AQA

Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

# GCSE
# ELECTRONICS

## Unit 1 Written Paper

Monday 13 June 2016 Afternoon Time allowed: 2 hours

**Materials**
For this paper you must have:
- a pencil
- a ruler
- a calculator.

**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.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show the working of your calculations.

**Information**
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 150.
- A list of formulae is provided on page 2, which you may wish to use in your answers.
- Any correct electronics solution will gain credit.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary, where appropriate.

## Information Sheet

The following information may be useful when answering some questions in this examination.

**Resistor colour code**

The colours in the resistor colour code correspond to the following values.

| | | | | | |
|---|---|---|---|---|---|
| BLACK | 0 | YELLOW | 4 | GREY | 8 |
| BROWN | 1 | GREEN | 5 | WHITE | 9 |
| RED | 2 | BLUE | 6 | | |
| ORANGE | 3 | VIOLET | 7 | | |

The fourth band colour gives the tolerance.

GOLD $\pm$ 5% SILVER $\pm$ 10%

**Resistor printed code** (BS 1852)

R means $\times$ 1 K means $\times$ 1000 M means $\times$ 1 000 000

Position of the letter gives the decimal point.

Tolerances are indicated by adding a letter at the end.

J $\pm$ 5% K $\pm$ 10% M $\pm$ 20%

eg 5K6J = 5.6 k $\Omega$ $\pm$ 5%

**Preferred values for resistors (E24 series)**

1.0, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1 and their multiples of ten.

**Resistance**

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}} \qquad R = \frac{V}{I}$$

Effective resistance, $R$, of up to four resistors in series is given by $R = R_1 + R_2 + R_3 + R_4$

Effective resistance, $R$, of two resistors in parallel is given by $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

**Power**

$$\text{Power} = \text{Voltage} \times \text{Current} \qquad P = VI$$

**Amplifiers**

$$\text{Voltage gain } G_V = \frac{V_{out}}{V_{in}}$$

**Astable and monostable generators using 555 timers**

(a) Monostable mode time period $T = 1.1\ R_1 \times C_1$

(b) Astable mode time period $T = \frac{(R_1 + 2R_2)C_1}{1.44}$

**ac theory**

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

$$\text{Frequency} = \frac{1}{\text{Period}} \qquad f = \frac{1}{T}$$

Answer **all** questions in the spaces provided.

**1** A technician is working with mains electricity.

**1 (a)** State **two** different effects on the body that could occur if the technician were to touch the mains live wire.

**[2 marks]**

1 _____

2 _____

**1 (b)** State **three** things you should do if you found the technician after he had touched the mains live wire.

**[3 marks]**

1 _____

2 _____

3 _____

**1 (c)** Name the devices described in **Table 1** and draw their circuit symbols.

**[7 marks]**

**Table 1**

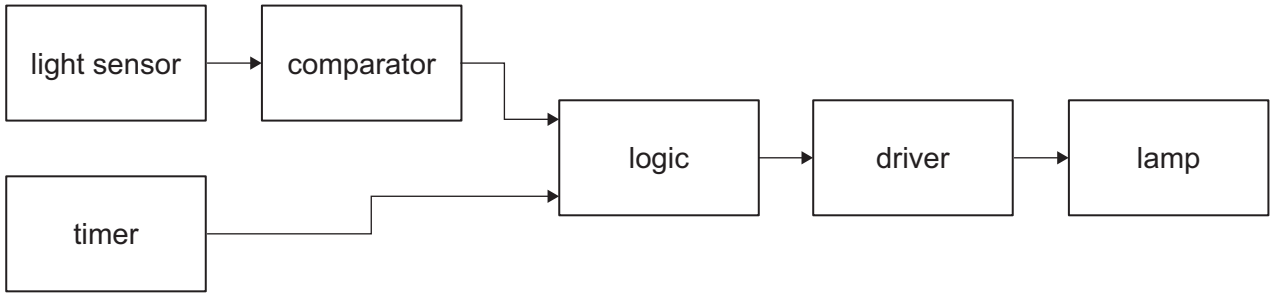
| Description | Name | Symbol |
|---|---|---|
| A thin piece of wire that is designed to melt if too much current flows through it. | | |
| A polarised device that can store a lethal charge even after it has been disconnected from the electrical supply. | | |
| A device that reduces a high alternating voltage to a safer and lower alternating voltage. | | |

**12**

**2** A street lamp is turned on when it gets dark but is turned off at midnight to save energy.

The system diagram is shown in **Figure 1**.

**Figure 1**




**2 (a) (i)** Name the **two** subsystems that are inputs.

**[2 marks]**

1 _____

2 _____

**2 (a) (ii)** Name the subsystem that is an output.

**[1 mark]**

_____

**2 (b)** Name the subsystem in which you could find:

**2 (b) (i)** an AND gate

**[1 mark]**

**2 (b) (ii)** a light dependent resistor (LDR)

**[1 mark]**

**2 (b) (iii)** a MOSFET and an electromagnetic relay

**[1 mark]**

**2 (b) (iv)** an op-amp.

**[1 mark]**

**2 (c) (i)** Name the subsystem that produces an analogue output.

**[1 mark]**

**2 (c) (ii)** Name the subsystem that is a digital process.

**[1 mark]**

**2 (c) (iii)** Name the subsystem that is an analogue to digital converter (ADC).

**[1 mark]**

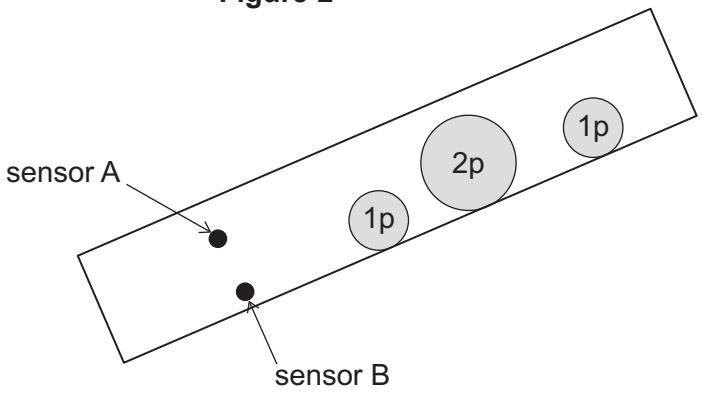
**10**

**3** A student builds a device to detect the difference between 1p coins and 2p coins.

The coins roll down a slope towards sensor A and sensor B.

**Figure 2** shows the device.

**Figure 2**




Each sensor gives a high output when a coin is in front of it.

The sensors are connected to the inputs of a logic gate.

The output of the logic gate is low only when a 2p coin is in front of the sensors.

