Access Tuition

A-Level Physics

Discrete Semiconductor Devices

Mark Scheme

Time available: 73 minutes
Marks available: 42 marks

1. (a) Silicon dioxide layer ✓

Accept Silicon dioxide

1

(b)

drain	☐
gate	☐
source	✓

1

(c) For lamp $P = I^2 R$

$I = \sqrt{(P/R)} = \sqrt{(0.65\ \text{W} / 154\ \Omega)} = 65\ \text{mA}$ ✓$_1$

Must use $P = I^2 R$

This leads to a voltage across the lamp of approx 10 V and a V_{DS} of approx 2 V

Read from graph to give $V_{GS} = 3.4$ V ✓$_2$

Accept a V_{GS} *range of 3.3 V to 3.5 V*

2

(d) Current consumption on stand-by: $8.5 \times 10^9 \times 10 \times 10^{-9} = 85$ A ✓1

Makes a meaningful calculation (one which can lead to a conclusion) using data for the CPU.

Battery life: 3600 C × 3.110 = 1.12×10^4 C ✓$_2$

Makes a meaningful calculation (one which can lead to a conclusion) using data for battery.

Use $1.12 \times 10^4 = 85 \times t$

Gives t = 131.8 seconds (accept 132 seconds OR just over 2 mins) which is much less than 12 hours ✓$_3$

Uses the value of t to reach a valid conclusion

OR

Uses the values of the currents from the CPU and battery to reach a valid conclusion

3

[7]

2. (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 $R_\lambda = \dfrac{I_p}{P}$ $\quad I_p = R_\lambda \times P \quad 0.50 \times 4 \times 10^{-6} = 2\ \mu A$ ✓ ecf

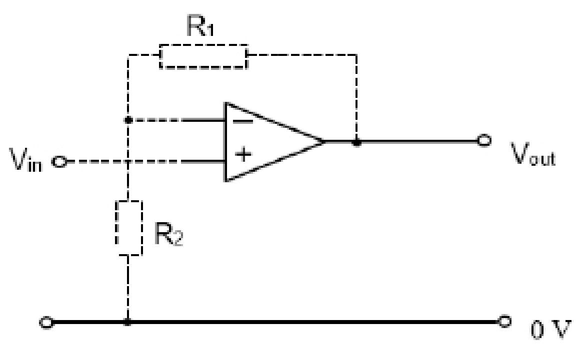
$V_{out} = I_p \times R$ 2 μA × 560 kΩ = +1.12 V ✓

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]

3. (a) **With the north pole facing the sensor:**

Higher sensitivity/larger gradient ✓ over very short range ✓
Some ambiguity in liquid level due to peak in graph – (more than one level referenced to a single output reading) ✓

OR

With the south pole facing the sensor:

Less sensitivity/smaller gradient ✓ but covers a larger range ✓
No ambiguity in liquid level – (each level produces a discrete output up to saturation) ✓

Mark awarded for each compared point

3

(b) 2.4 divisions @ 5 ms / div = 12 ms

Periodic time T = 12 ms × 3 = 36 ms ✓

Or

7.2 divisions @ 5 ms / div = 36 ms

$f = 1 / T$; f = 1 / 36 ms ; 27.8 rev / sec ✓

27 full revolutions in one second ✓

One mark for appropriate reading from graph to produce periodic time (T).

One mark for frequency using their (T).

One mark for rounding down

3

[6]

4. (a) +ve knee develops at 0.7 V and does not exceed 1.5 V at 30 mA ✓

–ve knee develops at 5.1 V; 5 mA with near vertical drop. Does not exceed – 5.5 V at –30 mA ✓

2

(b) Zener diode provides a reference voltage for non-inverting input ✓

Or

Zener diode provides a stabilised voltage for non-inverting input ✓

Accept combination of the two statements

1

(c) **I = V/R** = 3.9 V / 100 Ω = 39 mA

This is larger than the minimum current to make Zener diode work so the resistor value is fine. ✓

P = I² R = $(39 \times 10^{-3})^2 \times 100$ = 0.152 watts

This is greater than the power rating for the resistor, so is not a suitable power rating for the resistor ✓

*Ecf from value of **I***

2

(d) The reference voltage at the non-inverting input is now smaller ✓

This will cause the output **W** to switch at a lower light intensity than before ✓

2

(e) $Q = (\overline{X + Y}) . W$ ✓

Accept transformations eg

$Q = \overline{X} . (\overline{Y + \overline{W}})$

$Q = \overline{X} . Y . \overline{W}$

1

(f) MOSFET has large input impedance

OR

MOSFET causes no loading of the logic gate output. ✓

1

[9]

5. (a) High input resistance ✓

low / no energy consumption when in the ON and OFF states✓
OR
No input current / control by pd only.

2

(b) Prevents static charge building up on gate (-source capacitor) ✓
Makes gate voltage 0 V when no water / nothing between probes ✓

2

(c) Identifies or attempts to use potential divider equation ✓

2.4 = 12 x 1 / (R_{probes} +1) leading to R_{probes} = 9.6 / 2.4 = 4 MΩ ✓

2

[6]

6. (a) Photoconductive (accept reverse bias)

1

(b)

	Tick (✓) if correct
Non-inverting amplifier	
Comparator	✓
Summing amplifier	
Difference amplifier	

1

(c) Light level ~ 1000 lux +/- 10%

1

(d) V_x = IR; V_x = 100 μA × 20 kΩ = 2 V

1

(e) Rule that if $V_- > V_+$ then V_{out} is 0 V (low)

1

Voltage drop across LED so LED is ON

Do not allow LED is ON if supported by incorrect reason

1

[6]