Surname	
Other Names	
Candidate Signature	

AQA

General Certificate of Secondary Education
June 2012

Electronics   44301

Unit 1   Written Paper

Monday 11 June 2012   9.00 am to 11.00 am

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

Time allowed
- 2 hours

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 booklet. 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 and other information, which you may wish to use in your answers is provided on page 2.
- Any correct electronics solution will gain credit.
- You will be marked on your ability to use good English to organise information clearly and to use specialist vocabulary where appropriate.

44301

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 ± 5%   SILVER ± 10%

Resistor printed code (BS 1852)

R means × 1   K means × 1000   M means × 1 000 000

Position of the 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%

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 $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$

Power

Power = Voltage × Current;   P = VI

Amplifiers

Voltage gain $G_V = \dfrac{V_{out}}{V_{in}}$

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 $T = \dfrac{(R_1 + 2R_2)C_1}{1.44}$

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

1 (a) List **three** things you should do if you find someone in a workshop who is in contact with the mains electrical supply.

1 ....

2 ....

3 ....

(3 marks)

1 (b) Name and describe **two** effects of mains electric current flowing through a human body.

Name of effect 1 ....

Description ....

....

Name of effect 2 ....

Description ....

....

(4 marks)

1 (c) An electric heater has a power rating of 1000 W (1 kW).

1 (c) (i) Calculate the current that the heater will draw from a 230 V supply.

....

....

(2 marks)

1 (c) (ii) Mains fuses are available in 1 A, 3 A, 5 A, 10 A and 13 A ratings. Which one would be best for this heater?
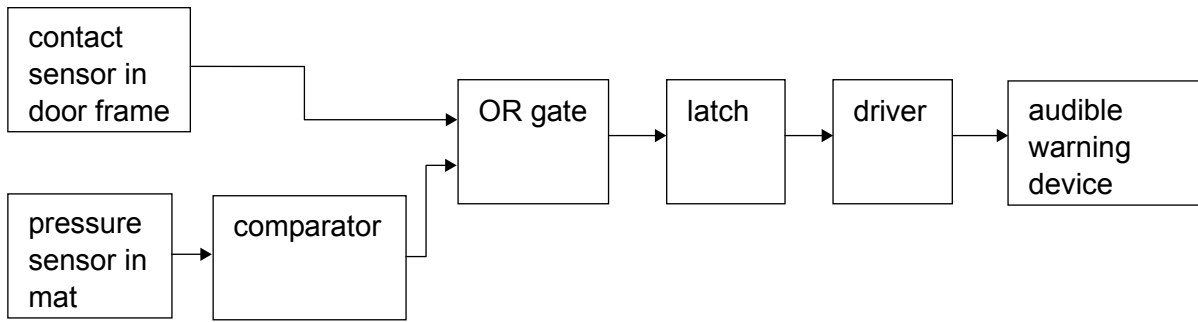
....

(1 mark)

10

Turn over ▶

2 The block diagram of a burglar alarm system is shown below.

```
┌──────────┐
│ contact  │──────────┐
│ sensor in│          │      ┌────────┐   ┌───────┐   ┌────────┐   ┌──────────┐
│door frame│          └─────▶│ OR gate│──▶│ latch │──▶│ driver │──▶│ audible  │
└──────────┘                 │        │   │       │   │        │   │ warning  │
                        ┌───▶│        │   │       │   │        │   │ device   │
┌──────────┐ ┌─────────┐│    └────────┘   └───────┘   └────────┘   └──────────┘
│ pressure │ │comparator││
│ sensor in│▶│         ├┘
│ mat      │ │         │
└──────────┘ └─────────┘
```

2 (a) In the diagram, which block represents

2 (a) (i) an input ....

2 (a) (ii) an output ....

2 (a) (iii) a simple memory? ....

(3 marks)

2 (b) In which block would you find

2 (b) (i) a D-type flip-flop ....

2 (b) (ii) an op-amp ....

2 (b) (iii) a buzzer? ....

(3 marks)

2 (c) Which block functions as

2 (c) (i) a logic subsystem ....

2 (c) (ii) an analogue to digital converter? ....

(2 marks)

2 (d) A burglar opens the door. Describe the operation of the rest of the system.

....

....

....
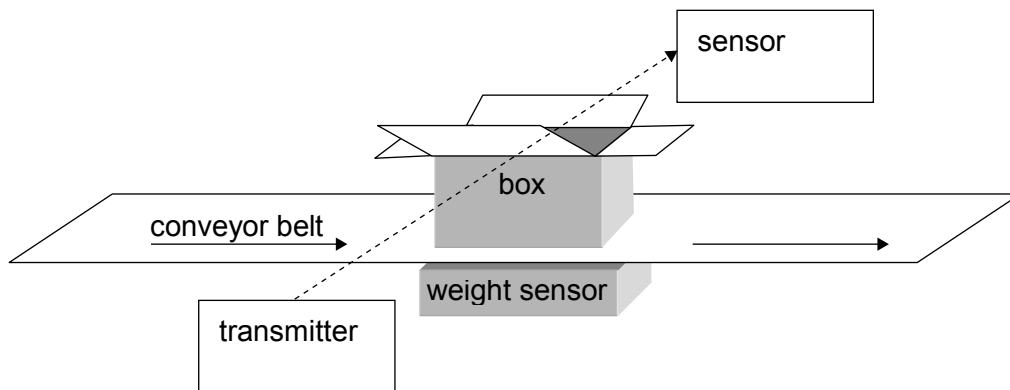
(2 marks)

10

3 A machine staples the flaps on a box when a product has been placed in the box and its flaps have been folded down.

The box moves along a conveyor belt which has a weight sensor under the belt at the stapler location.

3 (a) Name a type of transmitter and sensor you could use to detect when the flaps are closed.

3 (a) (i) Type of transmitter ....

(1 mark)

3 (a) (ii) Type of sensor ....

(1 mark)

3 (a) (iii) How will this detect when the flaps are closed?

....

....

(1 mark)

3 (b) The weight sensor gives a logic 1 only when the box is loaded with the product. The flap sensor gives a logic 1 when it detects that the box flaps are folded down.

3 (b) (i) What type of logic gate could use the logic signals from the weight sensor and the flap sensor to give a logic 1 output to trigger the stapling machine?

