AQA

General Certificate of Secondary Education
June 2015

Design and Technology: Electronic Products

45401

Unit 1 Written Paper

Tuesday 19 May 2015   9.00 am to 11.00 am

For this paper you must have:
● a black pen, a pencil, a ruler, an eraser and a pencil sharpener.

A

Time allowed
● 2 hours

Instructions
● Use black ink or black ball-point pen. Use pencil only for drawing.
● 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 answer book. Cross through any work you do not want to be marked.

Information
● The marks for questions are shown in brackets.
● The maximum mark for this paper is 120.
● Section A relates to the context referred to in the Preliminary Material that was previously issued.
● You are reminded of the need for good English and clear presentation in your answers. Quality of Written Communication will be assessed in Question 5.
● You may use a calculator.

You may need to use one or more of the following formulae when answering questions which include calculations.

Potential Difference   Potential Difference = Current x Resistance   (V = I x R)

Series Resistors R_{total} = R_1 + R_2 + R_3 etc

Potential Divider

Vs

R_1

— **V out**

R_2

0V
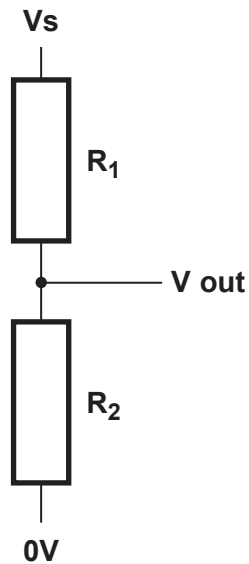
$$V\ out\ =\ \frac{R_2}{R_1 + R_2}\ x\ Vs$$

where V out = signal value
Vs = supply voltage
R_1 and R_2 are resistance values

Time Constant   Time Constant $\simeq$ Resistance x Capacitance   (T $\simeq$ R x C)

Astable Frequency for 555 $f = \dfrac{1.44}{(R_1 + 2R_2)\ x\ C}$

Mark Space Ratio $= \dfrac{Time\ high}{Time\ low}$

Time High $= 0.693\ x\ (R_1 + R_2)\ x\ C$

Time Low $= 0.693\ x\ R_2\ x\ C$

Inverting Op. Amps   Gain $= \dfrac{-Rf}{Rin}$ Where Rf = feedback resistor value
Where Rin = input resistor value

You may need to use the following information when answering some of the questions.

The figures shown below and their decade multiples or submultiples are the series of preferred values in accordance with BS:2488.

E12 Resistor series   10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82

E24 Resistor series   10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91

Capacitor series   10, 22, 47

Resistor Colour Code

Colour	Band 1	Band 2	Band 3 (No. of 0s)	Band 4 (Tolerance)
Black	0	0	None	
Brown	1	1	0	
Red	2	2	00	
Orange	3	3	000	
Yellow	4	4	0000	
Green	5	5	00000	
Blue	6	6	000000	
Violet	7	7	–	
Grey	8	8	–	
White	9	9	–	
				Gold = 5%
				Silver = 10%

Turn over for the first question

Turn over ▶

Section A

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

You are advised to spend about 35 minutes on this question.

1   This question is about designing a child's educational toy.

Design Brief

You are asked to design an educational toy to help pre-school children learn about shapes and spaces through play.

Here are some images that may help you.

Design Requirements

The educational toy must:

- give a light and sound output when shapes have been placed in the correct space
- be safe for children to use
- be fun and appealing to children
- use a microcontroller-based circuit capable of controlling sound and light outputs.

1 (a) Give **four** more design requirements for the toy.

Two design requirements should be for the toy casing.

Two design requirements should be for the circuit.

An example is given below.

The case will be made from a tough and durable material.

[4 marks]

Design requirements for the toy casing:

1 ....

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2 ....

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Design requirements for the circuit:

1 ....

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2 ....

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1 (b) Using the information given in the design brief and requirements on page 4, and your four design requirements above, sketch **two** different ideas for the toy.

You should sketch your ideas on the next page.

