

Sensing Devices

Question paper 1

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Current of Electricity
Sub Topic	Sensing Devices
Paper Type	Theory
Booklet	Question paper 1

Time Allowed: 66 minutes

Score: /55

Percentage: /100

CHEMISTRY ONLINE

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

- 1 A thermistor has resistance $3900\ \Omega$ at $0\ ^\circ\text{C}$ and resistance $1250\ \Omega$ at $30\ ^\circ\text{C}$. The thermistor is connected into the circuit of Fig. 8.1 in order to monitor temperature changes.

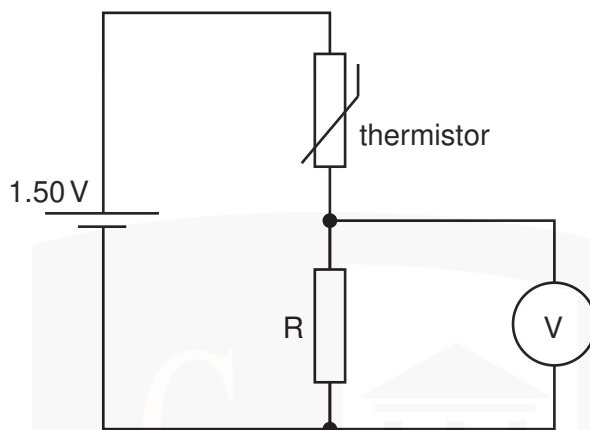


Fig. 8.1

The battery of e.m.f. $1.50\ \text{V}$ has negligible internal resistance and the voltmeter has infinite resistance.

- (a) The voltmeter is to read $1.00\ \text{V}$ at $0\ ^\circ\text{C}$. Show that the resistance of resistor R is $7800\ \Omega$.

[2]

- (b) The temperature of the thermistor is increased to $30\ ^\circ\text{C}$. Determine the reading on the voltmeter.

reading = V [2]

- (c) The voltmeter in Fig. 8.1 is replaced with one having a resistance of $7800\ \Omega$. Calculate the reading on this voltmeter for the thermistor at a temperature of $0\ ^\circ\text{C}$.

reading = V [2]



- 2 (a) The strain in a beam is to be monitored using a strain gauge.
The strain gauge is included in the potential divider circuit shown in Fig. 9.1.

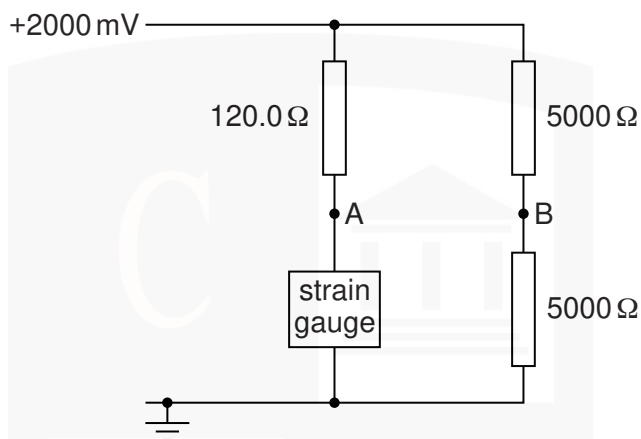


Fig. 9.1

The strain gauge has a resistance of 120.0 Ω when it is not strained. The resistance increases to 121.5 Ω when the strain is ϵ .

Calculate the potential difference between points A and B on Fig. 9.1 when the strain in the gauge is ϵ .

potential difference = mV [3]

- (b) An inverting amplifier, incorporating an operational amplifier (op-amp), uses a high-resistance voltmeter to display the output. A partially completed circuit for the amplifier is shown in Fig. 9.2.

