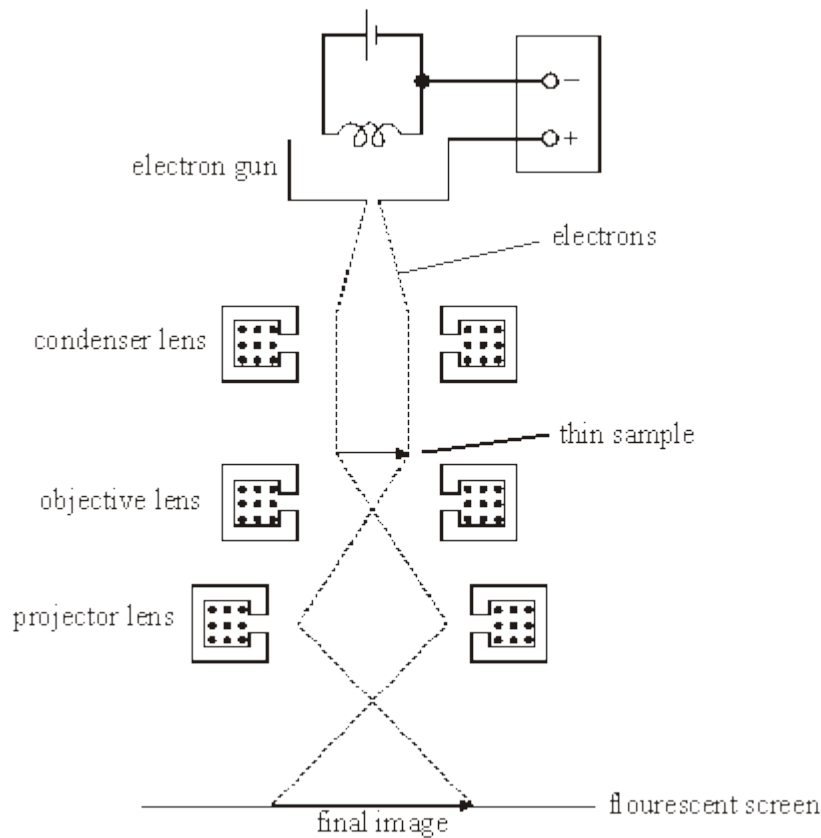**1** In a transmission electron microscope, electrons from a heated filament are accelerated through a certain potential difference and then directed in a beam through a thin sample. The electrons scattered by the sample are focused by magnetic lenses onto a fluorescent screen where an image of the sample is formed, as shown in the figure below.

(a) State and explain **one** reason why it is important that the electrons in the beam have the same speed.

....

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....

(2)

(b)   When the potential difference is increased, a more detailed image is seen. Explain why this change happens.

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(3)
(Total 5 marks)

2   The audio signals on an audio CD are digitally encoded. Part of the audio CD specification describes the encoding as:

'PCM with 16-bit values sampled at 44.1 kHz'.

(a)   Explain why 44.1 kHz is a suitable sampling frequency for high quality audio recording.

....

....

....

....

(3)

(b)   Calculate the number of different voltage levels which can be detected in each sample.

....

(1)

(c)   The **quantisation error** is the voltage step difference between each level.
The peak-to-peak signal voltage is 5 V.

Calculate the quantisation error for an audio CD.

....

....

(2)

(d)   A call centre uses an audio CD to play music to callers while they are waiting for their calls to be answered. The telephone system operates in the frequency range 300 Hz to 3 kHz.

Describe **two** different effects this will have on the quality of the music the callers hear.

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(2)
(Total 8 marks)

Mark schemes

1 (a) force on an electron in a magnetic field depends on speed **(1)**
electrons at different speeds would be focussed differently so image
would be blurred **(1)**
[or electrons at different speeds would have different (de Broglie)
wavelengths
therefore resolution would be reduced]

2

(b) increase in pd increases speed **(1)**
increase in speed/momentum/E_k causes reduction of (de Broglie)
wavelength **(1)**
reduced (de Broglie) wavelength gives better resolution **(1)**

3

[5]

2 (a) upper audio frequency maximum 15−20kHz ✓
sampling frequency must be higher ✓ than 2× ✓ highest audio frequency

3

(b) 65536 ✓

allow 65535

1

(c) 5 / 65535 ✓ = 76µV ✓

allow 65536

ecf from (b)

2

(d) high & low frequencies are lost *or* reduced bandwidth ✓
reference to perceived quality, e.g. lack of bass / treble in the music, 'tinny', or similar
✓

2

[8]