SECONDARY 4
2022

ELECTRONICS

6063/01
2 hours

CANDIDATE NAME			
CLASS		INDEX NUMBER	

READ THESE INSTRUCTIONS FIRST
Do not turn over the page until you are told to do so.
Write your name, class, and index number in the spaces provided above.
Write in dark blue or black ink pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, and glue or correction fluid/tape.

Sections A and B
Answer **all** the questions.
Write your answers in the spaces provided on the question paper.

Approved electronic calculators are allowed for use in this paper.

The number of marks is given in brackets [ ] at the end of each question or part question.

The total mark for this paper is **100**.

FOR EXAMINER'S USE	
Section A	**/ 55**
Section B	**/ 45**
TOTAL	**/ 100**

This document consists of **25** printed pages including the cover page

[Turn over

Resistor Colour Code

1st Colour Band 1st Digit	2nd Colour Band 2nd Digit	3rd Colour Band Multiplier	4th Colour Band Tolerance
Black 0	Black 0	Black 0	Gold ± 5 %
Brown 1	Brown 1	Brown 1	Red ± 2 %
Red 2	Red 2	Red 2	
Orange 3	Orange 3	Orange 3	
Yellow 4	Yellow 4	Yellow 4	
Green 5	Green 5	Green 5	
Blue 6	Blue 6	Blue 6	
Violet 7	Violet 7	Violet 7	
Grey 8	Grey 8	Silver 0.01	
White 9	White 9	Gold 0.1	

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.

FORMULAE

Astable and monostable generators using 555 timers

Monostable mode — Period $T = 1.1RC$

Astable mode frequency ($t_1 + t_2$) — Period $T = \dfrac{(R_1 + 2R_2)C}{1.44}$

Bipolar Junction Transistor (BJT)

Current gain $\beta = \dfrac{\text{Collector current}}{\text{Base current}}$

Voltage gain (for voltage-divider biased CE amplifier, emitter resistor unbypassed)

$$\cong -\frac{R_C}{R_E}$$

[Turn over

Table on Boolean Algebra

Single variable theorems	Laws of Complementation	• $\overline{0}=1$ • $\overline{1}=0$ • $\overline{\overline{A}}=A$
	AND Laws	• $A\cdot 0=0$ • $A\cdot 1=A$ • $A\cdot A=A$ • $A\cdot\overline{A}=0$
	OR Laws	• $A+0=A$ • $A+1=1$ • $A+A=A$ • $A+\overline{A}=1$
Multivariable theorems	Commutative Laws	• $A+B=B+A$ • $A\cdot B=B\cdot A$
	Associative Laws	• $A+(B+C)=(A+B)+C=A+B+C$ • $A(B\cdot C)=(A\cdot B)\cdot C=A\cdot B\cdot C$
	Distributive Laws	• $A\cdot(B+C)=A\cdot B+A\cdot C$ • $(A+B)\cdot(C+D)=A\cdot C+B\cdot C+A\cdot D+B\cdot D$
	Absorptive Laws	• $A+A\cdot B=A$ • $A\cdot(A+B)=A$ • $A+\overline{A}\cdot B=A+B$ • $A\cdot(\overline{A}+B)=A\cdot B$
	DeMorgan's Theorems	• $\overline{(A+B)}=\overline{A}\cdot\overline{B}$ • $\overline{(A\cdot B)}=\overline{A}+\overline{B}$

Section A

[Turn over

Answer **all** questions.
Write your answers in the spaces provided.

1 In Table 1.1, tick (√) the type of subsystem that matches the function of each of the following components. [3]

	Type of subsystem		
Component	Input	Process	Output
Thermistor			
Buzzer			
AND gate			

Table 1.1

[Total: 3 marks]

2 Table 2.1 below shows two types of wire.

Wire	Length /m	Cross sectional area / m^2	Material
A	0.20	59×10^{-9}	Nichrome
B	0.20	118×10^{-9}	Nichrome

Table 2.1

Based on Table 2.1, compare the resistance of wire A and B.
Explain your answer. [2]

……..……

……..……

……..……

[Total: 2 marks]

[Turn over

3 Fig. 3.1 shows a resistor with coloured bands.

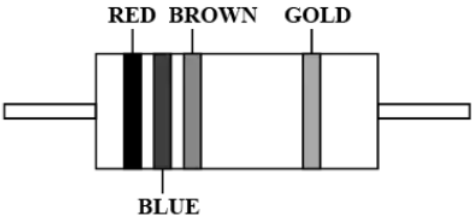


Fig 3.1

Determine the range of resistance values for the resistor in Fig. 3.1. Leave your answers in exact values. [2]

……

[Total: 2 marks]

4 Fig. 4.1 shows a circuit with four resistors connected to a 10 V battery.

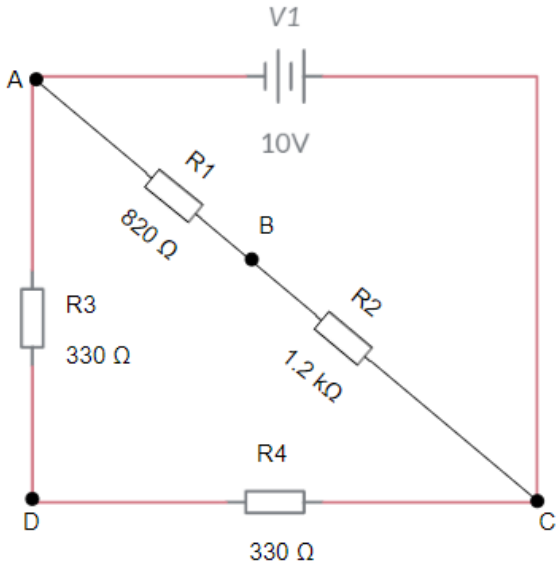


Fig. 4.1

(a) Calculate the effective resistance of the circuit. [3]

……

(b) State the potential difference across R3. [1]

……

[Turn over

(c) Determine the power delivered to R3. [2]

.....

(d) Circle the suitable power rating for R3. [1]

0.125 W **0.25 W** **0.5 W** **1.0 W** **2.0 W**

(e) Fig. 4.2 shows a wire connected between point CD.

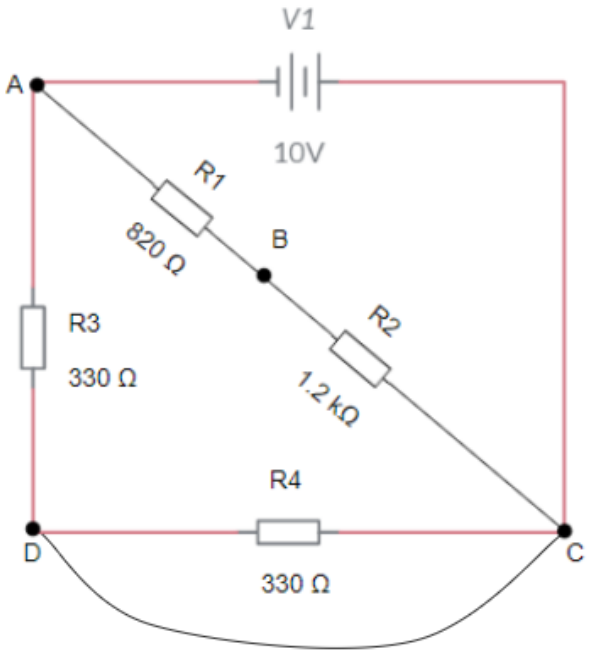


Fig. 4.2

State the change, if any, in the current passing through R3.
Explain your answer. [2]

.....

.....

.....

.....

[Total: 9 marks]

[Turn over

5 Fig. 5.1 shows the direction of the currents in a circuit.

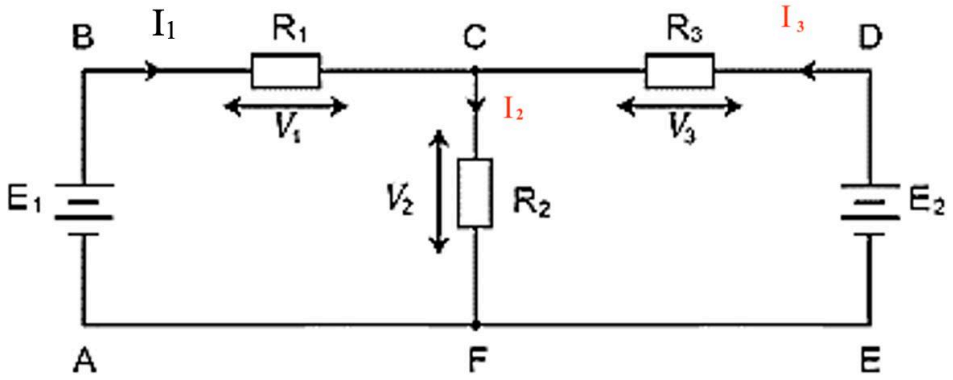


Fig. 5.1

(a) Using KVL, form the equation for the loops ABCFA and FCDEF. [2]

Loop ABCFA: ……

Loop FCDEF: ……

(b) Using KCL, form the equation for the junction C. [1]

…..……

[Total: 3 marks]

[Turn over

6 Fig. 6.1 shows the breadboard connection of a circuit.

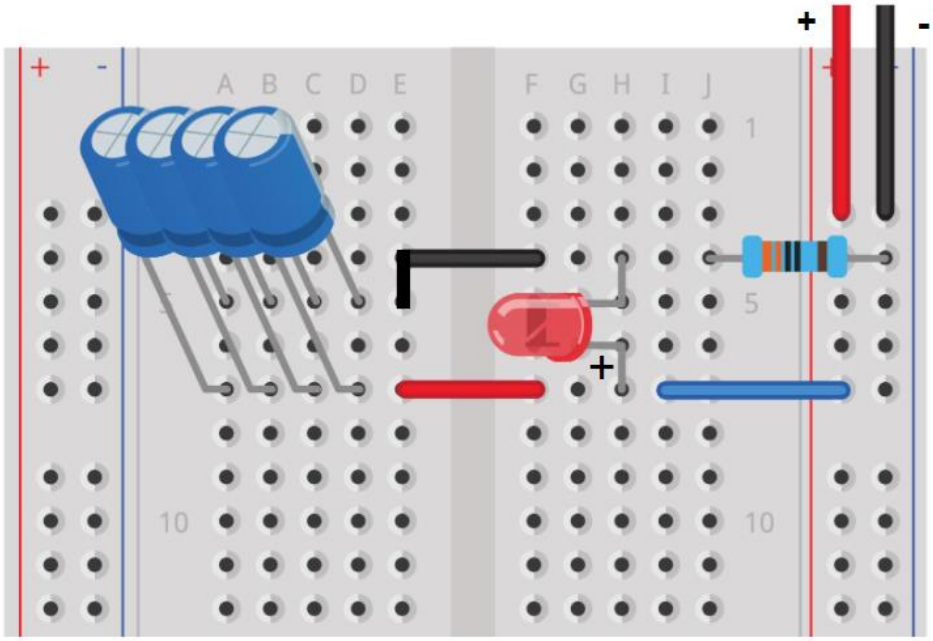


Fig. 6.1

(a) In the space below, draw the circuit diagram of Fig. 6.1. [3]

+

-

(b) Based on your circuit diagram in **(a)**, determine the total capacitance of the circuit. Each capacitor is 220 uF. [2]

.....

[Total:5 marks]

[Turn over

7 Fig. 7.1 shows two different diode circuits, where Vin is connected to the input circuit.

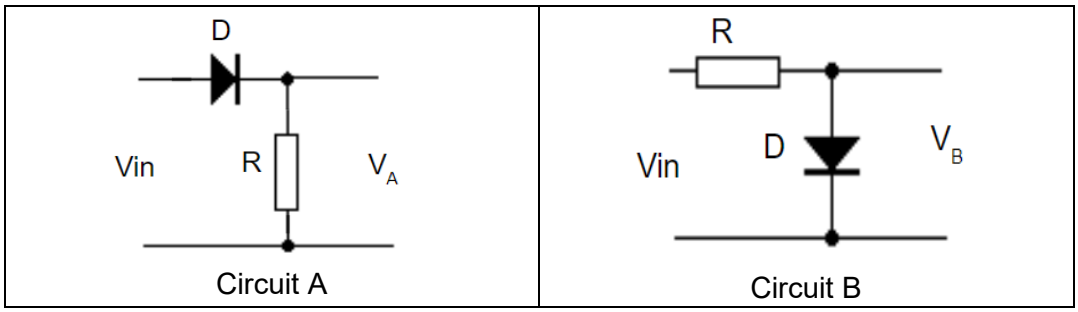


Fig. 7.1

Sketch and label the peak voltages on Fig. 7.2 to show the output of circuit A and circuit B using the simplified diode model. Assume that the diode has a forward voltage of 0.70 V

(a)

Circuit A [2]

(b)

Circuit B [3]