**3 (a) (i)** Complete the truth table (**Table 2**) for this gate.

**[2 marks]**

**Table 2**

| Sensor A | Sensor B | Output |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | |
| 1 | 0 | 1 |
| 1 | 1 | |

**3 (a) (ii)** Draw a circle around the type of gate that would give this output.

**[1 mark]**

AND NAND NOR NOT OR

**3 (a) (iii)** Draw the symbol for this gate and label the inputs and the output.

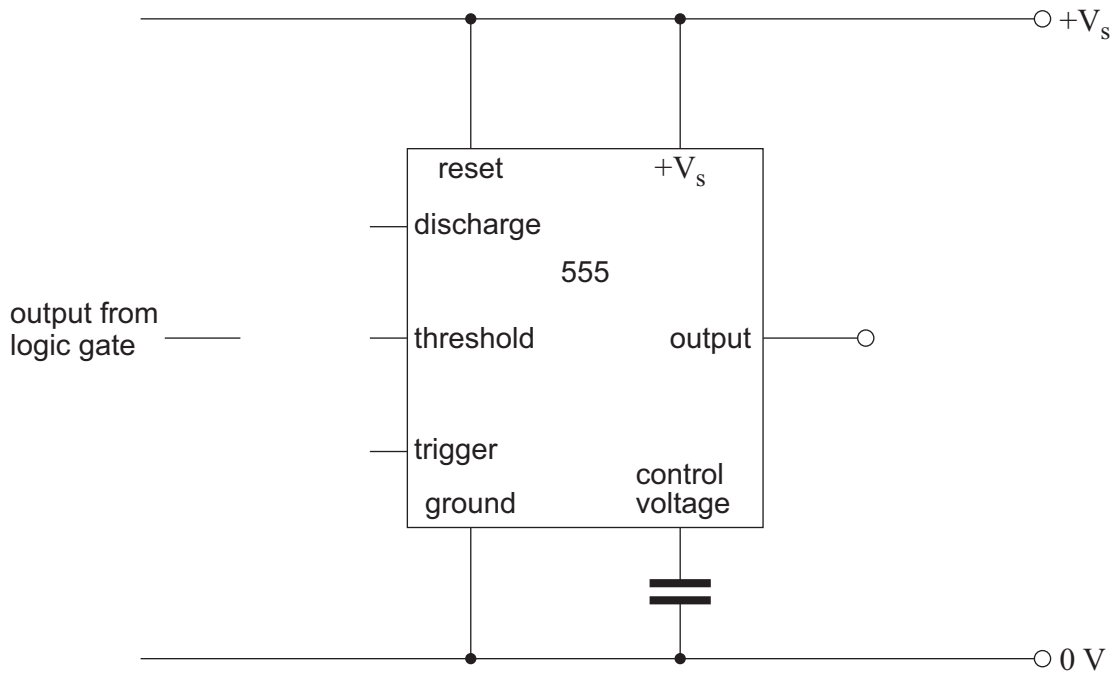
**[3 marks]**

**3 (b)** The output of the logic gate in part **(a)** is connected to a monostable.

**3 (b) (i)** Complete the circuit diagram in **Figure 3** to show how a 555 timer should be connected as a monostable by adding a capacitor, a resistor and the missing wire links.

**[4 marks]**

**Figure 3**



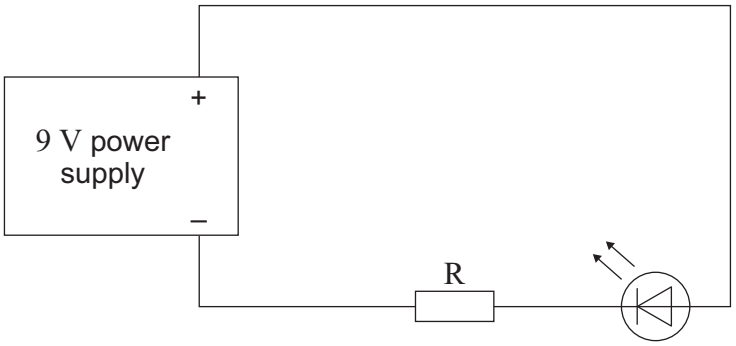

**3 (b) (ii)** Add to the monostable in **Figure 3** an LED that will light up when the output is high and include a protective resistor.

**[3 marks]**

13

**4** A student connects an LED to a 9 V supply as shown in **Figure 4**.

**Figure 4**




**4 (a)** Draw onto **Figure 4** a voltmeter to measure the voltage across resistor R. Label the meter to show its polarity.

**[3 marks]**

**4 (b)** When the LED is conducting, the voltage across it is 3.3 V.

The current through the LED is **not** to exceed 5 mA.

**4 (b) (i)** Show that the voltage across resistor R in **Figure 4** is 5.7 V.

**[1 mark]**

_____

**4 (b) (ii)** Convert 5 mA into amps.

**[1 mark]**

_____

**4 (b) (iii)** Calculate the value of resistor R when the current is 5 mA.

**[2 marks]**

_____

_____

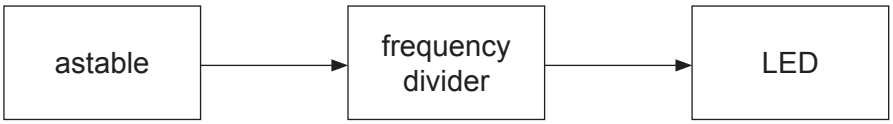
**4 (b) (iv)** Choose the best value for resistor R from the E24 series.

**[1 mark]**

_____

**4 (c)** The student decides to use an astable to make the LED flash on and off using the system in **Figure 5.**

**Figure 5**



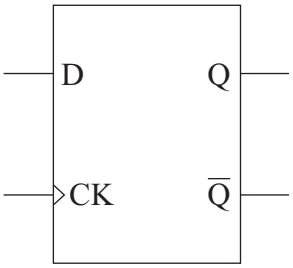

She uses a D-type flip-flop as a frequency divider to halve the frequency of the pulses from the astable.

**4 (c) (i)** Complete **Figure 6** to show how a D-type flip-flop should be connected to halve the frequency of the pulses from the astable.

Label the input and the **two** outputs of the frequency divider.

**[4 marks]**

**Figure 6**

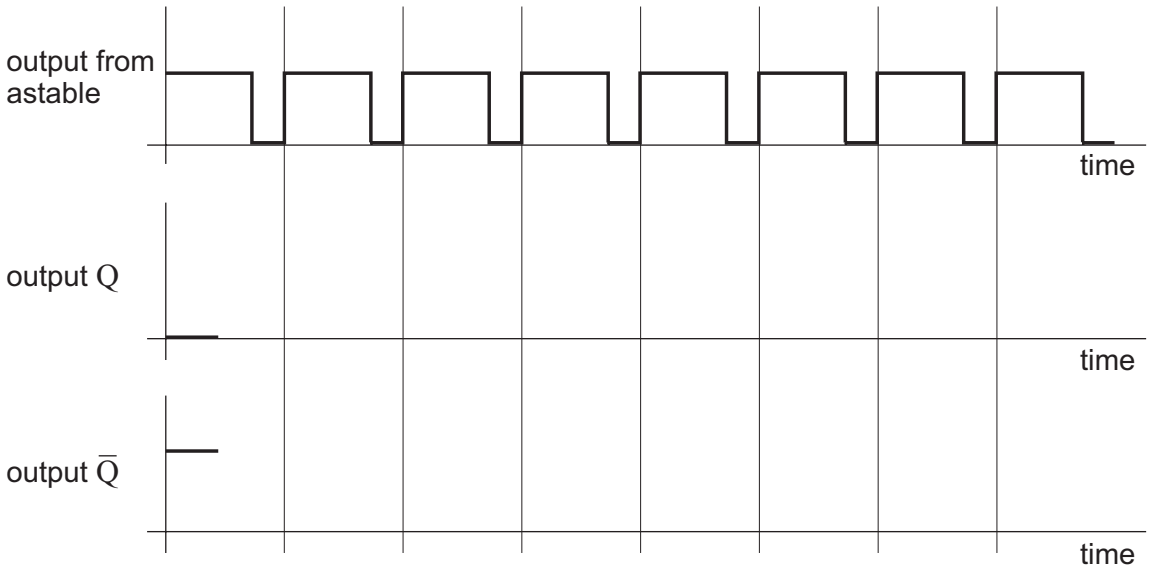



**4 (c) (ii)** **Figure 7** shows the pulses from the astable.

Draw onto **Figure 7** the outputs from the frequency divider.

