Mark schemes

1.

(a) Photoconductive mode

Accept 'reverse bias'

1

(b) Dark currents will become a source of noise – need to keep S:N as high as possible OWTTE

OR

Need to have a large difference in signal when detector is in light and dark ✓

Must include idea of 'noise'

OR

Must include concept of large signal change to represent digital signal

1

(c) At 850 nm, R_λ = 0.50 A/W ✓

Reading from graph

Allow 0.49 A/W to 0.51 A/W

Using $R_\lambda = \frac{I_p}{P}$ $I_p = R_\lambda \times P$ $0.50 \times 4 \times 10^{-6} = 2\ \mu A$ ✓ ecf

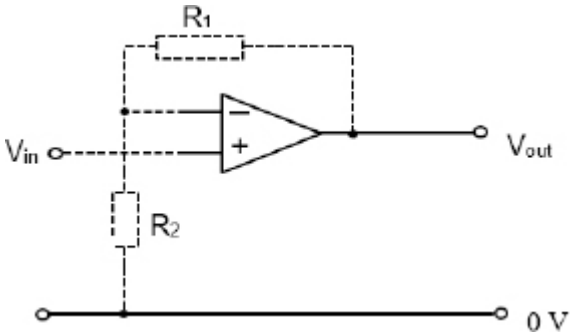
$V_{out} = I_p \times R$ 2 μA × 560 kΩ = +1.12 V ✓

Accept voltage in range of 1.10 V to 1.14 V

Accept value without + sign

3

(d)



Correct configuration of R_1 and R_2 ✓

R_1 : R_2 ratio 3 : 1 in suggested range ✓

Label the input point which must have a direct connection to the non-inverting input ✓

One mark only

An inverting op amp configuration with a voltage gain –4.

3

[8]

2. **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	QoWC
L3 5–6 marks	All bullet points in the question are covered in detail. The candidate shows good knowledge and uses 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 and will appreciate the impact of the technology on society.	The student presents relevant information coherently, employing structure, style and sp&g to render meaning clear. The text is legible.
L2 3–4 marks	All of the main processes are addressed and most of the detail is present. There may be an understanding of the impact of the technology on society. There will be some structure, but may be brief or unclear in parts.	The student presents relevant information and in a way which assists the communication of meaning. The text is legible. Sp&g are sufficiently accurate not to obscure meaning.
L1 1–2 marks	A limited answer with significant detail missing. The impact on society may be stated basically but not developed. Candidates may be able to recall some technical terms, but these may be used without expansion or understanding. The material may lack organisation.	The student presents some relevant information in a simple form. The text is usually legible. Sp&g allow meaning to be derived although errors are sometimes obstructive.
0	The work contains no significant analysis of the question asked.	The student's presentation, spelling, punctuation and grammar seriously obstruct understanding.

Expected information:

***Quantisation** – the conversion of a continuously varying voltage level by sampling into one that contains discrete (stepped) voltage levels*

Factors affecting quality of conversion

i) Sampling rate:

• The number of times/second that the analogue signal is assigned a digital code

*• Audio requires a sample rate = 2 × highest frequency component -------- **(Nyquist rate)***

*• Under sampling will cause a loss in quality. -------- **(Aliasing)***

• Over sampling results in superfluous data

ii) Size of digital code:

*• Number of bits per sample determines smallest change in analogue signal that can cause a change in digital code – ---------- **resolution***

*• **CD** – standard is 16 bits*

The combination of these two factors will determine the amount of data generated in the conversion process. The quantity of data will be very large and will probably require compression techniques to be applied

Advantages of a digital format:

• Good noise immunity

• Digital recordings don't degrade with frequent use in the same way as analogue recordings (Tape v CD)

• Digital files can be saved and manipulated by computer

• Can be coded for downloading across the Internet

Disadvantages of a digital format

• Can be conceived as being too clinical

• Data can become corrupt

• Format compatibility issues

Further points:

Why digital is dominant format in the recording industry

• V. good digital system is cheaper than v. good analogue system

• Scratch resistant format even on CDs

• Development of small personal music devices

• Development of downloads using personal computer

• Development of higher density storage devices (CD to SSD)

[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

(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

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4. (a)

comparator	✓
differential amplifier	
inverting amplifier	
non-inverting amplifier	

1

(b) Photodiode current from graph = 80 μA ✓

Allow ± 5 μA in reading from the graph

Voltage across resistor V_R
$V_R = I \times R = 80 \times 10^{-6} \times 39 \times 10^3$
$V_R = 3.12$ V ✓

Allow a V_R = 2.93 V to 3.32 V

Voltage at non-inverting pin (V_+) = (5 – 3.12) = 1.88 V ✓

Allow a V_+ value of 2.07 V to 1.68 V

3

(c) Voltage at inverting pin (V–) is 2.2 V ✓
V– > V+ so output is low / 0 V so LED will light / on ✓

First mark *is for correct value of (V–)*

Second mark *is for correct application / conclusion using V_+ = 1.9 V together with their value for (V–)*

2

[6]

5. (a) Numerical value for capacitor = 6.9 pF ✓

Substitution of values into formula alone – not sufficient for mark.

1

(b) Y and X most suitable / (W and Z out of range) ✓

Y better than X as value falls within centre of range. ✓

implied choice – 1 mark

reason – 1 mark

2

(c) Evidence of reading at 0.7 V_{max} (350 mV) ✓

Bandwidth 20 kHz ✓ Allow range (19–21 kHz)

1 mark only for:

Evidence of reading at 0.5 V_{max} (250 mV)

Bandwidth 25 kHz ✓ Allow range (24–26 kHz)

2

(d) $Q = f_0 / f_B$ = 198 kHz / 20 kHz = 9.9 ✓

Allow ecf from (c)

1

(e) **Either:**

Listener hears overlapping stations - due to increase in bandwidth. ✓

Or

Listener hears station more faintly - due to energy loss / wider energy distribution ✓

Accept S/N argument as weaker stations become more prominent and can be considered as noise.

1

[7]

6. (a) $f = 1 / (2\pi \sqrt{LC})$

$C = 1/ f^2 4\pi^2 L$

$C = 1/ (910 \times 10^3)^2 \times 4 \times \pi^2 \times 1.1 \times 10^{-3}$

$C = 27.8$ pF (accept 28pF)

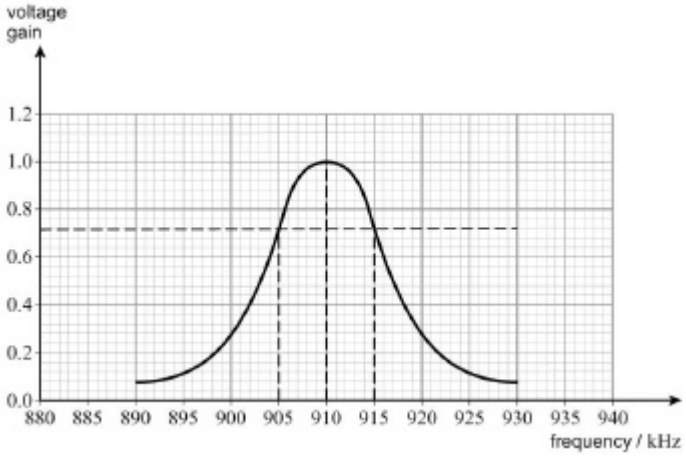
Formula with correct substitution / evidence of correct working

Answer

1

1

(b)



General shape around f_0 and to max of 1.0 on relative voltage gain axis

1

10 kHz bandwidth

at 0.71 gain

1

Frequencies (905 – 910 – 915) kHz (identified / used)

1

(c) Smaller Q factor leads to:

(Any **two** from)
(i) Broader bandwidth
(ii) More noise / (hiss) detected
(iii) Less selectivity
(iv) More susceptible to crosstalk from neighbouring stations on the frequency spectrum.
(v) Less gain due to energy loss / loss of signal detail

2

[7]