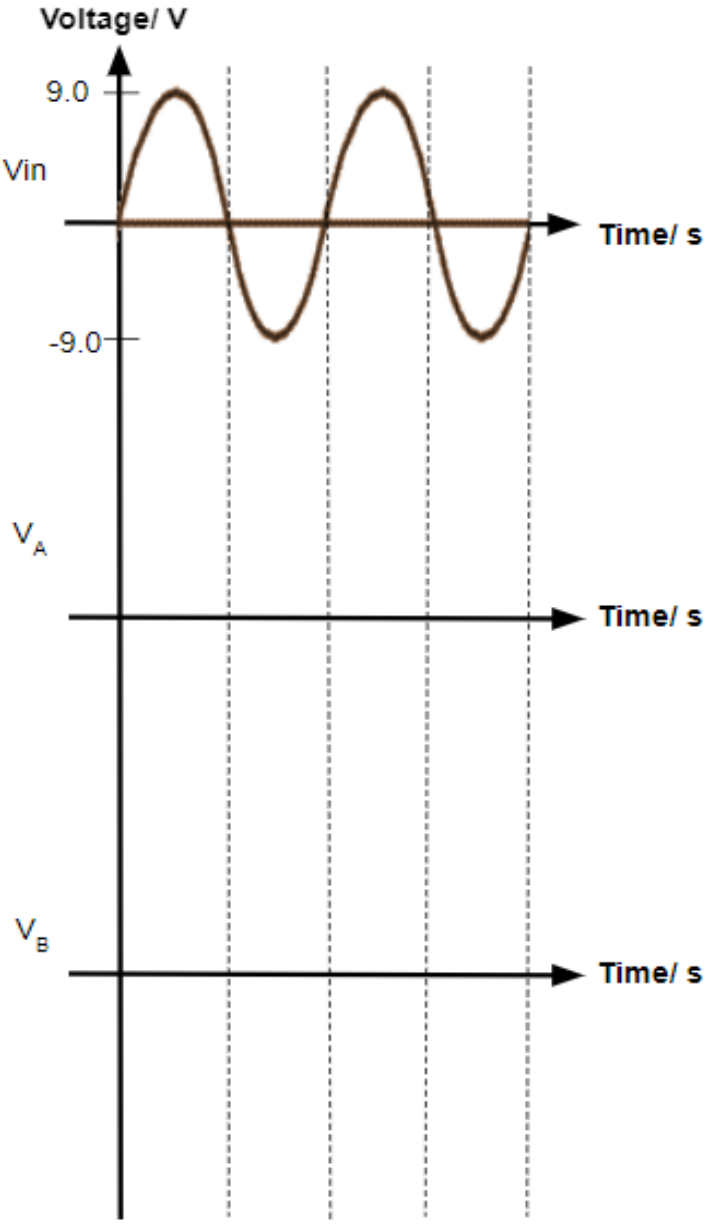
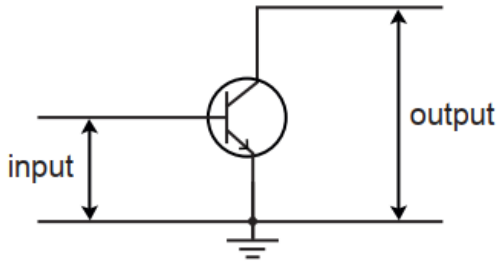


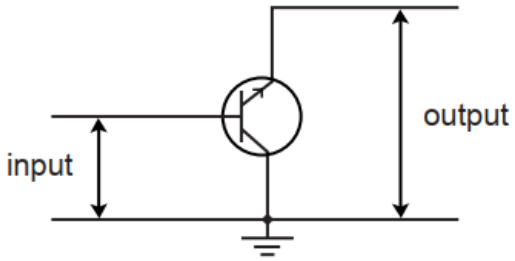
Fig 7.2 **[Total: 5 marks]**

[Turn over

8 **(a)** Fig. 8.1 shows two configurations of the BJT amplifier.
State each configuration in Fig. 8.1. [2]



Ans:



Ans:

Fig. 8.1

(b) Fig. 8.2 shows a BJT configured as an amplifier. Assume V_{BE} to be 0.70 V.
Fig. 8.3 shows the Vin and Vout waveform.

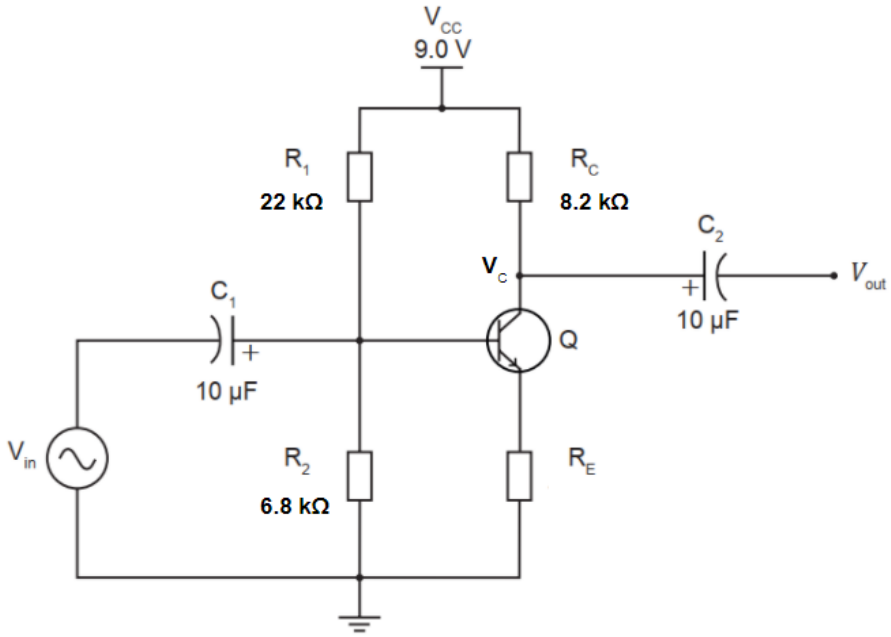


Fig. 8.2

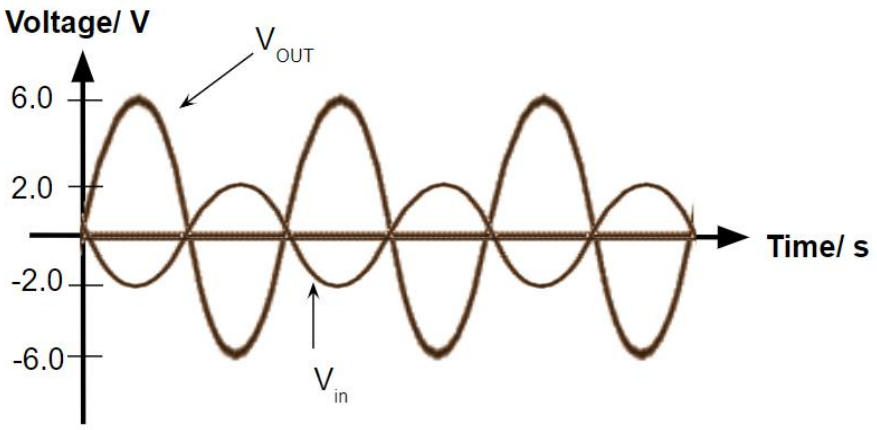


Fig. 8.3

[Turn over

(i) Determine the voltage gain of the amplifier. [1]

……..……..

