An electronic sensor may be represented by the block diagram of Fig. 10.1.

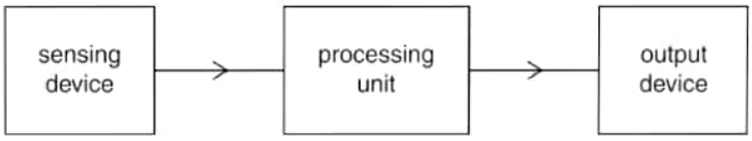

Fig. 10.1

(a) State suitable sensing devices, one in each case, for the detection of

(i) change of temperature,

..... [1]

(ii) pressure changes in a sound wave.

..... [1]

(b) The ideal operational amplifier (op-amp) shown in Fig. 10.2 is to be used as a processing unit.

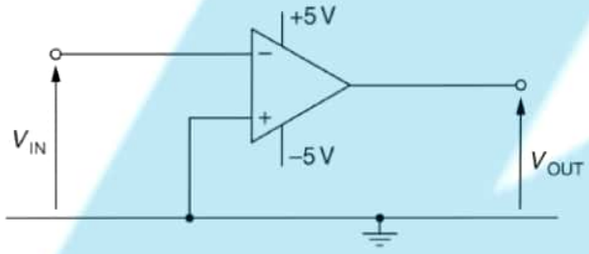

Fig. 10.2

(i) State the value of the output potential V_{OUT} for an input potential V_{IN} of +0.5 V. Explain your answer.

.....

.....

.....

..... [3]

(ii) A sensing device produces a variable potential V_{IN}.
The variation with time t of V_{IN} is shown in Fig. 10.3.

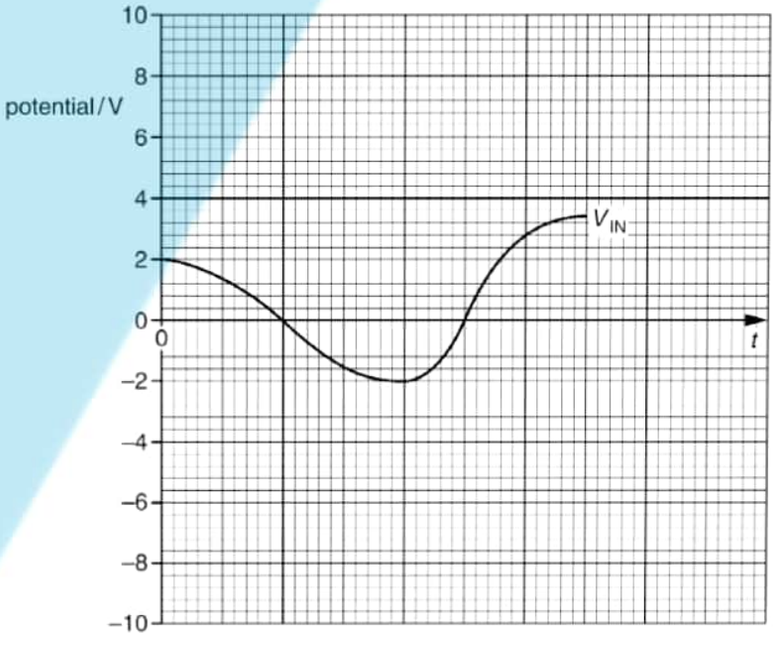

Fig. 10.3

On the axes of Fig. 10.3, sketch the variation with time t of the output potential V_{OUT}. [3]

(a) A circuit incorporating an ideal operational amplifier (op-amp) is shown in Fig. 11.1.

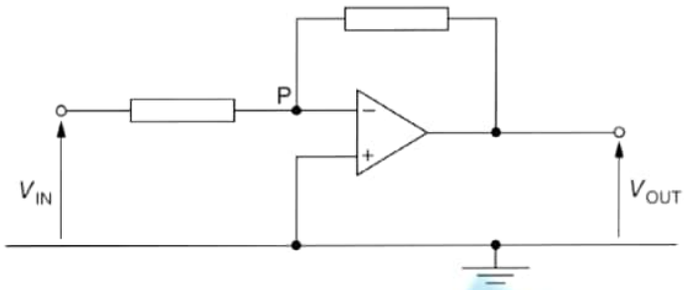

Fig. 11.1

(i) State the name of this circuit.

..... [1]

(ii) Explain why the point P is referred to as a *virtual earth*.

.....

.....

.....

..... [3]

(b) The circuit of Fig. 11.1 is modified, as shown in Fig. 11.2.

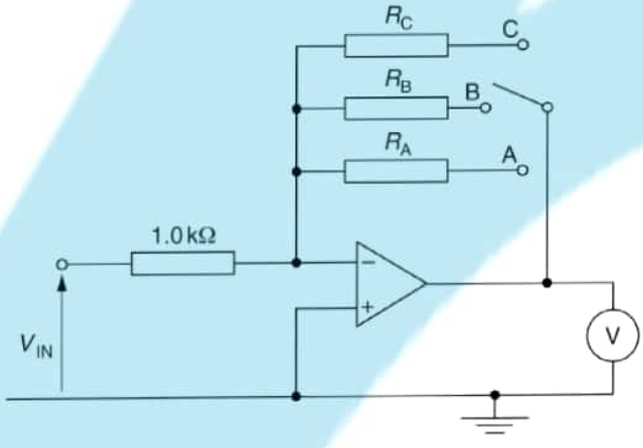

Fig. 11.2

The voltmeter has infinite resistance and its full-scale deflection is 1.0 V.
The input potential to the circuit is V_{IN}.
The switch position may be changed in order to have different values of resistance in the circuit.

(i) The input potential V_{IN} and the switch position are varied.
For each switch position, the reading of the voltmeter is 1.0 V.
Complete Fig. 11.3 for the switch positions shown.

switch position	V_{IN}/mV	resistance
A	10	R_A = ...
B	100	R_B = ...
C	.....	R_C = 1.0 kΩ

Fig. 11.3

[3]

(ii) By reference to your answers in **(i)**, suggest a use for the circuit of Fig. 11.2.

.....

..... [1]

(a) State the function of a comparator circuit incorporating an operational amplifier (op-amp).

.....

.....

.....

..... [3]

(b) An ideal op-amp is incorporated into the circuit of Fig. 10.1.

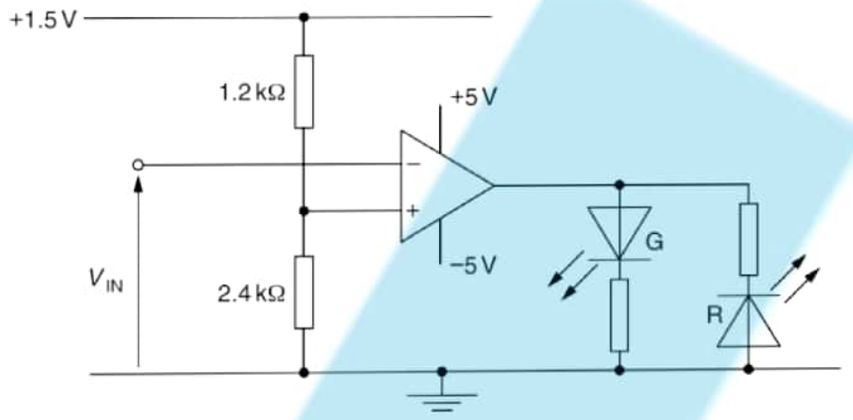

Fig. 10.1

(i) On Fig. 10.1, draw a circle around the part of the circuit that is being used as an output device. [1]

(ii) Show that the potential at the non-inverting input of the op-amp is 1.0 V.