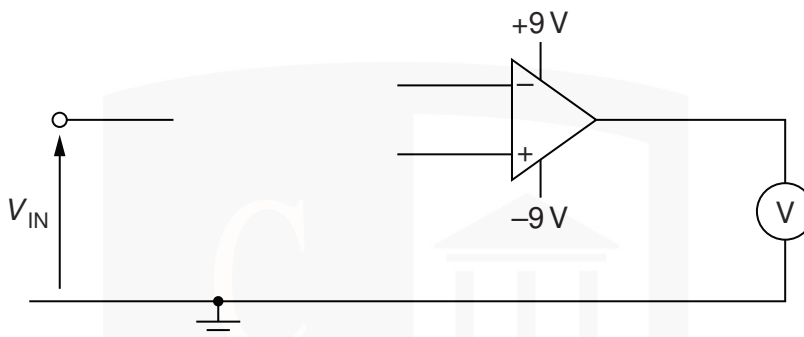


Fig. 9.2

The voltmeter is to indicate a full-scale deflection of +6.0V for an input potential V_{IN} of 0.15V.

- (i) On Fig. 9.2,
1. complete the circuit for the inverting amplifier, [2]
 2. mark, with the letter P, the positive terminal of the voltmeter. [1]
- (ii) Suggest appropriate values for the resistors you have shown in Fig. 9.2. Label the resistors in Fig. 9.2 with these values. [2]

CHEMISTRY ONLINE
— TUITION —

3 (a) Suggest electrical sensing devices, one in each case, that may be used to monitor changes in

(i) light intensity,

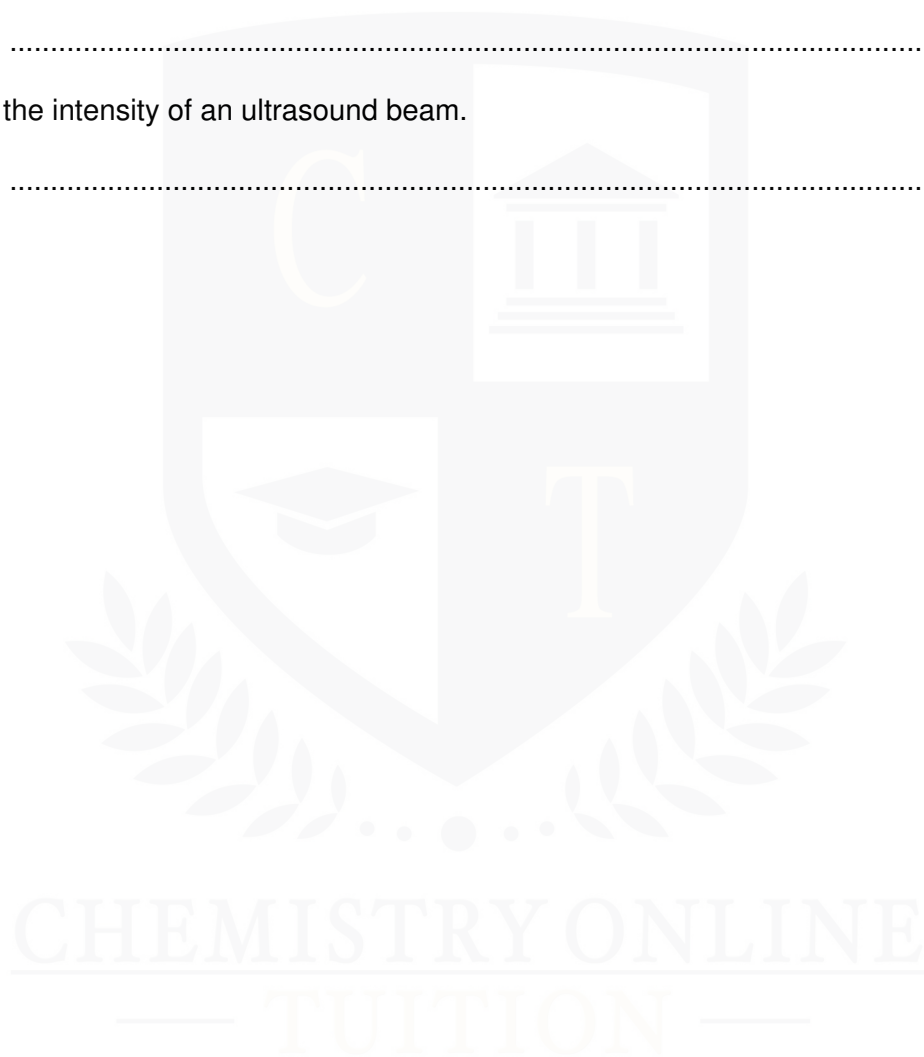
.....[1]

(ii) the width of a crack in a welded joint,

.....[1]

(iii) the intensity of an ultrasound beam.

.....[1]



- (b) A student designs the circuit of Fig. 9.1 to detect changes in temperature in the range 0°C to 100°C .

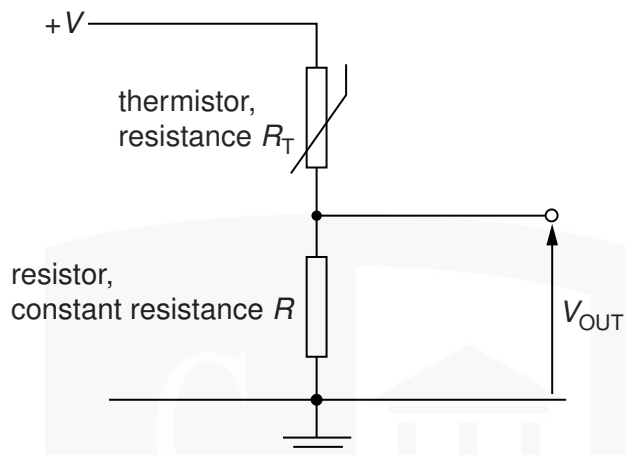


Fig. 9.1

The resistance of the thermistor is R_T and that of the resistor is R .
The student monitors the potential difference V_{OUT} .

State and explain

- (i) whether V_{OUT} increases or decreases as the temperature of the thermistor increases,

.....

[3]

- (ii) whether the change in V_{OUT} varies linearly with the change in temperature of the thermistor.

.....

[2]

- 4 The volume of fuel in the fuel tank of a car is monitored using a sensing device. The device gives a voltage output that is measured using a voltmeter. The variation of voltmeter reading with the volume of fuel in the tank is shown in Fig. 9.1.

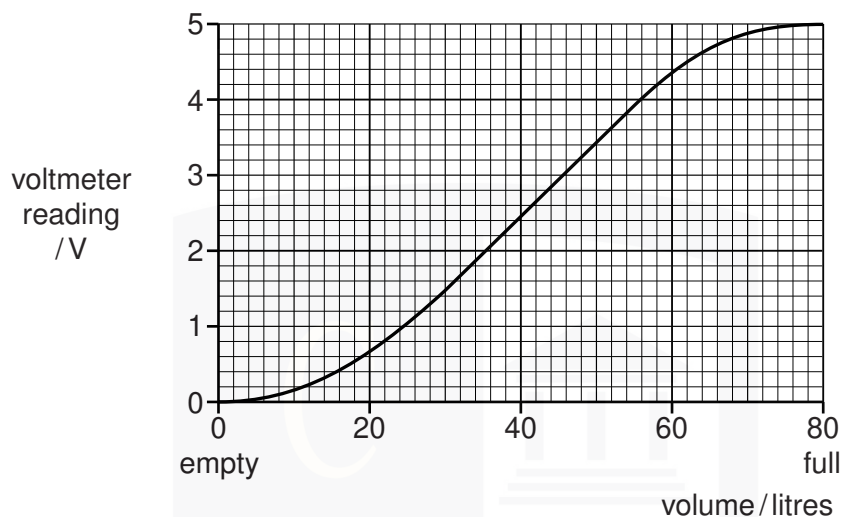


Fig. 9.1

- (a) Use Fig. 9.1 to determine the range of volume over which the volume has a linear relationship to the voltmeter reading.

from litres to litres [1]

- (b) Suggest why, comparing values from Fig. 9.1,

- (i) when the tank is nearly full, the voltmeter readings give the impression that fuel consumption is low,

.....

 [2]

- (ii) when the voltmeter first indicates that the tank is nearly empty, there is more fuel remaining than is expected.

.....

 [2]

- 5 (a) The resistance of a light-dependent resistor (LDR) is approximately $500\ \Omega$ in daylight. Suggest an approximate value for the resistance of the LDR in darkness.

resistance = Ω [1]

- (b) An electronic light-meter is used to warn when light intensity becomes low. A light-dependent resistor is connected into the circuit of Fig. 9.1.

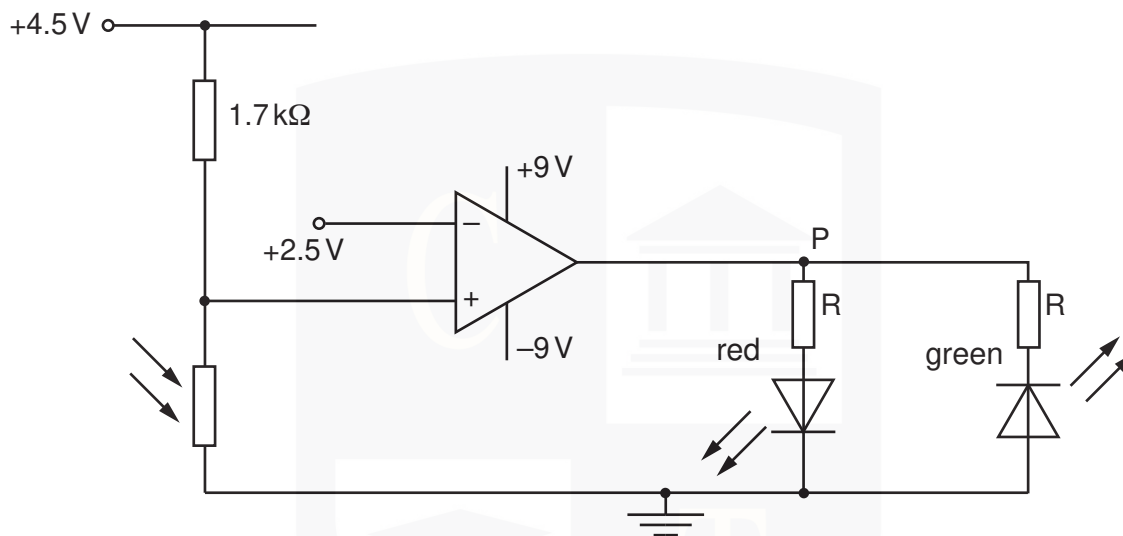


Fig. 9.1

The operational amplifier (op-amp) is ideal.

The resistors R are to ensure that the light-emitting diodes (LEDs) do not over-heat.

- (i) On Fig. 9.1, mark the polarity of the point P for the red LED to be emitting light. [1]
- (ii) The LDR is in daylight and has a resistance of $500\ \Omega$. State and explain which diode, red or green, will be emitting light.

.....

.....

.....

..... [3]

- (iii) The intensity of the light decreases and the LDR is in darkness. State and explain the effect on the LEDs of this change in intensity.

.....

.....

..... [2]

- 6 (a) Describe the structure of a metal wire strain gauge. You may draw a diagram if you wish.

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..... [3]

- (b) A strain gauge S is connected into the circuit of Fig. 9.1.

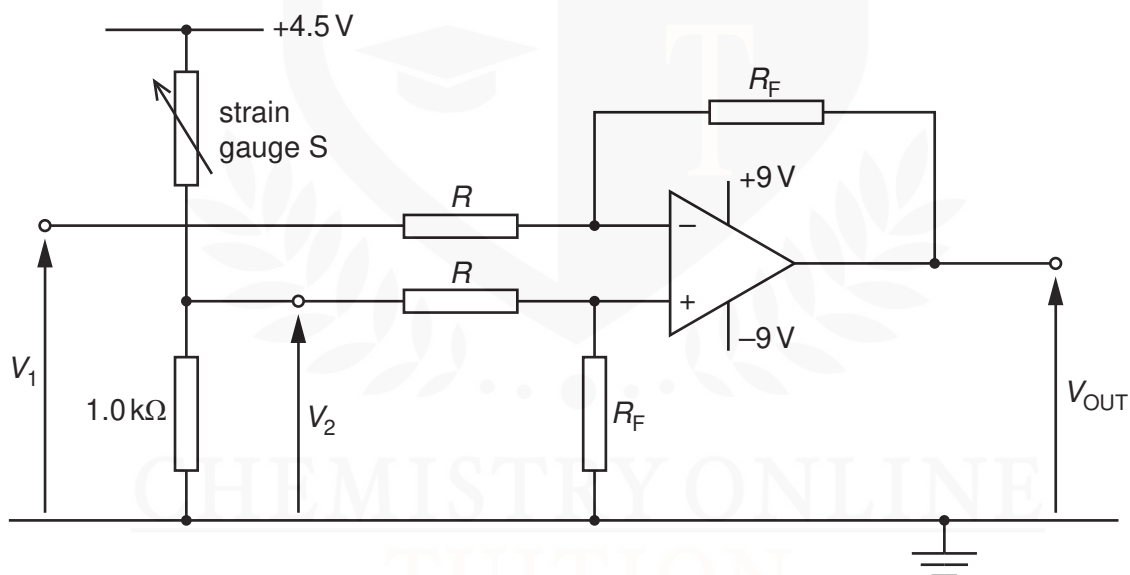


Fig. 9.1

The operational amplifier (op-amp) is ideal.

The output potential V_{OUT} of the circuit is given by the expression

$$V_{OUT} = \frac{R_F}{R} \times (V_2 - V_1).$$

- (i) State the name given to the ratio $\frac{R_F}{R}$.

..... [1]

- (ii) The strain gauge S has resistance $125\ \Omega$ when not under strain.
Calculate the magnitude of V_1 such that, when the strain gauge S is not strained, the output V_{OUT} is zero.

$$V_1 = \dots\dots\dots\text{ V [3]}$$

- (iii) In a particular test, the resistance of S increases to $128\ \Omega$. V_1 is unchanged.
The ratio $\frac{R_F}{R}$ is 12.
Calculate the magnitude of V_{OUT} .

$$V_{OUT} = \dots\dots\dots\text{ V [2]}$$

CHEMISTRY ONLINE
— TUITION —

7 (a) State the name of an electrical sensing device that will respond to changes in

(i) length,

..... [1]

(ii) pressure.

..... [1]

(b) A relay is sometimes used as the output of a sensing circuit.

The output of a particular sensing circuit is either +2 V or -2 V.

On Fig. 10.1, draw symbols for a relay and any other necessary component so that the external circuit is switched on only when the output from the sensing circuit is +2 V.



Fig. 10.1

[4]

- 8 A metal wire strain gauge is firmly fixed across a crack in a wall, as shown in Fig. 9.1, so that the growth of the crack may be monitored.

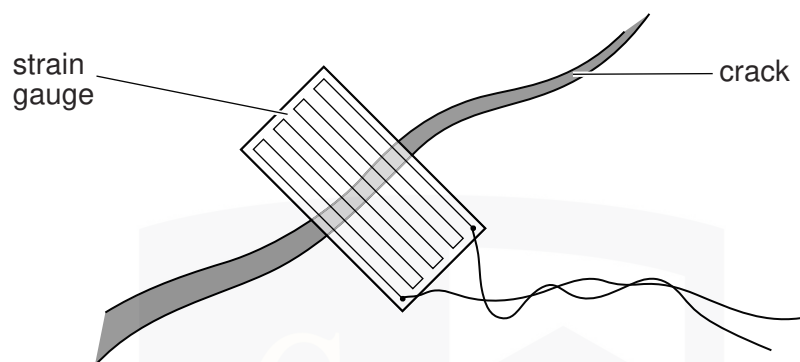


Fig. 9.1

- (a) Explain why, as the crack becomes wider, the resistance of the strain gauge increases.

.....

.....

.....

..... [3]

- (b) The strain gauge has an initial resistance of 143.0Ω and, after being fixed in position across the crack for several weeks, the resistance is found to be 146.2Ω .

The change in the area of cross-section of the strain gauge wire is negligible.

Calculate the percentage increase in the width of the crack. Explain your working.

increase = % [3]