td>10</td><td></td><td>

Marks are for AO2 (analyse)

Level of response question:

<table>
<tr><th>Level</th><th>Description</th><th>Mark Range</th></tr>
<tr><td>4</td><td>A line of reasoning has been followed to produce a coherent, relevant, substantiated and logically structured response. Answers in this level will demonstrate a clear justification of the use of lossy compression and will show a developed awareness of how the benefits of lossy compression are related to one another. The response covers all four aspects (lossy, ethical, legal, cultural) of the question. A range of the points made will have been expanded upon using clear examples and references to real world implications.</td><td>10–12</td></tr>
<tr><td>3</td><td>A line of reasoning has been followed to produce a coherent, relevant, substantiated and logically structured response. Answers in this level will address the use of lossy compression but there may not always be a clearly demonstrated understanding of the benefits. The response covers at least three aspects (lossy, ethical, legal, cultural) of the question. Some of the points made will have been expanded on and some of these will have been expanded upon using examples but these might not always exemplify the points made or be lacking in references to real world implications.</td><td>7–9</td></tr>
<tr><td>2</td><td>A line of reasoning has been followed to produce a mostly coherent, relevant, substantiated and logically structured response. The response lists some issues that are likely to focus on only two or three aspects (lossy, ethical, legal, cultural) of the question. Some of the points made will have been expanded upon but are likely to be lacking in clear examples or may not wholly relate to the points being made.</td><td>4–6</td></tr>
<tr><td>1</td><td>There is no evidence that a line of reasoning has been followed. Answers in this level may identify a point relating to the use of lossy compression but this part of the question may not be addressed at all. The response will attempt to identify some issues raised by the question; points are not likely to be expanded upon but where they are, the examples will be irrelevant or not relate to the points being made.</td><td>1–3</td></tr>
</table>

Indicative Content

Justifying lossy compression:

- Scale / volume of data: the company has a large volume of audio to store (because of the number of users that could have the smart speaker).
- Size of files: lossy compression can reduce the file size (of individual audio files to be transmitted/stored) // greater compression than lossless.
- Audio quality: it is still possible for files to retain (sufficient) quality (to permit analysis) // the audio quality depends on the amount of information retained / lost after applying lossy compression // remove unnecessary / redundant data.

</td><td>12</td></tr>
</table>

Ethical, legal and cultural examples are likely to overlap; when marking student responses, credit should be given for the range and clarity of points made, regardless of category. Points could include:

Ethical:

- The company has a justifiable goal, (ie by seeking to provide voice controls and improve its algorithms, the company is benefitting its customers, particularly individuals who cannot use traditional input methods).
- The company may record activity that is illegal, raising questions about its responsibility to report the activity to the authorities and duty of care to customers.
- Company employees may misuse the recordings for their own purposes.
- Company employees may be exposed to inappropriate material, raising questions about the duty of care that the company has for its employees.
- Creating 'a slippery slope' through the recordings, ie if the company is allowed to record customers for this purpose, where will it stop?
- The company is contributing to an erosion of privacy for individuals in their home / increasing existing surveillance.
- The company should obtain permission / consent from users before recording them in clear and understandable terms so that customers are providing informed consent.
- There is the potential for increased distrust between users and the company.
- The company may use the recordings for purposes other than improving the voice recognition algorithms.

Legal:

- The company must comply with legislation specifically covering the transmission and storage of data across different countries / territories of operation, including the General Data Protection Regulation (GDPR) or the Data Protection Act.
- The company has a responsibility to ensure their security / integrity / confidentiality / availability of the customer data it stores.
- The company must introduce controls to take account of individual privacy rights / legislation across different countries / territories of operation.
- The international nature of the company means that it may have opportunities to circumvent legislation within particular / different countries / territories, eg by getting user permission to transmit data to and store data in less restrictive countries / territories.

Cultural:

- All users being recorded can have benefits for groups of users with languages / dialects / accents where data is not widely available (even within the same country / territory).
- All users being recorded can allow the algorithms to advance more quickly, potentially allowing the company to make its products available across languages / user groups / countries / territories more quickly.
- The company should consider the customs and cultural norms of its different users (religions) / countries / territories of operation, particularly with regard to respecting expectations of privacy.
- Weighing up the benefit to specific user groups who rely more heavily on voice control, (eg individuals with physical disabilities) against the compromised privacy.

