Mark schemes

1. **The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2-mark (L1), 3 or 4-mark (L2) and 5 or 6-mark (L3) answer.**

Level	Criteria
L3 **6 marks**	Candidate matches the **three** areas of the communications spectrum with the correct pathway. They provide a coherent and comprehensive explanation of the properties of each pathway. The answer has structure and detail.
L3 **5 marks**	Candidate matches the **three** areas of the communications spectrum with the correct pathway. They provide a comprehensive explanation of the properties of each pathway, but the answer may lack structure / detail.
L2 **4 marks**	Candidate matches **two** areas of the communications spectrum with the correct pathway. They provide a coherent and comprehensive explanation of the properties of each pathway. The answer has structure and detail.
L2 **3 marks**	Candidate matches the **two** areas of the communications spectrum with the correct pathway. They provide a comprehensive explanation of the properties of each pathway, but the answer may lack structure / detail.
L1 **2 marks**	Candidate matches **one** area of the communications spectrum with the correct pathway. They provide a coherent and comprehensive explanation of the properties of that pathway. The answer has some structure and detail.
L1 **1 mark**	Candidate matches **one** area of the communications spectrum with the correct pathway. They provide some explanation of the properties of the pathway. The answer may lack structure / detail.
L1 **0 marks**	The work contains no significant analysis of the question asked.

Longwave

Typical frequency range

Broadcasts between 150 kHz – 300 kHz which fits into the LF band.

Also accept extended (3 kHz – 500 kHz) range to allow for special applications.

Pathway – Ground (surface waves)

i. Generally, line of sight.

ii. Beyond the horizon communication by following earth's curvature.

iii. Diffraction in the atmosphere due to different refractive index.

iv. Diffraction due to interaction of the wave with conductive surface (earth).
v. Diffraction due to interaction with geographical topography – hills / buildings.
vi. Long distance propagation due to low attenuation of low frequency waves.
vii. Transmission severely attenuated by ionosphere so little reflection

Shortwave

Typical frequency range

Normally taken as 3 MHz – 30 MHz which includes the full HF band. (Accept lower limit of 1.7 MHz)

Pathway – Sky waves

i. Ionosphere acts to refract and hence reflect waves back to the earth.
ii. This allows beyond the horizon reception due to single/multiple reflections (skips).
iii. Below this frequency, ionosphere will absorb waves.
iv. Above this frequency, the wave will pass through the ionosphere.
v. Can suffer disruption due to the state of the ionosphere day/night effects or sunspot cycle.

Microwaves

Typical frequency range

Normally taken as 2 GHz – 100 GHz Accept 1.7 GHz – 300 GHz

Pathway – Space wave

i. Due to high frequency, microwaves do not diffract around terrestrial objects, so line of sight required.
ii. Microwaves travel straight through atmosphere and ionosphere.
iii. Significant attenuation of transmission by atmosphere and ionosphere.
iv. Different frequencies used for up-link and down-link so that satellite receiver is not desensitized.
v. Up-link normally at higher frequency (17 – 18 GHz) than down-link (10 – 13 GHz) since higher frequency gives narrower beam and can be given more power to overcome attenuation. (Converse argument for down-link based on wider target area and low power available from satellite).
vi. Microwave communication allows for greater bandwidth to carry complex information.

[6]

2. **Expected information:**

Longwave
f ~ 150 kHz – 300 kHz
λ ~ 2 km – 1 km
Aerial Very long
Mode Ground (surface) wave – diffracted
Application Some national radio – large coverage
National time signal

Shortwave
f ~ 3 Mhz – 30 MHz
λ ~ 100 m – 10 m
Aerial medium
Mode Sky wave – reflected from ionosphere (above ~ 500 kHz)
Application Some national radio – large coverage
Long distance comms. for ships and planes
Amateur radio enthusiasts

Microwave
f ~ 100 GHz – 2 GHz
λ ~ 3 mm – 150 mm
Aerial Very short
Mode Direct (space) wave -terrestrial line of sight hops OR space satellite
Application 3G telephone network
Satellite TV
Data transfer to remote locations eg (Falkland Islands)

1–2 marks: *A limited answer with significant detail missing. Candidates may be able to recall terms such as 'sky waves' & 'ground waves', but there may be confusion as to the spectral frequencies or application. The material may lack organisation and technical terms may not be fully understood or used incorrectly.*

