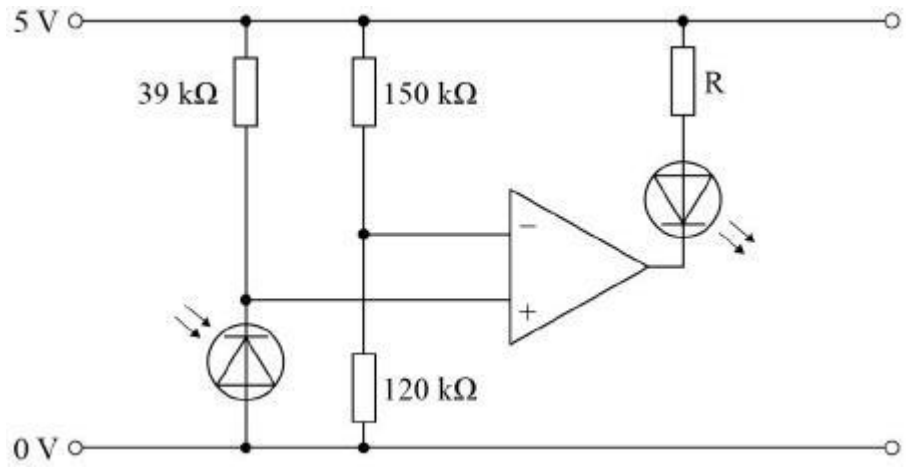
Name of the Student:_____
Max. Marks : 20 Marks **Time : 20 Minutes**

Q1.

Figure 1 shows a circuit containing a photodiode and an ideal operational amplifier. This circuit is used to monitor the intensity of monochromatic radiation.

Figure 1



(a) What is the configuration of the operational amplifier circuit shown in **Figure 1**? Tick (✓) **one** box.