		Students may be awarded marks for individual issues or expansions upon issues. Expansion points may include further details on how the issue may arise or the impact of the issue occurring. **Examples of expansion points could include:** • Company employees might lose or leak data due to coercion or inexperience. • If a personally identifiable recording is lost or leaks, there may be severe personal and/or professional consequences for the user(s) on the recording.	

Qu	Pt	Marking Guidance	Marks
11	1	**Mark is for AO1 (understanding)** Number of pixels multiplied by colour depth / the number of bits used to represent a pixel/colour; Width is multiplied by the height multiplied by the colour depth / the number of bits used to represent a pixel/colour; **MAX 1 mark**	1

Qu	Pt	Marking Guidance	Marks
11	2	**Mark is for AO1 (knowledge)** The number of samples taken/measured in a second/given period of time;	1

Qu	Pt	Marking Guidance	Marks
11	3	**Mark is for AO1 (knowledge)** The sample resolution is the number of bits used to represent/store each sample;	1

Qu	Pt	Marking Guidance	Marks
11	4	**Marks are for AO1 (knowledge) and AO1 (understanding)** **Mark as follows:** **AO1 (understanding) – 1 mark:** The quality may limit later editing possibilities; The sampled sound may not be fully reproducible // The quality of the reproduced sound will not be as good as the original sampled sound; **MAX 1 mark** **AO1 (knowledge) – 1 mark:** Data is discarded/lost when storing using a lossy format;	2

Qu	Pt	Marking Guidance	Marks
11	5	**Marks are for AO1 (understanding)** More compact representation; **NE.** requires less space Easy to modify / edit notes // easy to change values eg octave for entire score // easy to change instruments; Simple method to compose algorithmically; Musical score can be generated directly from a MIDI file; No data lost about musical notes // no data lost through sampling; **A.** "better quality" but only if there is some explanation of this related to the sampling process eg "no error introduced during sampling", "no background noise recorded" **A.** MIDI records the musician's inputs rather than the sound produced The MIDI file can be directly output to control an instrument / a device; **MAX 2**	2

<table>
<tr><th>Qu</th><th>Pt</th><th>Marking Guidance</th><th>Marks</th></tr>
<tr><td>12</td><td></td><td>

3 marks are for AO1 (understanding) and 6 marks are for AO2 (analyse)

Level of response question

<table>
<tr><th>Level</th><th>Description</th><th>Mark Range</th></tr>
<tr><td>3</td><td>A line of reasoning has been followed to produce a coherent, relevant, substantiated and logically structured response. The response covers a wide range of issues that are consistently explained and/or supported by examples.
A very good understanding of how an image is captured is shown.
The response covers a wide range of moral/ethical, legal and cultural arguments, or examines a smaller range of arguments in greater depth.</td><td>7–9</td></tr>
<tr><td>2</td><td>A line of reasoning has been followed to produce a mostly coherent, relevant, substantiated and logically structured response. The response must include some analysis of the moral, ethical, legal or cultural issues involved.
The response may include some understanding of how the image is captured.

The response will cover a range of arguments in some depth.</td><td>4–6</td></tr>
<tr><td>1</td><td>There is little evidence that a line of reasoning has been followed. The response covers a small number of points which could cover either the image capture, or the moral, ethical, legal or cultural issues, or both.

The response lacks range and depth.</td><td>1–3</td></tr>
</table>

Indicative content:

AO1

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.
- A (colour) filter is applied to generate separate data values for red, green and blue colour components.
- The pixels are recorded as a group/array.

AO2

Note: Some points may fit under more than one category. These have been indicated with a #.

</td><td>9</td></tr>
</table>

		Moral/Ethical • Could the AI or computer program include unconscious bias as a result of the dataset it has access to or the programmers? • Would the owners of the system use the system to steer customers towards more expensive/higher profit garments? • Will the owners of the system use the data collected for other purposes? # • May put pressure on users to spend more money than they have. • Application may include advertising for certain brands. • Photographs may be uploaded by third parties and the result used without knowledge / consent of the person in the photograph. # • Might the application recommend outfits which may be deemed inappropriate by some? **Legal** • Will the data be stored securely? # • Who will own copyright of the generated images? • An image identifies a living person and so can be classed as personal data under the Data Protection Act / GDPR. • How will the application authenticate that the photograph is of the person using the system or has the permission of the person whose photograph it is? • Will there be an age authentication of the user of the system? Will there be an age restriction? How is this verified? • How long will the images be made available for? **Cultural** • Some outfits suggested may be offensive to certain groups of users (eg in certain religions) • Could the AI make inappropriate decisions about what clothes to suggest based on ethnicity / gender / disability / body-size? • Developers may deliberately or unintentionally (due to the algorithm) influence fashion trends.	