Marks will be awarded for:

● features to make the toy appealing to children

● the location of sound and light output components

● creative ideas

● quality of communication.

[8 marks]

Turn over ▶

Idea 1

Idea 2
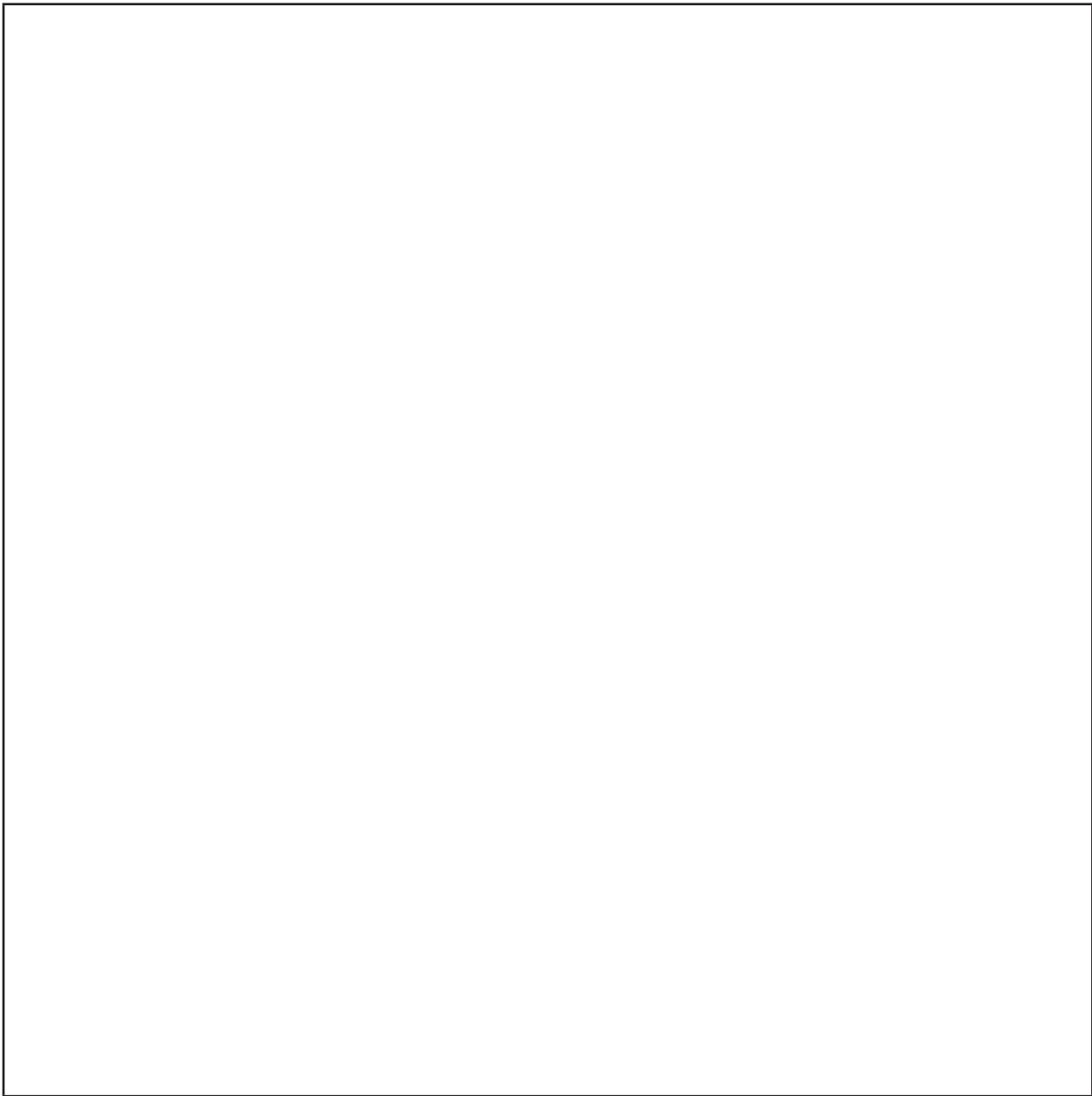
1 (c) Choose **one** of your ideas from part (b).

