

Q1.

- 13 (a) correct signal voltages.....(-1 each error or omission)..... B2
 corresponding binary numbers...(-1 each error or omission)..... B2 [4]
- (b) signal changes at correct positions B1
 correct levels B1 [2]
- (c) (use ADC and DAC with) larger number of bits..... M1
 makes smaller 'step height' A1
 sample more frequently M1
 makes smaller 'step depth' A1 [4]

Q2.

- 14 (a) central conductor with outer screening..... B1
 insulation between inner and outer and also as cladding..... B1 [2]
- (b) e.g. greater bandwidth
 immune to e.m. interference
 radiates less e.m. power
 less cross-talk
 lower noise levels..... (1 each, max 3)..... B3 [3]

Q3.

- 15 10 m → 100 m worldwide
 more than 100 m 1000 km
 less than 10 m line of sight or worldwide using satellites
 (-1 each error or omission)..... B5 [5]

Q4.

- 10 (a) correct values of 2, 5, 10, 15 and 4 (-1 each error) B2
 graph drawn as a series of steps M1
 steps occurring at correct times A1 [4]
- (b) sample more frequently B1
 greater number of bits B1 [2]

Q5.

- | | | | |
|--------|---|----------------|-----|
| 10 (a) | correct values of 2, 5, 10, 15 and 4 (<i>-1 each error</i>) graph drawn as a series of steps steps occurring at correct times | B2 M1 A1 | [4] |
| (b) | sample more frequently greater number of bits | B1 B1 | [2] |

Q6.

- | | | | |
|------------|---|----------------------|------------|
| 11 (a) (i) | frequency of carrier wave varies in synchrony with <u>displacement</u> of information signal | M1 A1 | [2] |
| (ii) | 1. zero (accept constant) 2. upper limit 530 kHz lower limit 470 kHz changes upper limit → lower limit → upper limit at 8000 s^{-1} | B1 B1 B1 B1 | [1] [3] |
| (b) | e.g. more radio stations required / shorter range more complex electronics larger bandwidth required (<i>any two sensible suggestions, 1 each</i>) | B2 | [2] |

Q7.

- | | | | |
|------------|--|----------------------------|-----|
| 12 (a) (i) | picking up of signal in one cable from a second (nearby) cable | M1 A1 | [2] |
| (ii) | <u>random</u> (unwanted) signal / power that masks / added to / interferes with / distorts transmitted signal (<i>allow this mark in (i) or (ii)</i>) | B1 B1 | [2] |
| (b) | if P is power at receiver, $30 = 10\lg(P / (6.5 \times 10^{-6}))$ $P = 6.5 \times 10^{-3} \text{ W}$ loss along cable = $10\lg(\{26 \times 10^{-3}\} / \{6.5 \times 10^{-3}\})$ = 6.0 dB length = $6.0 / 0.2 = 30 \text{ km}$ | C1 C1 C1 C1 A1 | [5] |

Q8.

- 12 (a) loss / reduction in power / energy / voltage/ amplitude (of the signal) B1 [1]
- (b) (i) attenuation = $125 \times 7 = 875$ dB A1 [1]
- (ii) 20 amplifiers
gain = $20 \times 43 = 860$ dB A1 [1]
- (c) gain = $10 \lg(P_1/P_2)$ C1
overall gain = -15 dB / attenuation is 15 dB C1
 $-15 = 10 \lg(P / 450)$
 $P = 14$ mW A1 [3]

Q9.

- 13 (a) switch; tuning cct; (r.f.) amplifier; demodulator;
serial-to-parallel converter; DAC; (a.f.) amplifier
mark as 2 sets of 2 marks each
- 5 blocks identified correctly B2
(each error or omission, deduct 1 mark)
5 blocks in correct order B2 [4]
(4 or 3 blocks in correct order, allow 1 mark)
- (b) phone transmits signal (to identify itself) (1)
signal received by (several) base stations (1)
transferred to cellular exchange (1)
computer selects base station with strongest signal (1)
assigns a (carrier) frequency (1)
(any four, 1 each, max 4) B4 [4]

Q10.

- 11 (a) frequency of carrier wave varies (in synchrony) with signal M1
(in synchrony) with displacement of signal A1 [2]
- (b) advantages e.g. less noise / less interference
greater bandwidth / better quality
(1 each, max 2)
disadvantages e.g. short range / more transmitters / line of sight
more complex circuitry
greater expense
(1 each, max 2) B4 [4]

Q11.