....

....

(1 mark)

Question 3 continues on the next page

Turn over ▶

3 (b) (ii) Draw the logic symbol for this gate in the space below.   Label its inputs from each of the two sensors and the output to the stapler.

(4 marks)

3 (b) (iii) Complete the truth table to show the operation of your chosen logic gate.

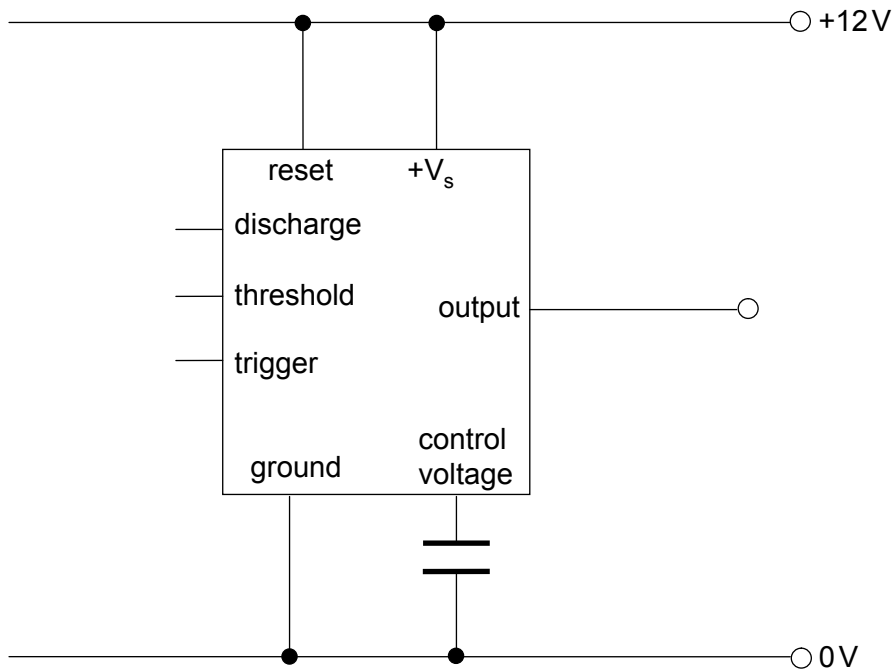| Weight sensor	Flap sensor	Stapler
0	0	
0	1	
1	0	
1	1	

(2 marks)

10

4 A technician uses a 555 timer IC to make an astable.

4 (a) (i) Complete the circuit diagram of the astable below. Draw wire links, and draw and label two timing resistors R_1 and R_2, and the timing capacitor C_1, to complete the circuit diagram.

(5 marks)

4 (a) (ii) R_1 is $1\,k\Omega$ and R_2 is $100\,k\Omega$, and C_1 is $0.01\,\mu F$, calculate the output time period of the astable.

....

....

....
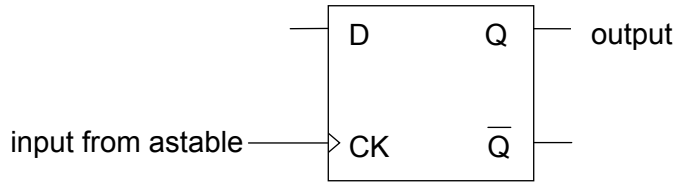
(3 marks)

Question 4 continues on the next page

Turn over ▶

4 (b) A second signal is required which must be at exactly half the frequency of the first signal. To achieve this, the subsystem shown below is connected to the output of the astable. Name this subsystem and draw in one wire that would make it divide the frequency by two.

Name of subsystem ....

```
                    ┌──────────────┐
                ────┤ D          Q ├──── output
                    │              │
input from astable ─▷ CK        Q̄ ├────
                    └──────────────┘
```

(2 marks)

4 (c) (i) What type of IC could be loaded with software so that it generates both output signals from parts (a) and (b) at the same time?

....

(1 mark)

4 (c) (ii) State **one** advantage of using this type of IC.

....

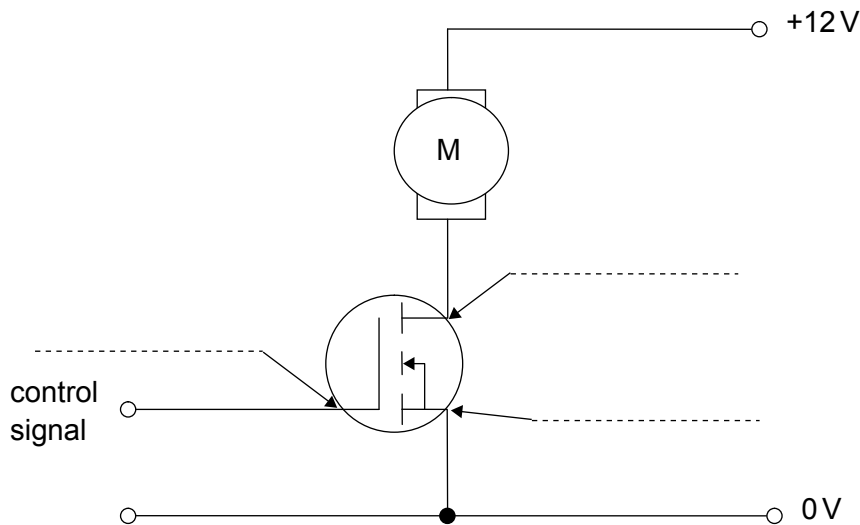...

(1 mark)

12

5 A driver or switch circuit for an electric motor is shown below.

5 (a) (i) What type of transistor is shown here?

....
(1 mark)

5 (a) (ii) Label the **three** leads of the transistor on the diagram. *(3 marks)*

5 (a) (iii) Draw on the diagram a suitable component in the correct position which is required to protect the transistor in this application. *(3 marks)*

5 (b) The motor has 12 V across it when 6 A passes through it.

5 (b) (i) Calculate the effective resistance of the motor.

....

....
(2 marks)

5 (b) (ii) If the motor is stalled (stopped when it is switched on), it takes double its normal current. State a suitable current rating for the transistor.
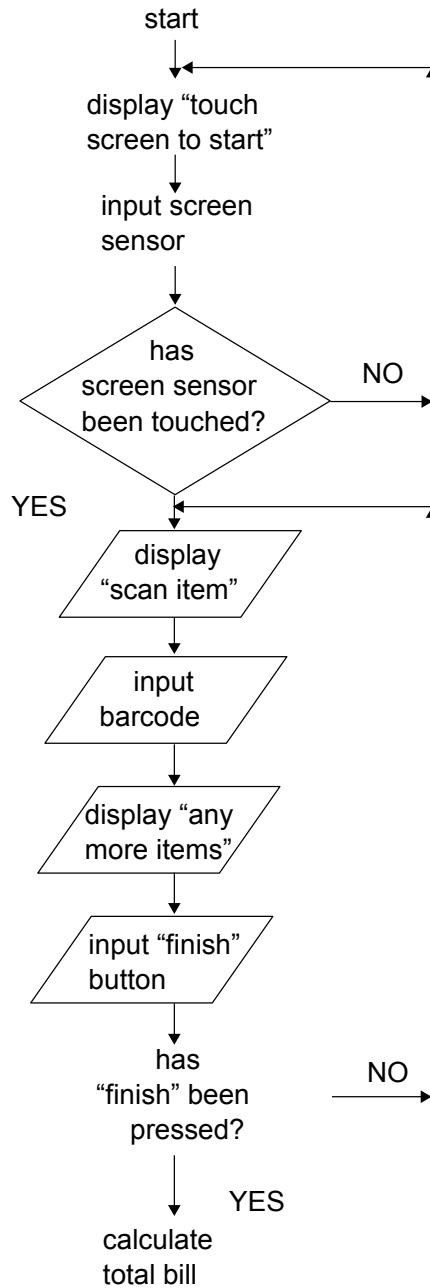
....
(1 mark)

Turn over ▶

6 Part of a flowchart for a self-scan checkout terminal in a supermarket is shown below. Some of the flowchart symbols have been left out.

6 (a) Draw the correct flowchart symbols at the five places where they are missing on the diagram. *(5 marks)*

6 (b) Label on the flowchart

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

(5 marks)

1 0

6 (c)   Continue the flowchart to give customers the options of paying by cash or card, calculate change if cash is selected, and deliver a receipt. The last stage of the first flowchart is repeated here as your starting point.
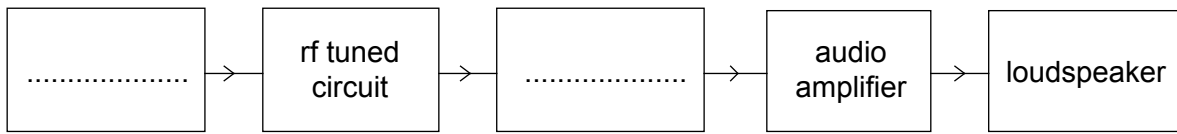
Calculate
total bill

↓

(8 marks)

18

Turn over ▶

7 This diagram shows how subsystems are connected together to make a simple radio receiver.

| .... | → | rf tuned circuit | → | .... | → | audio amplifier | → | loudspeaker |

7 (a) Write in the names of the **two** unlabelled subsystems. *(2 marks)*

7 (b) State the function of the rf tuned circuit subsystem.

....

....
(2 marks)

7 (c) State the lowest frequency you would expect from the output of the audio amplifier.

....
(1 mark)

7 (d) The abbreviations AM and FM are often used to describe radio signals.

7 (d) (i) What does FM stand for?

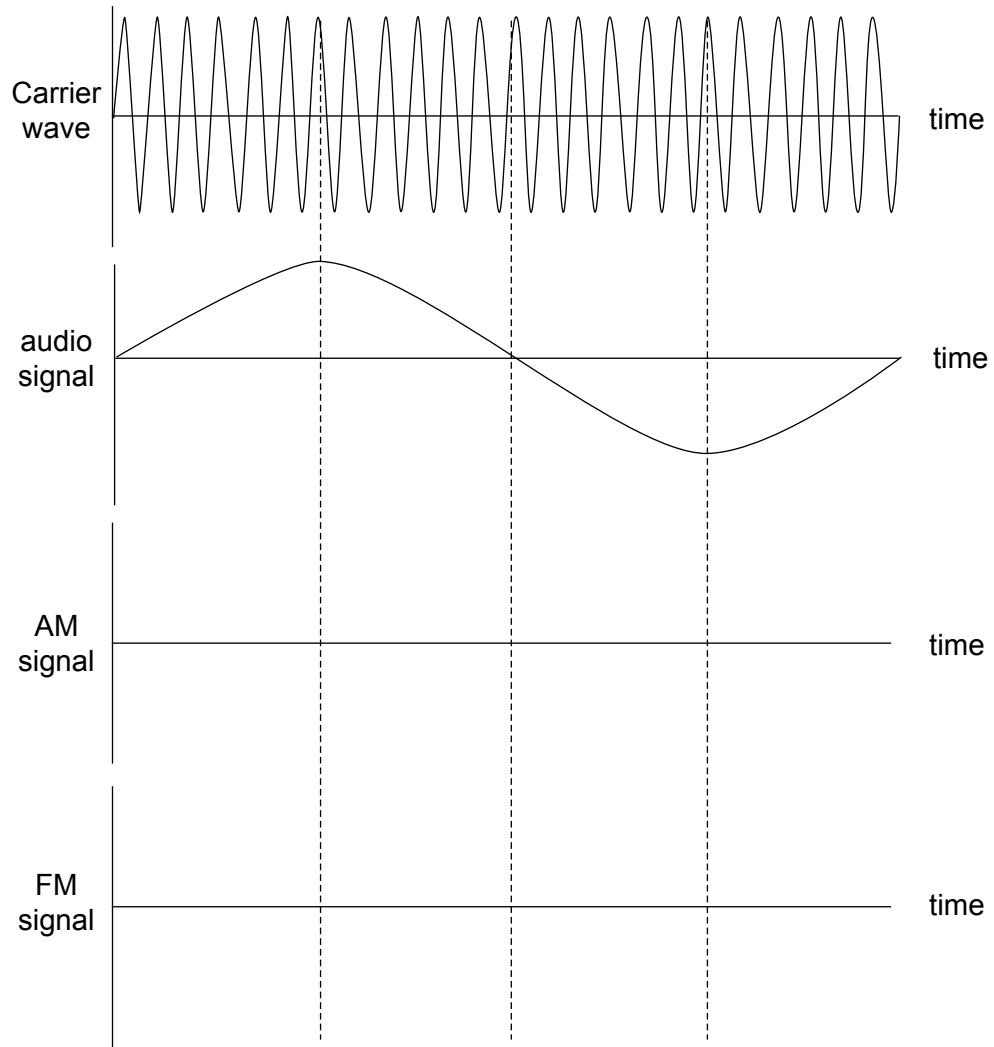...