Use notes and sketches to produce a detailed design for the **case** of the toy to meet the design brief and your design requirements.

Marks will be awarded for:

- case construction details

[2 marks]

- materials to be used

[2 marks]

- details of how the shapes will trigger the circuit

[3 marks]

- quality of communication.

[3 marks]

Turn over ▶

1 (d) The circuit of the toy must give a sound and light output.

1 (d) (i) Describe how a microcontroller can be used to make the toy fun and appealing for young children.

[2 marks]

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1 (d) (ii) Complete the system diagram below by naming one input component and two output components for the toy.

[3 marks]

Input component   Process component   Output components

[ ] → Microcontroller → [ ]

→ [ ]
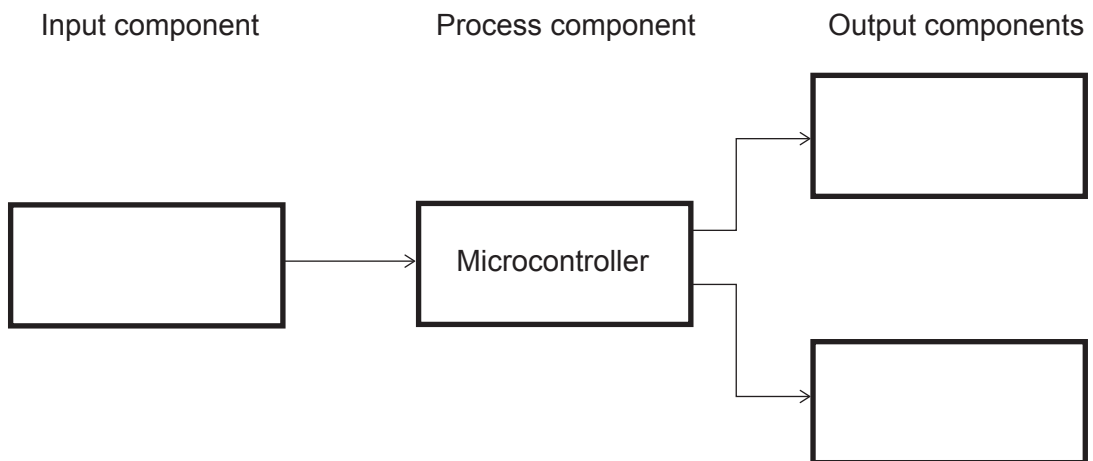
1 (e) Use notes and a circuit diagram to show how the microcontroller and output components are connected.

[4 marks]

1 (f) Discuss the safety issues that need to be considered when designing toys for young children.

[4 marks]

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35

Turn over ▶

Section B

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

You are advised to spend about 15 minutes on this question.

2 This question is about switching circuits.

2 (a) Study the switches shown below.
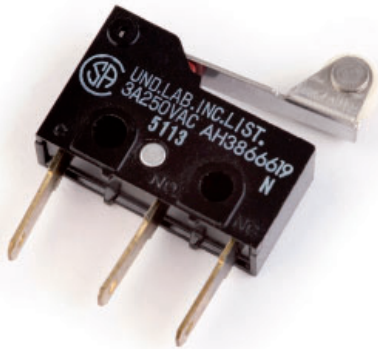
Switch **A**   Switch **B**
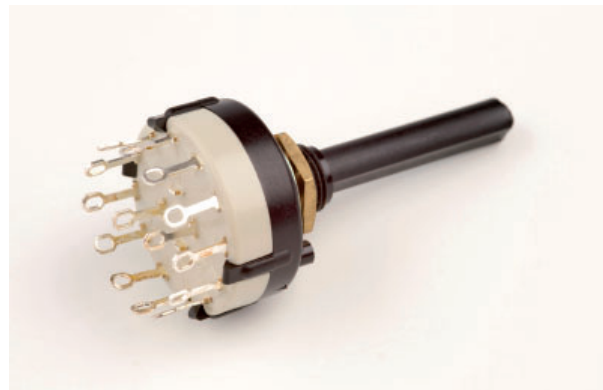
Name the switches and give **one** suitable use for each switch.

