AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname ______________________

Forename(s) ______________________

Candidate signature ______________________

A-level
PHYSICS

Paper 3
Section B Electronics

Monday 3 June 2019 Afternoon

Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 50 minutes on this section.

Materials

For this paper you must have:

- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 35.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

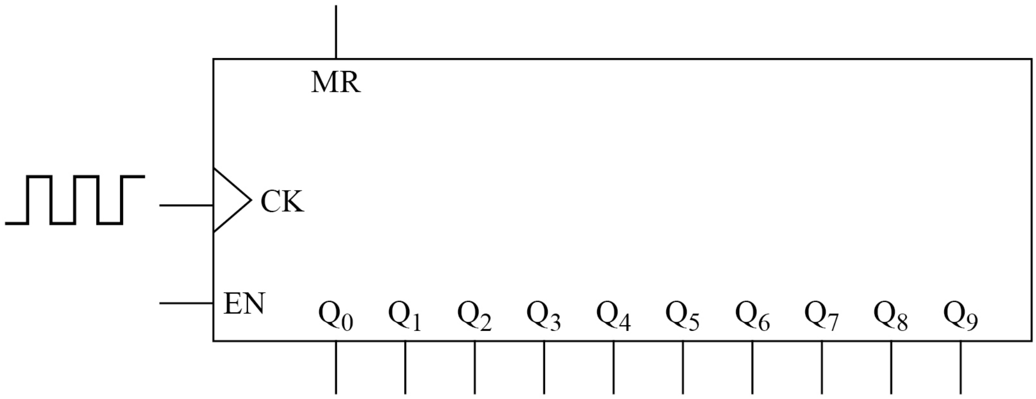
Do not write outside the box

Section B

Answer **all** questions in this section.

0 1 **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

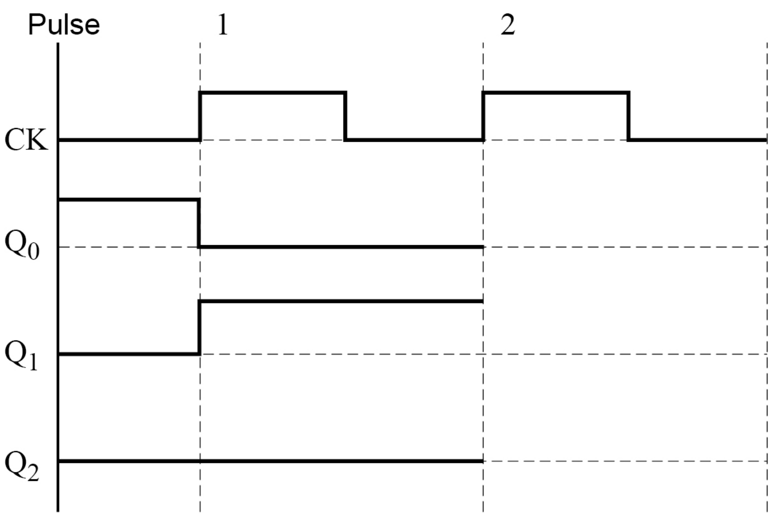


0 1 . 1 **Figure 2** shows part of the timing diagram for a Johnson decade counter.
This timing diagram shows the output logic states against time. The counter is reset to make $Q_0 = 1$ and then the first two pulses are applied.