**[3 marks]**

**Figure 7**




**15**

**5** This question is about a simple radio receiver.

**5 (a) (i)** Describe the function of the loudspeaker in a radio receiver.

**[2 marks]**

**5 (a) (ii)** Describe the function of the tuned circuit in a radio receiver.

**[2 marks]**

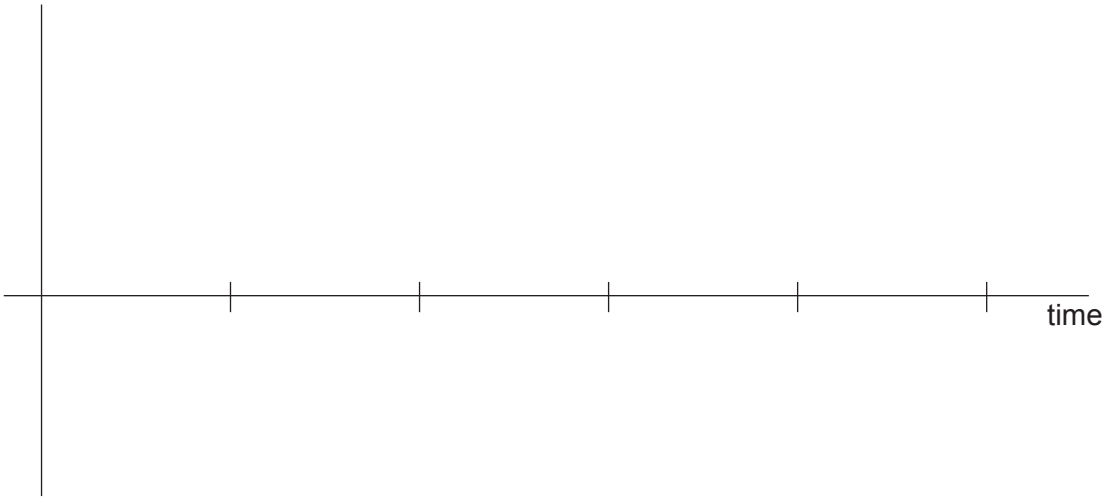
**5 (b) (i)** State the property of the carrier wave that is varied in an AM radio signal.

**[1 mark]**

**5 (b) (ii)** Draw a diagram of an AM radio signal on the axes in **Figure 8**.

**[2 marks]**

**Figure 8**



**5 (c)** Explain the difference between analogue and digital signals.

Explain whether a simple radio receiver is an analogue or digital circuit when receiving an AM broadcast station.

Answer the question in continuous prose.

The quality of written communication will be assessed in your answer.

**[5 marks]**

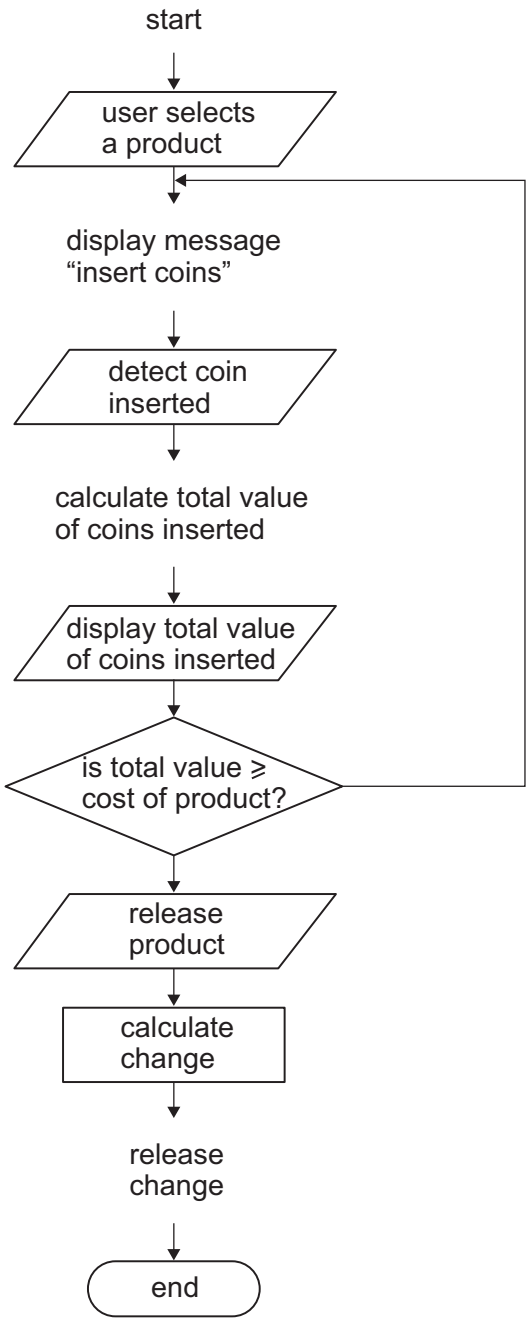
12

**Turn over for the next question**

**6** A vending machine sells products such as sweets and chocolates.

**Figure 9** shows the flow chart for the vending machine.

**Figure 9**




**6 (a)** Add to the flow chart **four** symbols where they are missing.

**[4 marks]**

**6 (b)** Label on **Figure 9**:

an input box  an output box  a decision box  a loop  a process box

**[5 marks]**

**6 (c)** The vending machine only accepts valid coins.

When a coin is put in the vending machine, a unit inside it:

- measures the weight of the coin
- compares the weight with the weight of a valid coin
- rejects the coin if its weight does not match the weight of a valid coin
- if the weight matches the weight of a valid coin then it records the value of the coin and accepts it into the coin box.

Draw a flow chart for the operation of the unit.

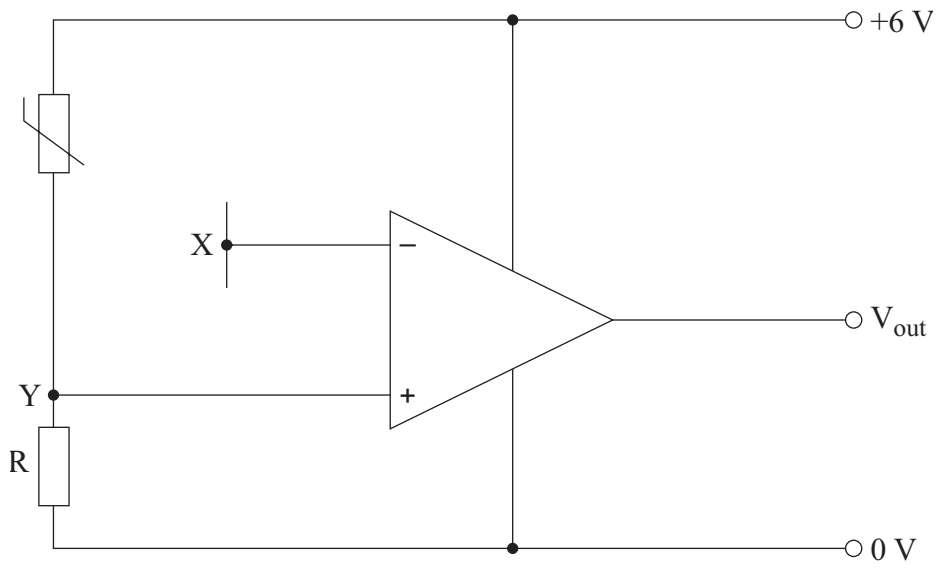
**[5 marks]**

14

**7** A student is building a device to sound a buzzer if a baby's bath water is hotter than 37 ºC.

**Figure 10** shows part of the circuit for his project.

**Figure 10**




**7 (a) (i)** Name the connection on the op-amp that is labelled with a plus sign.

**[1 mark]**

**7 (a) (ii)** Draw **two** components on **Figure 10** that will produce a fixed voltage of 4 V at X. Label each component with a suitable value.