Qu	Pt	Marking Guidance	Marks
13	1	**Mark is for AO1 (knowledge)** Analogue to Digital Converter // ADC;	1

Qu	Pt	Marking Guidance	Marks
13	2	**Marks are for AO2 (application)** **2 marks** for correctly showing the number of colours that can be used 2^5 // 32 **1 mark** awarded for working out the colour depth (5) used in the bitmap image if the correct answer is not shown $\frac{(845 \times 8)}{(52 \times 26)}$	2

Qu	Pt	Marking Guidance	Marks
13	3	**Mark is for AO1 (knowledge)** Metadata;	1

Qu	Pt	Marking Guidance	Marks
13	4	**Marks are for AO2 (application)** **3 marks** for the correct answer including the unit of time 42 seconds or **2 marks** for 42 with no time unit If answer is incorrect then award **1 method mark for two or three steps** from the list below or **2 method marks for all four steps**. • multiplying by 8000 • multiplying by 12 096 • dividing by 24 // multiplying by 24 on same side of = as the time value • dividing by 96 000 // multiplying by 96 000 on same side of = as the time value The following method points are equivalent to performing **two** of the method points in the list above: • multiplying by (or showing a numerator of) 96 768 000 • dividing by (or showing a denominator of) 2 304 000 // multiplying by 2 304 000 on same side of the = as the time value	3

Qu	Pt	Marking Guidance	Marks
13	5	**Mark is for AO1 (understanding)** There is reduced quantisation error // each sample can be represented/stored more accurately; **NE.** improved sound quality **NE**. increases accuracy of measurement **R.** references to more samples / sample rate	1

Qu	Pt	Marking Guidance	Marks
13	6	**Marks are for AO1 (understanding)** Music represented as sequence of MIDI (event) messages // uses messages to represent different events in a piece of music; **A.** Music represented as sequence of instructions **NE.** Music represented as sequence of notes Playback of music is the combination of event messages with a specified ordering; One example of data that might be contained in a message: • Channel • Note on / note off • Pitch / frequency / note number • Volume / loudness • Velocity • Key pressure / aftertouch • Duration / length • Timbre • Instrument • Pedal effects • Pitch bend • Note envelope; MIDI messages are usually two or three bytes long; First byte of each MIDI message is a status byte (others are data bytes); Bit rate is 31 250 bits per second; MSB value of 1 indicates status byte, 0 indicates data bytes; Status bytes are divided into a command and a channel number (4 bits for each); Sixteen channels are supported; **Max 2**	2

Qu	Pt	Marking Guidance	Marks
13	7	**Mark is for AO1 (understanding)** File sizes are (typically) smaller // More compact representation; Easy to modify/edit (at note level); Ease of manipulation for entire recordings // easy to change recording values (eg changing an octave for an entire score); Easy to change instruments; Simple method to compose algorithmically; Musical score can be generated directly from a MIDI file; A MIDI file can be directly output to control a device; MIDI records the musician's inputs rather than the sound produced; Ease of composing/combining/overlaying existing recordings; No data lost about musical notes // no data lost through sampling; **A.** "better quality" but only if it there is some explanation of this eg "no error introduced during sampling", "no background noise recorded" **Max 1**	1

Qu	Pt	Marking Guidance	Marks
14	1	**Mark is for AO2 (application)** S00ZE;	1

Qu	Pt	Marking Guidance	Marks
14	2	**Marks are for AO1 (understanding)** Each letter/character is always encrypted to the same letter/character; The letters/characters in the ciphertext will have the same frequency as their corresponding letters/characters in the plaintext (allowing the correspondence to be worked out given enough ciphertext); **A.** The ciphertext is susceptible to frequency analysis There are a very small number of possible keys (25 **A.**26) (so it can be cracked by brute force); If a single mapping is known then the remaining (25) can be easily calculated; The ciphertext will retain structural properties of the plaintext message; **A.** Examples of structural properties, eg some letters frequently occur next to each other, some letters rarely appear next to each other, position of spaces can identify word lengths, common short words can be identified **Max 2**	2