3–4 marks: *The roles of at least two links are covered and most of the detail is present. There will be some structure, but it may be either brief or unclear in parts.*

5–6 marks: *All three links are covered in detail. The candidate shows good knowledge and uses technical terms correctly. The answer has structure and clearly conveys the information required by the question. The candidate may show a depth of understanding that goes beyond basic recall.*

[6]

3. (a) Audio range (bandwidth) is 20 kHz ✓

The sampling frequency should be at least **twice** the maximum frequency / bandwidth ✓

Reference to Nyquist theorem without reference to numerical data – 1 mark only

2

(b) 6.5536×10^4

Allow other correct numbers

eg 65536

1

(c) For one channel:

$44.1 \times 10^3 \times 16 \times 3.5 \times 60 = 148.175$ megabits. ✓

For Stereo:

(2 x 148.175) ÷ 8 = 37.04 megabytes ✓
(Accept 37 megabytes)

***Two** marks for 37 megabytes with no working shown.*

2

(d) Lower quality music over telephone line due to: telephone call has lower bandwidth than original audio file ✓
loss of high and low frequencies from music ✓

***One** mark for general comment relating to ratio of bandwidths of the two systems where CD bandwidth has been taken to be in region of 15 kHz – 20 kHz*

2

[7]

4. **The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2 mark (L1), 3 or 4 mark (L2) and 5 or 6 mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist in marking this question.**

Level	Criteria
L3 **6 marks**	The candidate shows a good knowledge of **PCM**, **TDM** and the process of noise reduction using **regenerators** in this context. They use the technical terms correctly, the answer has structure and clearly conveys the information required by the question. The candidate may show a depth of understanding that goes beyond basic recall.
L3 **5 marks**	The candidate shows a good knowledge of **PCM**, **TDM** and the process of noise reduction using **regenerators** in this context. However, there may be minor gaps in knowledge / detail OR the style and structure may lead to a lack of clarity in some of the information being presented.
4 marks	The candidate will show a good understanding of **two** of the processes / subsystems in bold in this context. Technical terms will be used correctly and the information will generally be presented in a structured and coherent manner
3 marks	The candidate will show a good basic understanding of **two** of the processes / subsystems in bold. However, there may be minor gaps in knowledge / detail OR the style and structure may lead to a lack of clarity in some of the information being presented.
2 marks	The candidate will show a superficial understanding of **two** of the processes / subsystems in bold. Overall, this will be a limited answer with significant detail missing. The material may lack clarity / organisation.
1 mark	The candidate will show a superficial understanding of **one** of the processes / subsystems in bold. Overall this will be a limited answer. The material may lack clarity / organisation.
0 marks	The work contains no significant analysis of any of the techniques / subsystems in bold.

PCM

PCM *– the analog signal is* ***sampled*** *and then* ***quantised****, converting it into a* ***serial*** *n-bit* ***binary code*** *for transmission.*

The sampling, which should be done at ***twice the max frequency*** *contained within the signal and quantisation are responsible for the* ***bit rate*** *which will determine the* ***bandwidth*** *needed for transmission.*

TDM

Without ***TDM****, the 15 channels of speech would each need their own cable to create an independent link as the total bandwidth would exceed that of the link.*

With ***TDM****, the system allocates* ***time slots*** *so that data blocks of code from each speech channel can be transmitted in sequence* ***(multiplexed)*** *across a single link. The full* ***bandwidth*** *of the link is available to each channel.*

Regenerators

Regenerators *work by using a* ***switching*** *circuit (****Schmitt trigger****) which has two different* ***switching thresholds****. This will usually take out most of the noise sitting on the signal.*

[6]