(ii) Calculate the R_E. [1]

……..……..

(iii) If the emitter current I_E = 0.52 mA, state the collector current I_c. [1]

……..……..

(iv) Calculate the collector voltage V_C. [2]

……..……..

[Total:7 marks]

[Turn over

9 The Boolean expression of the combination logic with inputs P, Q and output R.

$$R = (\overline{P + Q}) + (P \cdot Q)$$

(a) Using two input logic gates, complete the combination logic circuit of the Boolean expression R below. [3]

(b) NAND gates are also known as Universal gates.
Show how two input NAND gates can be used to represent AND gate. [2]

(c) Complete the truth table of the combination logic in Table 9.1. [3]

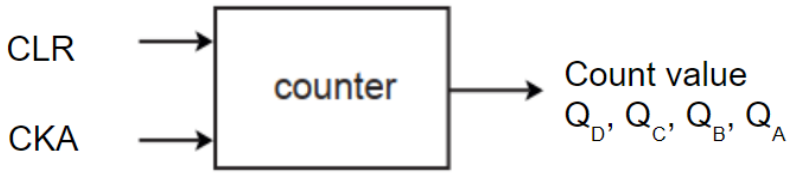
P	Q	$(\overline{P + Q})$	$(P \cdot Q)$	R
0	0			
0	1			
1	0			
1	1			

Table 9.1

[Total: 8 marks]

[Turn over

10 Fig. 10.1 shows the timing diagram of the decade counter.



(a) Complete the timing diagram. [4]

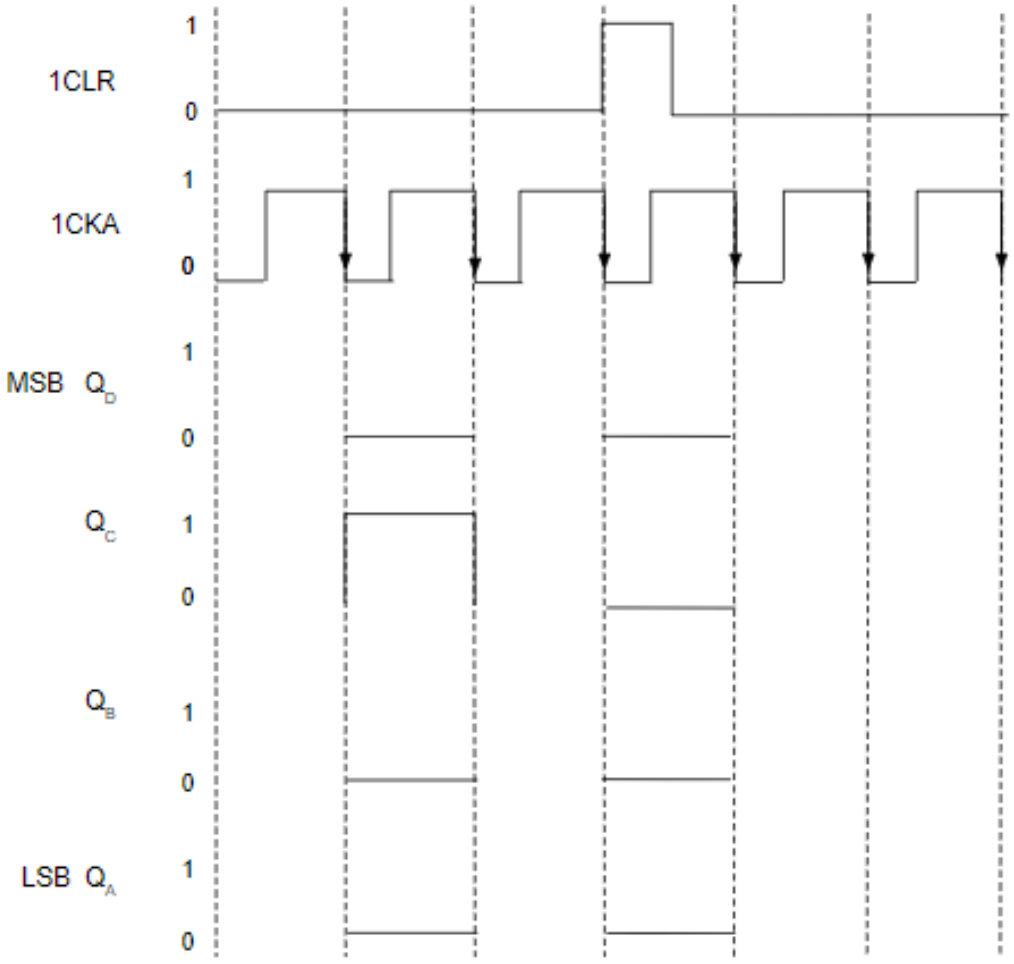


Fig. 10.1

(b) The decade counter is connected to the 7-segement display module.
State the last digit shown on the 7-segment display before the 1CLR is activated. [1]

……

(c) To activate 1CLR automatically, 1CLR is connected to the output of an AND gate.
The input of the AND gate is connected to the output pins of the counter.
State the output pins that are connected to the AND gate. [1]

……

[Total: 6 marks]

[Turn over

11 A system is designed to turn on the mini sprinkler in a tree-frog terrarium under the following conditions:

- When the humidity is low, and the lighting condition is dim.
- When the lighting condition is high, and the temperature in the terrarium is high.

Sprinkler S, 0 = OFF
1 = ON

Temperature sensor C, 0 = Temperature LOW
1 = Temperature HIGH

Humidity sensor B, 0 = High
1 = Low

Light sensor A, 0 = Dim
1 = Bright

(a) Complete the truth table of the system below. [3]

Light Sensor A	Humidity sensor B	Temperature sensor C	Sprinkler S
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Table 11.1

(b) Write down the SOP Boolean expression of S in Table 11.1. [2]

S =……..…….……

[Total: 5 marks]

[Turn over

Section B

Answer **all** questions.

Write your answers in the spaces provided.

12 An engineer builds a water level alarm system for a water tank. He uses a water sensor which consists of a float that is attached to a potentiometer as shown in the Fig. 12.1. As the float rises, the output voltage of the potentiometer Vpot also increases

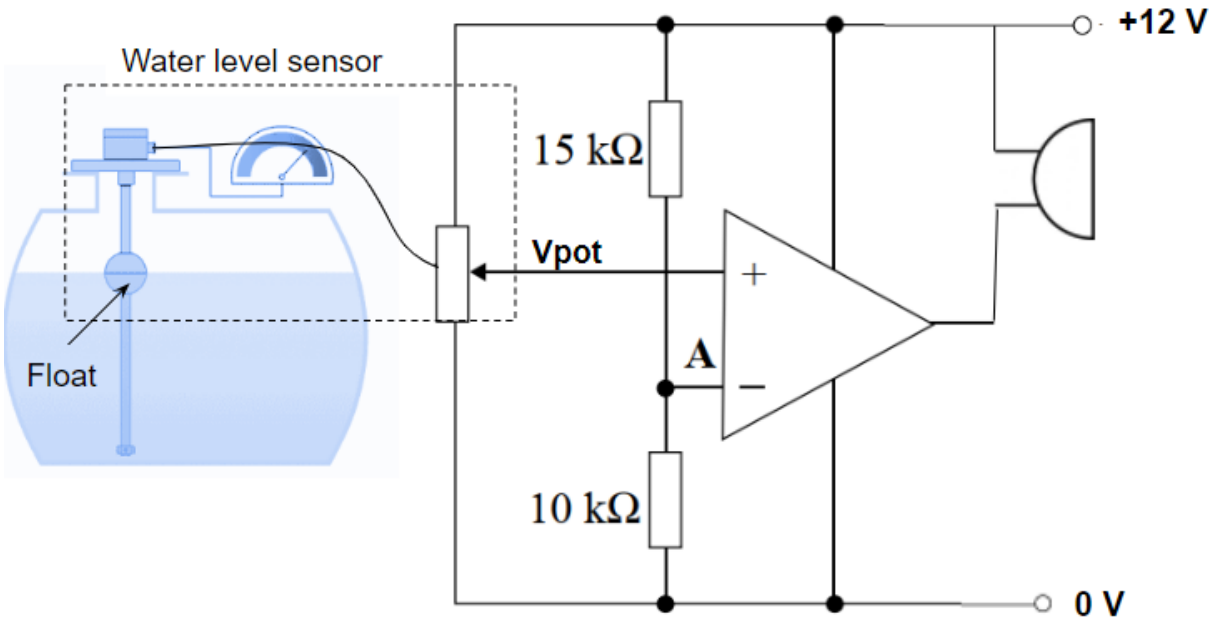


Fig. 12.1

(a) Determine the voltage at point A. [2]

.....

[Turn over

(b) Fig. 12.2 shows the characteristic graph of output of the potentiometer Vpot and the water depth in the tank.

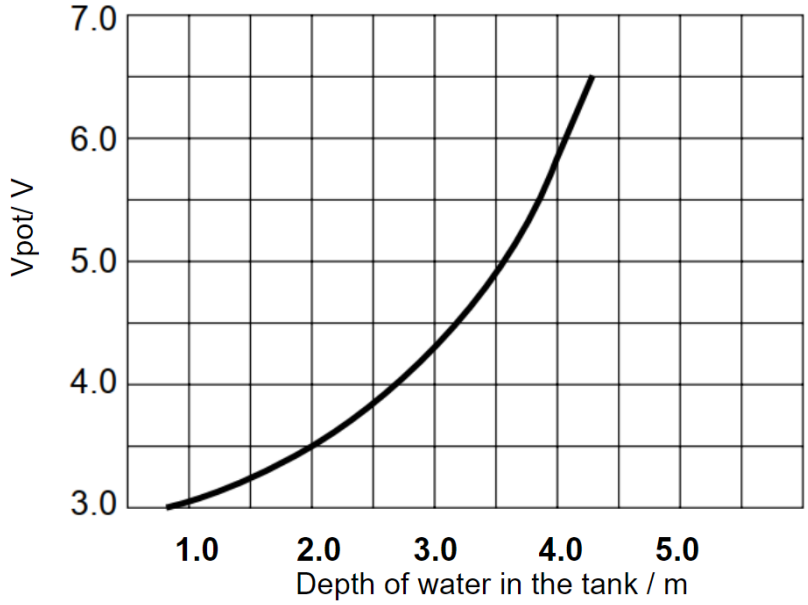


Fig. 12.2

(i) State and explain if the alarm is turned on when the water depth is at 2.0 m. [3]

……

……

……

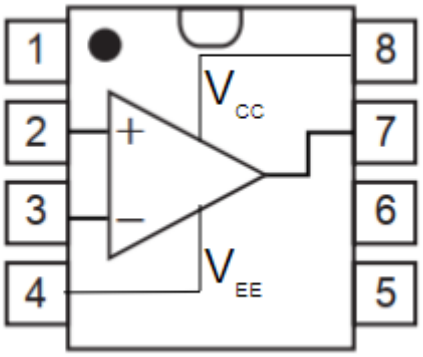
……

(ii) Estimate the depth of water in the tank that will stop the alarm. [1]

……

[Turn over

(c) In Table 12.1, identify the pin numbers of the voltage comparator in Fig. 12.3. [4]



Description of pin connections	Pin number/s
Supply Voltage	
GND / 0V	
Inverting input	
Non-inverting input	
Output	7
Unused pins	5, 6

Fig. 12.3 **Table 12.1**

(d) The engineer wants to enhance his circuit by considering the use of the two different configurations of 555 timer circuit as shown in Fig. 12.4.

(i) State the term used to describe each 555-timer circuit. [2]

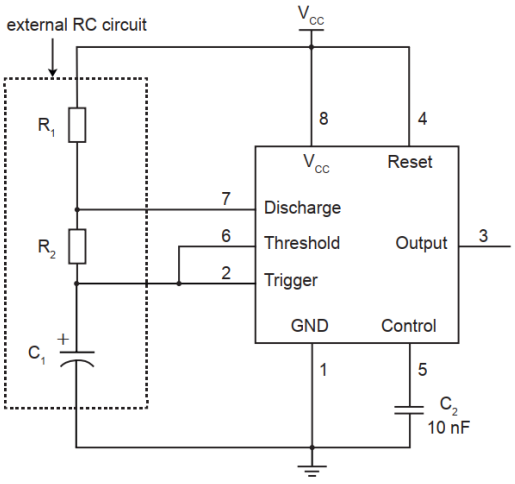
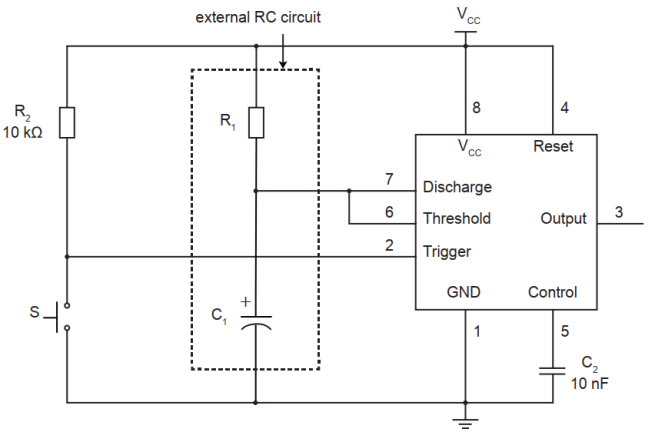
Circuit A	Circuit B
	
Circuit A:	Circuit B:

Fig. 12.4

(ii) Describe one main difference between the two circuits. [2]

……

……

……

[Turn over

(iii) The engineer decides to add circuit A into the system as an enhancement. Fig. 12.5 shows how Circuit A is connected to the system.

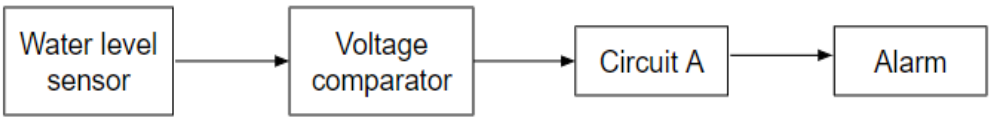


Fig. 12.5

State which pin on circuit A is connected to the output of the voltage comparator. [1]

…….

[Total: 15 Marks]

[Turn over

13 Fig. 13.1 shows an incomplete circuit where current I_B= 74 uA is used to drive a load that is rated at 9.0 V 800 mA. However, during the test, the load did not perform at the rated condition.

The transistor specification:
β_{dc} for transistor is 100
V_{BE} for transistor is 0.70V

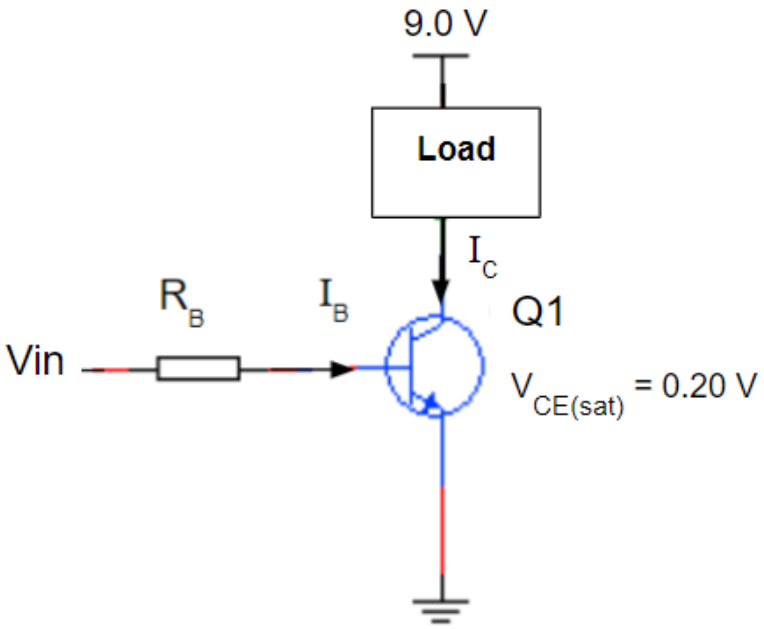


Fig. 13.1

(a) **(i)** Show that the load is not operating at its rated current. [2]

……

……

……

(ii) Other than using a Darlington pair, suggest two other design modifications that can be made to Fig. 13.1 to increase the load current. [2]

……

……

……

……

[Turn over

(b) Fig. 13.2 shows the modified circuit with the load connected to a Darlington pair that is driven by the current I_B= 74 uA.

The transistor specification:
β_{dc} for each transistor is 100
V_{BE} for transistor is 0.70V

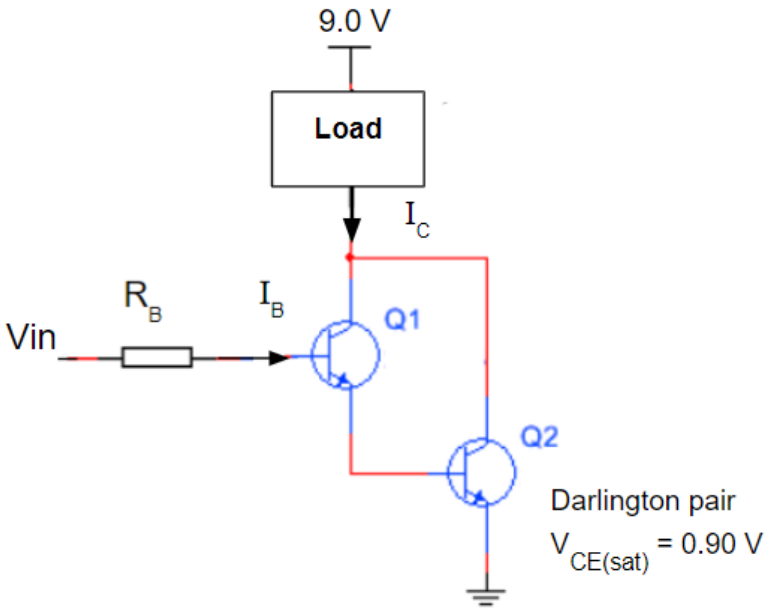


Fig. 13.2

(i) Determine the collector current $I_{C(sat)}$ that is needed to drive the Darlington pair into saturation. The load resistance is 11Ω. [2]

……

(ii) The input voltage Vin is at 3.3 V when the transistor enters saturation. Determine the resistance R_B. [2]

……

(iii) Circle a suitable E24 series resistor for R_B. [1]

20 kΩ 22 kΩ 24 kΩ 27 kΩ 30 kΩ 33 kΩ

[Turn over

(c) Fig. 13.3 shows the incomplete structure of the load which consists of the component K1 and a motor.

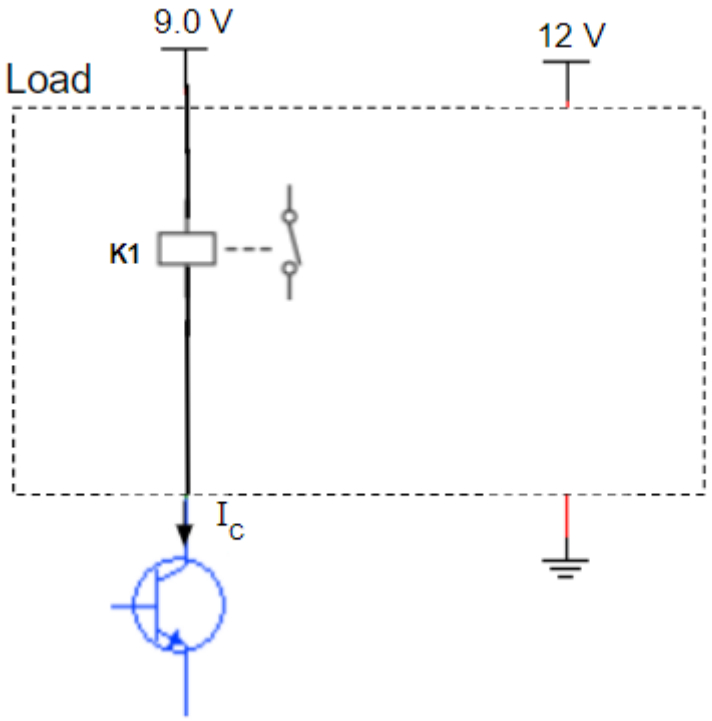


Fig. 13.3

(i) Name component K1: ……..…….....……...….[1]

(ii) A component is added to prevent the negative voltage spike from damaging the transistor when the power supply is suddenly cut off.

1. Name the component: ……....[1]

2. Draw on Fig. 13.3 to show how the component is connected. [1]

(iii) Complete the circuit on Fig. 13.3 to show how K1 is used to control a motor that runs on 12 V. [3]

[Total: 15 marks]

[Turn over

14 Fig. 14.1 shows a turnstile gate system that is installed to allow authorized personnel to enter and exit a building.

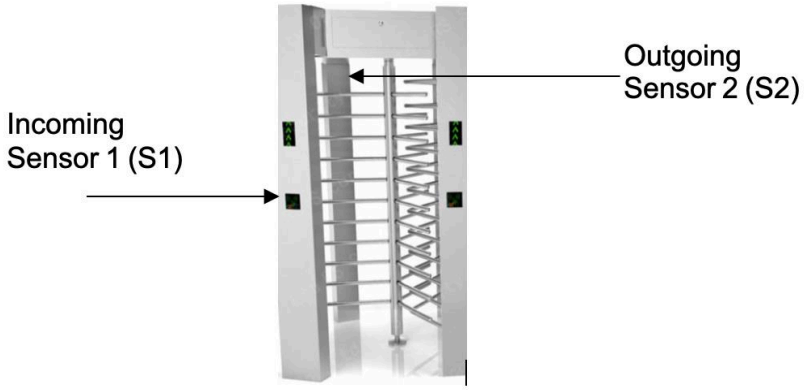


Fig. 14.1

Fig. 14.2 shows the block diagram of the system.

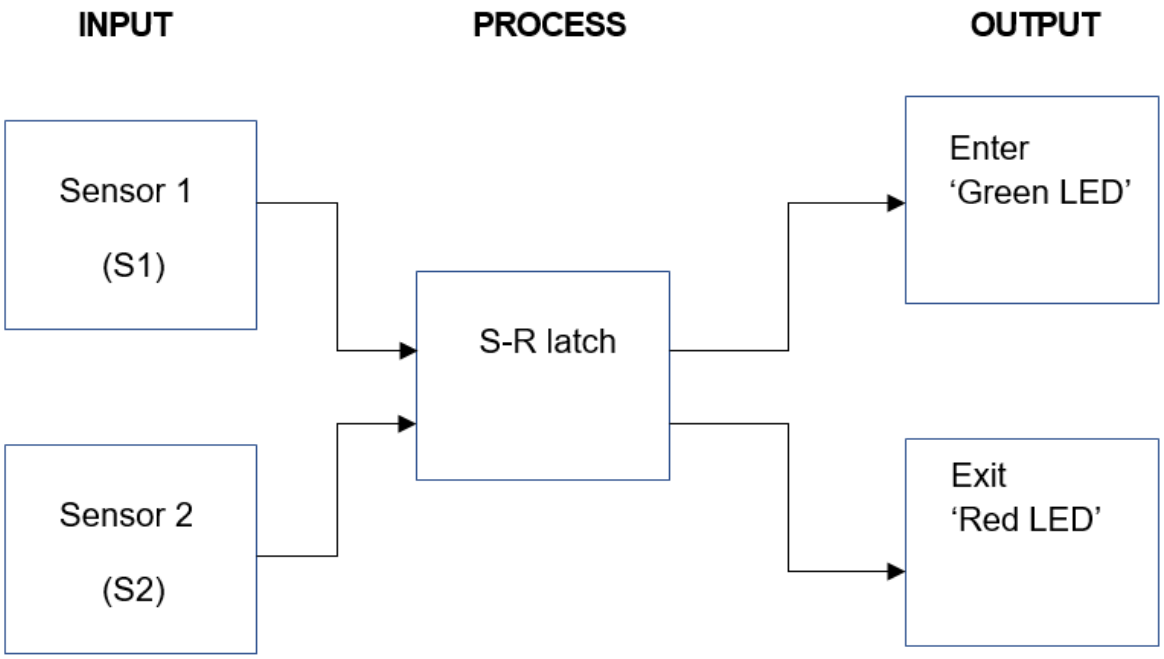


Fig 14.2

[Turn over

Fig. 14.3 shows a switch used to sense the direction the gate is turning.

Condition of switch:
Entering the building - Lever arm pressed = High '1'
Exit from building - Lever arm released = Low '0'

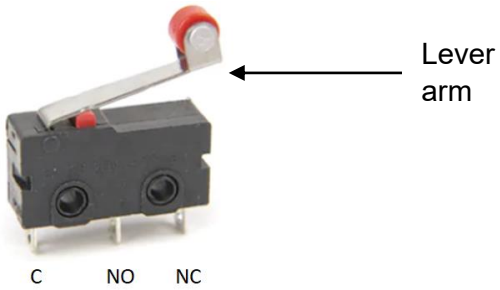


Fig. 14.3

(a) The three connection legs on the switch are marked C, NO and NC.
In the table below, state what these abbreviations stand for. [3]

Marking	Meaning
C	
NO	
NC	

(b) On Fig. 14.4, draw the connections to provide a logic 0 signal when the switch is pressed. [2]

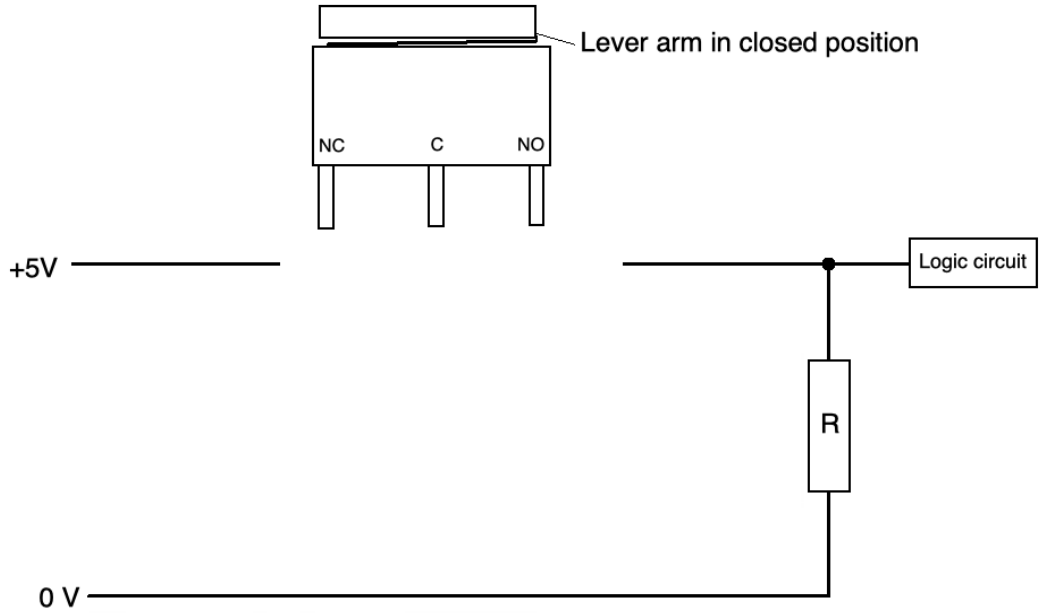


Fig. 14.4

[Turn over

(c) When using a mechanical switch, contact bounce can be a problem.

(i) Sketch the output signal produced by a mechanical switch during contact bounce. [1]

(ii) State what can be used to eliminate contact bounce. [1]

.....

(d) Fig. 14.5 shows a truth table and an incomplete circuit diagram for the S-R latch.

(i) Complete the circuit diagram so it functions as shown in the truth table. [4]

Sensor 1 (S1)	Sensor 2 (S2)	Green LED	Red LED
0	0	0	1
1	0	1	0
0	0	1	0
0	1	0	1
0	0	0	1

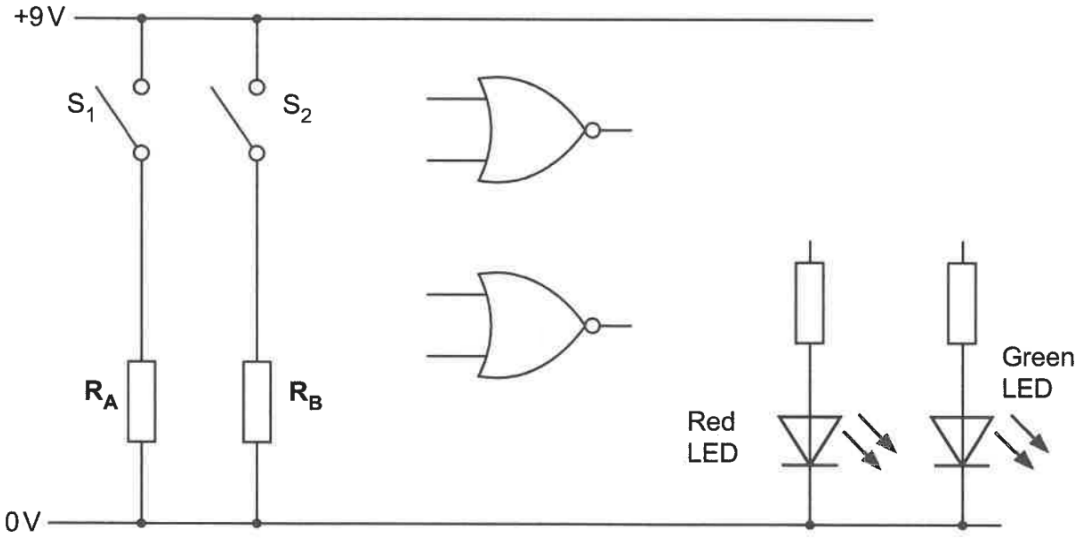


Fig. 14.5

[Turn over

(ii) State the term used to describe $R_{A.}$ [1]

…..

(iii) Describe the function of the resistor R_A in the circuit. [2]

…..

.....

(iv) Fig. 14.6 shows an IC layout for 74LS02 NOR gate IC, circle the pin 10 on Fig. 14.6. [1]

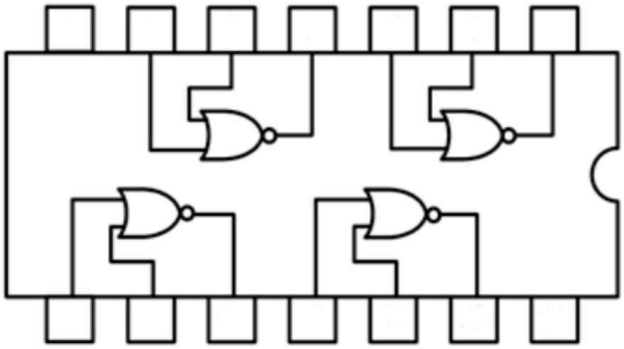


Fig.14.6

[Total: 15 marks]

END OF PAPER

[Turn over