**[3 marks]**

**7 (a) (iii)** State the value of the output voltage ($V_{out}$) when the voltage at Y is 4.2 V.

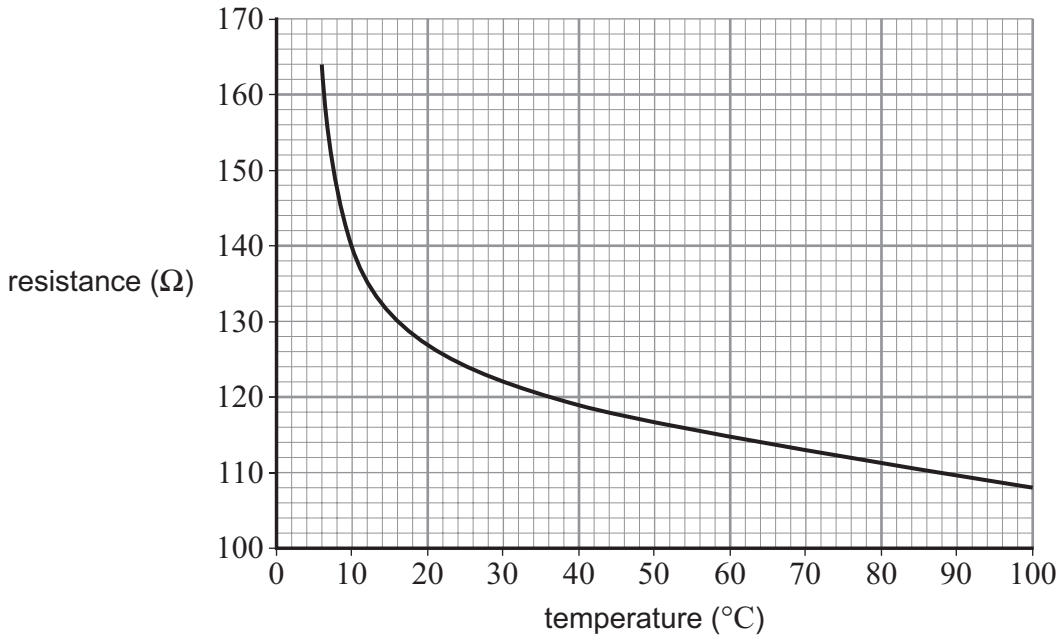
**[1 mark]**

**7 (a) (iv)** State the value of the output voltage ($V_{out}$) when the voltage at Y is 2.8 V.

**[1 mark]**

**7 (b)** The student measures the resistance of the thermistor at different temperatures and plots the graph in **Figure 11**.

**Figure 11**




**7 (b) (i)** State the temperature of the thermistor when its resistance is 140 Ω.

**[1 mark]**

**7 (b) (ii)** State the resistance of the thermistor at a temperature of 37 ºC.

**[1 mark]**

**7 (b) (iii)** Calculate the value the student should use for resistor R in **Figure 10** so that the output will switch at 37 ºC.

**[2 marks]**

**Question 7 continues on the next page**

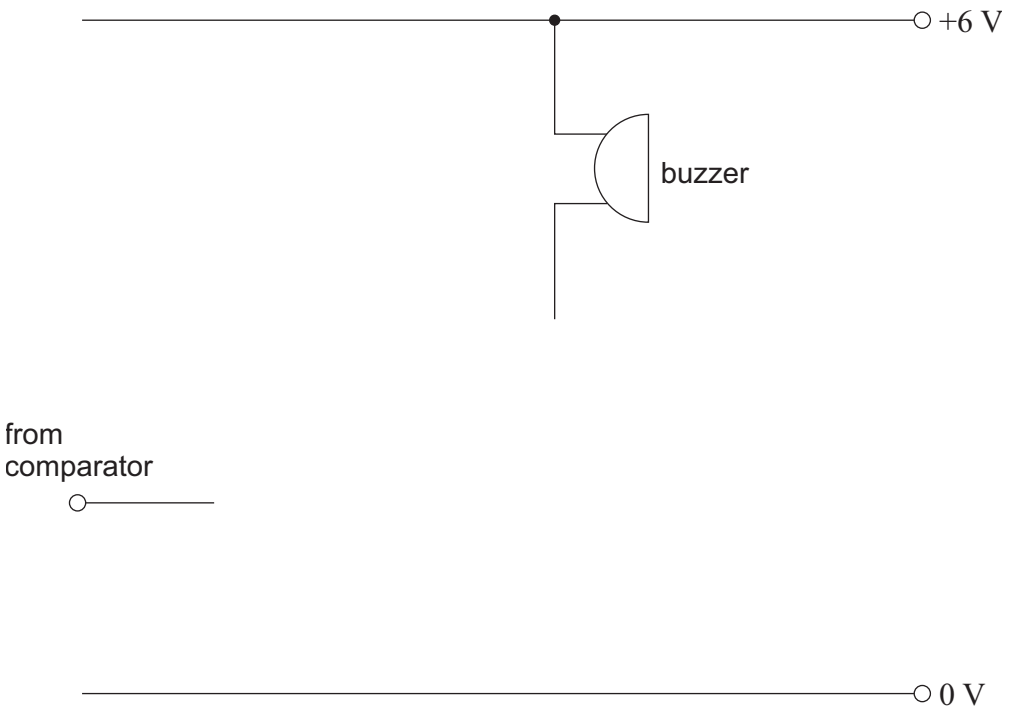
**7 (c)** The student uses a MOSFET to switch on the buzzer.

Complete **Figure 12** to show how the MOSFET should be connected.

Label the names of the MOSFET's **three** leads.

**[5 marks]**

**Figure 12**

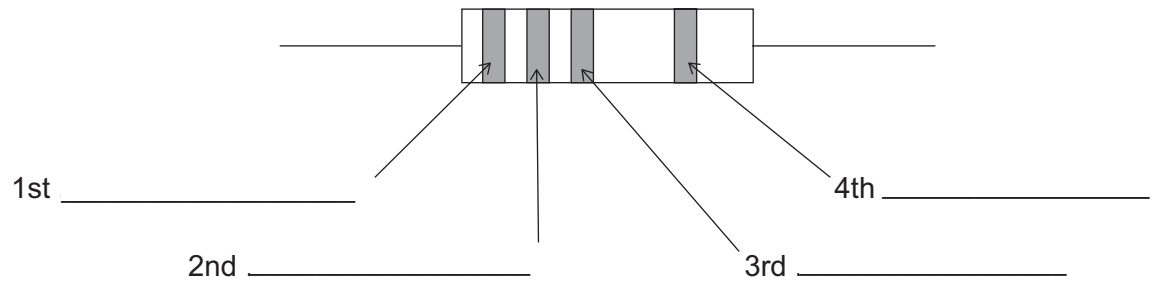



**7 (d)** During testing, the student connects an LED with a $680\ \Omega$ series resistor to the output of the op-amp. The resistor has a tolerance of $\pm 5\%$.