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

[2 marks]

Figure 2



Question 1 continues on the next page

Turn over ►

Do not write outside the box

0 1 . 2 A student sets up the counter to make the traffic light sequence:

red → red + amber → green → amber

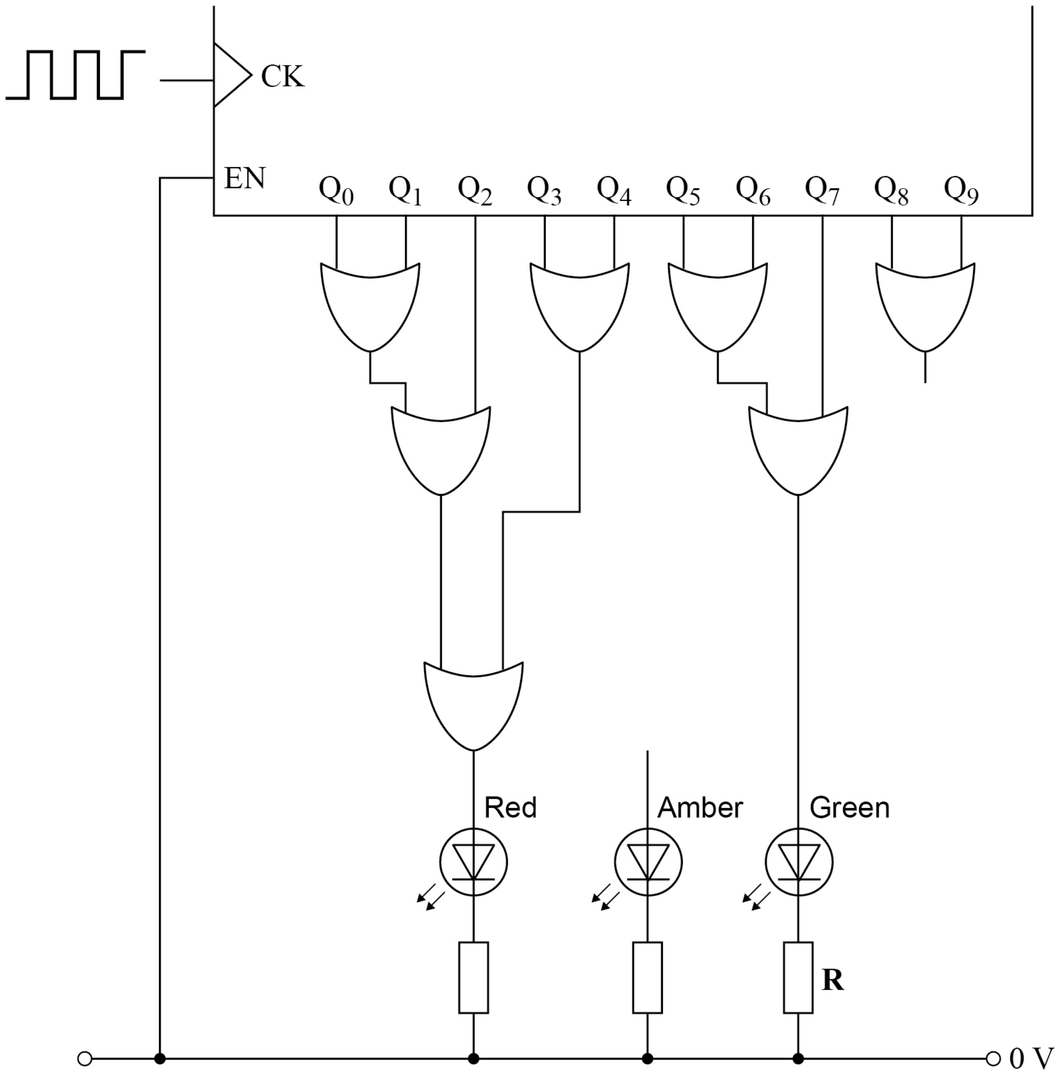
The sequence then repeats.

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.

[1 mark]

Figure 3



Do not write outside the box

0 1 . 3 State **two** factors that determine the ON time for the green LED shown in **Figure 3**.

[2 marks]

1 ____

____

2 ____

____

0 1 . 4 The potential difference across the green LED is $2.1\ \mathrm{V}$ when it is lit. The current through it should not exceed $9\ \mathrm{mA}$.

All logic gate outputs are:
logic low = $0\ \mathrm{V}$
logic high = $9\ \mathrm{V}$.