[4 marks]

Switch **A**

Name ....

Use...

....

Switch **B**

Name ....

Use...

....

2 (b) An incomplete circuit diagram for a torch controlled by a thyristor is shown below.
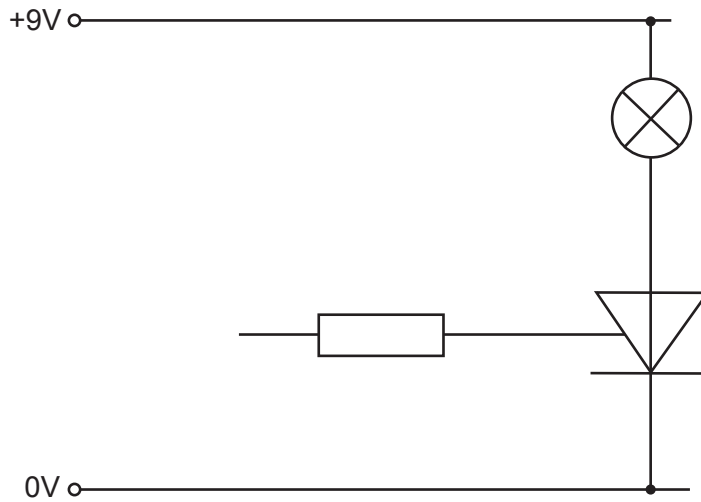
Add **two** switches to the circuit diagram so that:

- when one switch is pressed and released, the lamp switches on and stays on

- when the second switch is pressed and released, the lamp switches off.

[4 marks]

2 (c) On the diagram below, name the three connections of a thyristor.

[3 marks]

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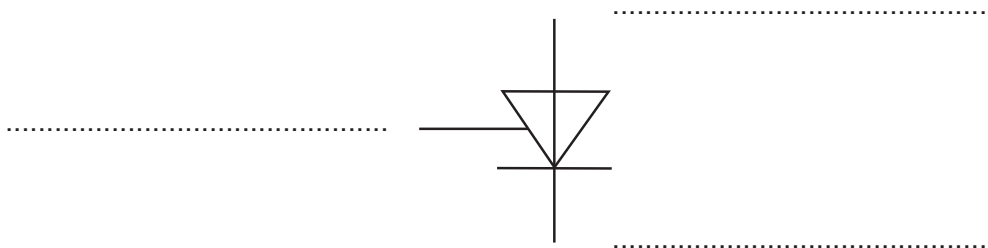
Turn over ▶

2 (d) A thyristor is an example of a bistable.

Explain what is meant by the term bistable.

[2 marks]

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2 (e) Study the television remote control shown below.

Explain why membrane switches are suitable for a remote control.

[4 marks]

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17

You are advised to spend about 10 minutes on this question.

This question is about a transistor circuit.

3 A circuit diagram for an automatic temperature alarm is shown below.
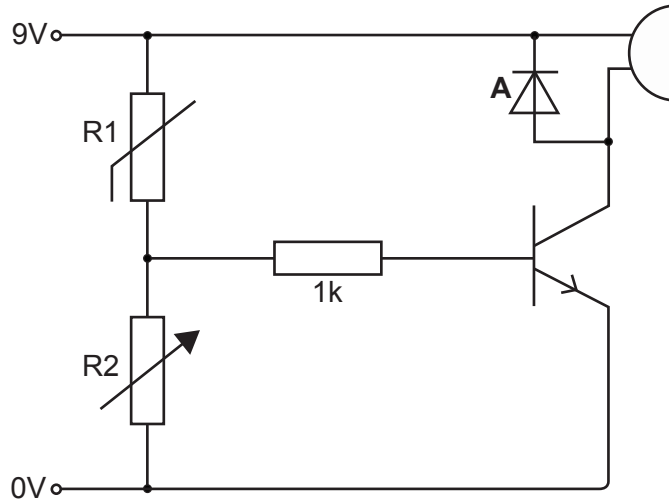
3 (a) Calculate the output voltage V_{out} of the potential divider when:

R1 = 20k and R2 = 10k.