Label **Figure 13** with the colours of the four bands.

**[3 marks]**

**Figure 13**



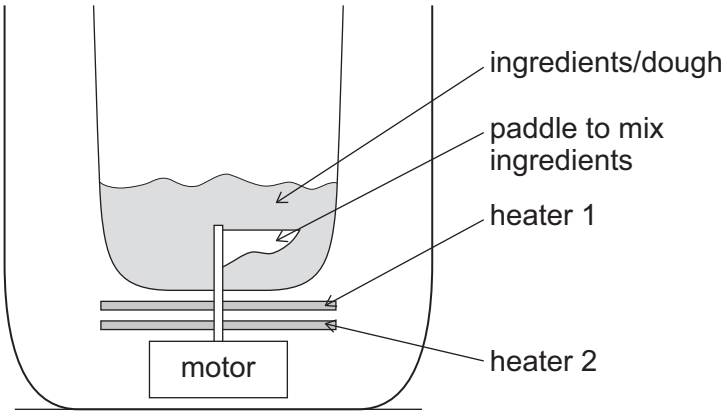

18

**Turn over for the next question**

**DO NOT WRITE ON THIS PAGE**
**ANSWER IN THE SPACES PROVIDED**

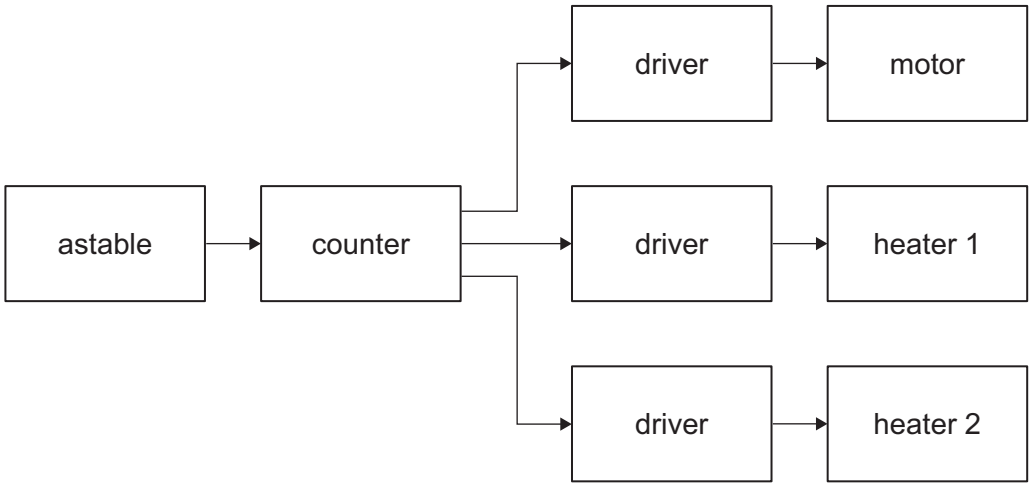
**8** A technician is developing a machine to make bread. The parts used to mix the ingredients and heat the dough are shown in **Figure 14**.

**Figure 14**




The heaters and the motor that turns the mixing paddle are controlled by the system shown in **Figure 15**.

**Figure 15**



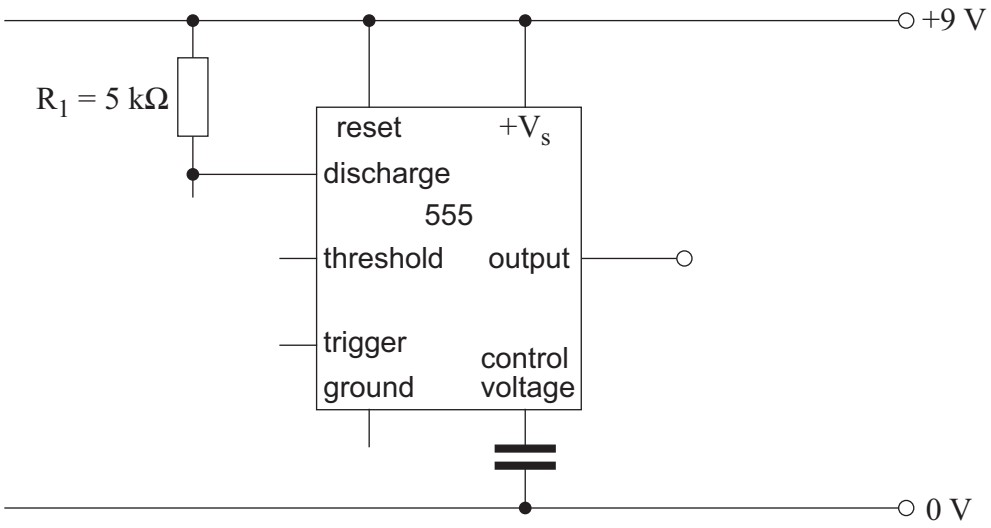
**8 (a)** The astable uses a 555 timer IC to produce pulses.

Complete the circuit diagram in **Figure 16** to show how the 555 should be connected.

Add a resistor ($R_2$), an electrolytic capacitor ($C_1$) and the wire links needed.

**[4 marks]**

**Figure 16**




**8 (b)** Show that a time period of about 10 minutes would be produced if the timing capacitor ($C_1$) has a value of $2200\ \mu F$ and the value of $R_2$ is $200\ k\Omega$.

**[3 marks]**

**8 (c)** Binary numbers are often used in electronics. Decimal 6 is 110 in binary.

**8 (c) (i)** Draw a circle around the binary number which is the same as decimal 8.

**[1 mark]**

0101 0111 1000 1111

**8 (c) (ii)** Draw a circle around the decimal number which is the same as binary 101.

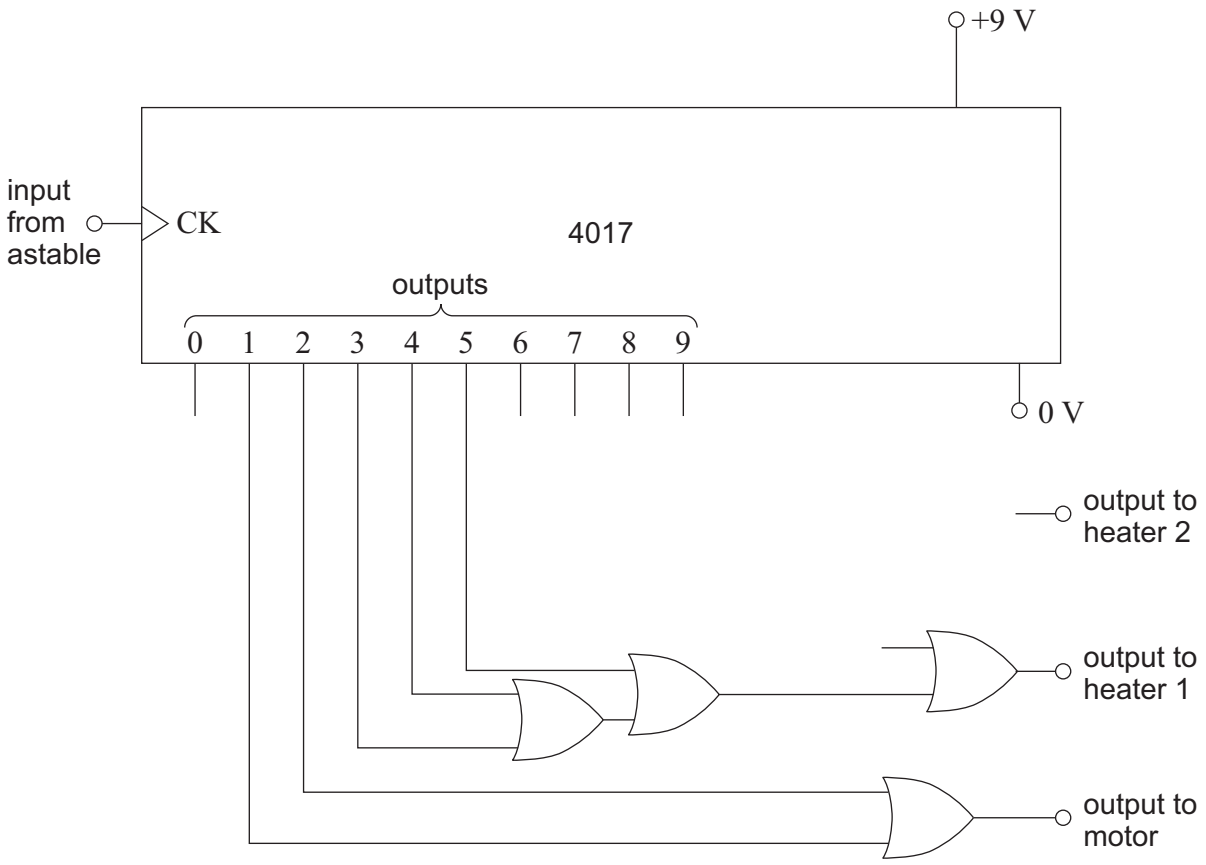
**[1 mark]**

3 5 7 11 101

**Question 8 continues on the next page**

**8 (d)** **Figure 17** shows part of the circuit for the counter.

**Figure 17**




**8 (d) (i)** The motor mixes the ingredients into dough for 20 minutes. The technician wants heater 1 to warm the dough at first for 30 minutes. Heater 2 then comes on **as well as** heater 1 so that the dough is baked at full heat by both heaters for an additional 30 minutes.

Add **two** more OR gates to **Figure 17** to show this situation.

**[3 marks]**

**8 (d) (ii)** State where the technician could add an LED to **Figure 17** to indicate that cooking is complete.

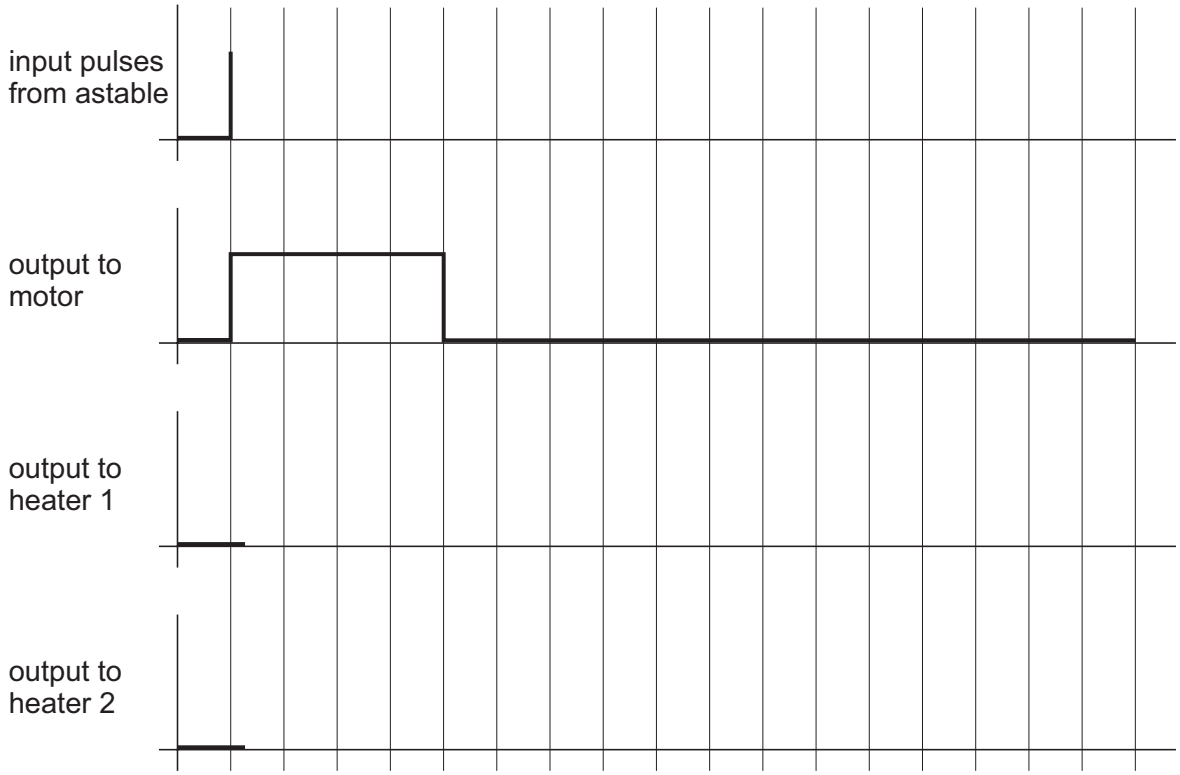
**[1 mark]**

_____

**8 (d) (iii)** Complete the timing diagram on **Figure 18** by adding the input pulses from the astable and the outputs to heater 1 and heater 2.

**[5 marks]**

**Figure 18**



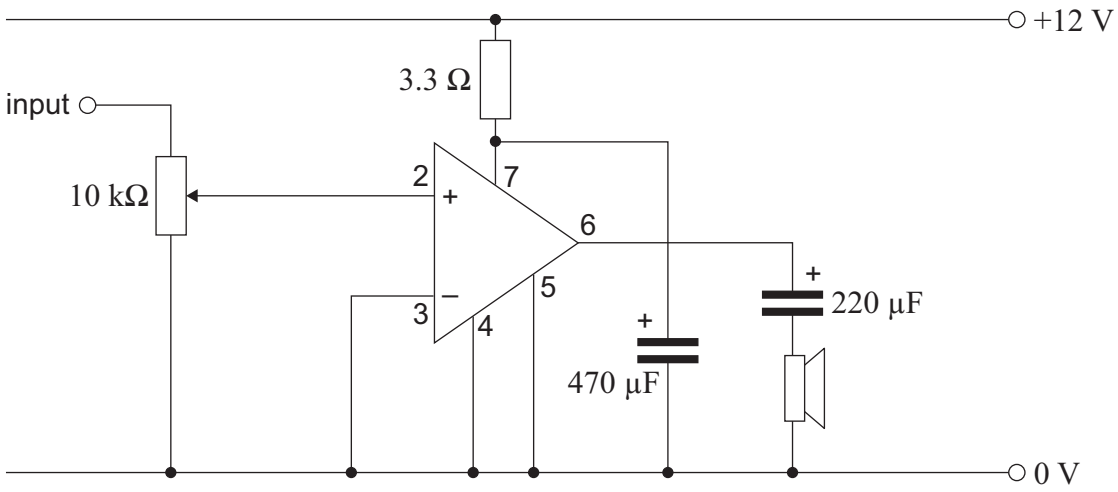

18

**Turn over for the next question**

**9** A student is building a low-power audio amplifier using the circuit shown in **Figure 19**.

The IC is in an 8-pin package and pins 1 and 8 are not connected.