The student suggests that a resistor of resistance $720\ \Omega$ and a tolerance of $\pm 5\%$ should be used for **R**.

Deduce whether the student's suggestion would be suitable.

[3 marks]

____

____

____

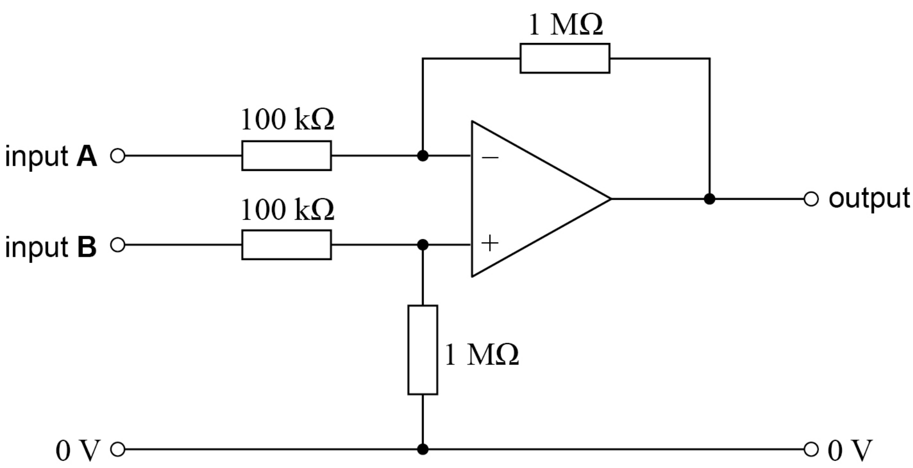
____

8

Do not write outside the box

0 2 **Figure 4** shows an operational amplifier circuit used in an audio mixing desk.

Figure 4



The power supply for the amplifier is $-12\ \text{V}$ and $+12\ \text{V}$ but this is not shown in **Figure 4**.

0 2 . 1 What is the operational amplifier configuration shown in **Figure 4**?
Tick (✓) **one** box.

[1 mark]

non-inverting amplifier ☐

comparator ☐

summing amplifier ☐

difference amplifier ☐

Do not write outside the box

0 2 . 2 The circuit shown in **Figure 4** is tested by making the following connections:

- input **A** is connected to an audio signal of amplitude $150\ \text{mV}$
- input **B** is connected to $0\ \text{V}$.

Calculate the amplitude of the output voltage.

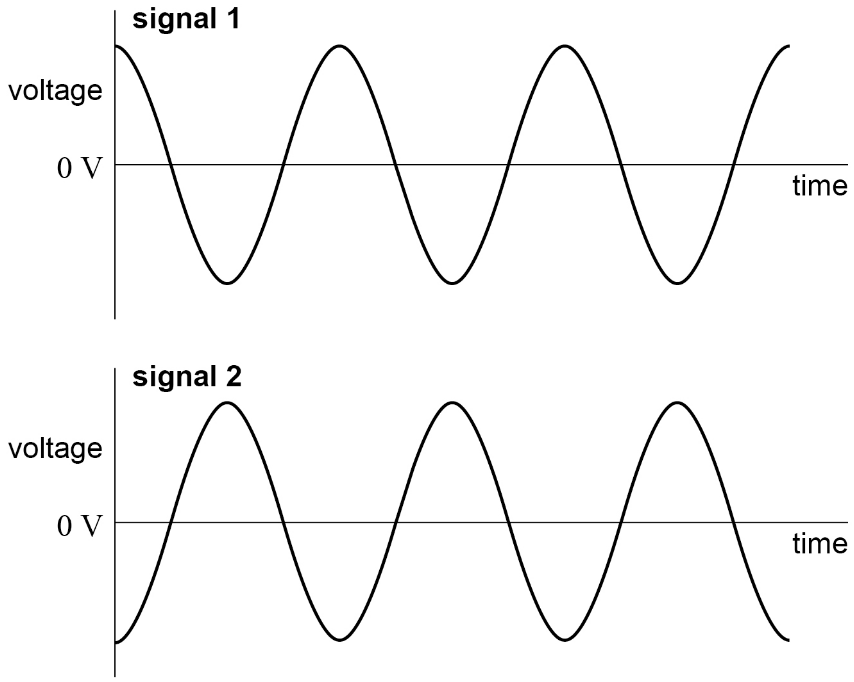
[2 marks]