5. (a) **D ✓**

1

(b) **A ✓**

1

(c) One of: ✓

Attenuation of e-m wave across transmission path

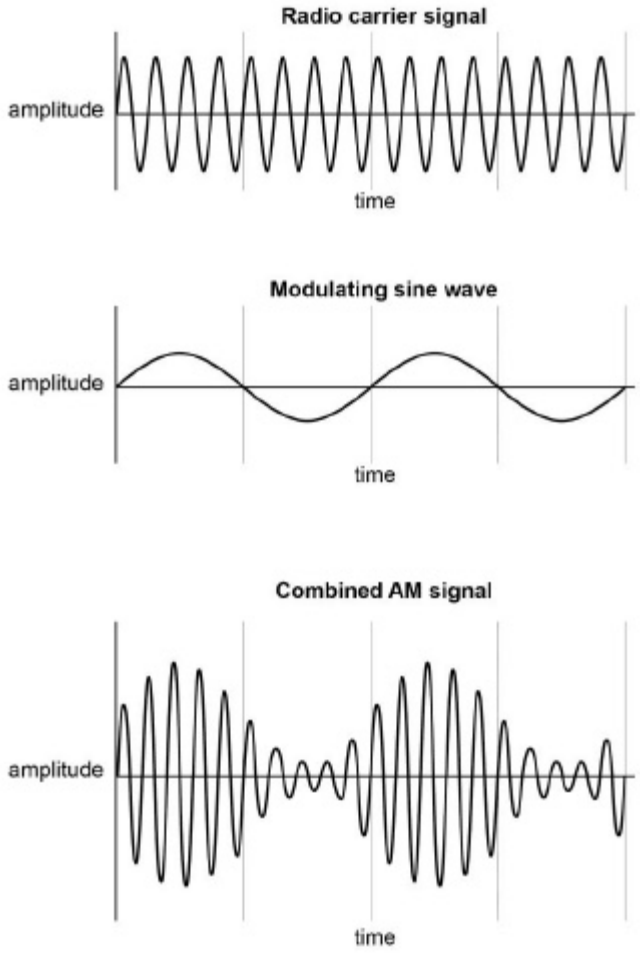
Small fraction of radiated energy in direction of receiver

Energy loss due to reflection from ground / natural topography / absorption in atmosphere

Accept any other reasonable response

1

(d)



Correct relative positions of envelope max – min on AM and an attempt made to keep carrier frequency constant ✓

Modulating signal forms envelope around carrier

1

(e) About 55 stations can be picked up in London

- A full audio frequency of 20 kHz would require a bandwidth of 40 kHz for each station ✓
- 55 × 40 kHz = 2200 kHz. This is twice as much as waveband available ✓ so stations would have to overlap leading to crosstalk / interference ✓

Accept equivalent arguments / calculations

3

[7]

6. The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2 mark (L1), 3 or 4 mark (L2) and 5 or 6 mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist in marking this question.

Level	Criteria
L3 **6 marks**	The candidate shows a good knowledge of the **three** general properties of copper wire and optic fibre. They use technical terms correctly, the answer has structure and clearly conveys the information required. They reach a conclusion based on the supporting evidence.
L3 **5 marks**	The candidate shows a good knowledge of the **three** general properties of copper wire and optic fibre. However, there may be minor gaps in knowledge OR the style / structure may lead to a lack of clarity in some of the information being presented. There is a supported conclusion.
L2 **4 marks**	The candidate shows a good understanding of **two** general properties of copper wire and optic fibre. Technical terms will be used correctly and the information will generally be presented in a structured and coherent manner. A conclusion will be drawn from the information presented.
L2 **3 marks**	The candidate shows a good knowledge of **two** general properties of copper wire and optic fibre. There may be minor gaps in knowledge / detail which may lead to a lack of clarity. There will be a conclusion which draws some support from the information presented.
L1 **2 marks**	The candidate shows some knowledge of **two** general properties of copper wire and optic fibre. There may be significant gaps in knowledge / detail which may lead to a lack of clarity. There may be no supported conclusion.
L1 **1 marks**	The candidate shows some understanding of **one** of the general properties of copper wire and optic fibre. Overall, this will be a limited answer with significant detail missing. There may be a lack of structure and clarity.
L1 **0 marks**	The work contains no significant analysis of the question asked.

		Copper	Optic fibre
Physical	**Corrosion**	Will corrode unless well protected	Glass doesn't corrode
	Weight / connectivity	Heavier, easier to join	Lightweight, more difficult to join sections
External interference	**Security**	Can be tapped without breaking cable	Cannot be tapped unless broken into
	External access	Can pick up noise / cross talk	Immune from noise – can be used in noisy environments
Signal-carrying properties	**Signal degradation / attenuation**	High attenuation	Low attenuation / Possible pulse smearing
	Bandwidth / info carrying capacity	Relatively low bandwidth / fewer channels	Greater bandwidth / capacity / more channels / possibility of sending multiple types of signal eg data + talk

[6]