**Figure 19**



**9 (a)** **Figure 20** shows part of the circuit built on a breadboard.

Complete the diagram by adding:

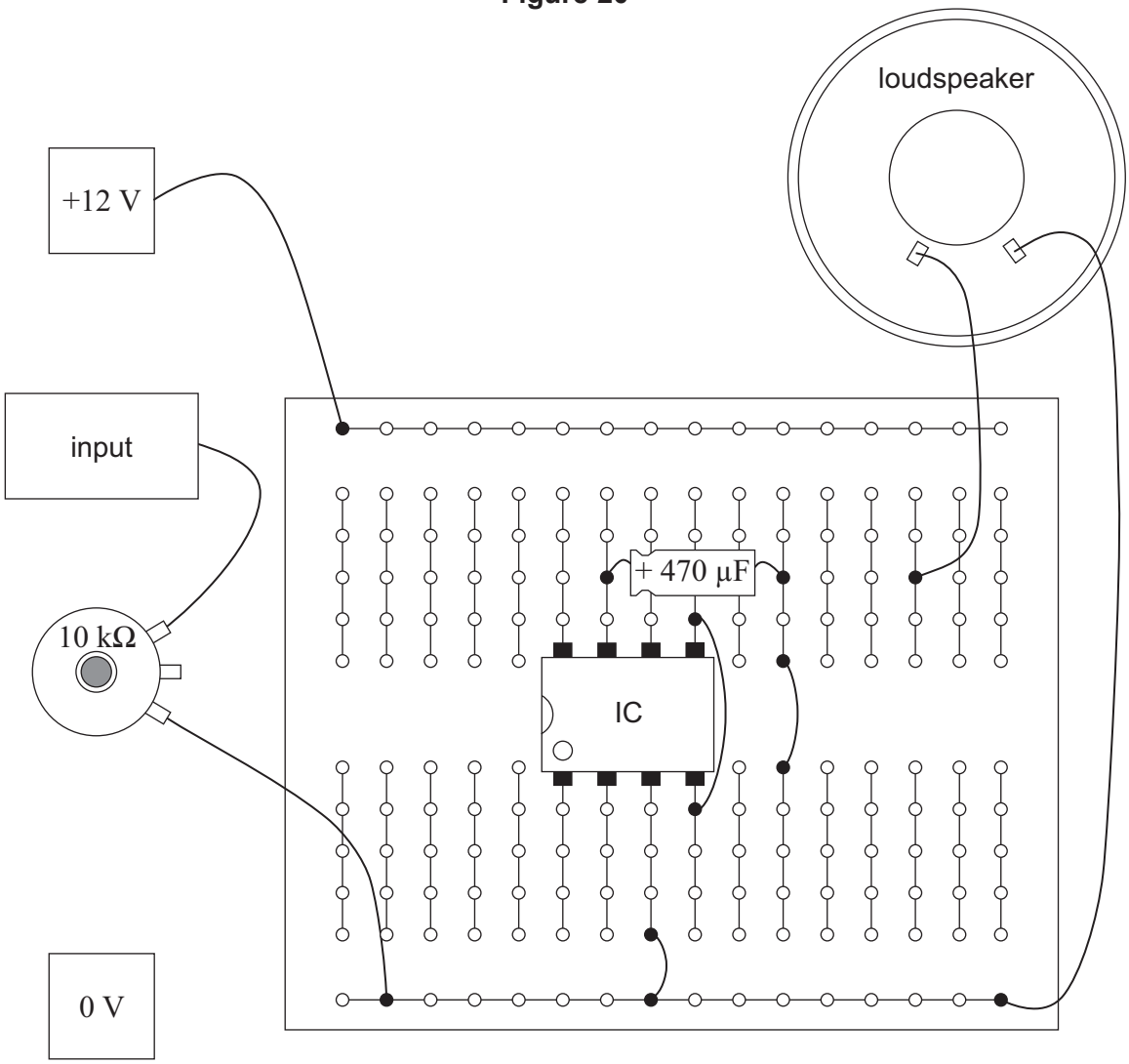
- 3.3 Ω resistor 
- 220 μF capacitor 

- and **four** wire links.

The pin numbers for the IC are shown in **Figure 19**.

**[7 marks]**

**Figure 20**



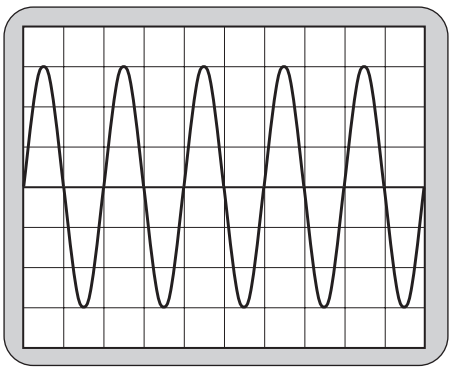

**Question 9 continues on the next page**

**9 (b)** The student tests the amplifier. He connects a signal generator to its input and an oscilloscope to its output.

**Figure 21** shows the trace that is produced.

**Figure 21**

The timebase is set to $5$ ms per division.



**9 (b) (i)** The peak voltage of the output signal is $3$ V.

Calculate the y-sensitivity of the oscilloscope.

**[2 marks]**

**9 (b) (ii)** The signal generator is set to produce an input signal with a peak voltage of $0.2$ V.

Calculate the voltage gain of the amplifier.

**[2 marks]**

**9 (b) (iii)** Calculate the rms voltage of the output signal.

**[2 marks]**

**9 (b) (iv)** Calculate the rms power delivered to the 8 Ω loudspeaker.

**[2 marks]**

**9 (b) (v)** Calculate, using **Figure 21**, the period of the output signal.

**[2 marks]**

**9 (b) (vi)** Calculate the frequency of the output signal.

**[2 marks]**

**9 (c)** Explain the term bandwidth of an amplifier.

**[2 marks]**

**9 (d)** Another version of this IC comes in a 14-pin package.

Six of the pins should be soldered to a large area of copper on the circuit board.

Explain the purpose of soldering several pins to a large area of copper.

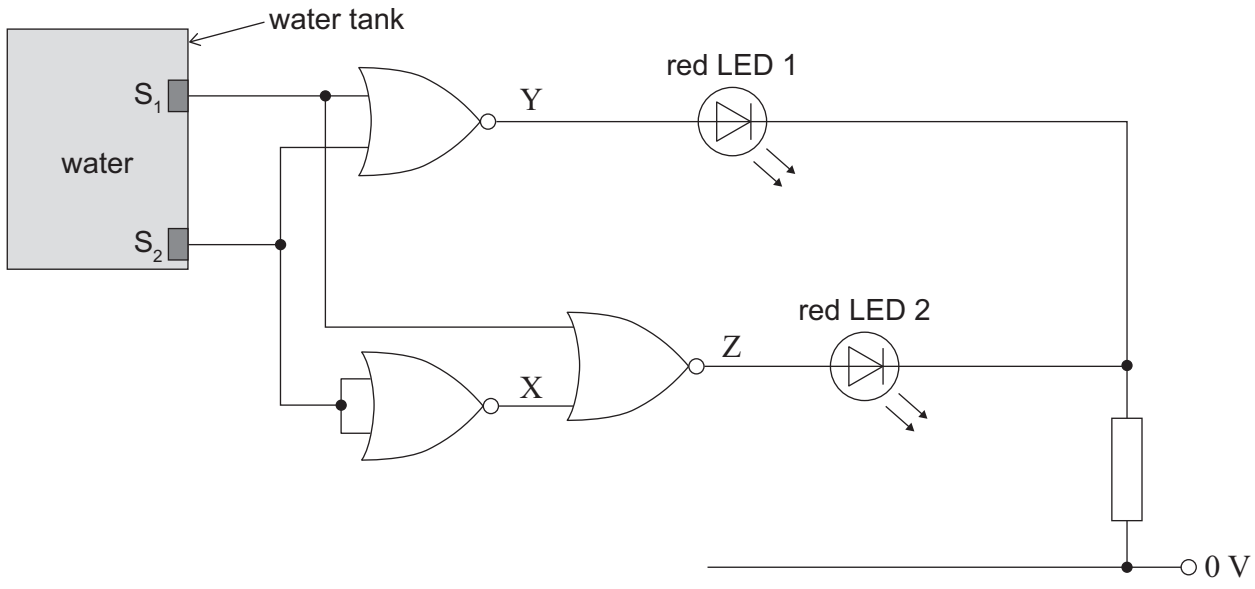
**[2 marks]**

**23**

**Turn over for the next question**

**10 (a)** **Figure 22** shows a water tank with two temperature sensors, $S_1$ and $S_2$.

**Figure 22**




**10 (a) (i)** Draw a circle around the type of gate used in the system shown in **Figure 22**.

**[1 mark]**

AND NAND NOR NOT OR

**10 (a) (ii)** Complete the truth table (**Table 3**) for this type of gate.

**[1 mark]**

**Table 3**

| A | B | P |
|---|---|---|
| 0 | 0 | |
| 0 | 1 | |
| 1 | 0 | |
| 1 | 1 | |

**10 (a) (iii)** Complete the truth table (**Table 4**) for the system shown in **Figure 22**.

**[3 marks]**

**Table 4**

| Sensor $S_1$ | Sensor $S_2$ | X | Y | Z |
|---|---|---|---|---|
| 0 | 0 | | | |
| 0 | 1 | | | |
| 1 | 0 | | | |
| 1 | 1 | | | |

**10 (a) (iv)** The two red LEDs share the same protective resistor in this circuit.

State why this does **not** affect the operation of the LEDs.

**[1 mark]**

_____

**10 (a) (v)** The hottest water is always at the top of the tank.

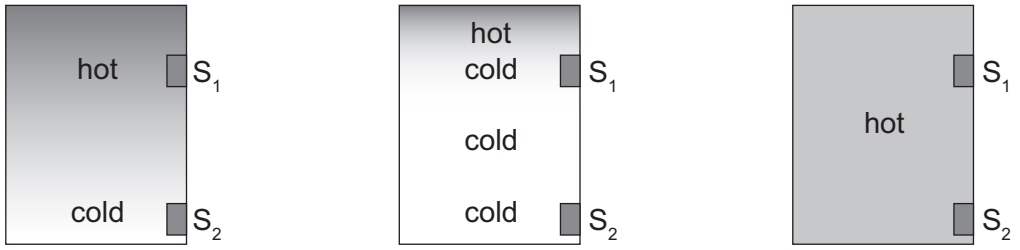
The sensors both give a high when cold and a low when hot.

**Figure 23** shows three different situations.

Write on the answer line the LEDs which would be lit, if any, in each situation.

**[3 marks]**

**Figure 23**




_____ _____ _____

**Question 10 continues on the next page**

**10 (b)** A boiler is used to heat the water in the tank in part **(a).**

A switch is used to choose whether to heat the whole tank of hot water or only half the water in the tank. The two temperature sensors also control the boiler as well as the LEDs.

Complete the diagram in **Figure 24** to show how the boiler could be made to turn on if:

- half a tank of hot water has been chosen **and** the sensor for half a tank is cold

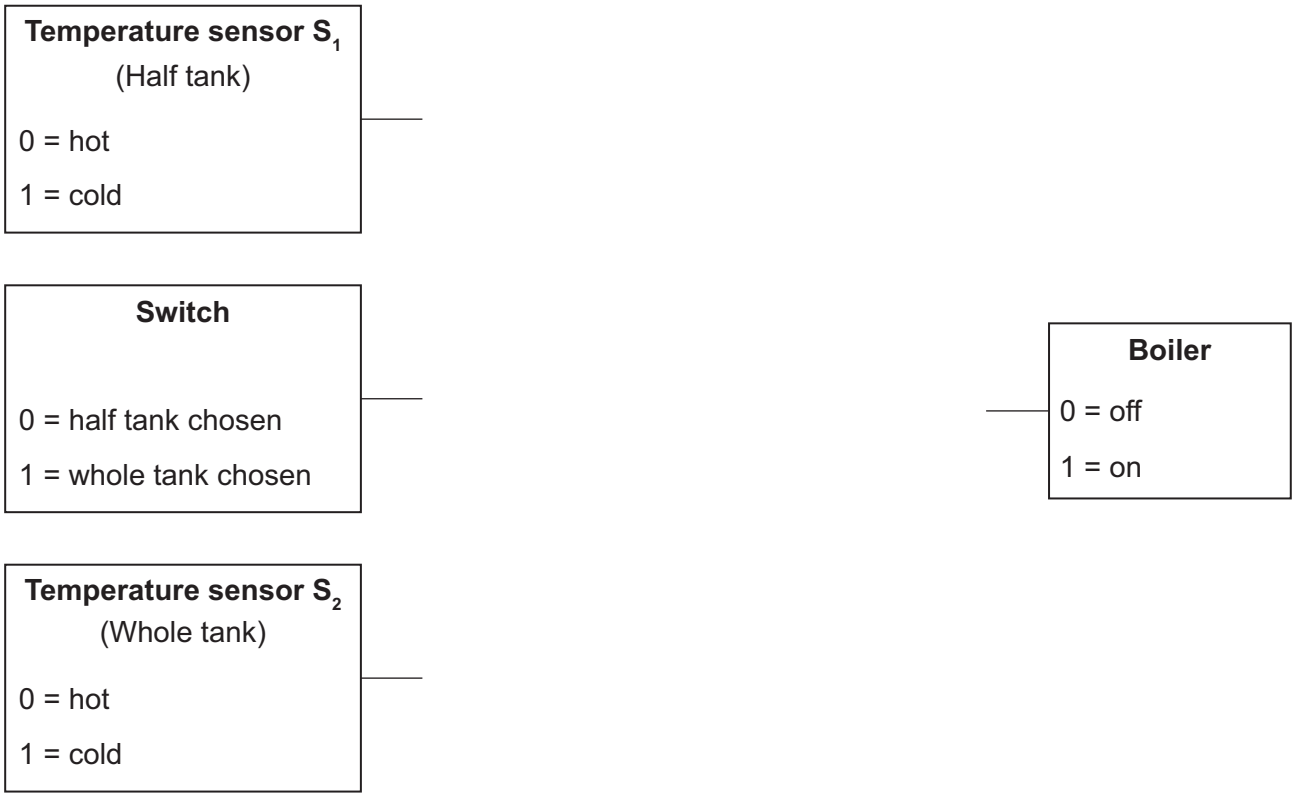
**or**

- a whole tank has been chosen **and** the sensor for a whole tank is cold.

Use only **two** AND gates, an OR gate and a NOT gate.

**[6 marks]**

**Figure 24**

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**END OF QUESTIONS**