output voltage = ________________________ V

Question 2 continues on the next page

0 2 . 3 A microphone converts a sound wave into the voltage signal labelled **signal 1** in **Figure 5**. 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.

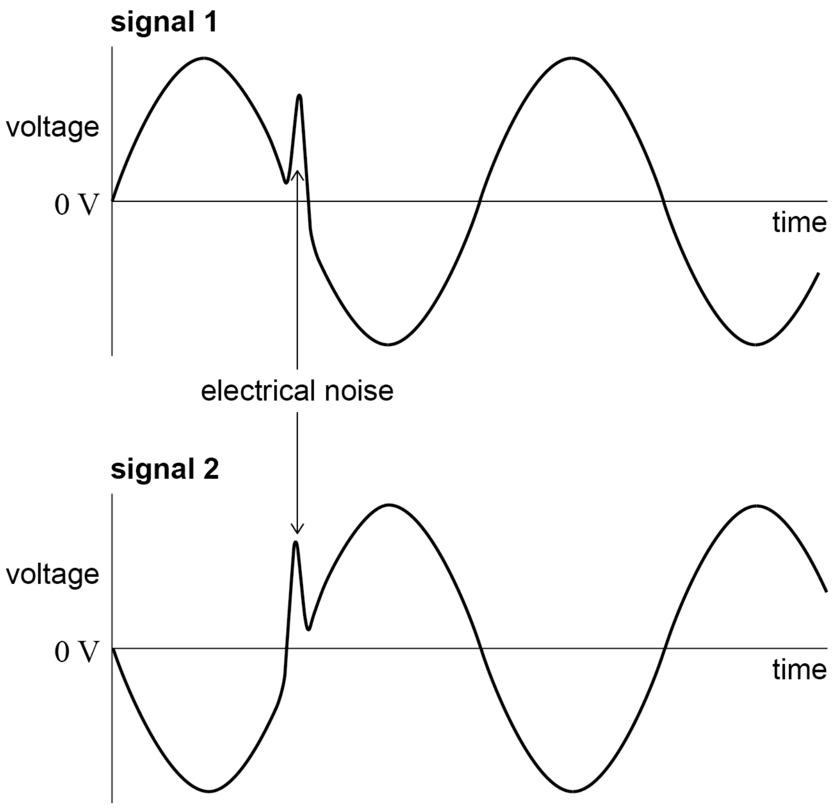
Figure 5



Do not write outside the box

Figure 6 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 4**.

Figure 6



The connections made in question **02.2** 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 marks]

