General Certificate of Secondary Education
June 2005

ELECTRONICS   **3432/H**
HIGHER TIER

AQA
ASSESSMENT and
QUALIFICATIONS
ALLIANCE

Thursday 26 May 2005   9.00 am to 11.00 am   **H**

In addition to this paper you will require:
- a pencil and a ruler;
- a calculator.

Time allowed: 2 hours

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided.
- Show the working of your calculations.

Information
- The maximum mark for this paper is 150.
- Mark allocations are shown in brackets.
- A list of formulae and other information, which you may wish to use in your answers, is provided on page 2.
- You are reminded of the need for good English and clear presentation in your answers.

3432/H

Information Sheet

The following information may be useful in answering the questions.

1. **Power**
   Power = voltage x current; $P = VI$

2. **Amplifiers**
   Voltage gain $G_V = \dfrac{V_{OUT}}{V_{IN}}$

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

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

   The fourth band colour gives the tolerance.
   GOLD ±5%   SILVER ±10%   No fourth band ±20%

4. **Resistor printed code** (BS 1852)
   R means × 1
   K means × 1000
   M means × 1 000 000
   Position of letter gives the decimal point.
   Tolerances are indicated by adding a letter at the end.
   J ± 5%   K ± 10%   M ± 20%

   e.g. 5K6J = 5.6 kΩ ± 5%

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 multiples of ten.

6. Resistance = $\dfrac{\text{voltage}}{\text{current}}$; $R = \dfrac{V}{I}$

7. Effective resistance, R, of resistors in series is given by $R = R_1 + R_2 + R_3$

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

9. **A.C. waveforms**
   (a)   Frequency of waveform = $\dfrac{1}{\text{time period}}$; $f = \dfrac{1}{T}$

   (b)   peak value = 1.4 x rms value

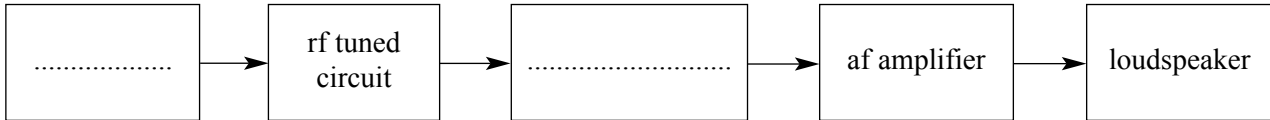10. **Astable and monostable generators using 555 timers**

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

   (b)   Astable mode, time period $T = \dfrac{(R_1 + 2R_2)\, C_1}{1.44}$
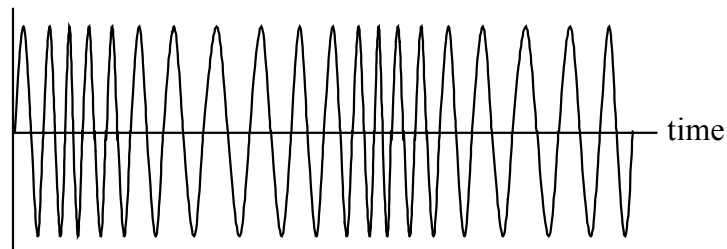
TURN OVER FOR THE FIRST QUESTION

Turn over ▶

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

1 (a) Name the missing blocks on this diagram of a simple radio receiver.

```
┌──────────────┐     ┌──────────────┐     ┌──────────────┐     ┌──────────────┐     ┌──────────────┐
│ ............ │ ──▶ │  rf tuned    │ ──▶ │ ............ │ ──▶ │ af amplifier │ ──▶ │  loudspeaker │
│              │     │   circuit    │     │              │     │              │     │              │
└──────────────┘     └──────────────┘     └──────────────┘     └──────────────┘     └──────────────┘
```

(2 marks)

(b)

        — time

(i) Name the type of modulation of the carrier wave represented in this diagram.

....

(ii) Name another type of modulation commonly used in radios.

....

(2 marks)

(c) (i) What is the name given to the ability of a radio to pick out a station with a particular frequency from others close to it?

....

(ii) What is the name given to the ability of a radio to pick up weak signals?

....

(2 marks)

(d) In this part of the question draw a circle around the correct answer.

(i) Which of these IC types can be used as an audio amplifier?

4013   4017   LM386   555

(ii) Which power listed below is the most realistic for the maximum power output from this audio amplifier?

1 mW   10 mW   0.5 W   30 W

(iii) In which frequency range would an audio amplifier IC operate?

0 – 20 Hz   20 Hz – 20 kHz   20 kHz – 1 MHz   1 MHz – 5 MHz

(iv) What would be a suitable resistance for the loudspeaker connected to the amplifier?

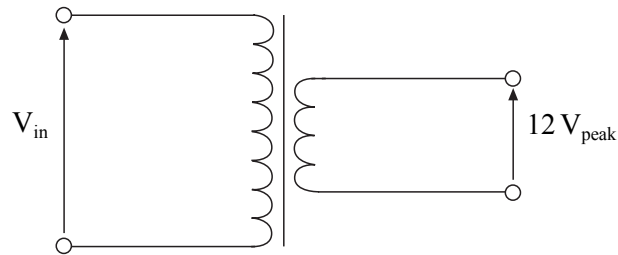0.5 Ω   8 Ω   1000 Ω   5000 Ω

(4 marks)

$\overline{10}$

TURN OVER FOR THE NEXT QUESTION

Turn over ▶

2 A power supply contains a transformer which has an output with a peak value of 12 V.

V_{in} $12\,V_{peak}$

(a)   (i)   The frequency of the output is 50 Hz. Calculate the time period in seconds.

....

....

   (ii)   State the time period in milliseconds.

....

   (iii)   Draw the trace you would expect to see if you connected the $12\,V_{peak}$ output to an oscilloscope with the settings indicated below.

The Y sensitivity is set to 5 V per cm
The timebase is set to 5 ms per cm

1 cm

1 cm
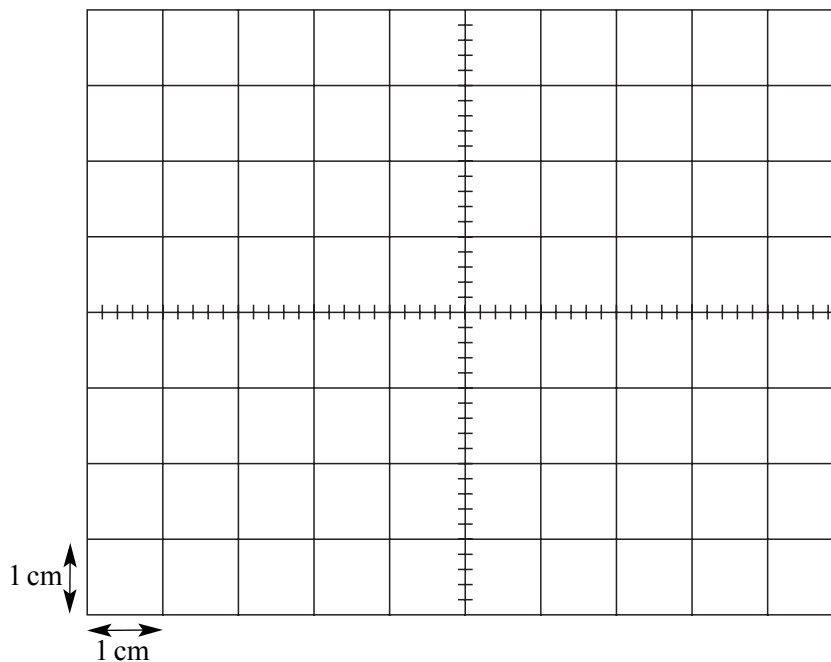
   (iv)   Calculate the rms value of the output voltage from the transformer.

....

....

(8 marks)

(b) (i) The transformer is part of a power supply which produces a rectified, smoothed and regulated voltage output and contains a fuse. Label each of the four boxes with the name of an appropriate component.

....

....
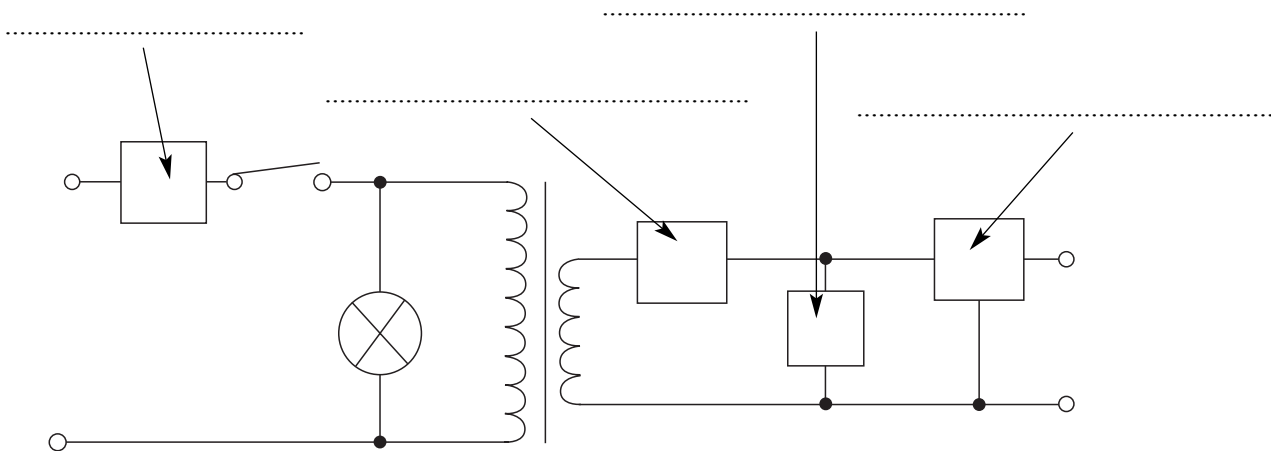
(ii) The power supply has a maximum power consumption of 80 W and operates from 230 V mains. Calculate the mains current.

....

....

(iii) Draw a circle around the best value for the fuse in this power supply.

100 mA   250 mA   1 A   5 A   13 A

(7 marks)

(c) The power supply is connected to the mains using a 3 pin plug. Label the names and colours of the wires in the plug.

Name ....

Colour ....

Name ....

Colour ....

Name ....

Colour ....

(3 marks)

18

Turn over ▶
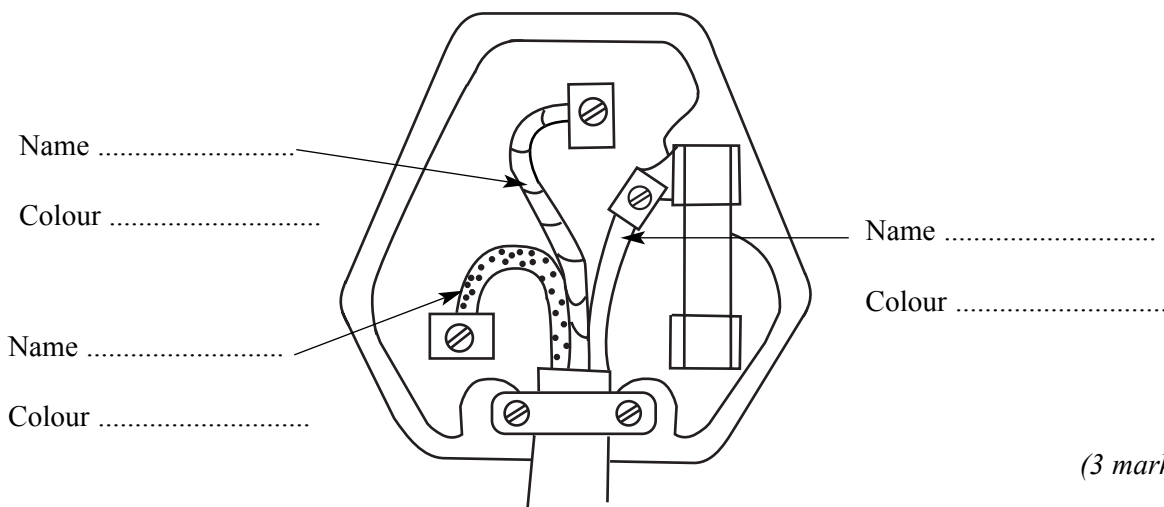
3   The flowchart describes the operation of a simple house intruder alarm.
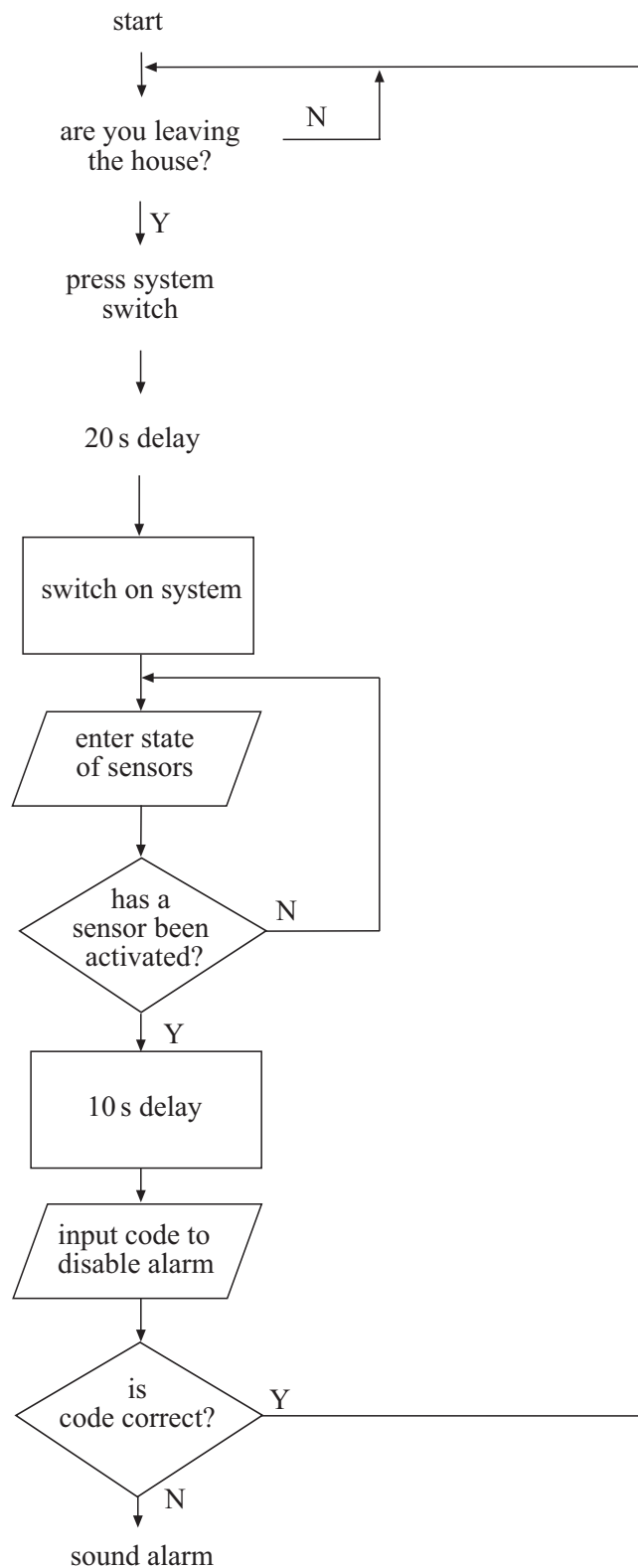Some of the flowchart symbols have been left out.

start

are you leaving
the house?   N

↓ Y

press system
switch

20 s delay

switch on system

enter state
of sensors

has a
sensor been
activated?   N

↓ Y

10 s delay

input code to
disable alarm

is
code correct?   Y

↓ N

sound alarm

(a)   Draw the correct flowchart symbols at **five** places where they are missing on the diagram.

(5 marks)

(b)   Label on the flowchart:

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

(5 marks)

(c) An intruder, who does not know the correct code in order to disable the alarm, enters the house after the alarm has been set.
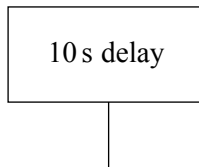Using the flowchart in part (a), describe the sequence of events that will occur.

....

....

....

....

....

(5 marks)

(d) Using the lower part of the flowchart in part (a) as a guide, draw a new flowchart that would allow two incorrect attempts at entering the code before sounding the alarm when a third incorrect attempt is made. Start your flowchart from the 10 s delay box.

```
┌──────────────┐
│  10 s delay  │
└──────┬───────┘
       │
```

(5 marks)

20

Turn over ▶

4 A student designs a simple house intruder alarm system. One input to the system is a reed switch on the front door. When the front door is opened a 10 s timer starts. The person entering has to input a code number on a keypad connected to a logic gate to disable the system during these 10 s. If the correct code number is not entered a second timer is triggered which operates an audible warning device.

(a) Draw a system diagram for this alarm system.

(6 marks)

(b)   The reed switch input circuit is shown below.
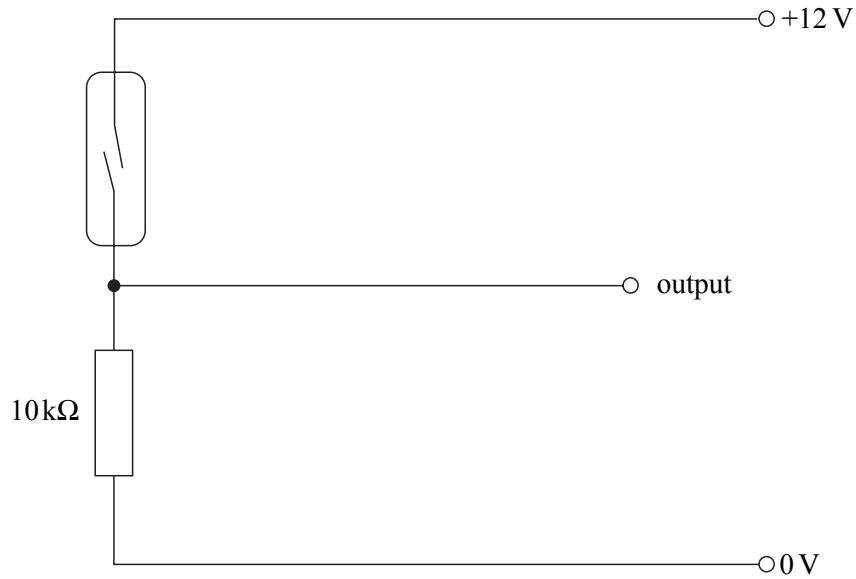
A magnet on the door keeps the reed switch closed when the door is shut. The reed switch contacts open when the door opens.

(i)   State the output voltage when:

the door is shut; ....

the door is opened. ....

(ii)   Calculate the current flowing through the circuit when the door is shut.

....

....
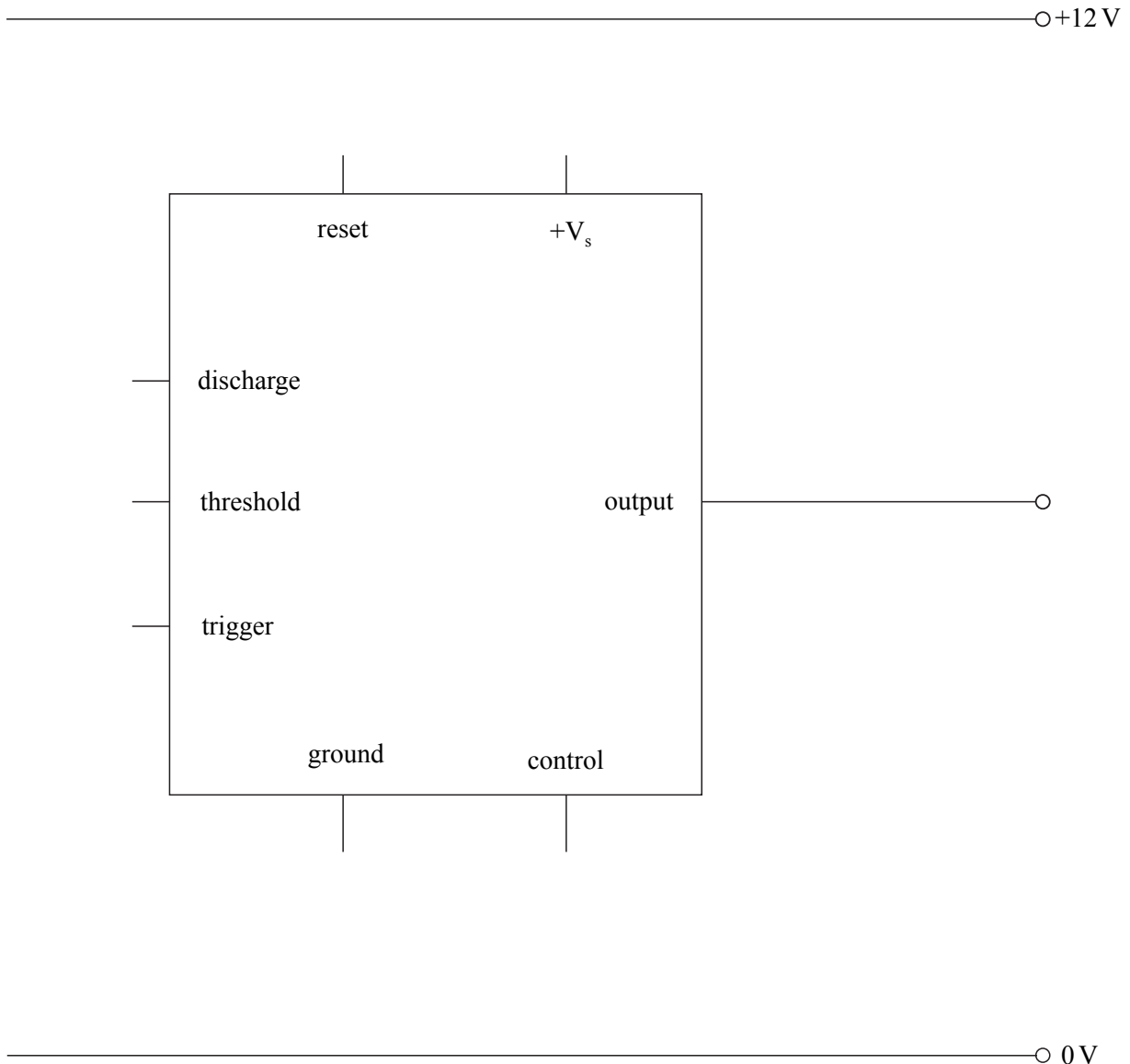
(4 marks)

QUESTION 4 CONTINUES ON THE NEXT PAGE

Turn over ▶

(c) Complete the circuit diagram below to show how a 555 IC would be connected to form the 10 s timer. Include all components and label the input.

o +12 V

reset   +V$_s$

discharge

threshold   output   o

trigger

ground   control

o 0 V

(8 marks)

(d) (i) Explain how the 10 s timer is triggered by the door opening. Include in your answer reference to voltage levels produced by the input circuit and those required by the monostable in its operation.

....

....

....
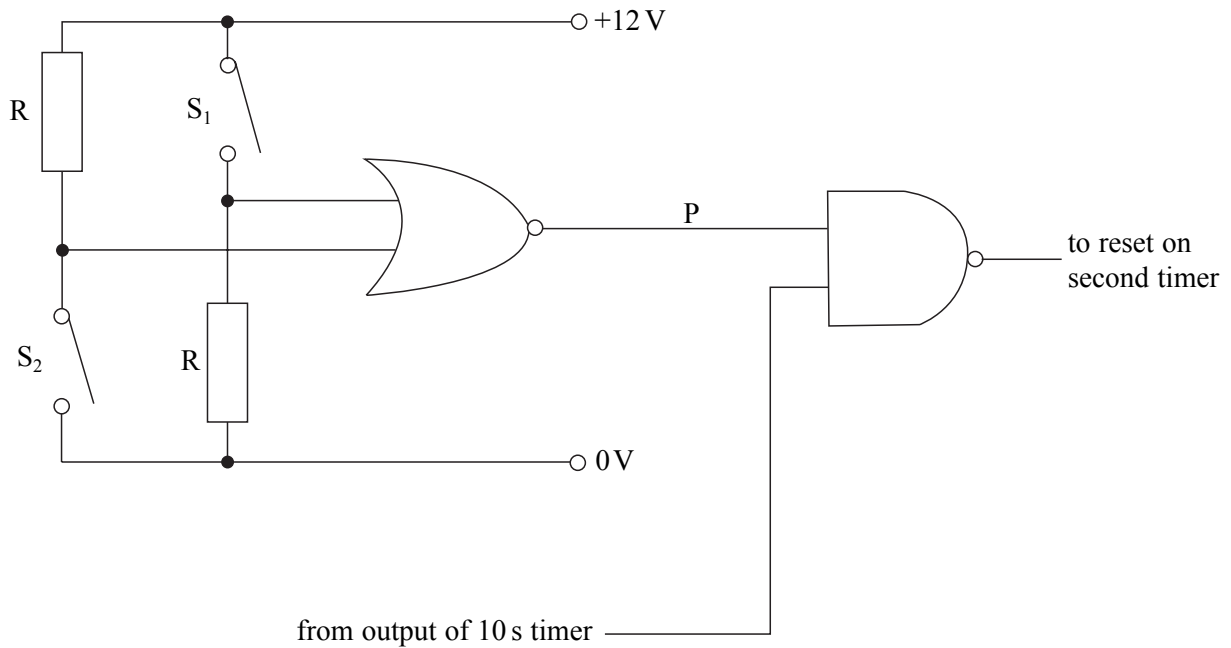
(ii) The second timer also uses a 555 IC and has a logic system connected to its reset input. What voltage level will:

1. stop the timer operating; ....

2. allow the timer to function? ....

(6 marks)

(e) The switches and logic gate circuit are shown below.

(i) Both switches S_1 and S_2 are shown open. State the condition of each switch required to give a logic 1 at P.

S_1 ....

S_2 ....

(ii) If the switches are set correctly in the first 10 s after entering the house, what logic level is sent to the second timer reset pin?
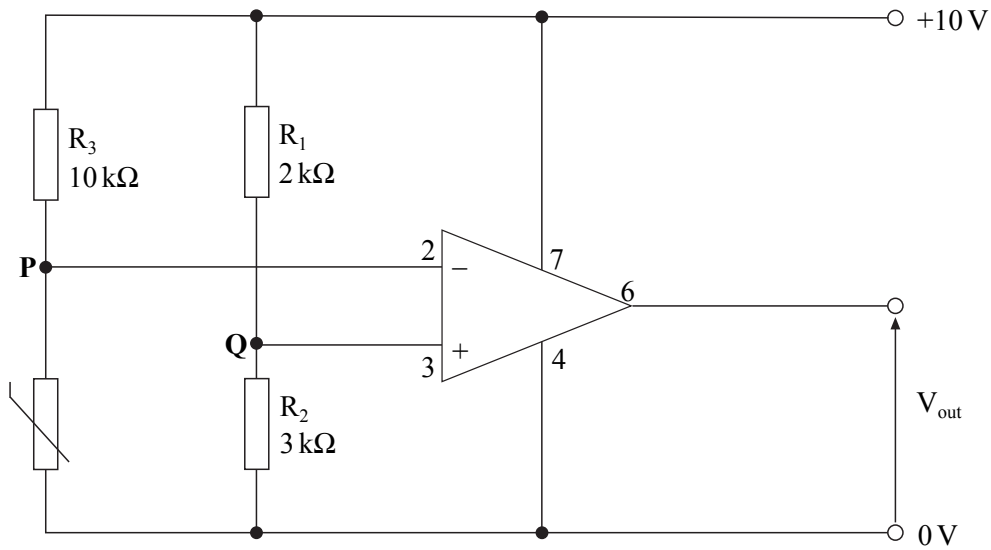
Logic level ....

(iii) Explain why the second timer can only be reset during the first 10 s after entering the house. Make reference to the type of gate that is connected to the second timer reset pin.

....

....

....

(6 marks)

30

Turn over ▶

5 A fridge alarm sounds if the temperature is too high. It uses the following circuit.

(a) (i) Calculate the combined resistance of resistors, R_1 and R_2.

....

(ii) Calculate the voltage at **Q**.

....

....

(iii) State the voltage at **P** just at the point when V_{out} changes.

....

(iv) Calculate the resistance of the thermistor when V_{out} changes.

....
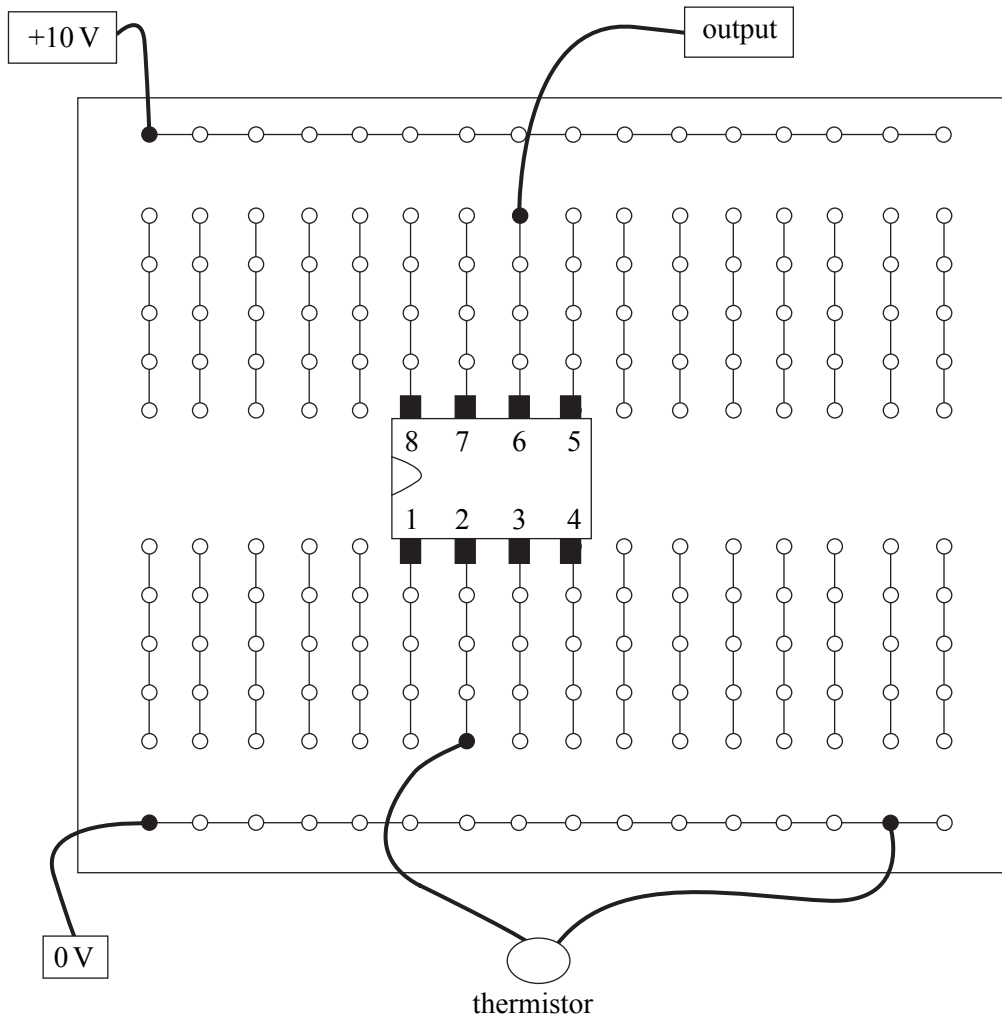
(v) What will happen to V_{out} when the temperature of the thermistor changes from being very cold to warm?

....

(6 marks)

(b) This circuit is built on breadboard. Complete the layout diagram and label the resistors. (The pin connection numbers for the op-amp are indicated on the diagram on **page 14**.)
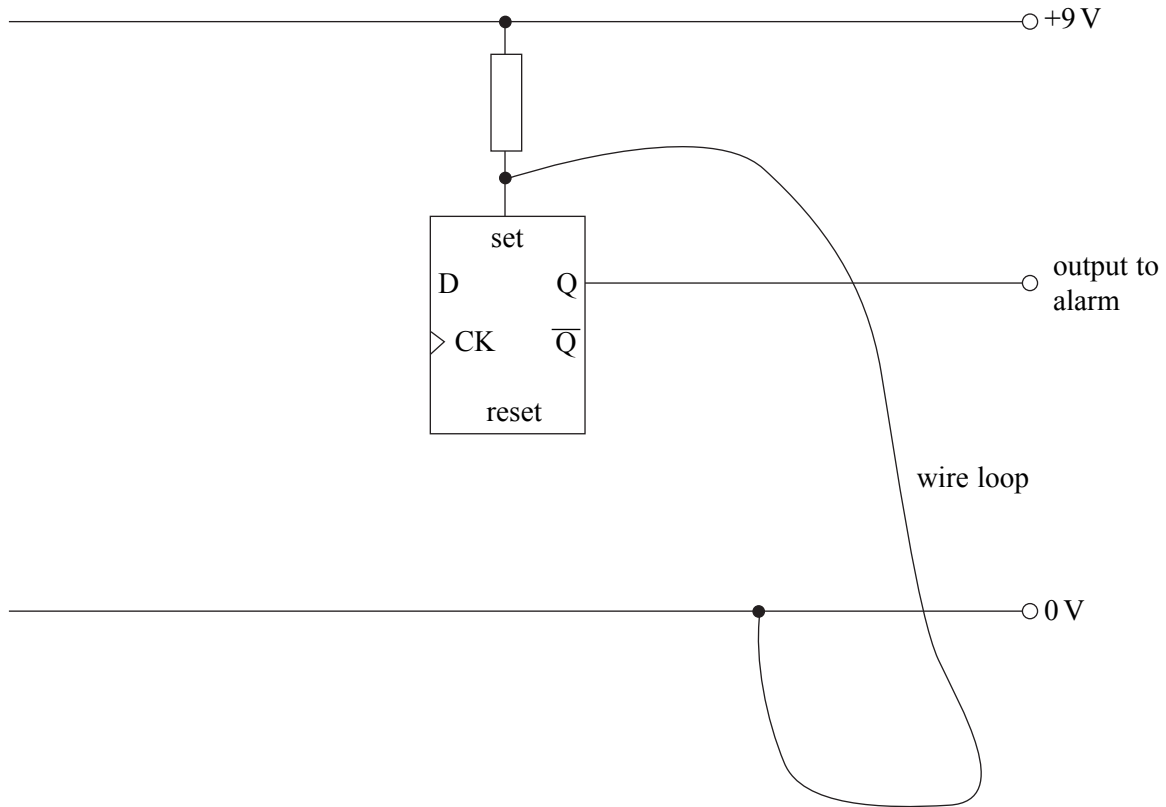
+10 V

output

8 7 6 5

1 2 3 4

0 V

thermistor

(9 marks)

15

Turn over ▶

6 An electrical goods shop has an anti-theft alarm which has a wire loop threaded through the handles of the CD players. If the wire is broken a siren sounds and can be reset using a key operated switch. The circuit uses a D-type flip-flop and part of it is shown below.

(a) (i) State the voltage at the set input to the flip-flop when the wire loop is complete.

....

(ii) State the voltage at the set input to the flip-flop when the wire loop is broken.

....

(iii) What happens to the two outputs of the flip-flop when the wire loop is broken?

....

....
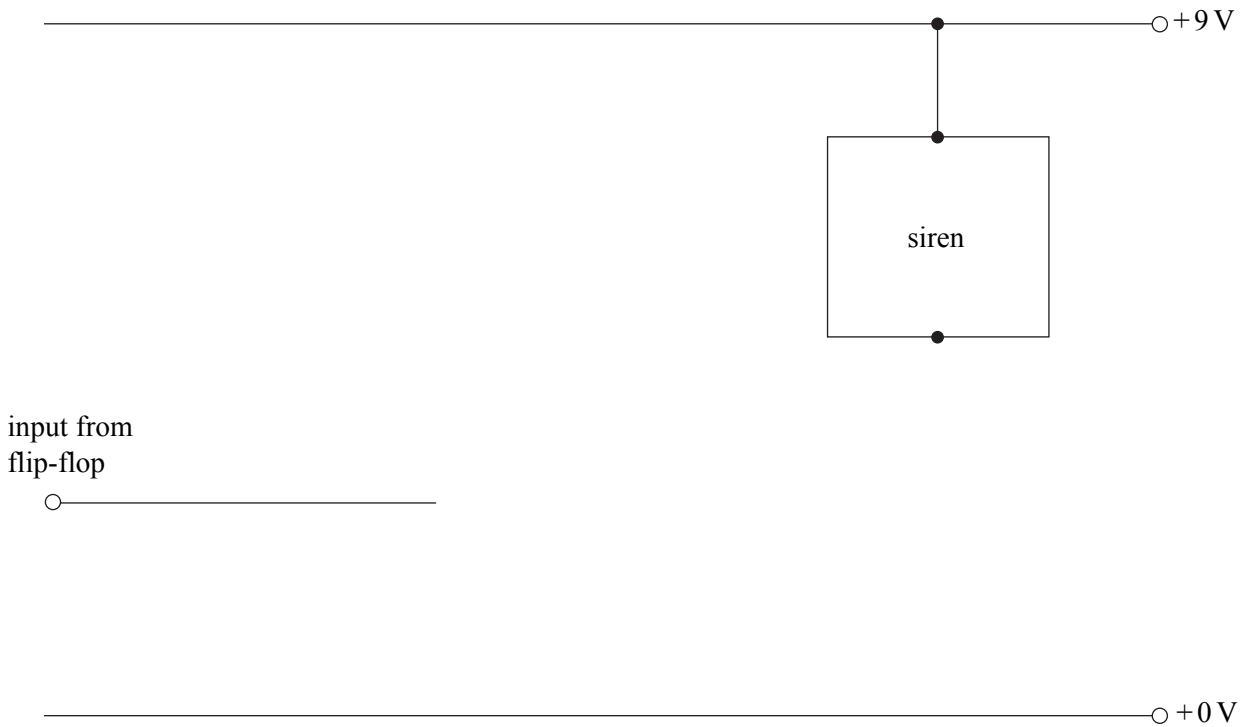*(4 marks)*

(b) Add to the diagram above a switch and resistor which could be used to provide a high voltage to the reset input when the switch is closed but keeps the reset input low when the switch is open.
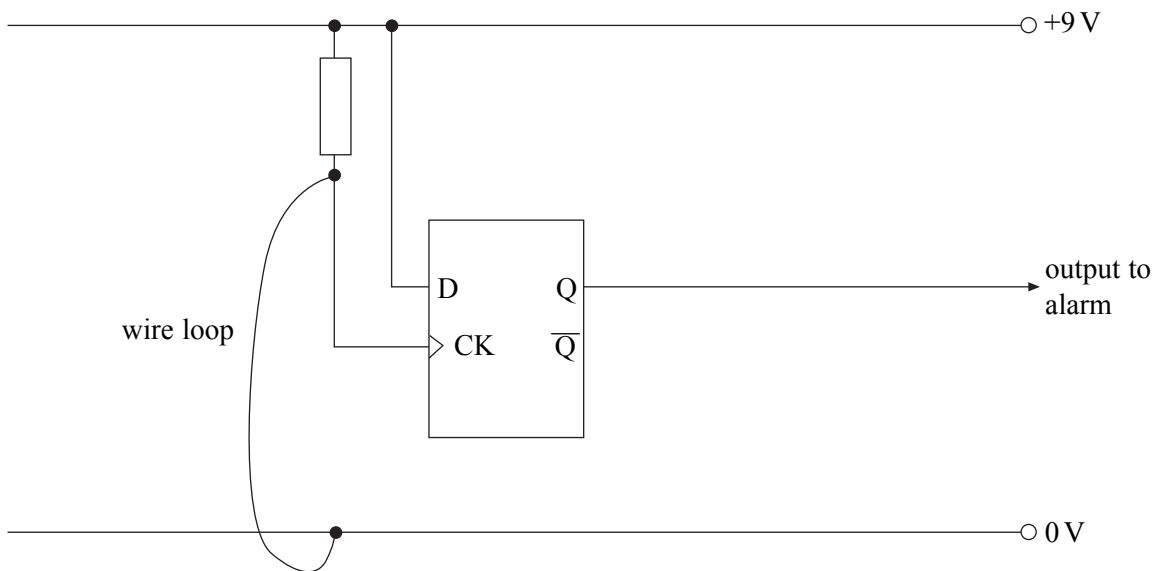*(2 marks)*

(c) The flip-flop cannot provide enough current to operate the siren. On the diagram below show how a bipolar transistor should be connected to switch on the siren.

+9 V

siren

input from
flip-flop

+0 V

(3 marks)

(d) An alternative method to trigger the alarm is to use the clock input (CK) on the flip-flop. The set and reset inputs are connected to 0 V.

+9 V

D   Q

output to
alarm

wire loop

CK $\overline{Q}$

0 V

Explain why Q goes high when the wire loop is broken.

....

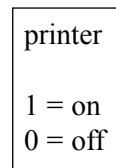...

(2 marks)

Turn over ▶

$\overline{11}$

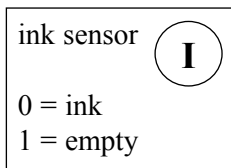**7** A printer will only start to print when a signal is received from a computer if the sensors indicate that the cartridge contains ink and there is paper in the tray.

(a) Using only AND and NOT gates, complete this diagram to show how the printer could be made to operate.

input from computer **C**
1 = print
0 = do not print

ink sensor **I**
0 = ink
1 = empty

paper sensor **P**
0 = paper
1 = no paper

printer
1 = on
0 = off
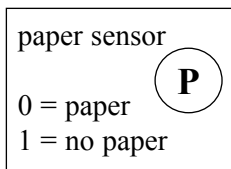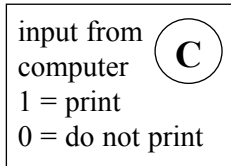
(4 marks)

(b) The system could also be made from a network of NOR gates.

C

I

P

X

Y

Z

output to printer
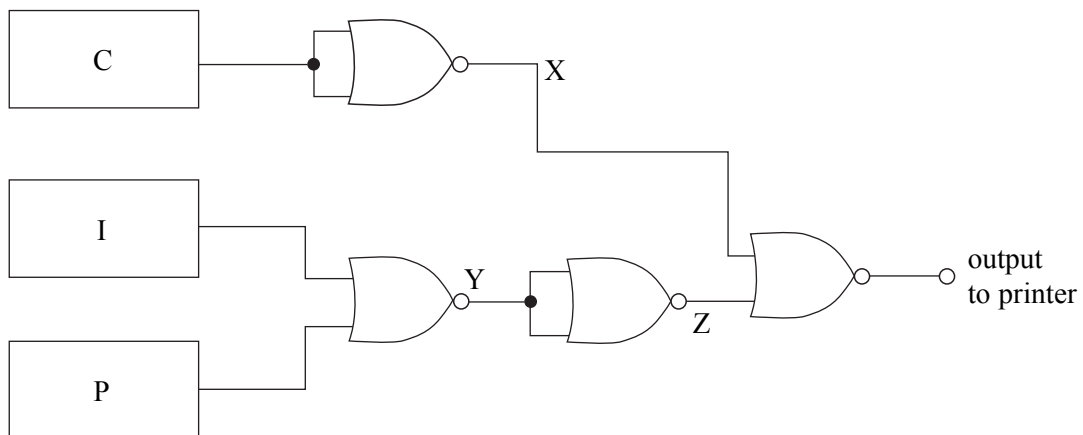
(i) Complete this truth table for a NOR gate.

A	B	S
0	0	
0	1	
1	0	
1	1	

(ii) Complete the truth table for the NOR gate system shown in part (b).

Computer C	Ink sensor I	Paper sensor P	X	Y	Z	Output
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

(iii) Explain why it might be better for a student to make this system out of NOR gates rather than AND and NOT gates.

....

....

....

(7 marks)

(c) The systems above are hardware. In practice the printer would be controlled by software.

(i) Explain what is meant by software.

....

....

(ii) Explain why it is better to control the printer using software.

....

....
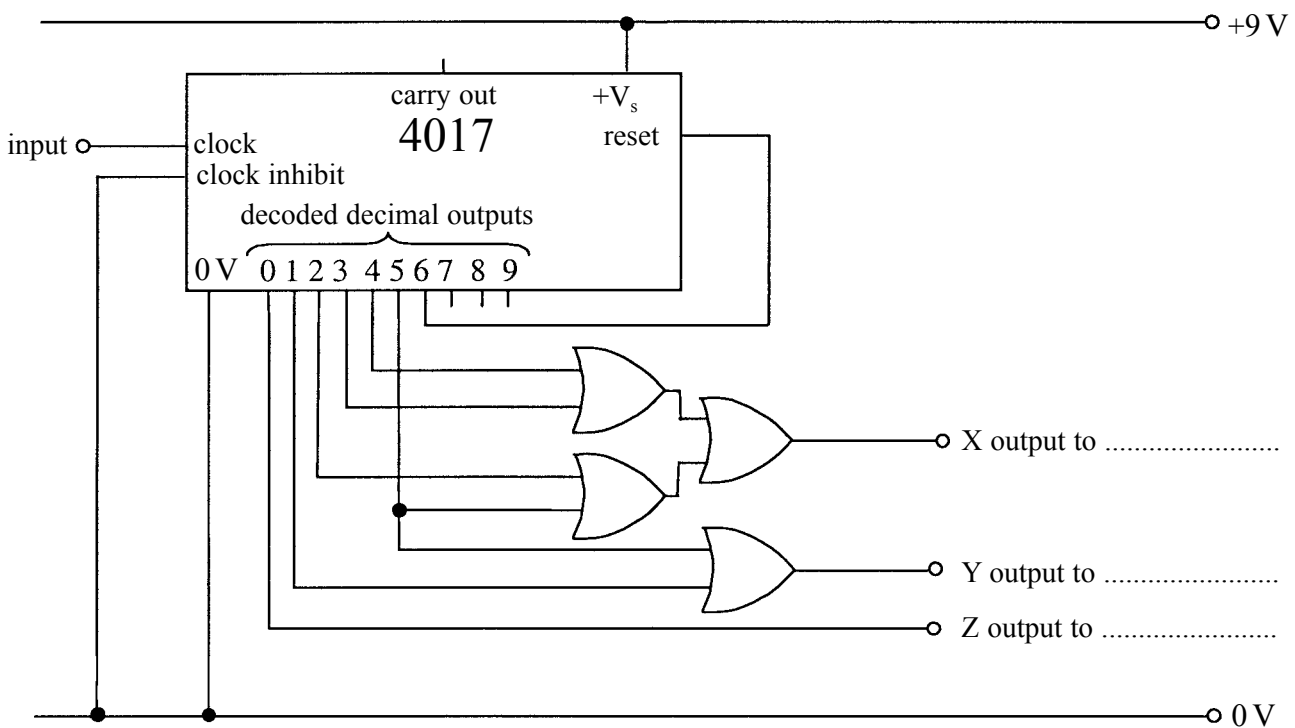
(4 marks)

15

Turn over ▶

8 Model traffic lights are controlled by a push switch. When the switch is pressed the traffic lights change from green to amber and then to red. After a time the lights change to red and amber and then back to green.

green   amber   red   red and amber   green
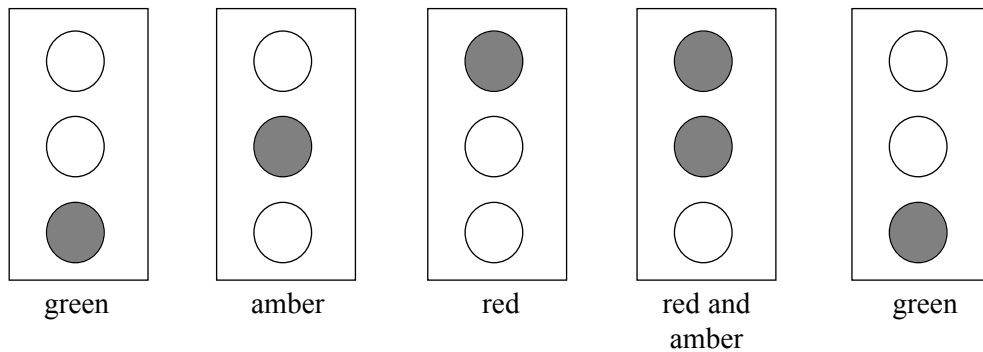
The model uses this circuit to switch on red, amber and green light emitting diodes (LEDs).

(a) The 4017 IC is reset before the switch is pressed. When the switch is pressed six pulses arrive at the input to the 4017 IC.

   (i) On the dotted lines in the diagram above state the colour of the LED to which each output should be connected.

   (ii) The amber LED comes on for 5 s each time. For how long is the red LED lit on its own?

....

(4 marks)

(b) (i) Complete the timing diagram showing the states of outputs X, Y and Z when the switch is pressed.
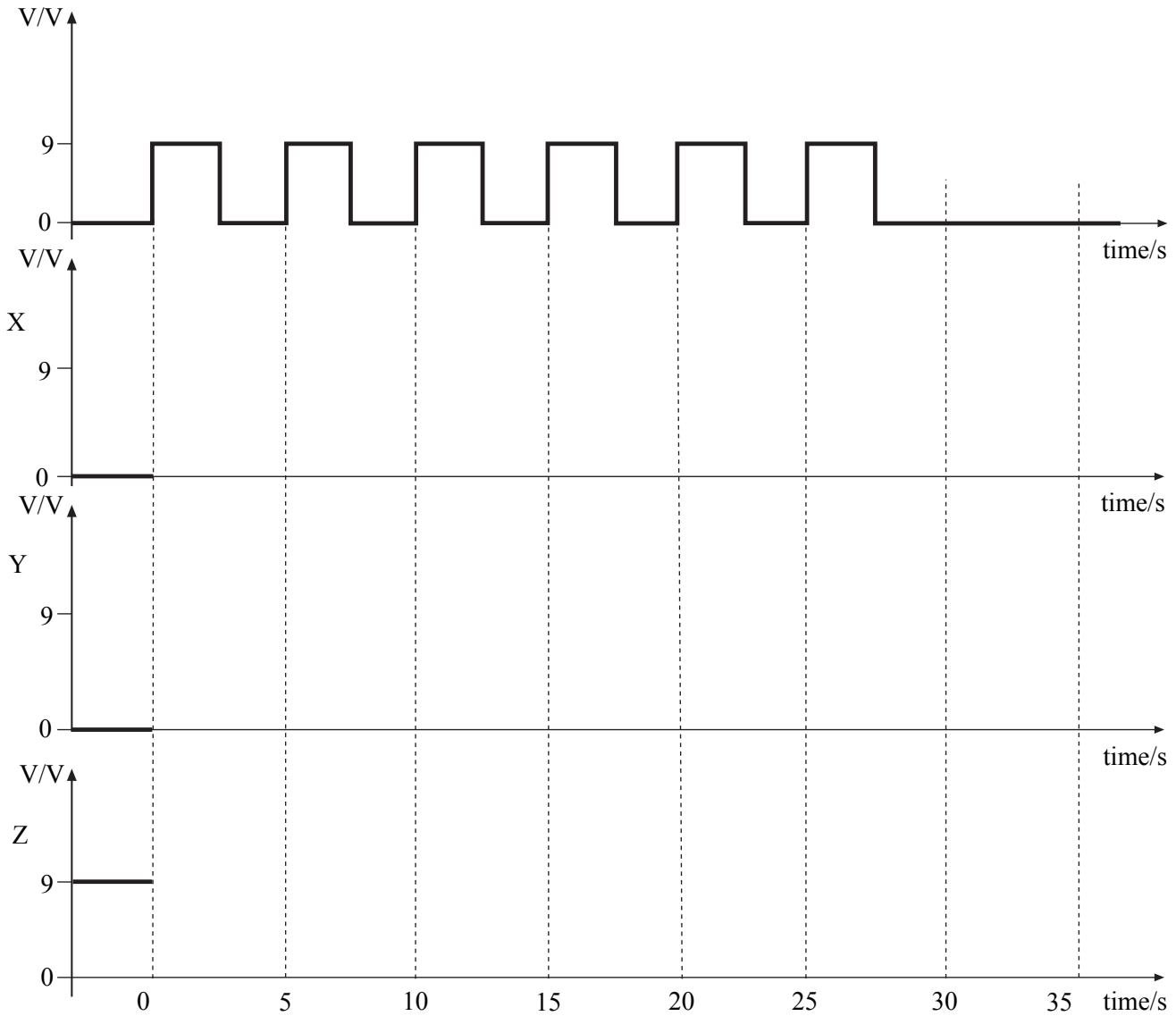
(ii) Explain how the circuit on **page 20** would have to be modified so that the red LED would be on for 10 s longer if eight pulses of the same period were input.

....

....

....
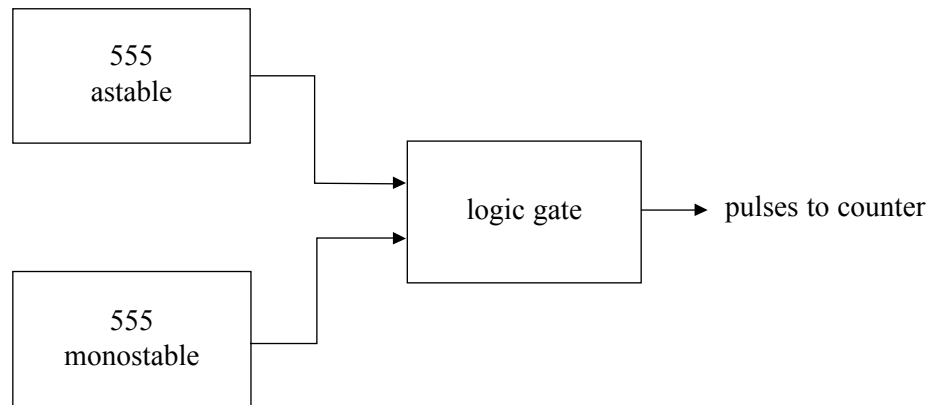
(8 marks)

QUESTION 8 CONTINUES ON THE NEXT PAGE

Turn over ▶

(c)   This system is used to produce the pulses. When the monostable is triggered six pulses go to the counter.

(i)   What type of logic gate should be used?

....

(ii) Complete the circuit below to show how a 555 timer IC can be connected to produce astable pulses. Show a timing capacitor, a resistor and the wire links needed.
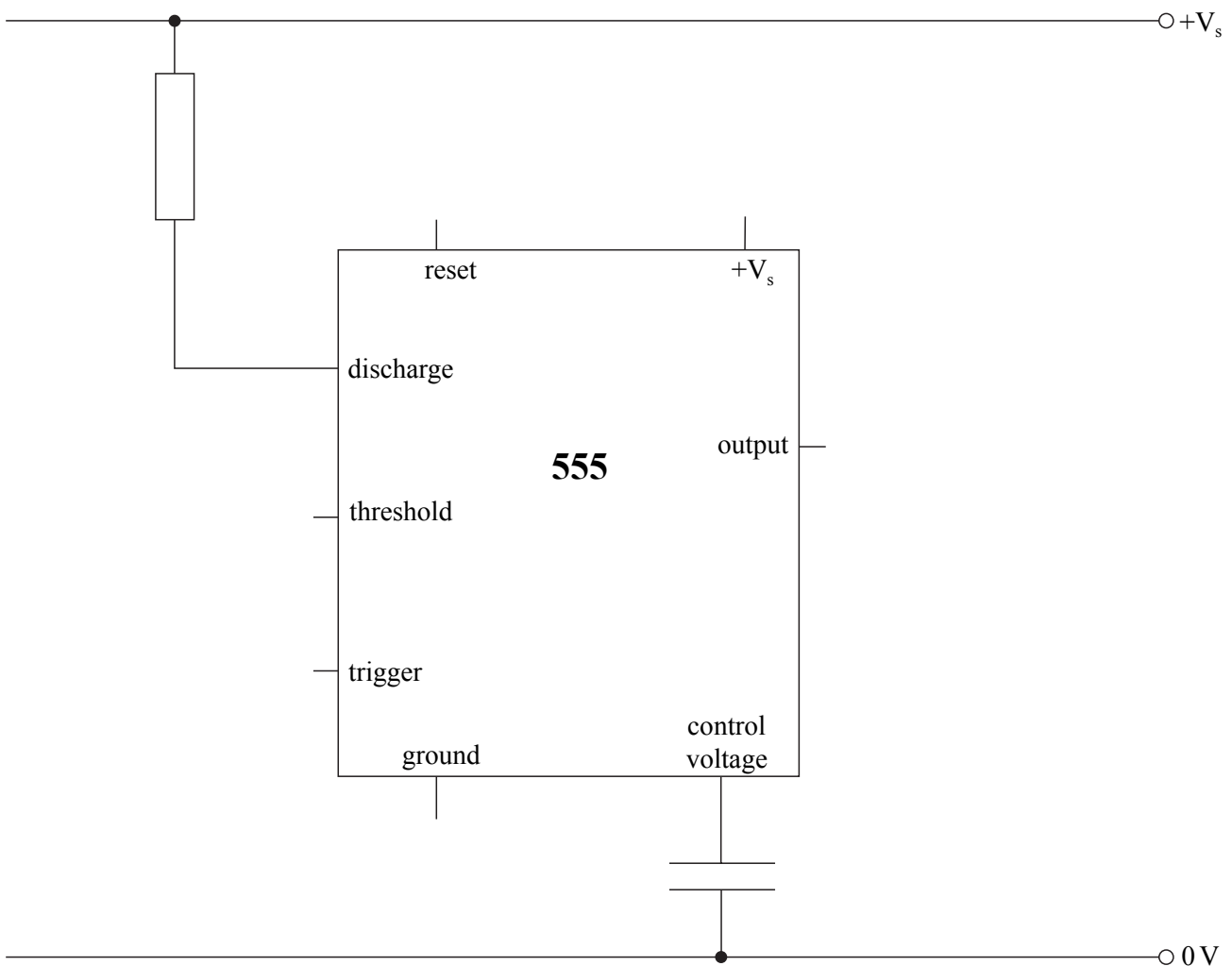
(iii) The monostable has a $47\,\mu F$ timing capacitor and a $620\,k\Omega$ resistor. Calculate the time period of the pulse produced.
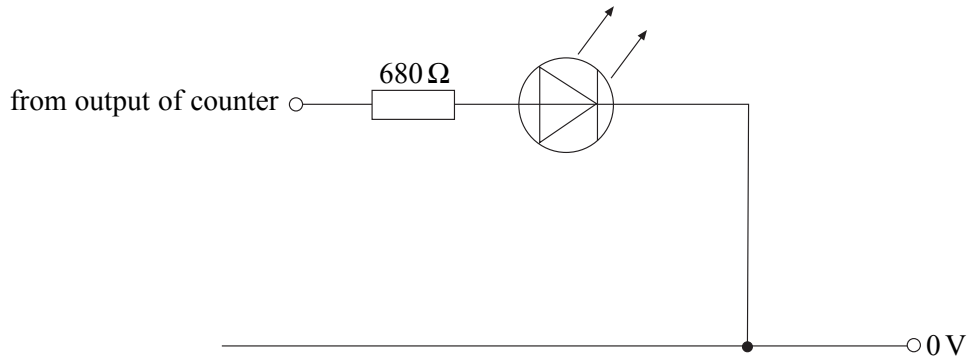
....

....

....

(10 marks)

(d) Each LED is connected in series with a resistor.

from output of counter $\circ$————[$680\,\Omega$]———▷—————————$\circ$ 0 V

(i) Explain why the resistor is needed.

....

....

(ii) The voltage across the LED is $2\,V$ and the circuit has a $9\,V$ supply. Calculate the voltage across the resistor.

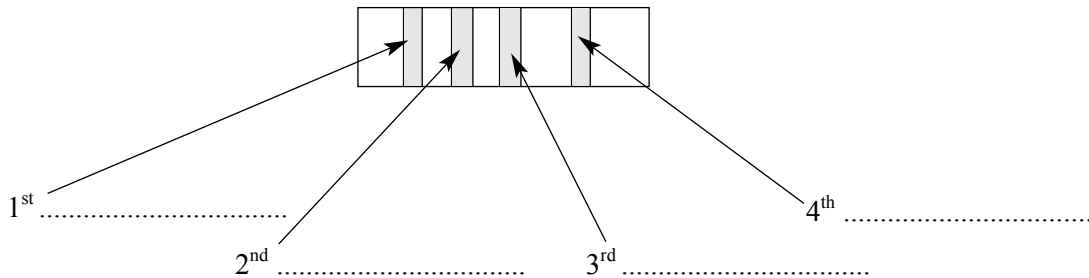...

(iii) Calculate the current passing through the LED.

....

....

(iv) The $680\,\Omega$ resistor has a tolerance of 5%. Label the coloured bands.

1st .... 4th ....

2nd .... 3rd ....

(9 marks)

END OF QUESTIONS

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE