# Sensing Devices

## Mark Scheme 1

| | |
|---|---|
| **Level** | International A Level |
| **Subject** | Physics |
| **Exam Board** | CIE |
| **Topic** | Current of Electricity |
| **Sub Topic** | Sensing Devices |
| **Paper Type** | Theory |
| **Booklet** | Mark Scheme 1 |

**Time Allowed:** **66 minutes**

**Score:** **/55**

**Percentage:** **/100**

| A* | A | B | C | D | E | U |
|---|---|---|---|---|---|---|
| >85% | '77.5% | 70% | 62.5% | 57.5% | 45% | <45% |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | **(a)** | $V/E = R/R_{tot}$ | or | $0.5 = I \times 3900$ | C1 | |
| | | $1.0/1.5 = R/(R + 3900)$ | or | $1.0 = 0.5R/3900$ | 1 | |
| | | $R = 7800\Omega$. | or | $R = 7800\Omega$ | A0 | **[2]** |
| | **(b)** | $V = 1.5 \times (7800/\{7800 + 1250\})$ | or | $I = 1.5/(7800 + 1250)$ | C1 | |
| | | $= 1.29$ V.. | or | $V = IR = 1.29$ V | A1 | **[2]** |
| | **(c)** | Combined resistance of R and voltmeter is 3900 Ω | | | C1 | |
| | | reading at 0 °C is 0.75 V | | | A1 | **[2]** |
| | | | | **Total** | | [6] |

2 **(a** $V_B = 1000$ mV
when strained, $V_A = 2000 \times 121.5/(121.5 + 120.0)$
$= 1006.2$ mV
change = 6.2 mV (*allow 6 mV)* A1 [3]

**(b) (** **1.** resistor between $V_{IN}$ and $V^-$ **and** $V^+$ connected to earth B1
resistor between $V^-$ and $V_{OUT}$ B1 [2]

**2.** P / + sign shown on earth side of voltmeter B1 [1]

**(ii)** ratio of $R_F / R_{IN} = 40$ M1
$R_{IN}$ between 100 Ω and 10 kΩ A1 [2]
*(any values must link to the correct resistors on the diagram)*

3 **(a (i)** light-dependent resistor/LDR B1 [1]

**(ii)** strain gauge B1 [1]

**(iii)** quartz/piezo-electric crystal B1 [1]

**(b) (** resistance of thermistor decreases as temperature increses M1
*etiher* $V_{OUT} = V \times R / (R + R_T)$
*or* current increases <u>and</u> $V_{OUT} = I R$ A1
$V_{OUT}$ increases A1 [3]

**(ii)** *either* change in $R_T$ with temperature is non-linear
*or* $V_{OUT}$ is not proportional to $R_T$/ change in $V_{OUT}$ with $R_T$ is non-linear M1
so change is non-linear A1 [2]

| | | | | |
|---|---|---|---|---|
| 4 | **(a** | 30 litres → 54 litres *(allow ± 4 litres on both limits)* | A1 | [1] |
| | **(b)** | only 0.1 V change in reading for 10 litre consumption *(or similar numbers)* | B1 | |
| | | above about 60 litres gradient is small compared to the gradient at about 40 litres | B1 | [2] |
| | **(ii)** | voltmeter reading (nearly) zero when fuel is left | C1 | |
| | | voltmeter reads only about 0.1 V when 10 litres of fuel left in tank | A1 | [2] |
| | | *("voltmeter reads zero when about 4 litres of fuel left in tank" scores 2 marks)* | | |
| 5 | **(a)** | any value greater than, or equal to, 5 kΩ | B1 | [1] |
| | **(b) (i)** | 'positive' shown in correct position | B1 | [1] |
| | **(ii)** | $V^+ = (500/2200) \times 4.5$ | | |
| | | $\approx 1\,V$ | B | |
| | | $V^- > V^+$ so output is negative | M1 | |
| | | green LED on, (red LED off) | A1 | [3] |
| | | *(allow full ecf of incorrect value of $V^+$)* | | |
| | **(iii)** | *either* $V^+$ increases *or* $V^+ > V^-$ | M1 | |
| | | green LED off, red LED on | A1 | [2] |
| 6 | **(a)** | <u>thin / fine</u> metal wire | B1 | |
| | | lay-out shown as a grid | B1 | |
| | | encased in plastic | B1 | [3] |
| | **(b) (i)** | gain (of amplifier) | B1 | [1] |
| | **(ii)** | for $V_{OUT} = 0$, then $V^+ = V^-$ *or* $V_1 = V_2$ | C1 | |
| | | $V_1 = (1000/1125) \times 4.5$ | C1 | |
| | | $V_1 = 4.0\,V$ | A1 | [3] |
| | **(iii)** | $V_2 = (1000 / 1128) \times 4.5$ | | |
| | | $= 3.99\,V$ | C1 | |
| | | $V_{OUT} = 12 \times (3.99 - 4.00)$ | | |
| | | $= (-)\ 0.12\,V$ | A1 | [2] |

7 **(a)** **(i)** strain gauge B1 [1]

**(ii)** piezo-electric / quartz crystal / transducer B1 [1]

**(b)** circuit: coil of relay connected between sensing circuit output and earth B1
switch across terminals of external circuit B1
diode in series with coil with correct polarity for diode B1
second diode with correct polarity B1 [4]

8 **(a)** resistance of wire = $\rho L / A$ ..... B1
as crack widens, $L$ increases .....M1
and $A$ decreases .....M1
so resistance increases ..... A0 [3]

**(b)** $\Delta L / L = \Delta R / R$ ..... B1
$= (146.2 - 143.0) / 143.0 \times 100$ ..... C1
$\Delta L / L = 2.24\%$ ..... A1 [3]

**[Total: 6]**