____

____

____

____

____

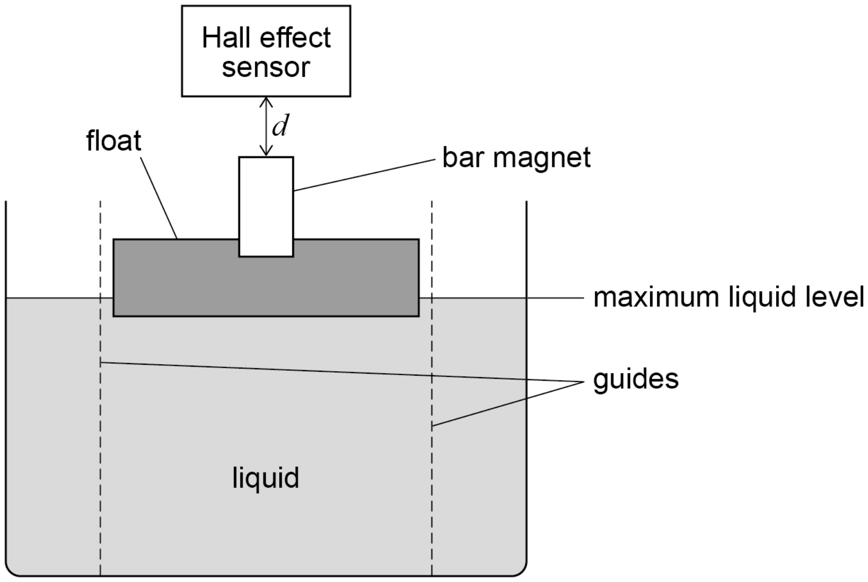
____

6

Turn over ►

0 3 **Figure 7** shows a system to monitor a tank filling with liquid in which a magnet is mounted on a float.

Figure 7



The Hall effect sensor produces an output voltage V. V depends on the distance d between the sensor and the magnet.

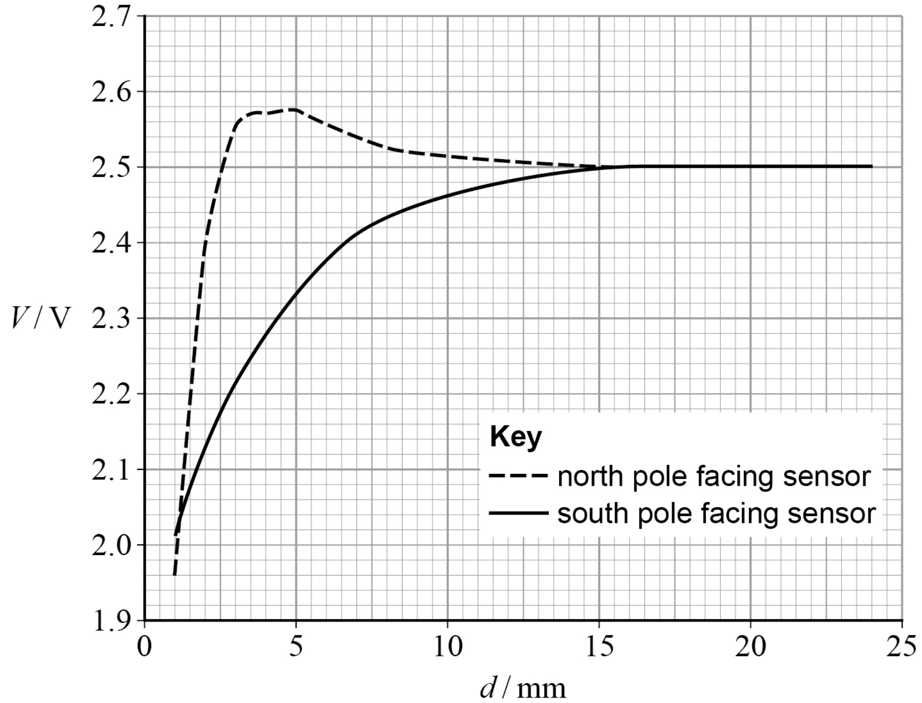
When V reaches a certain value, the flow of liquid to the tank is switched off.

The magnet may be arranged with either the north (N) or south (S) pole facing the sensor.

Do not write outside the box

Figure 8 shows how the magnitude of V varies with d for the two possible arrangements of the magnet.

Figure 8



0 3 . 1 Compare the advantages of the two arrangements for monitoring the movement of the magnet towards the Hall effect sensor.

In your answer you should compare:
- the sensitivity of the system
- the range of d over which the system is useful.

You may ignore any effect from the Earth's magnetic field.

