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 <u>or</u> 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 (*–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]

Q6.

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

Q7.

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

Q8.

12 **(a)** loss / reduction in power / energy / voltage/ amplitude (of the signal) B1 [1]

(b) **(i)** attenuation = 125 × 7 = 875 dB A1 [1]

(ii) 20 amplifiers
gain = 20 × 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 station<u>s</u> (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 <u>carrier</u> wave <u>varies</u> (in synchrony) with signal M1
(in synchrony) with <u>displacement</u> of signal A1 [2]

(b) advantages e.g. <u>less</u> noise / <u>less</u> interference
<u>greater</u> 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 × 10^3 / P_2)		
or –190 = 10 lg P_2 / 18 × 10^3)	C1	
power = 1.8 × 10^{-15} 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 × 10^{-19}))	C1	
minimum signal power = 1.93 × 10^{-16} W	C1	
signal loss = 10 lg(6.5 × 10^{-3})/(1.93 × 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) 640 kHz	A1	[1]
(iii) 560 kHz	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 — C1
attenuation = $10 \lg(P_1 / P_2)$ — C1
ratio = 1.7 — 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 — B1
uplink signal would be swamped by downlink signal — 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
$P_1 = 1.4 \times 10^{-16}$ 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 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 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)	M1	
			that is random	A1	[2]
	(b)		for digital, only the 'high' and the 'low' / 1 and 0 are necessary	M1	
			variation between 'highs' and 'lows' caused by noise not required	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	
			$P = 7.6 \times 10^{-17}$ 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	M1	
			(in synchrony) with the displacement of the information signal	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 $= (3.0 \times 10^{8}) / (909 \times 10^{3})$ $= 330\,\text{m}$	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	
		$= 16\,\text{dB}$	A1	[2]
	(c)	attenuation per unit length $= 16 / 85$ $= 0.19\,\text{dB km}^{-1}$	A1	[1]

Q22.

12 (a) takes all the simultaneous digits for one number B1
and 'sends' them one after another (along the transmission line) B1 [2]

(b) (i) 0111 A1 [1]

(ii) 0110 A1 [1]

(c) levels shown

t	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 <u>uninterrupted</u> 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 regenerated	M1	
	so that there is minimal noise	A1	
	e.g. extra data can be added	M1	
	so that signal can be checked for errors	A1	[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 number	M1	
	and transmits them one after another / down a single line	A1	[2]
	(d) increase number of bits in digital number at each sampling	M1	
	so that step height is reduced	A1	
	increase sampling <u>frequency</u> / reduce time between samples	M1	
	so that depth / width of step is reduced	A1	[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

$= 10 \lg (\{2.9 \times 10^{-6}\} / \{3.4 \times 10^{-9}\})$

$= 29\,\text{dB}$ — A1

maximum length $= (29 - 24) / 12$ — C1

$= 0.42\,\text{km} = 420\,\text{m}$ — A1 [4]

or signal-to-noise ratio at receiver $= 10 \lg (P_2 / P_1)$ — (C1)

at receiver, $24 = 10 \lg(P / \{3.4 \times 10^{-9}\})$

$P = 8.54 \times 10^{-7}\,\text{W}$ — (A1)

power loss in cables $= 10 \lg(\{2.9 \times 10^{-6}\} / \{8.54 \times 10^{-7}\})$ — (C1)

$= 5.3\,\text{dB}$

length $= 5.3 / 12\,\text{km}$

$= 440\,\text{m}$ — (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 <u>back to Earth</u> — 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)**	gain/dB = $10 \lg(P_2/P_1)$	C1	
			$26 = 10 \lg(P_2/9.3 \times 10^{-6})$		
			$P_2 = 3.7 \times 10^{-3}$ W	A1	[2]
		(ii)	power loss along fibre = 30 × 0.2 = 6.0 dB	C1	
			either $6 = 10 \lg(P/3.7 \times 10^{-3})$ *or* 6 dB = $4 \times 3.7 \times 10^{-3}$		
			or $32 = 10 \lg(P/9.3 \times 10^{-6})$		
			input power = 1.5×10^{-2} W	A1	[2]

Q33.

11 (a) (i)	switch	M1	
	so that one aerial can be used for transmission and reception	A1	[2]
(ii)	tuning circuit	M1	
	to select (one) carrier frequency (and reject others)	A1	[2]
(iii)	analogue-to-digital converter/ADC	M1	
	converts microphone output to a digital signal	A1	[2]
(iv)	(a.f.) amplifier *(not r.f. amplifier)*	M1	
	to increase (power of) signal to drive the loudspeaker	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. <u>carrier</u> frequencies can be re-used (without interference)	(M1)	
	so increased number of handsets can be used	(A1)	
	e.g. lower power transmitters	(M1)	
	so less interference	(A1)	
	e.g. UHF used	(M1)	
	so must be line-of-sight/short handset aerial	(A1)	
	(any two sensible suggestions with explanation, max 4)	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	
	$= 7.06 \times 10^5\ s^{-1}$		
	number $= 7.06 \times 10^6 \times 340$		
	$= 2.4 \times 10^8$	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 = $10^{2.5} \times 3.8 \times 10^{-8}$
= 1.2×10^{-5} W C1
attenuation in wire pair = $10\lg(\{3.0 \times 10^{-3}\}/\{1.2 \times 10^{-5}\})$
= 24 dB C1
attenuation per unit length = 24 / 1.4
= 17 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 × 10^{-3}} / P)		
		P = 1.8 × 10^{-9} W	A1	[3]
		(*answer 1.1 ×10^{8} W scores 1 mark only*)		
	(ii)	maximum attenuation = 10 lg ({450 × 10^{-3}} / {7.2 × 10^{-11}})		
		= 98 dB	C1	
		maximum length = 98/2.1		
		= 47 km	A1	[2]

Q39.

11 (a)	left-hand bit underlined	B1	[1]
(b)	1010, 1110, 1111, 1010, 1001		
	(*5 correct scores 2, 4 correct scores 1*)	A2	[2]
(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 gain of amplifiers is series found by addition, (not multiplication) (*any sensible suggestion*)	B1	[1]
(b)	(i)	optic fibre	B1	[1]
	(ii)	attenuation/dB = 10 lg(P_2/P_1)	C1	
		= 10 lg({6.5 × 10^{-3}}/{1.5 × 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 × 10^3}/P) — C1
$P = 9.8 \times 10^{-16}$ 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		
e.g. gains in dB for series amplifiers are added, not multiplied	B1	[1]

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		
or signal is highly amplified (before transmission) as downlink signal	B1	
prevents downlink signal swamping the uplink signal	B1	[2]
(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) –190 = 10 lg $(P_2/3.1)$ $P_2 = 3.1 \times 10^{-19}$ kW	C1 A1	 [2]
		(ii)	signal is amplified frequency is changed to prevent swamping of up-link signal by down-link (signal)	M1 M1 A1	 [3]

Q47.

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

Q48.

12	(a)		analogue: continuously variable digital: two/distinct levels only *or* 1 s and 0 s *or* highs and lows	B1 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 smaller step heights in reproduced signal smaller voltage/signal changes can be seen	B1 B1 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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(c)	greater number of voltage / signal levels	B1	
	smaller step heights in reproduced signal	B1	
	smaller voltage / signal changes can be seen	B1	[3]