comparator ☐

differential amplifier ☐

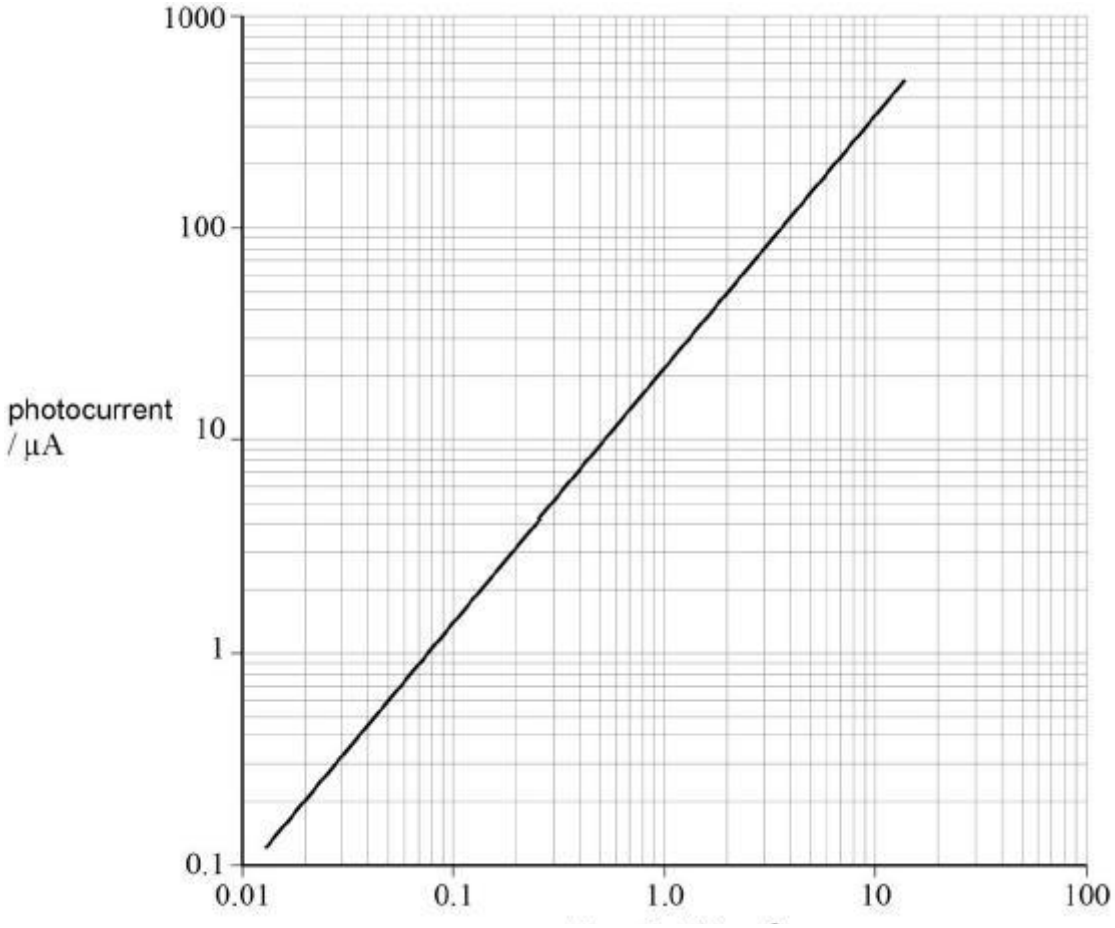
inverting amplifier ☐

non-inverting amplifier ☐

(1)

(b) **Figure 2** shows the variation of photocurrent with intensity for the monochromatic radiation incident on the photodiode.

Figure 2



Radiation of intensity 3.0 W m^{-2} is incident on the photodiode.

Show that the voltage at the non-inverting terminal (V_+) of the operational amplifier is 1.9 V.

(3)

(c) The intensity of radiation incident on the photodiode remains at 3.0 W m^{-2}.

Deduce whether the light-emitting diode (LED) in **Figure 1** is on or off.

_____

_____

_____

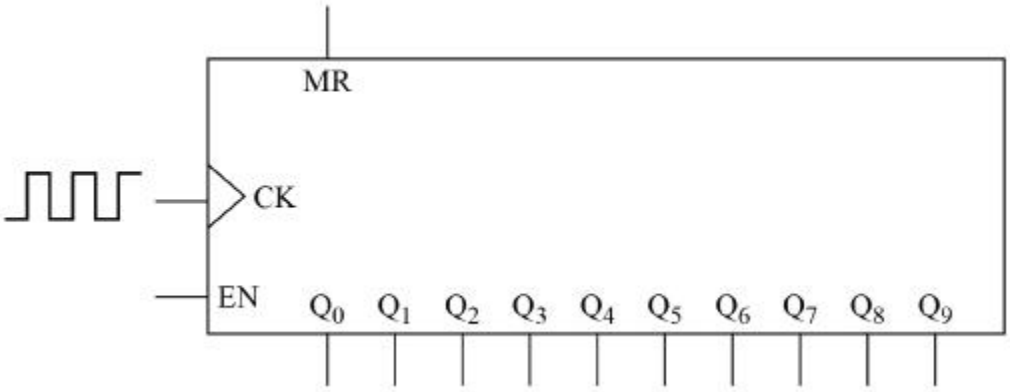
_____

(2)
(Total 6 marks)

Q2.

Figure 1 shows the basic layout for a Johnson decade counter.
The main input is the clock (CK).
The main outputs are shown as Q_0 to Q_9.