[3 marks]

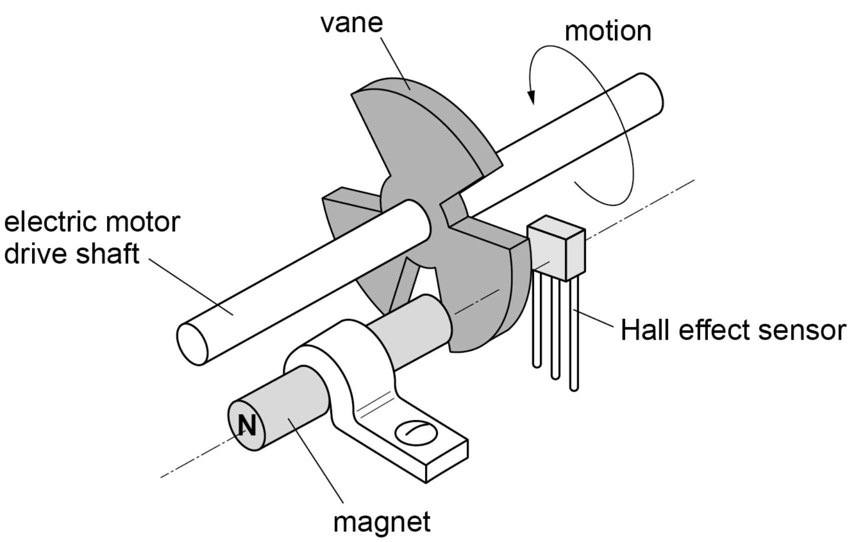
Question 3 continues on the next page

Turn over ►

Do not write outside the box

0 3 . 2 **Figure 9** shows a Hall effect sensor being used as a tachometer to monitor the rotational speed of the drive shaft of an electric motor.

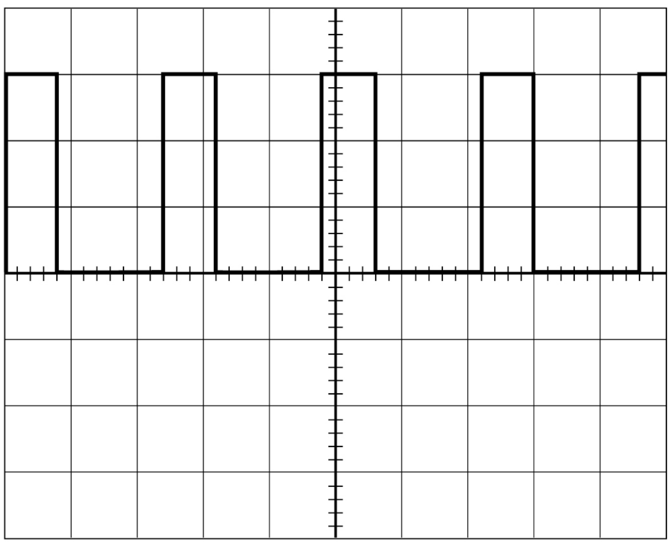
Figure 9



The output of the Hall effect sensor is connected to an oscilloscope. When the vane is between the magnet and the Hall effect sensor, the output of the Hall effect sensor is low.

The trace produced on the oscilloscope is shown in **Figure 10**.

Figure 10



Do not write outside the box

The time-base on the oscilloscope is set to $5\ \mathrm{ms}$ / div.

Calculate the number of complete revolutions of the drive shaft in one second.

[3 marks]

number of complete revolutions = ______________________

6

Turn over for the next question

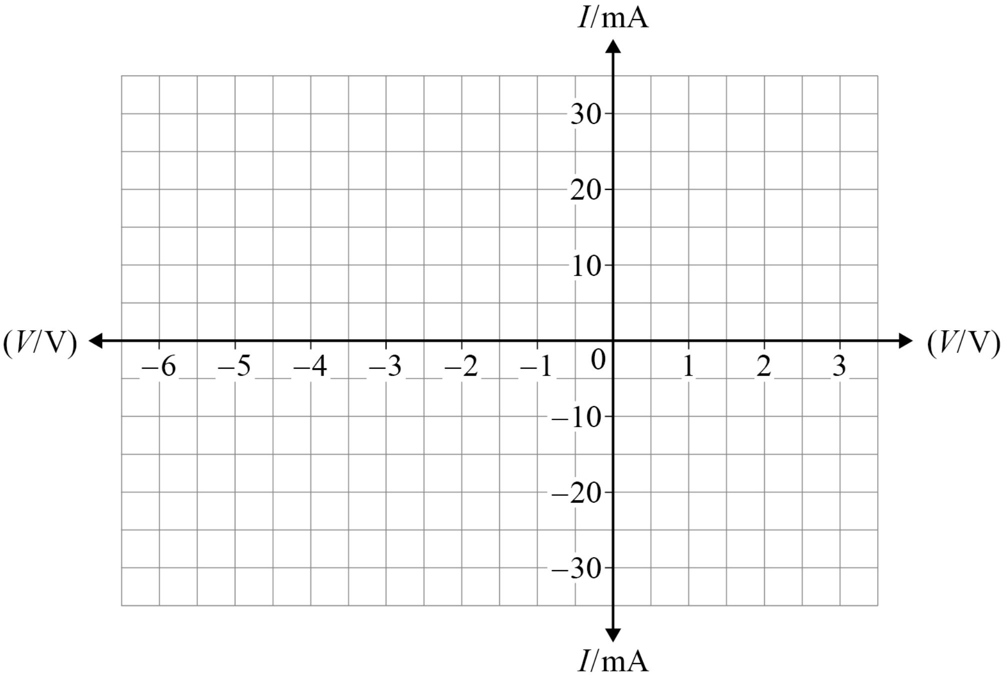
Do not write outside the box

0 4 A silicon-based 5.1 V Zener diode requires a minimum operating current I of 5.0 mA to maintain its Zener voltage V_z.

0 4 . 1 Draw on **Figure 11** the general I–V characteristic for this diode.

[2 marks]

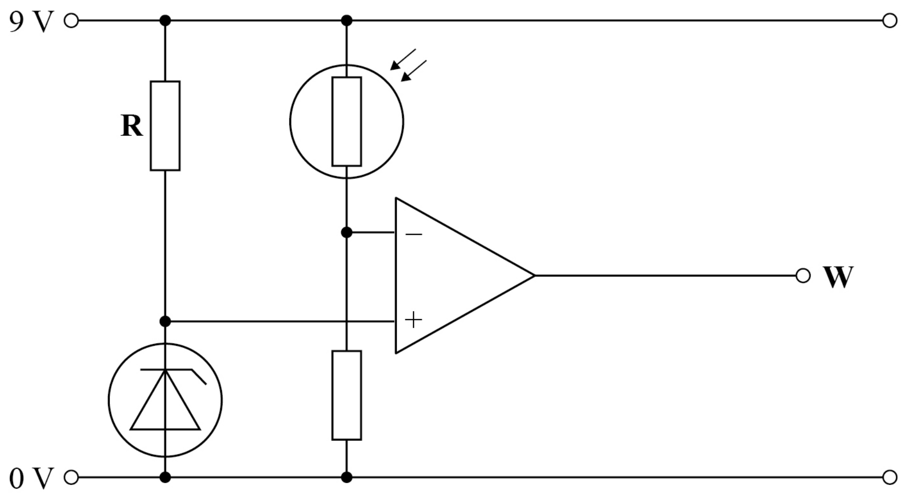
Figure 11



Do not write outside the box

0 4 . 2 **Figure 12** shows a circuit that uses a 5.1 V Zener diode.
The circuit causes the output $\mathbf{W}$ of the operational amplifier to change at a particular light intensity.

Figure 12



State the function of the Zener diode in this circuit.