- 12 (a) gain / loss/dB = $10 \lg(P_1/P_2)$ C1
 $190 = 10 \lg(18 \times 10^3 / P_2)$
 or $-190 = 10 \lg P_2 / 18 \times 10^3$ C1
 power = $1.8 \times 10^{-15} \text{ W}$ A1 [3]
- (b) (i) 11 GHz / 12 GHz B1 [1]
- (ii) e.g. so that input signal to satellite will not be 'swamped'
 to avoid interference of uplink with / by downlink B1 [1]

Q12.

- 12 (a) signal becomes distorted / noisy B1
 signal loses power / energy / intensity / is attenuated B1 [2]
- (b) (i) *either* numbers involved are smaller / more manageable / cover wider range
 or calculations involve addition & subtraction rather than multiplication and division B1 [1]
- (ii) $25 = 10 \lg(P_{\min} / (6.1 \times 10^{-19}))$ C1
 minimum signal power = $1.93 \times 10^{-16} \text{ W}$ C1
 signal loss = $10 \lg(6.5 \times 10^{-3} / (1.93 \times 10^{-16}))$
 = 135 dB C1
 maximum cable length = $135 / 1.6$ C1
 = 85 km so no repeaters necessary A1 [5]

Q13.

- 11 (a) frequency of carrier wave varies M1
 (in synchrony) with the displacement of the information signal A1 [2]
- (b) (i) 5.0V A1 [1]
- (ii) 640kHz A1 [1]
- (iii) 560kHz A1 [1]
- (iv) 7000 (*condone unit*) A1 [1]

Q14.

- 12 (a) e.g. acts as 'return' for the signal
shields inner core from noise / interference / cross-talk
(any two sensible answers, 1 each, max 2) B2 [2]
- (b) e.g. greater bandwidth
less attenuation (per unit length)
less noise / interference
(any two sensible answers, 1 each, max 2) B2 [2]
- (c) attenuation is 2.4 dB
attenuation = $10 \lg(P_1/P_2)$
ratio = 1.7 C1
C1
A1 [3]

Q15.

- 11 (a) e.g. unreliable communication (M1)
because ion layers vary in height / density (A1)
e.g. cannot carry all information required (M1)
bandwidth too narrow (A1)
e.g. coverage limited (M1)
reception poor in hilly areas (A1)
(any two sensible suggestions, M1 & A1 for each, max 4) [4]
- (b) signal must be amplified (greatly) before transmission back to Earth
uplink signal would be swamped by downlink signal B1
B1 [2]

Q16.

- 12 (a) (i) ratio / dB = $10 \lg(P_1 / P_2)$ C1
 $24 = 10 \lg(P_1 / \{5.6 \times 10^{-19}\})$ C1
 $P_1 = 1.4 \times 10^{-16} \text{ W}$ A1 [3]
- (ii) attenuation per unit length = $1 / L \times 10 \lg(P_1 / P_2)$ C1
 $1.9 = 1 / L \times 10 \lg(\{3.5 \times 10^{-3}\} / \{1.4 \times 10^{-16}\})$ C1
 $L = 1 \text{ km}$ A1 [3]
or
attenuation = $10 \lg(\{3.5 \times 10^{-3}\} / \{5.6 \times 10^{-19}\})$ (C1)
= 158 dB
attenuation along fibre = (158 – 24) (C1)
 $L = (158 - 24) / 1.9 = 71 \text{ km}$ (A1)
- (b) less attenuation (per unit length) / longer uninterrupted length of fibre B1 [1]

Q17.

- 13 (a) (i) no interference (between signals) near boundaries (of cells) B1 [1]
- (ii) for large area, signal strength would have to be greater and this could be hazardous to health B1 [1]
- (b) mobile phone is sending out an (identifying) signal M1
 computer/cellular exchange continuously selects cell/base station with strongest signal A1
 computer/cellular exchange allocates (carrier) frequency (and slot) A1 [3]

Q18.

- 11 (a) (i) loss of (signal) power B1 [1]
- (ii) unwanted power (on signal) that is random M1
 A1 [2]
- (b) for digital, only the 'high' and the 'low' / 1 and 0 are necessary variation between 'highs' and 'lows' caused by noise not required M1
 A1 [2]
- (c) attenuation = $10 \lg(P_2 / P_1)$ C1
either $195 = 10 \lg\{2.4 \times 10^3\} / P$
or $-195 = 10 \lg(P / 2.4 \times 10^3)$ C1
 $P = 7.6 \times 10^{-17} \text{ W}$ A1 [3]

Q19.

