Mark schemes

Q1.

(a) V_R = 5 V chosen and idea that the photocurrent increases linearly/ most throughout the light intensity change ✓

$(2 \times 10^{-5} - 5 \times 10^{-6})$ A OR $(20 \times 10^{-6} - 5 \times 10^{-6})$ A

Change in photocurrent = 15×10^{-6} A ✓

MP1 for reason of choice

MP2 for answer

*If no other mark awarded, allow **1 MAX** for identification of V_R = 1V and answer in range 5 to 6 $\times 10^{-6}$ A.*

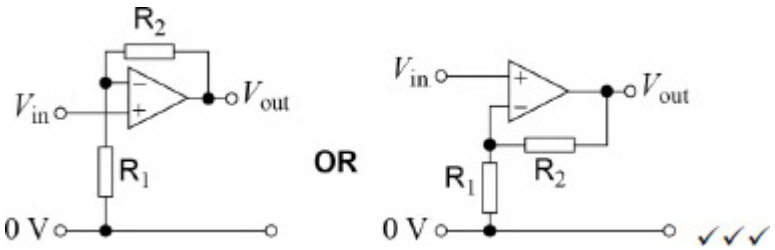
2

(b) Atomic particles need to interact with scintillation material to produce light ✓

Photodiode is used in photoconductive mode / with reverse bias ✓

2

(c)



✓✓✓

1st mark for correct configuration

2nd mark for only two resistors seen, in the ratio 9 : 1 for R_2:R_1

3rd mark:

- *output labelled*
- *resistor values within suggested range*

3

[7]

Q2.

(a) Method indicated for calculation of potential at **X** ✓

***MP1**: expect to see use of potential divider formula / other method (e.g V=IR) explained*

Correct calculation to give voltage at **X** = 5.00(125) V ✓

MP2**: Correct calculation for potential at **X

Reading = their value for potential at **X** - 5 V ✓

***MP3**: Expect to see 1.25 mV*

Allow 1.2 mV or 1.3 mV to 2 sf.

3

(b) A resistor (used instead of strain gauge **B)** would not have same response to temperature changes as strain gauge **A**

OR

Using strain gauge **B** will have same response to temperature as strain gauge **A** ✓

By using two strain gauges the (voltmeter) reading will only be affected by changes in strain (as temperature effects will cancel)

OR

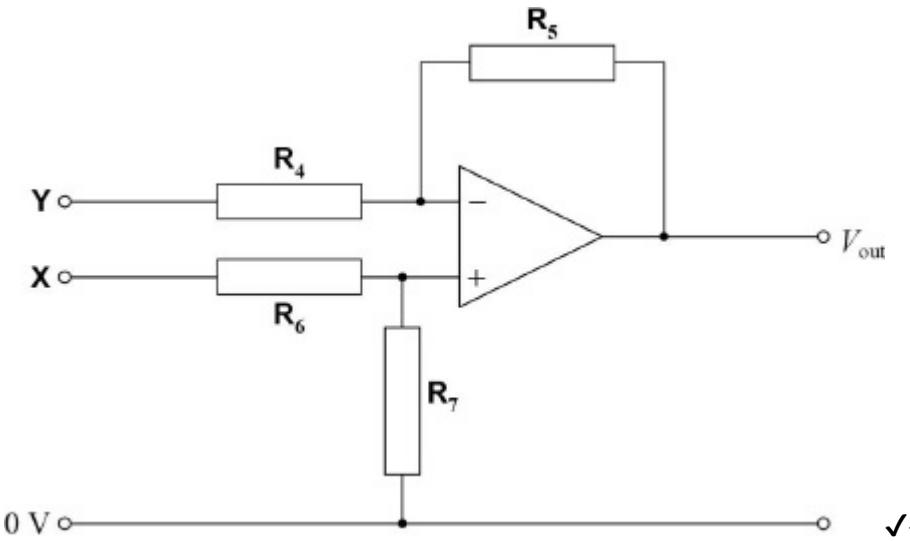
use of a resistor will cause the (voltmeter) reading to change due to strain and temperature changes ✓

Do not allow just the phrase:

'for temperature compensation'

2

(c)



✓✓✓

MP1: *for correct configuration*

Condone incorrect op amp terminal signs in ***MP1****.*

MP2: *for* ***X*** *and* ***Y*** *leading to correct op amp terminals.*

MP3: *for* $R_5/R_4 = R_7/R_6 = 5$

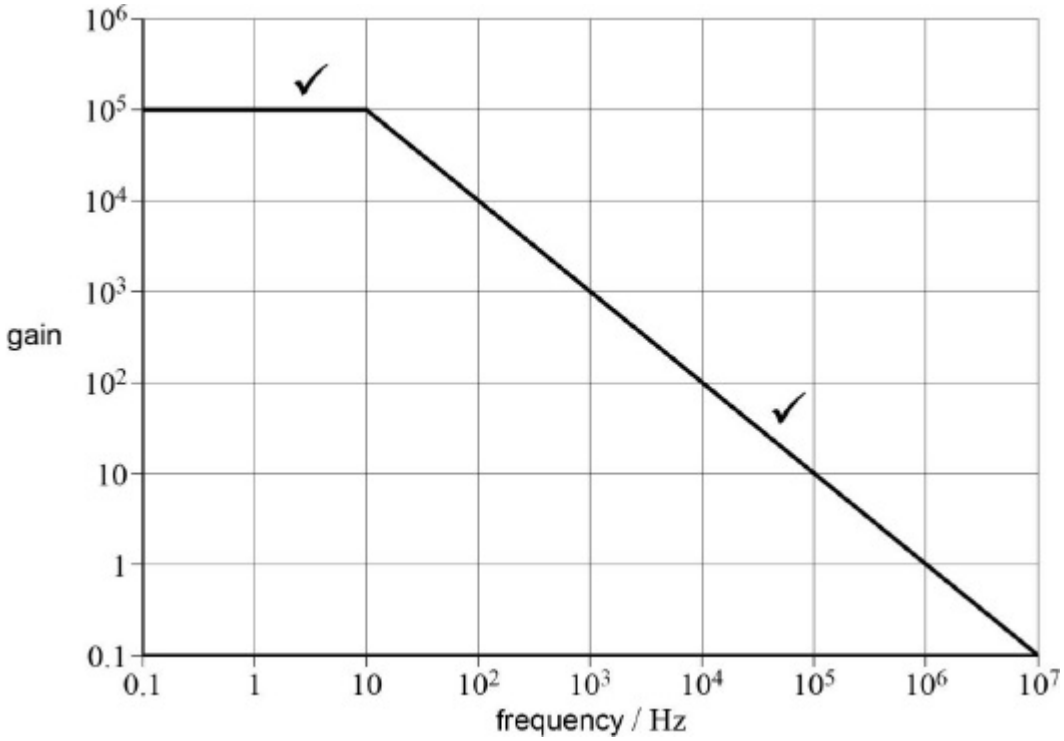
Do not award ***MP3*** *if any resistance value is outside the range (10 kΩ-10 MΩ)*

3

[8]

Q3.

(a)



MP1:

Flat top at gain = 10^5 *from 0.1-10 Hz*

Accept either sharp or rounded break frequency roll-off

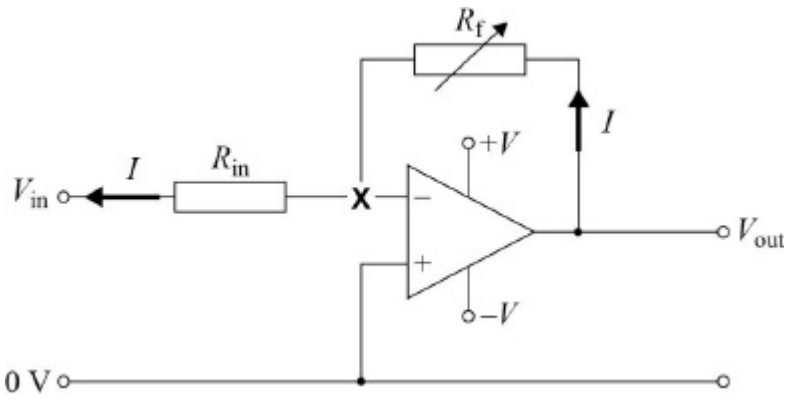
MP2:

Slope from end of flat down through unity gain and 10^6 *Hz*

Do not penalise if line not taken beyond unity gain and 10^6 *Hz*

2

(b)



***MP1**: for placing **X on a wire** somewhere between R_{in} and R_f and the inverting input.*

***MP2:** for showing **I** in the correct direction through both R_f and R_{in}*

2

(c) (Since the gain of the amplifier in this mode is $\frac{-R_f}{R_{in}}$)

(As R_f increases) the (closed loop voltage) gain increases ✓

(As gain increases then) bandwidth decreases ✓

If no other mark given, allow 1 mark for decrease in gain giving increase in bandwidth

2

[6]

Q4.

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.

Mark	Criteria
L3 6 marks	All three areas covered with at least two aspects covered in some detail. 6 marks can be awarded even if there is an error and/or parts of one aspect missing.
L3 5 marks	A fair attempt to analyse all three areas. If there are several errors or missing parts, then 5 marks should be awarded.
L2 4 marks	Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be gaps, there should only be an occasional error.
L2 3 marks	One area discussed and one discussed partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.
L1 2 marks	Only one area discussed or makes a partial attempt at two areas.
L1 1 marks	None of the three areas covered without significant error. Response is likely to show weakness in technical detail.
L1 0 marks	No relevant analysis.

The following information is likely to appear in the answer statements.

Component A - Zener diode

Role in circuit

- Used to provide a reference voltage for component B.
- Reference voltage set at a value below the noise level / to exclude the noise on the signal.

Useful characteristic properties

- Used in reverse bias mode.
- Produces a fixed reverse breakdown voltage.

Component B - operational amplifier

Role in circuit
- Used as a comparator.
- Output will saturate high when the input signal is larger than the reference voltage (V+ > V-).
- Output will drop to zero volts when the signal voltage is below the level of the reference voltage (V+ < V-).

Useful characteristic properties
- Very high open loop gain which provides saturation for very small voltage difference at the inputs.
- Very high input resistance - negligible load on input signals.
- Produces a clean switching pulse at the output when signal voltage transits the reference voltage.

Component C - MOSFET

Role in circuit
- Acts as a voltage-controlled switch.

Useful characteristic properties
- The MOSFET is a voltage-controlled device.
- Has a very high input resistance to interface with comparator (draws negligible current from the comparator).
- Low drain-source resistance when ON leads to very little power dissipated in the MOSFET.
- Can be considered as a current amplifier

[6]

Q5.

(a) Label the virtual earth point eg X, **on** the junction between the two resistors ✓

*Allow the centre of the 'X' to be placed **on** any of the three lines leading to the op amp inverting input junction.*

Do not allow an 'X' in space unless accompanied by unambiguous arrow.

1

(b) Set up equation for $I = V_{in} / R_{in} = - V_{out} / R_f$ then rearrange ✓

Reason to support setting up of equation ✓

Second mark given only if reason provided for one of:

I through R_{in} = I through R_f (Infinite input impedance)

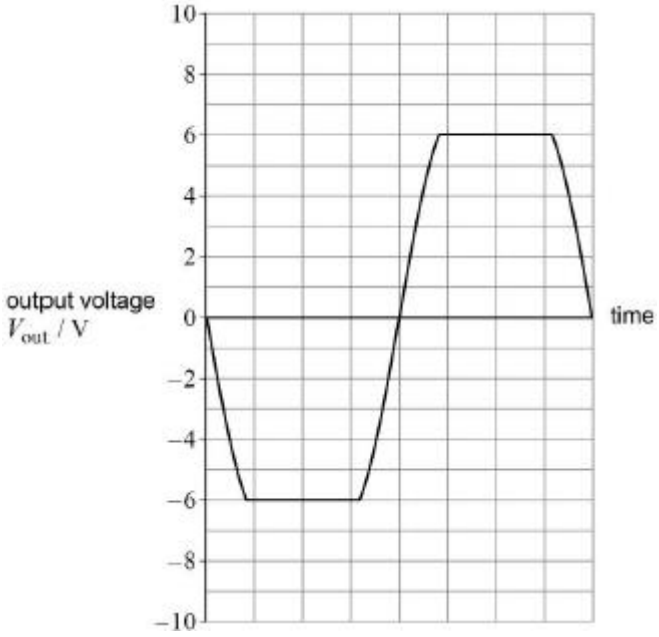
–ve sign (Virtual earth point used)

2

(c) Inverted sine wave of same period as signal shown in Fig 2A ✓

Attempt to use a gain of 20

and show a Cut-off/plateau at ± 6 V ✓

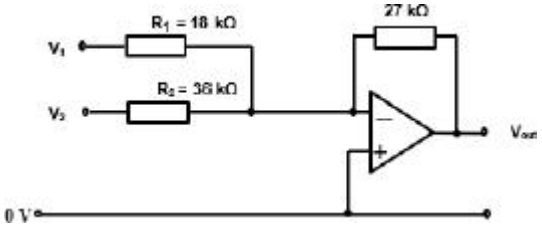


2

(d) 1 mark for correct connection of resistor R_1 and R_2 ✓

1 mark for correct values of R_1 and R_2 ✓

1 mark for values correct way round – referenced to V_1 and V_2 ✓



3

[8]