[1 mark]

0 4 . 3 Deduce whether a $100\ \Omega$, 0.13 W resistor is suitable for $\mathbf{R}$ in **Figure 12**.

[2 marks]

Question 4 continues on the next page

0 4 . 4 The circuit in **Figure 12** is rebuilt and the position of **R** is swapped with the position of the Zener diode.

Explain how this affects the light intensity at which **W** changes.

[2 marks]

____

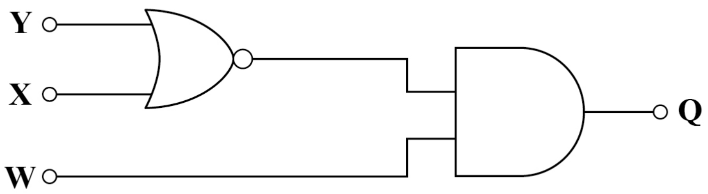
____

____

____

0 4 . 5 The output **W** from the operational amplifier shown in **Figure 12** becomes one of three inputs to the combinational logic circuit shown in **Figure 13**.

Figure 13



Write the Boolean algebra expression for the output **Q** in terms of **W**, **X** and **Y** based on the logic gates shown in **Figure 13**.

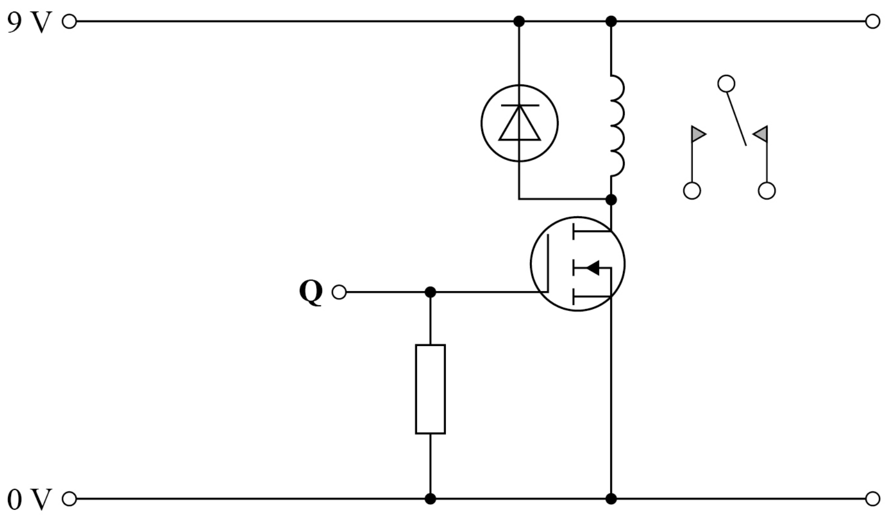
[1 mark]

Q = ______________________________

Do not write outside the box

0 4 . 6 Output **Q** from **Figure 13** becomes the input to the final part of the circuit shown in **Figure 14**.

Figure 14



The circuit uses a MOSFET to activate a relay.

State **one** property that makes the MOSFET suitable for interfacing with logic gates.

[1 mark]

9

Turn over for the next question

Do not write outside the box

0 5 A telephone company transmits 15 speech channels across a single transmission link. The analogue information is first subjected to pulse code modulation (PCM) before transmission using time division multiplexing (TDM). The transmission system incorporates regenerators which remove noise from the signal.

Explain the basic principles of:

- pulse code modulation (PCM)
- time division multiplexing (TDM)
- a regenerator.

[6 marks]

Do not write outside the box

6

END OF QUESTIONS

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Do not write outside the box

Question number	**Additional page, if required. Write the question numbers in the left-hand margin.**

Do not write outside the box

Question number	**Additional page, if required. Write the question numbers in the left-hand margin.**

Do not write outside the box

Question number	Additional page, if required. Write the question numbers in the left-hand margin.