- 12 (a) (i) modulator B1 [1]
- (ii) serial-to-parallel converter (*accept series-to-parallel converter*) B1 [1]
- (b) (i) enables one aerial to be used for transmission and receipt of signals A1 [1]
- (ii) all bits for one number arrive at one time B1
 bits are sent out one after another B1 [2]

Q20.

- 11 (a) (i) amplitude of the carrier wave varies (in synchrony) with the displacement of the information signal M1
A1 [2]
- (ii) e.g. more than one radio station can operate in same region/less interference
enables shorter aerial
increased range/less power required/less attenuation
less distortion
(any two sensible answers, 1 each) B2 [2]
- (b) (i) frequency = 909 kHz C1
wavelength = $(3.0 \times 10^8) / (909 \times 10^3)$
= 330 m A1 [2]
- (ii) bandwidth = 18 kHz A1 [1]
- (iii) frequency = 9000 Hz A1 [1]

Q21.

- 12 (a) for received signal, $28 = 10 \lg(P / \{0.36 \times 10^{-6}\})$ C1
 $P = 2.3 \times 10^{-4} \text{ W}$ A1 [2]
- (b) loss in fibre = $10 \lg(\{9.8 \times 10^{-3}\} / \{2.27 \times 10^{-4}\})$ C1
= 16 dB A1 [2]
- (c) attenuation per unit length = 16 / 85
= 0.19 dB km⁻¹ A1 [1]

Q22.

- 12 (a) takes all the simultaneous digits for one number and 'sends' them one after another (along the transmission line) B1
B1 [2]
- (b) (i) 0111 A1 [1]
 (ii) 0110 A1 [1]
- (c) levels shown
- | | | | | | | | |
|----------|---|-----|-----|-----|-----|-----|-----|
| <i>t</i> | 0 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1.2 |
| | 0 | 8 | 7 | 15 | 6 | 5 | 8 |
- (-1 for each error or omission) A2
 correct basic shape of graph i.e. series of steps M1
 with levels staying constant during correct time intervals A1 [4]
 (vertical lines in steps do not need to be shown)
- (d) increasing number of bits reduces step height M1
 increasing sampling frequency reduces step depth / width M1
 reproduction of signal is more exact A1 [3]

Q23.

- 10 (a) (i) amplitude (modulated) (*allow 'AM'*) B1 [1]
 (ii) carrier (frequency / wave) B1 [1]
 (iii) sideband (frequency) B1 [1]
- (b) 10 kHz B1 [1]
- (c) sketch: general shape i.e. any wave that is amplitude modulated M1
 correct period for modulating waveform (200 μs) A1
 correct period for carrier waveform (20 μs) A1 [3]

Q24.

- 11 (a) carrier frequencies can be re-used (simultaneously without interference) B1
 so that number of handsets possible is increased B1
 OR anything sensible e.g. UHF used (B1)
 so 'line of sight' (B1) [2]
- (b) handset sends out an (identifying) signal M1
 communicated by base stations to (computer at) exchange A1
computer selects base station with strongest signal B1
 and allocates a (carrier) frequency B1 [4]

Q25.

- 9 (a) IR has less attenuation (per unit length) B1
 fewer (repeater) amplifiers / longer uninterrupted length B1 [2]
- (b) *either* limited range B1
 (so) cells do not overlap (appreciably) B1 [2]
or short wavelength (B1)
 so convenient length aerial (on mobile phone) (B1)
- (c) large bandwidth / large information carrying capacity B1
 different so that uplink signal not swamped by downlink B1 [2]

Q26.

- 12 (a) e.g. signal can be regeneratedM1
 so that there is minimal noiseA1
 e.g. extra data can be addedM1
 so that signal can be checked for errorsA1 [4]
 (*any two, sensible suggestions, M1 + A1, max 4*)
- (b) (i) 1101 B1 [1]
 (ii) 5 B1 [1]
- (c) (i) block X: serial-to parallel B1
 block Y: DAC / digital-to-analogue (converter) B1 [2]
- (ii) takes the simultaneous / all bits of a numberM1
 and transmits them one after another / down a single line A1 [2]
- (d) increase number of bits in digital number at each samplingM1
 so that step height is reducedA1
 increase sampling frequency / reduce time between samplesM1
 so that depth / width of step is reducedA1 [4]
 (*do not allow 'smoother output'*)

[Total: 14]

Q27.