[4 marks]

Formula...

Working...

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Answer with units...

3 (b) (i) Insert a tick in the correct box to identify component **A** in the circuit diagram above.

[1 mark]

Capacitor ☐   Opto-isolator ☐   Diode ☐

3 (b) (ii) Explain the function of component **A** in the circuit on page 13.

[2 marks]

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3 (c) A Printed Circuit Board (PCB) layout for a circuit is shown below.
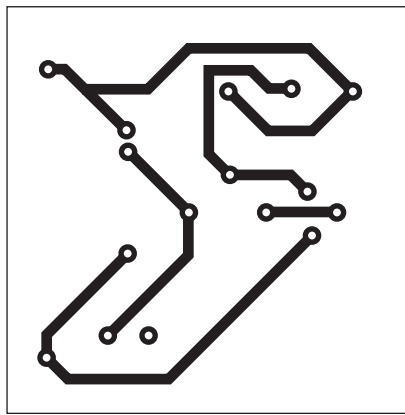
Suggest **two** advantages of using computer-aided design to generate a PCB layout.

[2 marks]

Advantage 1...

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Advantage 2...

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9

You are advised to spend about 10 minutes on this question.

4 This question is about counting.

A product to display the score in a football game is being developed.

- The score will be shown on a display.
- The display is controlled by a 4026 integrated circuit (IC).

4 (a) Complete the circuit diagram below by:

- connecting R1 and SW1 to create a count input for the 4026 IC
- drawing a PTM switch and a pull-down resistor which will reset the 4026 IC when the PTM is pressed and released.

[5 marks]
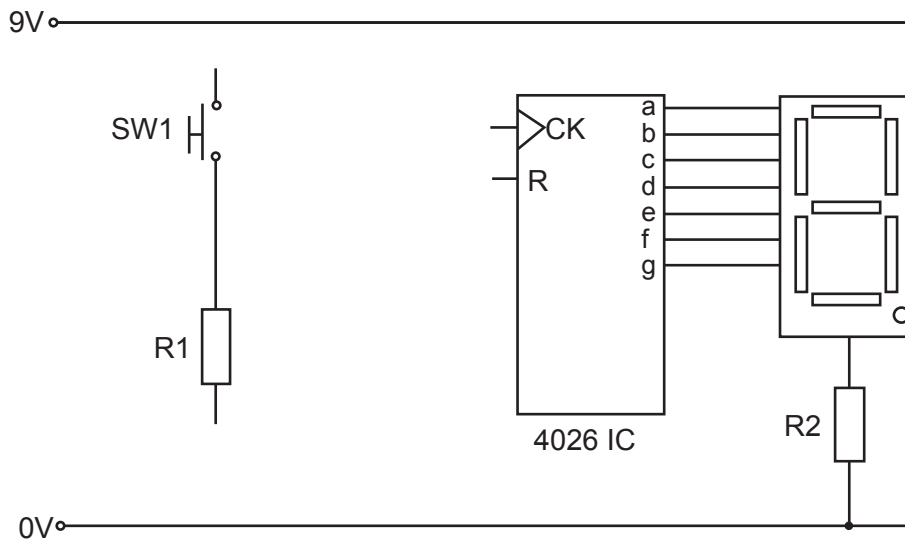
4 (b) In the diagram, R1 acts as a pull-down resistor.

Explain the purpose of the pull-down resistor.

[2 marks]

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Turn over ▶

4 (c) When the circuit was tested using a breadboard, the 4026 IC was affected by switch bounce.

Explain what is meant by switch bounce.

[2 marks]

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4 (d) Explain how switch bounce can be eliminated from a counting circuit.

[2 marks]

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11

You are advised to spend about 10 minutes on this question.

5 Modern cars have electronic devices to help motorists.

For example:

- satellite navigation systems to help arrive at a destination
- a device to warn that a seat belt is not being worn.

Discuss the advantages and disadvantages of electronic devices for a motorist.

Include various examples of devices in your answer.

You will be tested on the Quality of Written Communication in this question.

[8 marks]

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You are advised to spend about 15 minutes on this question.

6 This question is about plastics manufacturing processes and scales of production

6 (a) **One-off / prototype production.**

Explain the advantages of using the rapid prototyping process to manufacture a plastic component.

[3 marks]

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6 (b) **High volume production.**

A manufacturer is using injection moulding to produce a large number of plastic components.

Explain why the manufacturer has chosen this process.
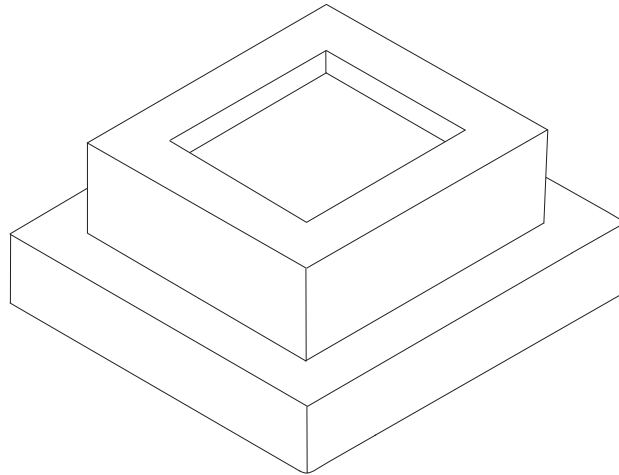
[3 marks]

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6 (c)   **Batch production.**

A medium-density fibreboard (MDF) former for a vacuum formed case is shown below.

Suggest **three** modifications to the MDF former that would improve the quality and ease of manufacture of the case.

[3 marks]

Modification 1...

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Modification 2...

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Modification 3...

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Question 6 continues on the next page

Turn over ▶

6 (d)   Use the space below to describe the vacuum forming process.

The first part of the process has been completed for you.

You may use a flowchart if you wish.

[7 marks]

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|                                           |
|        The former is ready to be used.    |
|                                           |
+-------------------------------------------+
                      |
                      v
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You are advised to spend about 25 minutes on this question.

7   This question is about timing circuits.

A kitchen timer is being developed.

7 (a) (i) Polarised components need to be connected correctly.
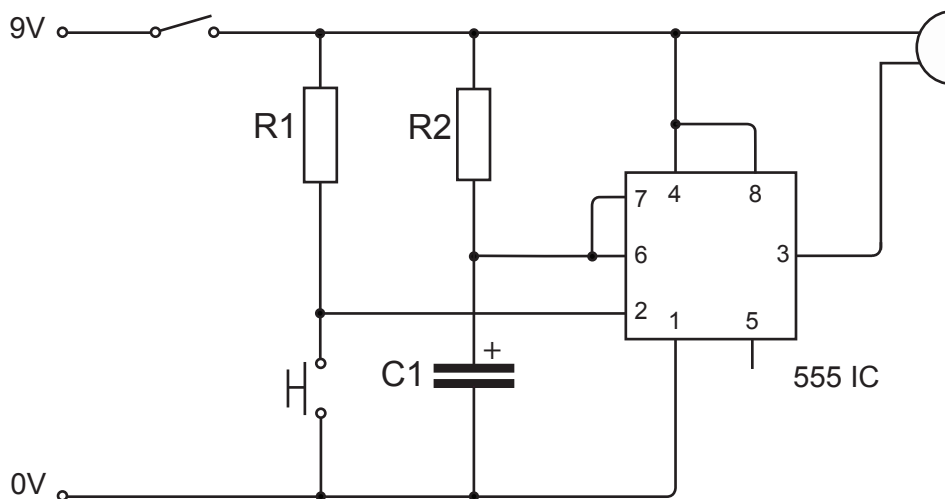
State why this is important.

[1 mark]

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7 (a) (ii) Study the 555 IC monostable circuit below.

Circle **two** components in the diagram that need to be connected with the correct polarity.

[2 marks]

Turn over ▶

7 (b) Explain the operation of the monostable circuit shown in 7(a)(ii).

You should include reference to the switches, R2, C1 and the 555 IC.

[4 marks]

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7 (c) Calculate the time constant for the monostable if R2 = 56k, and C1 = 1000 µF.

[4 marks]

Formula..

Working...

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Answer with units..

7 (d) Describe how the monostable circuit can be changed so that the time period can be adjusted to time different processes.
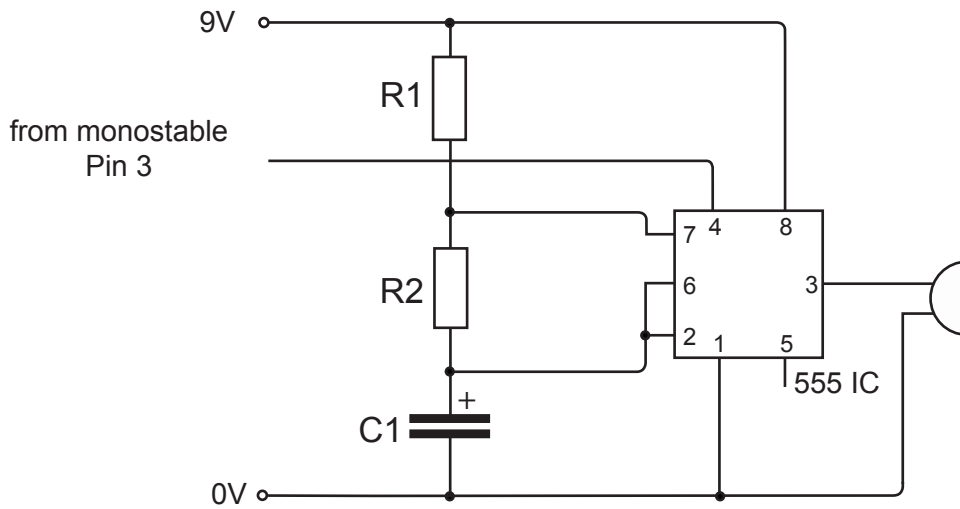
[2 marks]

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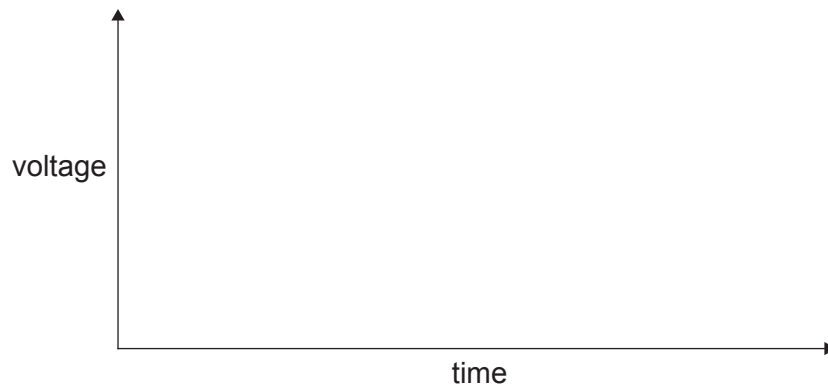
7 (e) An astable is added to the timer circuit to make the sound of the buzzer more noticeable.

On the axes below, draw the output waveform from pin 3 of the astable when the circuit is operating.

[2 marks]

7 (f) In a different circuit, the buzzer can be replaced by a piezo sounder.

Compare the use of a buzzer and a piezo sounder for generating sound.

[2 marks]

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Turn over ▶

7 (g) Another idea for a kitchen timer uses a microcontroller circuit.

In the space below, use a programming system to write a program for a kitchen timer so that:

- when a switch is pressed, a Light Emitting Diode (LED) flashes 15 times, on for 2 seconds and off for 2 seconds.
- after 15 flashes, a sounder generates a sound for 3 seconds.
- the circuit then resets.

[7 marks]

END OF QUESTIONS