7 (d) (ii) What does AM stand for?

....
(2 marks)

7 (d) (iii) On the blank axes below draw diagrams to show how the audio signal and the carrier wave can be combined to produce an AM and an FM signal. Your diagrams should show the correct relationship between the audio signal and the modulated wave.

Carrier wave ———— time

audio signal ———— time

AM signal ———— time

FM signal ———— time

(4 marks)

7 (e) Explain what is meant by the terms

7 (e) (i) sensitivity ....

....

7 (e) (ii) selectivity ....

....

(4 marks)

15

Turn over ▶

8   The logic diagram below is for a freezer alarm which sounds if the temperature is too high. It contains a light sensor so it does not sound at night and a push switch to test the battery and buzzer.

test switch

pushed   = 1
released = 0

temp sensor

warm = 1
cold   = 0

light sensor

dark   = 1
light   = 0

buzzer

1 = sound
0 = silent

X

Y
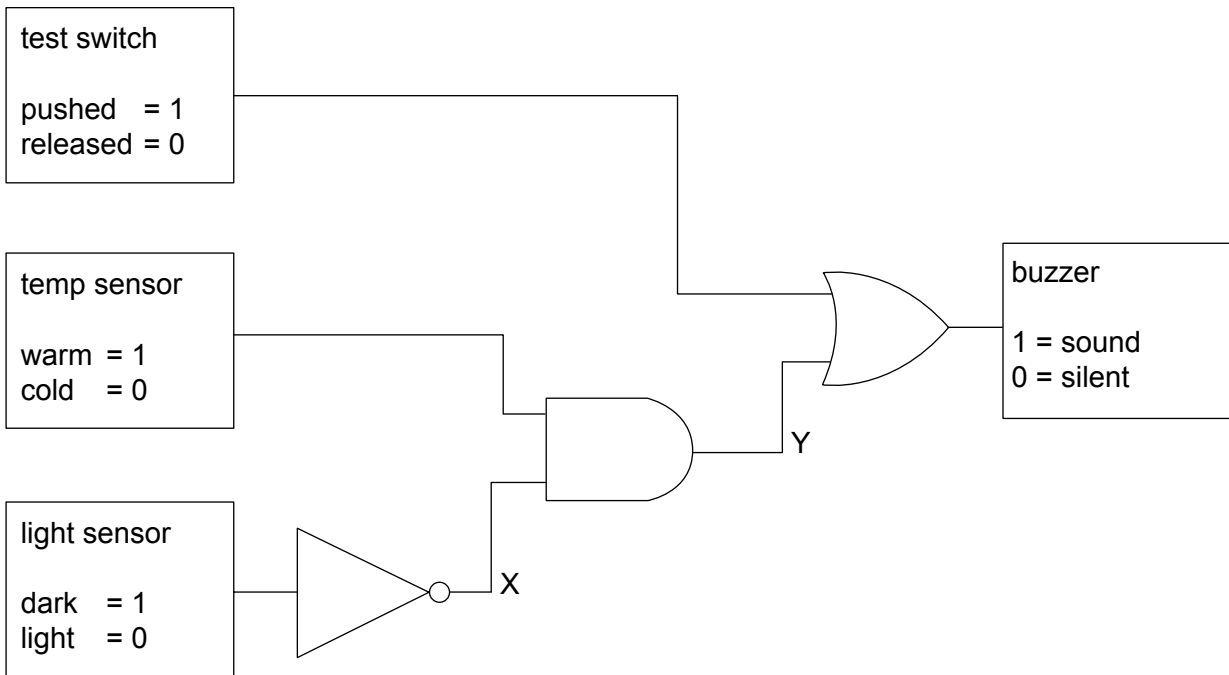
8 (a)   Complete the truth table for the logic diagram.

test switch	temp sensor	light sensor	X	Y	buzzer
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

(3 marks)

8 (b) The system could also be built using NOR gates.

8 (b) (i) Complete the truth table for a NOR gate.

A	B	Q
0	0	
0	1	
1	0	
1	1	

(1 mark)

test switch

pushed   = 1
released = 0

light sensor

dark = 1
light = 0

temp sensor

warm   = 1
cold   = 0

buzzer

1 = sound
0 = silent

S

R

P
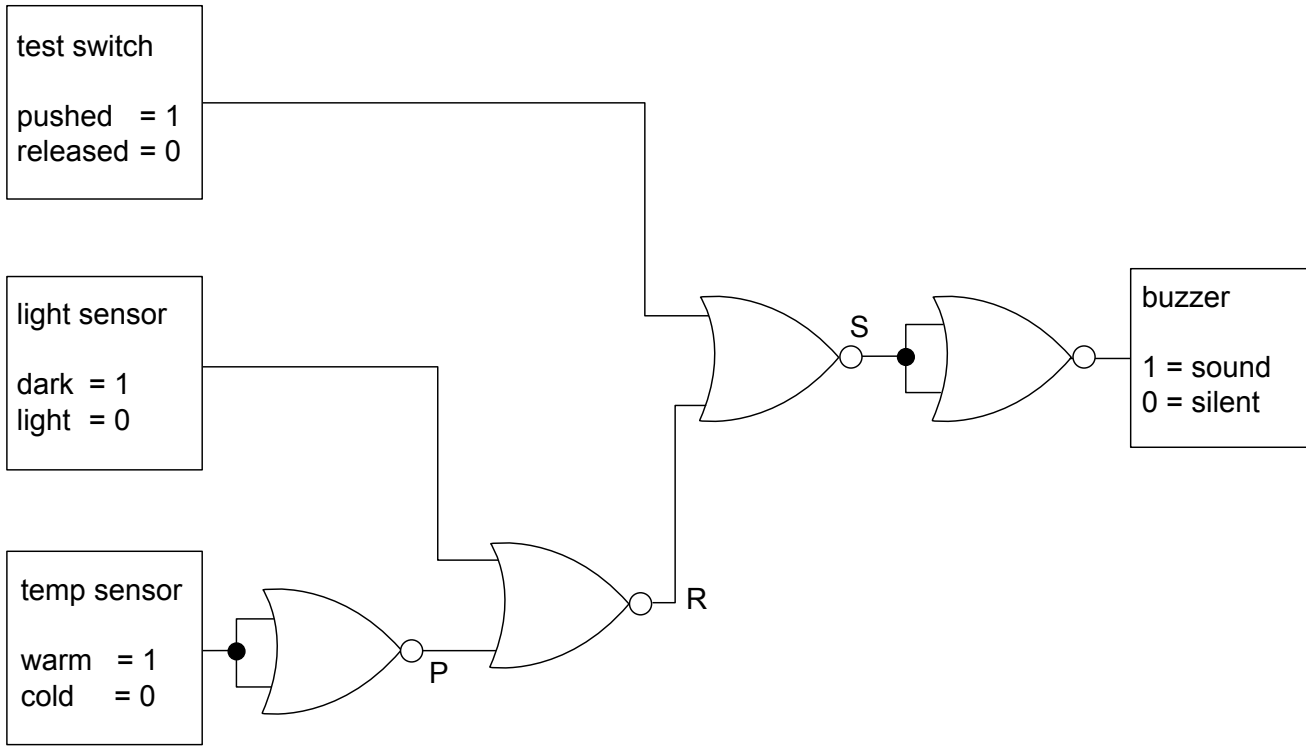
8 (b) (ii) Complete the truth table for this system.

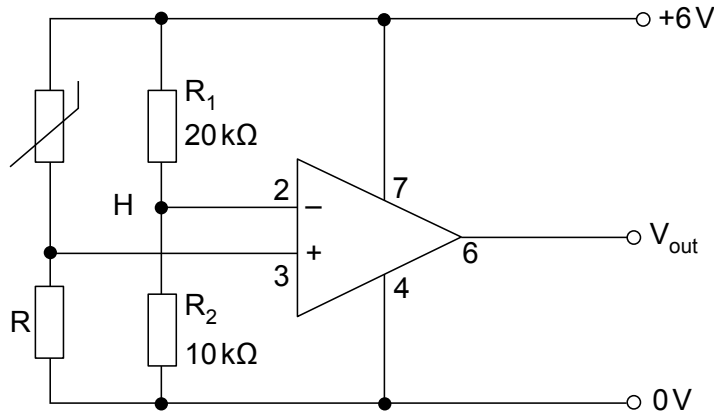| test switch	light sensor	temp sensor	P	R	S	buzzer
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

(4 marks)

Turn over ▶

8 (b) (iii) The original system in part (a) using AND, OR and NOT gates requires only three gates. State **two** advantages of using four NOR gates.

....

....

(2 marks)

8 (c) The temperature sensor consists of a thermistor connected in a comparator circuit.

8 (c) (i) Calculate the value of the voltage at point H.

....

....

(2 marks)

The data sheet for the thermistor includes the following graph.
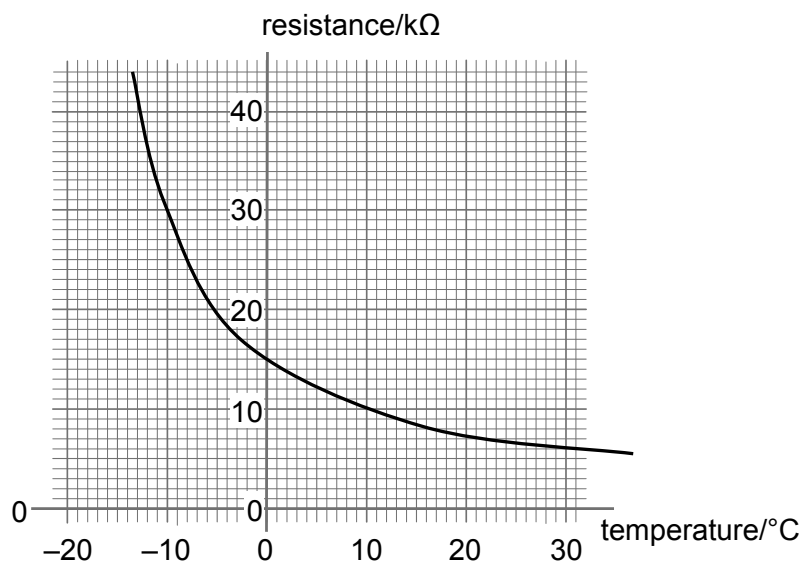
**8 (c) (ii)** State the resistance of the thermistor when the temperature is –10°C.

....

(1 mark)

8 (c) (iii) State or calculate a suitable value for R in the circuit diagram to make the comparator switch at –10°C.

....

....

(2 marks)