- 11 (a) amplitude modulation(allow AM) B1 [1]
- (b) (i) frequency = 1 / period C1
= 100 kHz A1 [2]
- (ii) frequency = 10 kHz A1 [1]
- (c) (i) vertical line at 100 kHz B1
vertical lines at 90 kHz and 110 kHz B1
lines at 90 kHz and 110 kHz same length and shorter than at 100 kHz B1 [3]
- (ii) 20 kHz B1 [1]
- [Total: 8]

Q28.

- 12 (a) (i) base stations B1 [1]
- (ii) cellular exchange B1 [1]
- (b) base station / X sends / receives signal to / from handset B1
call relayed to cellular exchange / Y (and on to PSTN) B1
computer at cellular exchange monitors signal from base stations B1
selects base station with strongest signal B1
allocates a (carrier) frequency / time slot for the call B1 [5]
- [Total: 7]

Q29.

- 11 (a) (i) unwanted random power / signal / energy B1 [1]
(ii) loss of (signal) power / energy B1 [1]
- (b) (i) *either* signal-to-noise ratio at mic. = $10 \lg (P_2 / P_1)$ C1
= $10 \lg \{ (2.9 \times 10^{-6}) / (3.4 \times 10^{-9}) \}$
= 29 dB A1
maximum length = $(29 - 24) / 12$ C1
= 0.42 km = 420 m A1 [4]
- or* signal-to-noise ratio at receiver = $10 \lg (P_2 / P_1)$ (C1)
at receiver, 24 = $10 \lg (P / (3.4 \times 10^{-9}))$
 $P = 8.54 \times 10^{-7}$ W (A1)
power loss in cables = $10 \lg \{ (2.9 \times 10^{-6}) / (8.54 \times 10^{-7}) \}$ (C1)
= 5.3 dB
length = $5.3 / 12$ km
= 440 m (A1)

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- (ii) use an amplifier M1
coupled to the microphone A1 [2]
(repeater amplifiers scores no mark)

Q30.

- 12 (a) (carrier wave) transmitted from Earth to satellite (1)
satellite receives greatly attenuated signal (1)
signal amplified and transmitted back to Earth B1
at a different (carrier) frequency B1
different frequencies prevent swamping of uplink signal (1)
e.g. of frequencies used (6/4 GHz, 14/11 GHz, 30/20 GHz) (1)
(two B1 marks plus any two other for additional physics) B2 [4]
- (b) advantage: e.g. much shorter time delay M1
because orbits are much lower A1
e.g. whole Earth may be covered (M1)
in several orbits / with network (A1)
- disadvantage: e.g. *either* must be tracked
or limited use in any one orbit M1
more satellites required for continuous operation A1 [4]

Q31.

- 12 (a) (i) 1. signal has same variation (with time) as the data B1
 2. consists of (a series of) 'highs' and 'lows' B1
either analogue is continuously variable (between limits)
or digital has no intermediate values B1 [3]
- (ii) e.g. can be regenerated / noise can be eliminated
 extra data can be added to check / correct transmitted signal
 (any two reasonable suggestions, 1 each) B2 [2]
- (b) (i) analogue signal is sampled at (regular time) intervals B1
 sampled signal is converted into a binary number B1 [2]
- (ii) one channel is required for each bit (of the digital number) B1 [1]

Q32.

- 10 (a) e.g. large bandwidth/carries more information
 low attenuation of signal
 low cost
 smaller diameter, easier handling, easier storage, less weight
 high security/no crosstalk
 low noise/no EM interference
 (allow any four sensible suggestions, 1 each, max 4) B4 [4]
- (b) (i) infra-red B1 [1]
- (ii) lower attenuation than for visible light B1 [1]
- (c) (i) $\text{gain/dB} = 10 \lg(P_2/P_1)$ C1
 $26 = 10 \lg(P_2/9.3 \times 10^{-6})$
 $P_2 = 3.7 \times 10^{-3} \text{ W}$ A1 [2]
- (ii) power loss along fibre = $30 \times 0.2 = 6.0 \text{ dB}$ C1
either $6 = 10 \lg(P/3.7 \times 10^{-3})$ or $6 \text{ dB} = 4 \times 3.7 \times 10^{-3}$
or $32 = 10 \lg(P/9.3 \times 10^{-6})$
 input power = $1.5 \times 10^{-2} \text{ W}$ A1 [2]

Q33.

- 11 (a) (i) switch
so that one aerial can be used for transmission and reception M1
A1 [2]
- (ii) tuning circuit
to select (one) carrier frequency (and reject others) M1
A1 [2]
- (iii) analogue-to-digital converter/ADC
converts microphone output to a digital signal M1
A1 [2]
- (iv) (a.f.) amplifier (*not r.f. amplifier*)
to increase (power of) signal to drive the loudspeaker M1
A1 [2]
- (b) e.g. short aerial so easy to handle
short range so less interference between base stations
larger waveband so more carrier frequencies
(any two sensible suggestions, 1 each, max 2) B2 [2]

Q34.

- 12 (a) e.g. carrier frequencies can be re-used (without interference)
so increased number of handsets can be used (M1)
e.g. lower power transmitters (A1)
so less interference (M1)
e.g. UHF used (A1)
so must be line-of-sight/short handset aerial (M1)
(any two sensible suggestions with explanation, max 4) (A1)
B4 [4]
- (b) computer at cellular exchange B1
monitors the signal power B1
relayed from several base stations B1
switches call to base station with strongest signal B1 [4]

Q35.

- 11 (a) e.g. noise can be eliminated/filtered/signal can be regenerated
extra bits can be added to check for errors
multiplexing possible
digital circuits are more reliable/cheaper
data can be encrypted for security
any sensible advantages, 1 each, max. 3 B3 [3]
- (b) (i) 1. higher frequencies can be reproduced B1 [1]
2. smaller changes in loudness/amplitude can be detected B1 [1]
- (ii) bit rate = $44.1 \times 10^3 \times 16$ C1
= $7.06 \times 10^5 \text{ s}^{-1}$
number = $7.06 \times 10^6 \times 340$
= 2.4×10^9 A1 [2]

Q36.

- 12 (a) (i) signal in one wire (pair) is picked up by a neighbouring wire (pair) B1 [1]
 (ii) outer of coaxial cable is earthed B1
 outer shields the core from noise / external signals B1 [2]

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- (b) attenuation per unit length = $1/L \times 10 \lg(P_2/P_1)$ C1
 signal power at receiver = $10^{2.5} \times 3.8 \times 10^{-8}$
 $= 1.2 \times 10^{-5} \text{ W}$ C1
 attenuation in wire pair = $10 \lg(\{3.0 \times 10^{-3}\} / \{1.2 \times 10^{-5}\})$
 $= 24 \text{ dB}$ C1
 attenuation per unit length = $24 / 1.4$
 $= 17 \text{ dB km}^{-1}$ A1 [4]
(other correct methods of calculation are possible)

Q37.

- 11 (a) high frequency wave B1
 the amplitude or the frequency is varied M1
 the variation represents the information signal /
 in synchrony with (the displacement of) the information signal. A1 [3]

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- (b) e.g. shorter aerial required
 longer transmission range / lower transmitter power / less attenuation
 allows more than one station in a region
 less distortion
(allow any three sensible suggestions, 1 mark each) B3 [3]

Q38.

- 12 (a) (i) e.g. linking a (land) telephone to the (local) exchange B1 [1]
 (ii) e.g. connecting an aerial to a television B1 [1]
 (iii) e.g. linking a ground station to a satellite B1 [1]
- (b) (i) attenuation = $10 \lg (P_2 / P_1)$ C1
 total attenuation = 2.1×40 (= 84 dB) C1
 $84 = 10 \lg \{(450 \times 10^{-3}) / P\}$
 $P = 1.8 \times 10^{-9} \text{ W}$ A1 [3]
 (answer $1.1 \times 10^8 \text{ W}$ scores 1 mark only)
- (ii) maximum attenuation = $10 \lg \{(450 \times 10^{-3}) / \{7.2 \times 10^{-11}\}\}$ C1
 = 98 dB
 maximum length = $98 / 2.1$
 = 47 km A1 [2]

Q39.

- 11 (a) left-hand bit underlined B1 [1]
- (b) 1010, 1110, 1111, 1010, 1001 A2 [2]
 (5 correct scores 2, 4 correct scores 1)
- (c) significant changes in detail of V between samplings M1
 so frequency too low A1 [2]

Q40.

- 12 (a) e.g. logarithm provides a smaller number B1 [1]
 gain of amplifiers is series found by addition, (not multiplication)
 (any sensible suggestion)
- (b) (i) optic fibre B1 [1]
- (ii) attenuation/dB = $10 \lg(P_2/P_1)$ C1
 = $10 \lg\{(6.5 \times 10^{-3}) / \{1.5 \times 10^{-15}\}\}$ C1
 = 126
 length = $126 / 1.8$
 = 70 km A1 [3]

Q41.