Figure 1

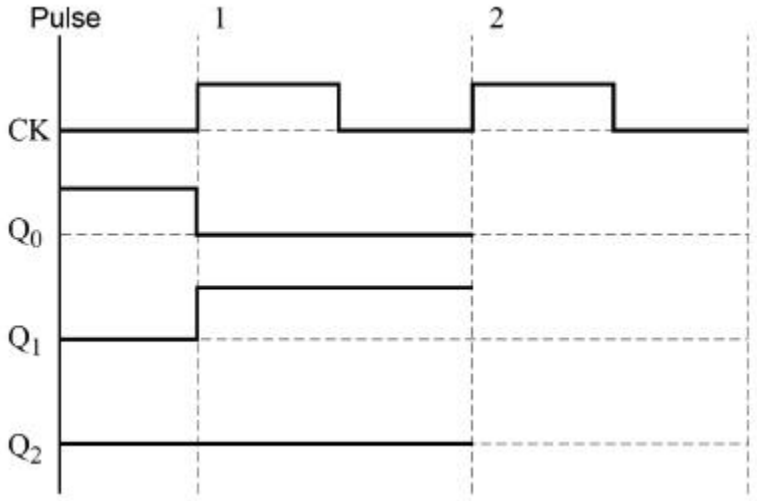


(a) **Figure 2** shows part of the timing diagram for a Johnson decade counter.

This timing diagram shows the output logic states against time. The counter is reset to make Q_0 = 1 and then the first two pulses are applied.

Complete **Figure 2** to show the logic states of Q_0, Q_1 and Q_2.

Figure 2



(2)

(b) A student sets up the counter to make the traffic light sequence:

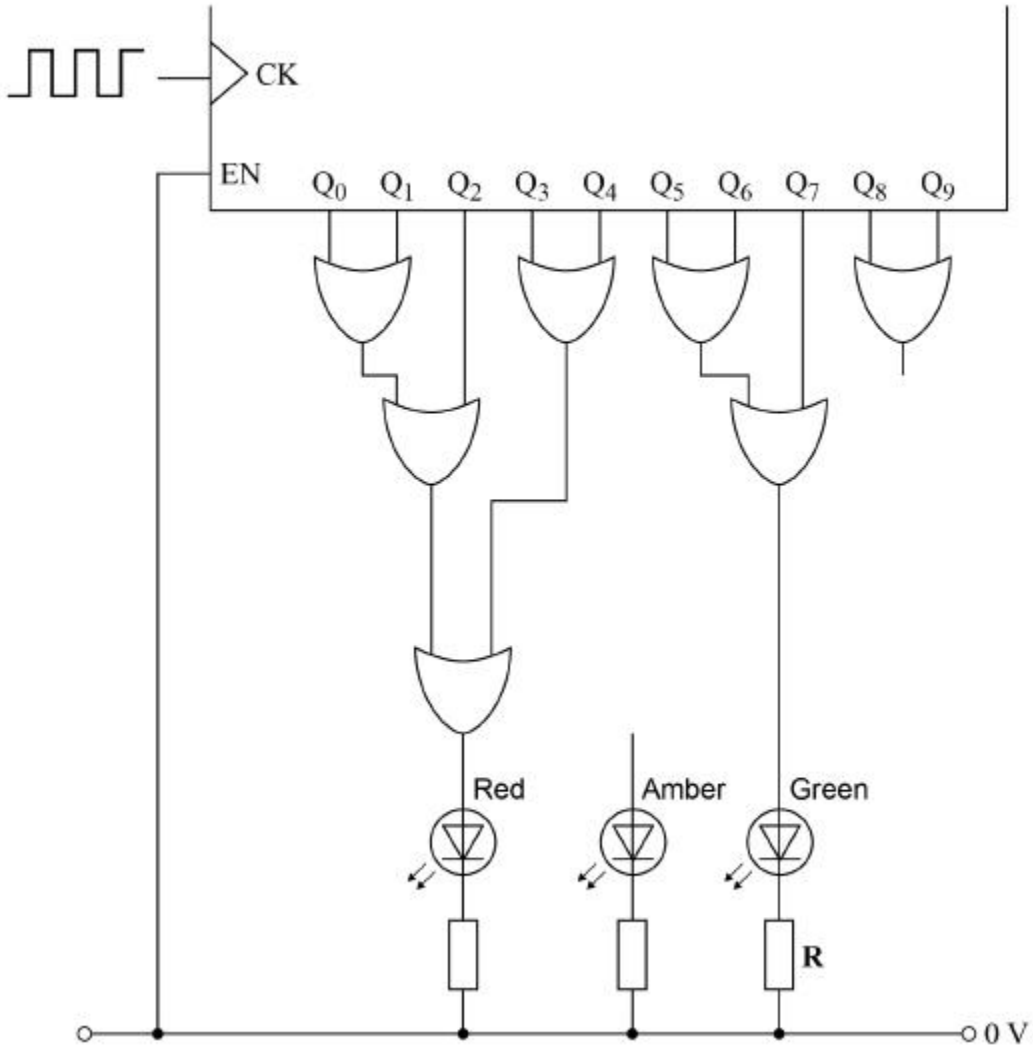
red → red + amber → green → amber

The sequence then repeats.

Figure 3 shows a partially completed diagram for producing this sequence.

Draw an OR gate and connections on **Figure 3** so that the LEDs go through the complete sequence.

Figure 3



(1)

(c) State **two** factors that determine the ON time for the green LED shown in **Figure 3**.

1 _____

_____

2 _____

_____

(2)

(d) The potential difference across the green LED is 2.1 V when it is lit. The current through it should not exceed 9 mA.

All logic gate outputs are:

logic low = 0 V
logic high = 9 V.

The student suggests that a resistor of resistance 720 Ω and a tolerance of ±5% should be used for **R**.

Deduce whether the student's suggestion would be suitable.

_____

_____

_____

_____

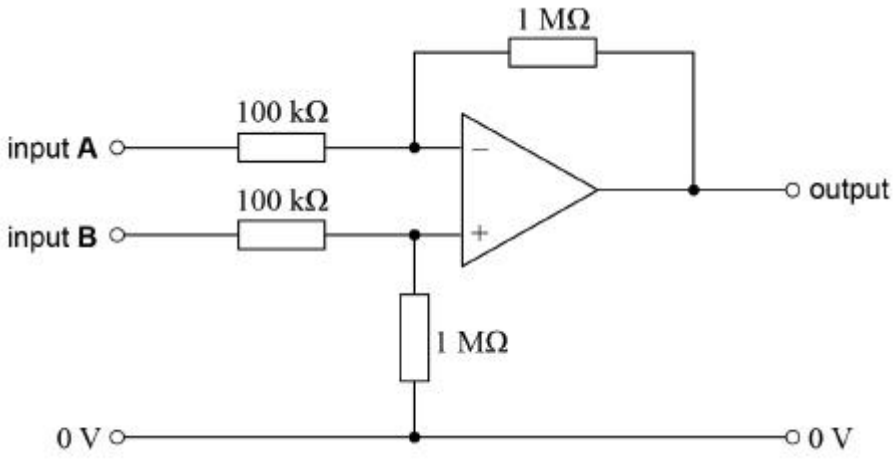
(3)

(Total 8 marks)

Q3.

Figure 1 shows an operational amplifier circuit used in an audio mixing desk.

Figure 1



The power supply for the amplifier is –12 V and +12 V but this is not shown in **Figure 1**.

(a) What is the operational amplifier configuration shown in **Figure 1**?
Tick (✔) **one** box.

non-inverting amplifier ☐

comparator ☐

summing amplifier ☐

difference amplifier ☐

(1)

(b) The circuit shown in **Figure 1** is tested by making the following connections:

- input **A** is connected to an audio signal of amplitude 150 mV
- input **B** is connected to 0 V.

Calculate the amplitude of the output voltage.

output voltage = _____ V

(2)

(c) A microphone converts a sound wave into the voltage signal labelled **signal 1** in **Figure 2**. At the same time the microphone produces a second signal, labelled **signal 2**. **Signal 2** is the inversion of **signal 1**.

These two signals travel along two separate wires in the same cable.

Figure 2

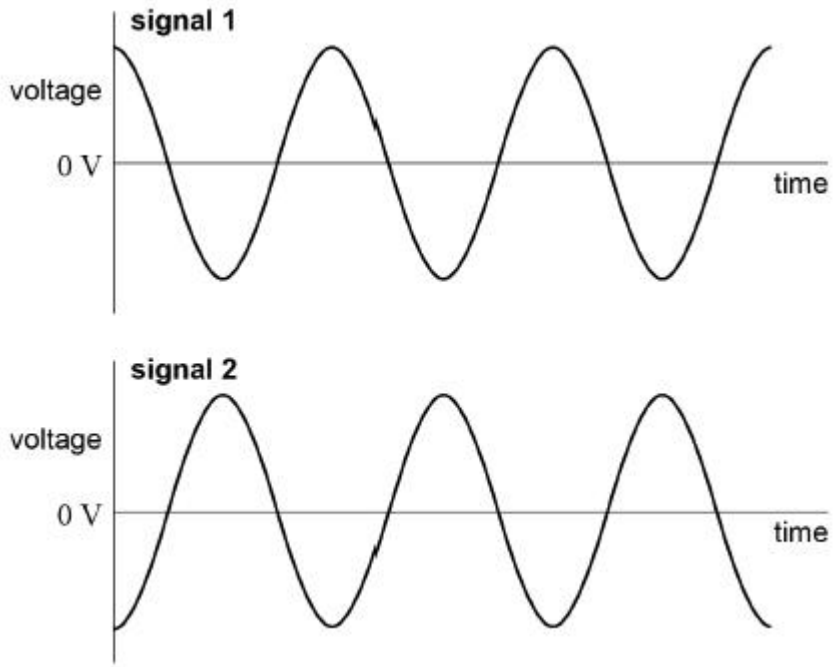
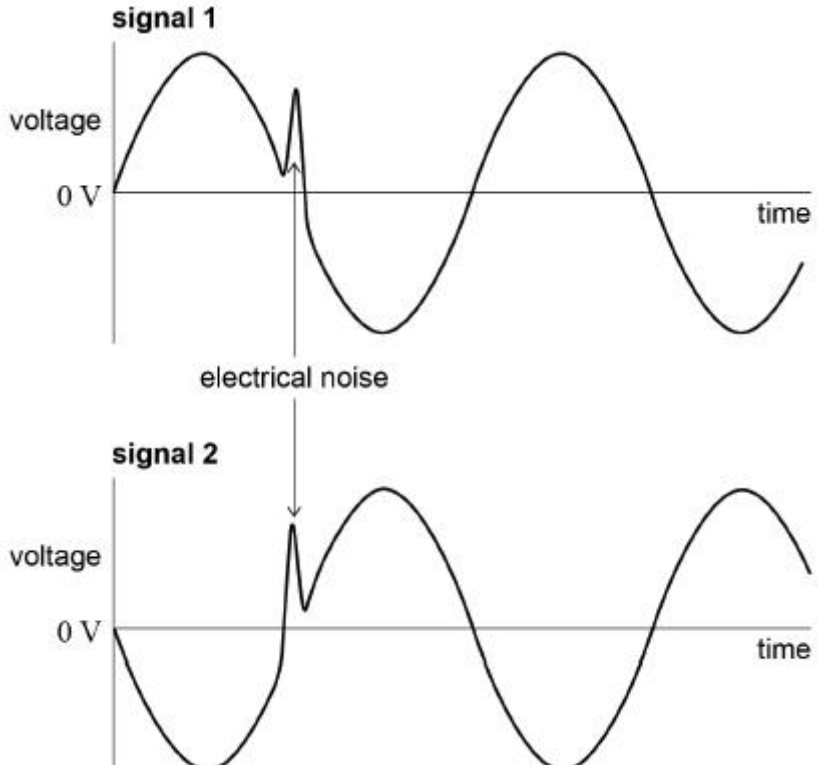


Figure 3 shows some electrical noise that has been picked up and added to the signals as they travel through the cable from the microphone to the operational amplifier circuit in **Figure 1**.

Figure 3



The connections made in question (b) are removed.

Signal 1 is connected to input **A** and **signal 2** is connected to input **B**.

Explain how the operational amplifier circuit affects the noise and strength of the output signal.

_____

_____

_____

_____

_____

_____

(3)

(Total 6 marks)