8 (d) A student decides to build the temperature sensor on prototype board. Complete this diagram by showing where the thermistor should be connected, adding the missing resistor and all the other missing connecting wires. Pin numbers are shown in the diagram for part (c).
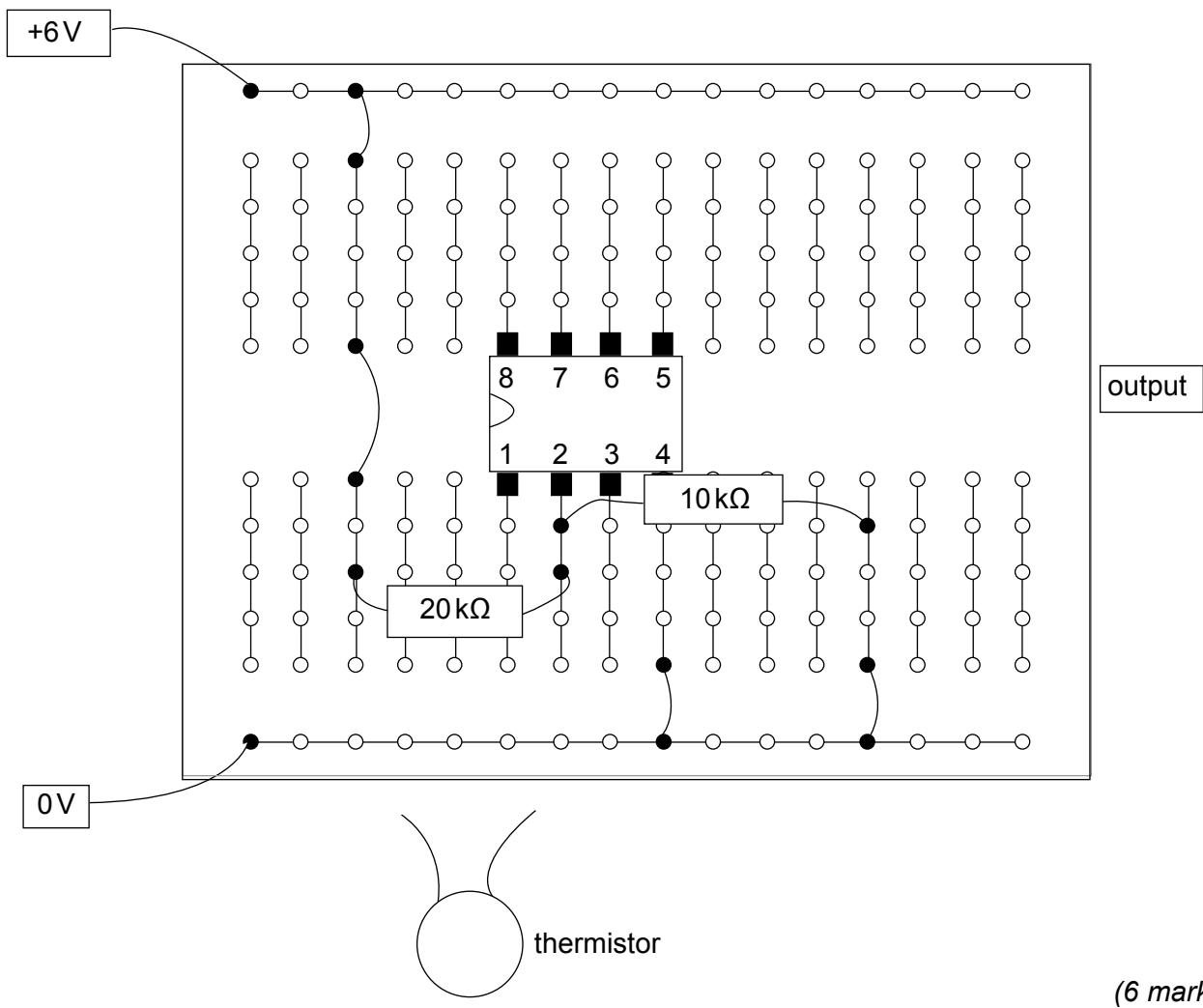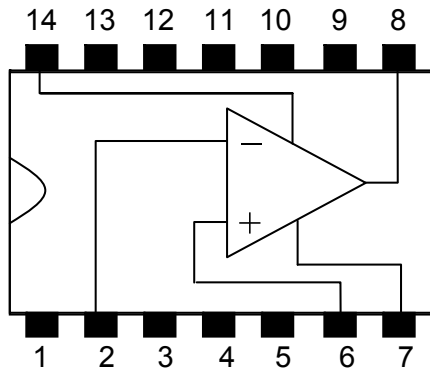

(6 marks)

Turn over ▶

9 An audio amplifier is built with the integrated circuit shown below.

14 13 12 11 10 9 8

1 2 3 4 5 6 7

9 (a) Name the functions of the following pins.

Pin 8 ....

Pin 2 ....

Pin 6 ....

Pins 7 and 14 ....

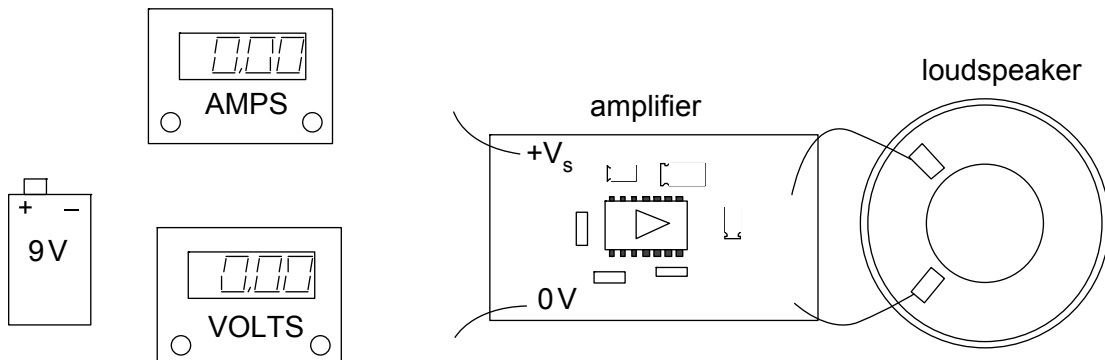*(4 marks)*

9 (b) (i) The amplifier circuit is constructed ready for testing. On the diagram below draw in wires to show how the amplifier circuit should be connected to a battery with a voltmeter to measure the voltage applied and an ammeter to measure the current drawn.

AMPS

+ −
9 V

VOLTS

amplifier
+V_s
0 V

loudspeaker

(4 marks)

9 (b) (ii) The voltmeter reads 8.8 V and the ammeter 0.12 A. Calculate the power input to the circuit.

....

....