- 11 (a) (i) *either* series of 'highs' and 'lows' or two discrete values with no intermediate values M1
A1 [2]
- (ii) e.g. noise can be eliminated (NOT 'no noise')
signal can be regenerated
addition of extra data to check for errors
larger data carrying capacity
cheaper circuits
more reliable circuits (*any three, 1 each*) B3 [3]
- (b) (i) 1. amplifier B1 [1]
2. digital-to-analogue converter (*allow DAC*) B1 [1]
- (ii) output of ADC is number of digits all at one time B1
parallel-to-serial sends digits one after another B1 [2]

Q42.

- 12 (a) e.g. no/little ionospheric reflection
large information carrying capacity
(*any two sensible suggestions, 1 each*) B2 [2]
- (b) prevents (very) low power signal received at satellite
being swamped by high-power transmitted signal M1
A1 [2]
- (c) attenuation / dB = $10 \lg(P_2/P_1)$ C1
 $185 = 10 \lg\{3.1 \times 10^3/P\}$ C1
 $P = 9.8 \times 10^{-16} \text{ W}$ A1 [3]

Q43.

- 13 (a) e.g. noise can be eliminated/waveform can be regenerated
extra bits of data can be added to check for errors
cheaper/more reliable
greater rate of transfer of data
(*1 each, max 2*) B2 [2]
- (b) receives bits all at one time B1
transmits the bits one after another B1 [2]
- (c) sampling frequency must be higher than/(at least) twice frequency to be sampled M1
either higher (range of) frequencies reproduced on the disc
or lower (range of) frequencies on phone A1
either higher quality (of sound) on disc
or high quality (of sound) not required for phone B1 [3]

Q44.

- 14 (a) reduction in power (allow intensity/amplitude) B1 [1]
- (b) (i) attenuation = 2.4×30
= 72 dB A1 [1]
- (ii) gain/attenuation/dB = $10 \lg(P_2/P_1)$ C1
 $72 = 10 \lg(P_{IN}/P_{OUT})$ or $-72 = 10 \lg(P_{OUT}/P_{IN})$ C1
 ratio = 1.6×10^7 A1 [3]
- (c) e.g. enables smaller/more manageable numbers to be used B1 [1]
 e.g. gains in dB for series amplifiers are added, not multiplied

Q45.

- 12 (a) (i) satellite is in equatorial orbit B1
 travelling from west to east B1
 period of 24 hours / 1 day B1 [3]

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- (ii) *either* uplink signal is highly attenuated B1
or signal is highly amplified (before transmission) as downlink signal B1 [2]
 prevents downlink signal swamping the uplink signal
- (b) speed of signal is same order of magnitude in both systems B1
 optic fibre link (much) shorter than via satellite M1
 time delay using optic fibre is less A1 [3]

Q46.

- 12 (a) (i) e.g. satellite communication, mobile phones, line of sight communication, wifi B1 [1]
 (ii) e.g. connection of TV to aerial, loudspeaker, microphone (if clearly identified) B1 [1]
 (iii) e.g. a.f. amplifier to loudspeaker, landline for phone B1 [1]
- (b) (i) attenuation/dB = $10 \lg (P_2/P_1)$ C1
 $-190 = 10 \lg (P_2/3.1)$
 $P_2 = 3.1 \times 10^{-19} \text{ kW}$ A1 [2]
- (ii) signal is amplified M1
 frequency is changed M1
 to prevent swamping of up-link signal by down-link (signal) A1 [3]

Q47.

- 13 (a) *either* for transmission and reception of signal M1
or switching between transmitted and received signals
either so that one aerial may be used A1 [2]
or so that transmission and reception can occur in quick succession
- (b) gives large signal for one (input) frequency M1
 (and) rejects/very small signal for all other frequencies A1 [2]

Q48.

- 12 (a) analogue: continuously variable B1
 digital: two/distinct levels only *or* 1s and 0s *or* highs and lows B1 [2]
- (b) (i) 5 A1 [1]
 (ii) 1 1 0 1 A1 [1]

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- (c) greater number of voltage/signal levels B1
 smaller step heights in reproduced signal B1
 smaller voltage/signal changes can be seen B1 [3]

Q49.

- 12 (a) analogue: continuously variable B1
digital: two/distinct levels only or 1 s and 0 s or highs and lows B1 [2]
- (b) (i) 5 A1 [1]
- (ii) 1 1 0 1 A1 [1]

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