[1]

(iii) The variation with time t of the potential V_{IN} at the inverting input of the op-amp is shown in Fig. 10.2.

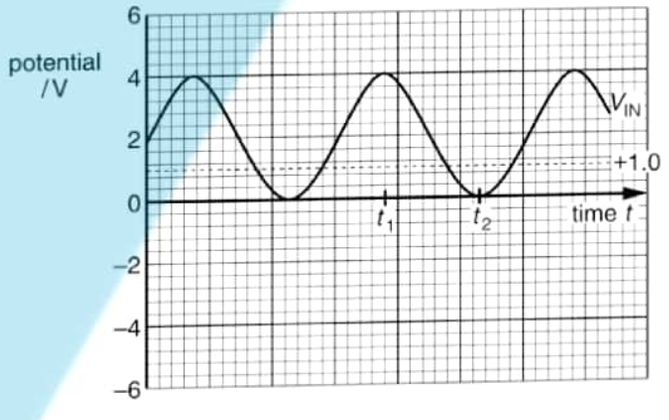

Fig. 10.2

1. On the axes of Fig. 10.2, draw the variation with time t of the output potential of the op-amp. [3]

2. State whether each diode is emitting light or is not emitting light at time t_1 and at time t_2.

   At time t_1, diode R will ..... and diode G will .....

   At time t_2, diode R will ..... and diode G will .....

   [2]

An operational amplifier (op-amp) is used in the comparator circuit of Fig. 10.1.

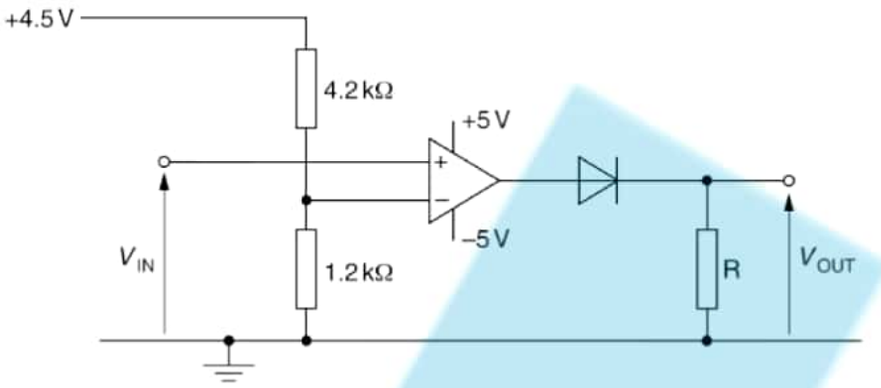

Fig. 10.1

(a) (i) Show that the potential at the inverting input of the op-amp is +1.0 V.

gain =

[1]

(ii) Explain why the potential difference across resistor R is + 5 V when V_{IN} is greater than 1.0 V and is zero when V_{IN} is less than 1.0 V.

$V_{IN} > 1.0$ V: .....

.....

.....

$V_{IN} < 1.0$ V: .....

.....

.....

[4]

(b) The variation with time t of the input voltage V_{IN} is shown in Fig. 10.2.

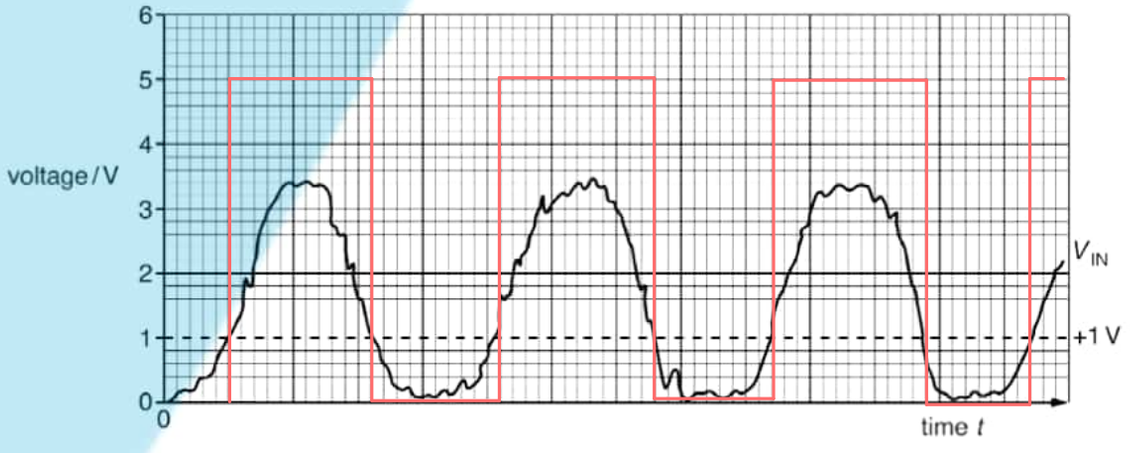

Fig. 10.2

(i) On the axes of Fig. 10.2, draw the variation with time t of the output potential V_{OUT}. [2]

(ii) Suggest a use for this type of circuit.

.....

..... [1]

The circuit of an inverting amplifier incorporating an ideal operational amplifier (op-amp) is shown in Fig. 8.1.

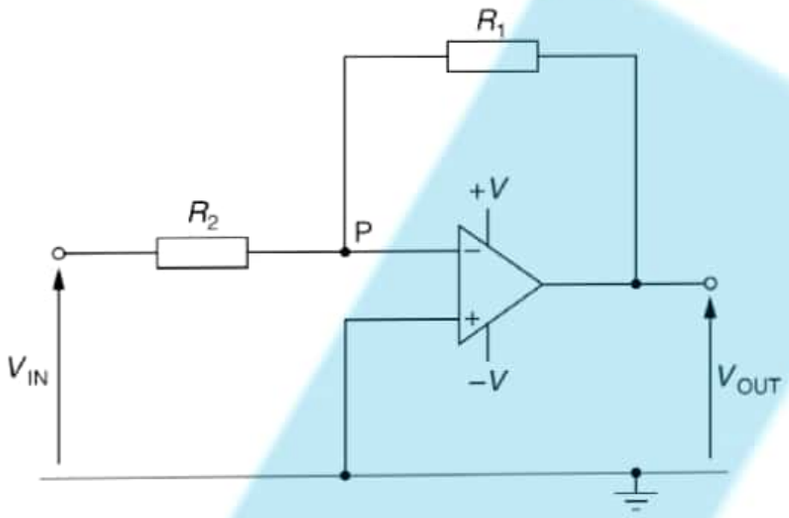

Fig. 8.1

(a) Explain why point P is known as a *virtual earth*.

.....

.....

..... [3]

(b) Derive an expression, in terms of the resistances R_1 and R_2, for the gain of the amplifier circuit.
Explain your working.

[3]

(c) A relay and the output terminals of the amplifier circuit are shown in Fig. 8.2.

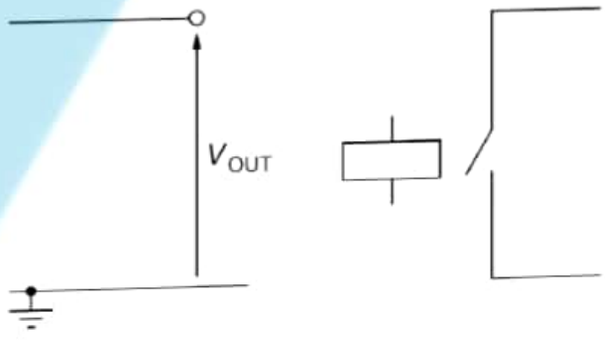

Fig. 8.2

On Fig. 8.2, show how the relay may be connected to the amplifier output so that the relay operates only when V_{OUT} is positive. [3]

[Total: 9]