(2 marks)

9 (b) (iii) In one test the amplifier works normally but the ammeter actually reads –0.12 A. Explain why the minus sign is displayed and whether the wiring needs to be changed.
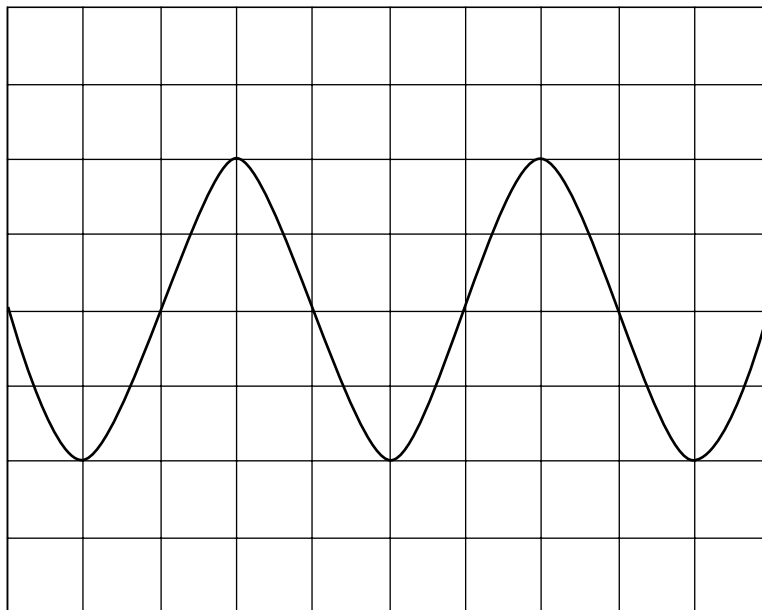
....

....

(2 marks)

9 (c) A signal generator provides an input signal to test the amplifier. An oscilloscope trace of the input signal is shown below.

The oscilloscope settings are :

Y sensitivity 0.1 V per division
timebase 5 ms per division

9 (c) (i) Calculate the time period of the input signal.

....

....

(2 marks)

9 (c) (ii) Calculate the frequency of the input signal.

....

....

(2 marks)

Question 9 continues on the next page

Turn over ▶

9 (c) (iii) Calculate the peak voltage of the input signal.

....

(2 marks)

9 (c) (iv) The amplifier has a voltage gain of 20. Calculate the peak value of the output voltage.

....

....
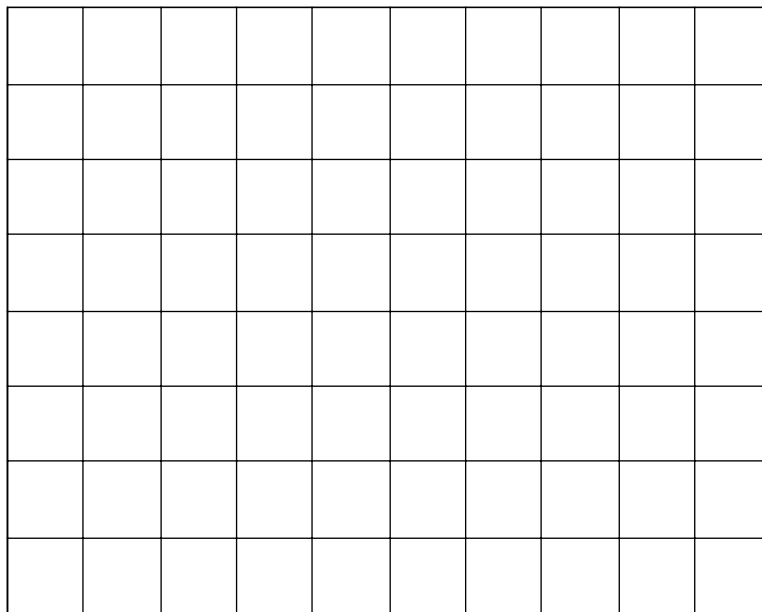
(2 marks)

9 (c) (v) Another oscilloscope is connected to the output of the amplifier.

The oscilloscope settings are:

Y sensitivity 1 V per division
timebase setting 5 ms per division.

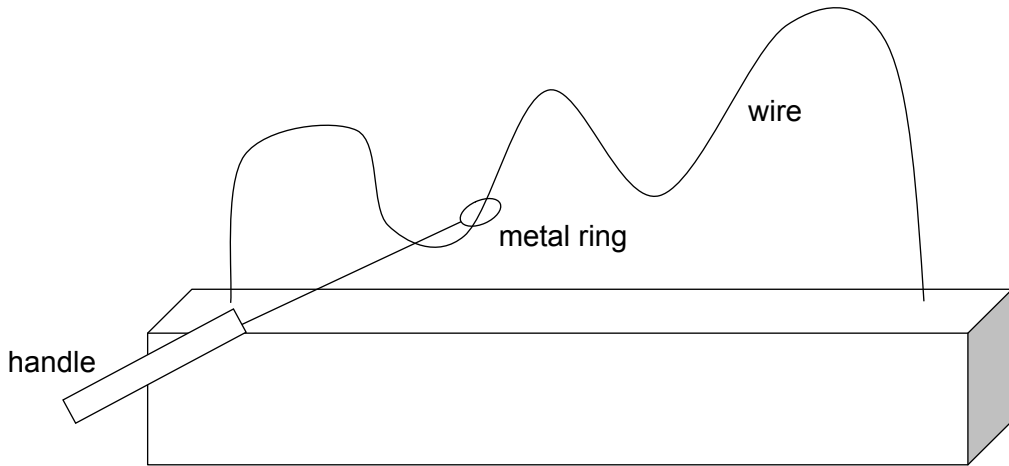Draw the appearance of the trace which would be obtained on the oscilloscope.

(3 marks)

9 (c) (vi) Calculate the rms value of the output voltage from the amplifier.

....

....
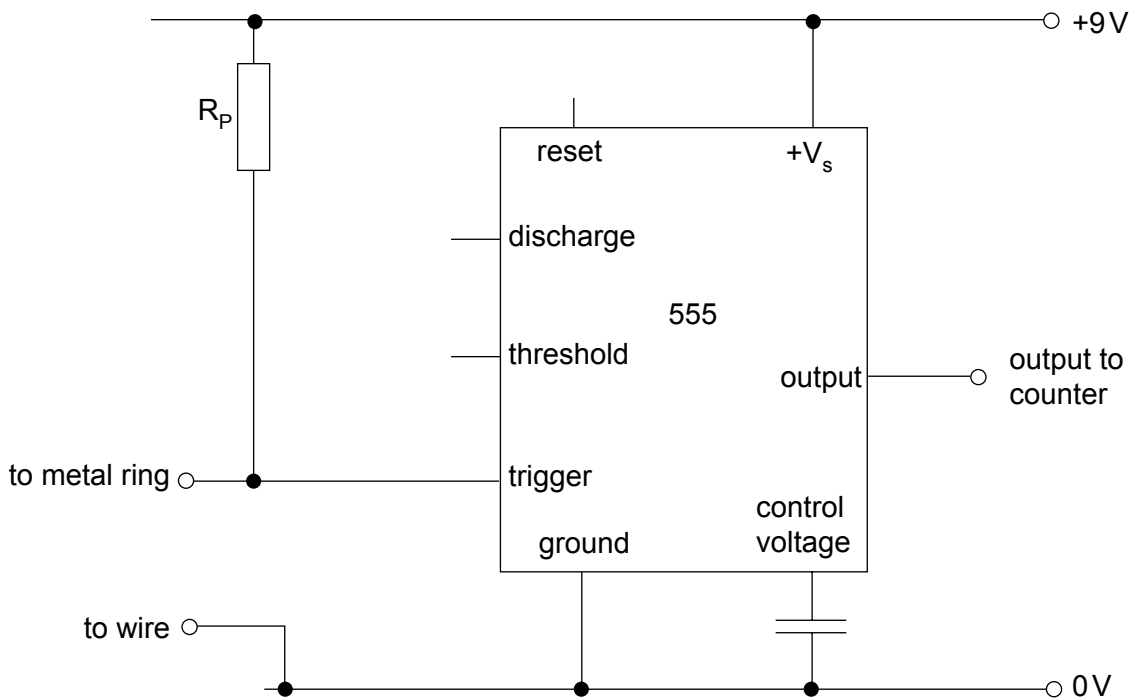
(2 marks)

10   A student decides to make a "steady hand game". The player must try to move a metal ring along a wire without it touching.

If the ring touches the wire a pulse is produced by a monostable circuit and the pulses are counted by a 4017 counter.

10 (a) (i)   Complete this diagram of the monostable circuit by adding a timing resistor R_1, a timing capacitor C_1 and wire links.

(4 marks)

Question 10 continues on the next page

Turn over ▶

10 (a) (ii) Explain what happens to the voltage at the trigger input when the ring touches the wire and how the monostable circuit responds to the change in voltage.
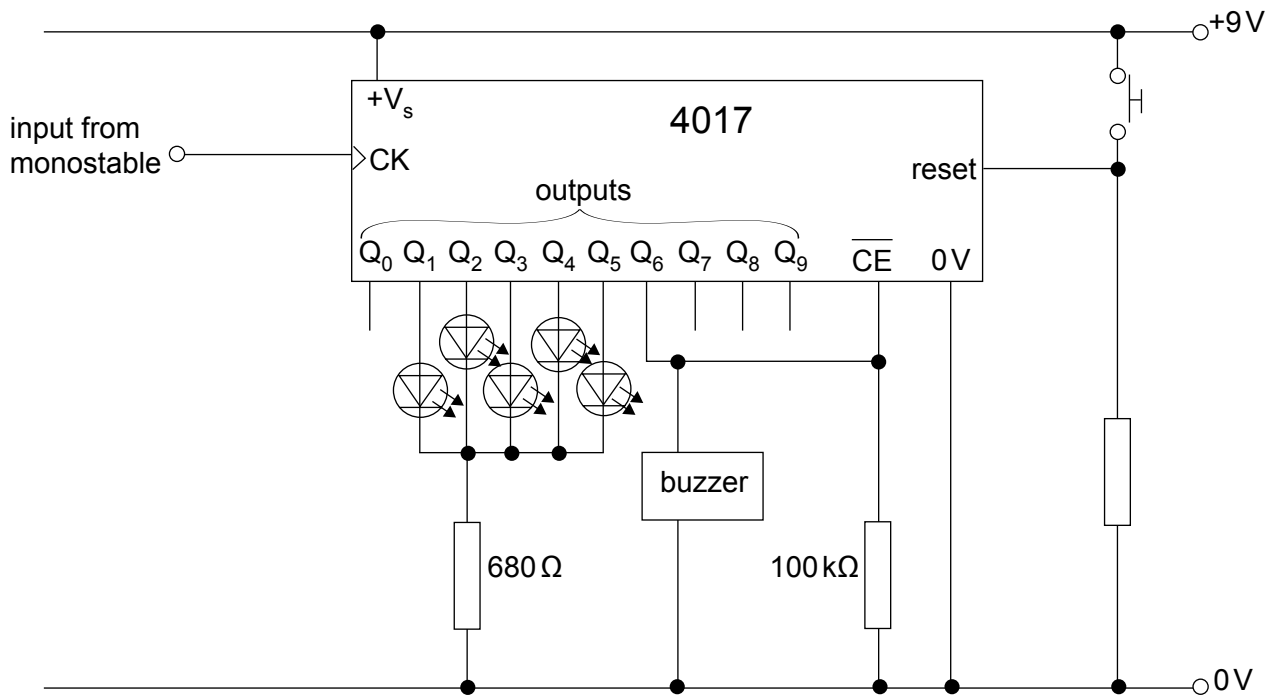
....

....

....

....

(3 marks)

10 (b) The monostable is connected to this 4017 circuit.

10 (b) (i) The student decides to add a green LED to the circuit to show that the counter has been reset and that the game can begin. Draw this LED on the circuit above.

(2 marks)

10 (b) (ii) Having reset the counter, explain what happens if the ring touches the wire five times as it moves along during the game.

....

....

....

(2 marks)

10 (b) (iii) If the ring touches the wire for a sixth time the buzzer will sound to indicate that the game is over.

The buzzer is connected to output Q_6. Explain why this output is also connected to the CE (count enable) input of the IC. In many applications CE is connected to the 0 V line but include in your explanation why (in this case) the 100 kΩ resistor is needed.

Answer this question in continuous prose, the quality of written communication will be assessed in your answer.

....

....

....

....

....

....

(5 marks)

10 (b) (iv) The 680 Ω LED protective resistor has a 5% tolerance. Label the colours of the bands on the diagram below.

....

....
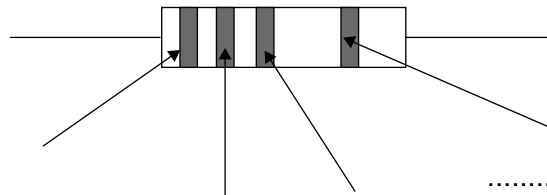
(3 marks)

19

END OF QUESTIONS

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED