WOODLANDS RING SECONDARY SCHOOL

Name : _____ Reg No. _____ Class : _____

EXAMINATION	**:**	**PRELIMINARY EXAMINATION**	
LEVEL	**:**	**SECONDARY 4 EXPRESS**	**DATE: 31 AUG 2022**
SUBJECT	**:**	**ELECTRONICS (6063)**	**PAPER: 1**
DURATION	**:**	**2 hours**	**MAX MARKS: 100**
SETTER(S)	**:**	**Mr Ong Chee Lim**	**Parent's/Guardian's Signature:**

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

You may use a calculator.

Section A
Answer **all** questions.

Section B
Answer **all** questions.

The number of marks is given in brackets [ ] at the end of each question or part question.
The total number of marks for this paper is 100.

100

This document consists of **22** printed pages.

DATASHEET

Resistor Colour Codes

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 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)

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

Table on Boolean algebra

Single variable theorems	Laws of Complementation	• $\overline{0} = 1$ • $\overline{1} = 0$ • $\overline{\overline{A}} = A$
	AND Laws	• $A.0 = 0$ • $A \cdot 1 = A$ • $A \cdot A = A$ • $A \cdot \overline{A} = 0$
	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	• $A + (B + C) = (A + B) + C = A + B + C$ • $A \cdot (B \cdot C) = (A \cdot B) \cdot C = A \cdot B \cdot C$
	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

Answer **all** questions in this section.

1 A heating lamp has seven subsystems to turn on the heat as shown in Fig. 1.1.

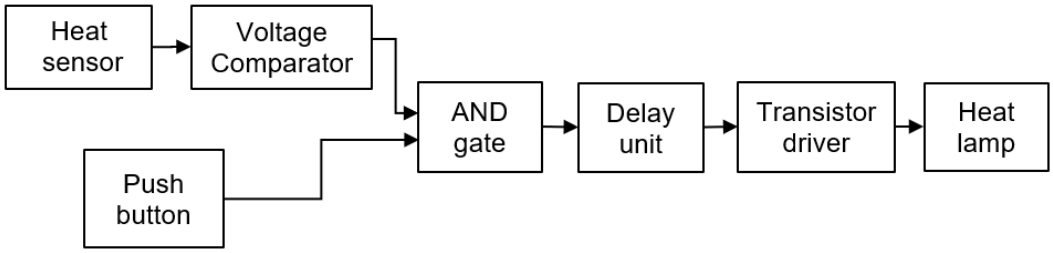

Fig. 1.1

Write the name(s) of each subsystem in the heating lamp to the correct function(s) in Table 1.1.

Table 1.1

Function of subsystem	Name(s) of subsystem
Input	
Output	
Logic	
Timer	
Analogue to digital converter	
Switch	

[6]

2 Fig. 2.1 shows a simple resistor circuit.

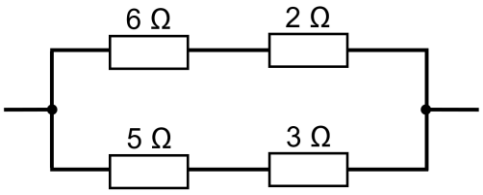

Fig. 2.1

Calculate the total effective resistance of the circuit.

…… [2]

3 **(a)** Draw the circuit symbol for a microphone.

[1]

(b) State the function of an input transducer.

…… [1]

4 Fig. 4.1 shows two electrolytic capacitors connected in parallel to smooth the output of a DC power supply. A resistor, R_{out}, is connected across the capacitors to discharge them when the power supply is switched off.

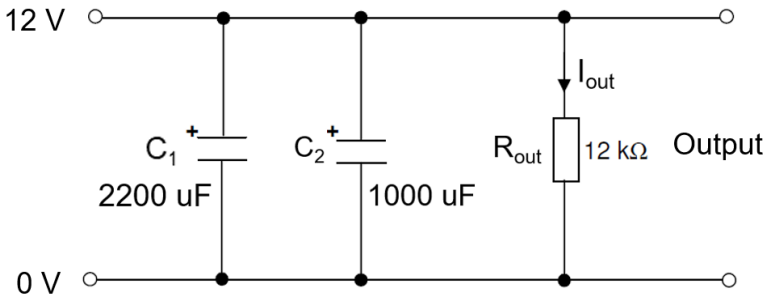

Fig. 4.1

Calculate

(a) the current, I_{out}, when the power supply is on,

…… [2]

(b) the total capacitance, C_T, of the two capacitors.

…… [2]

5 Fig. 5.1 shows a RC circuit with E = 12.0 V, R = 1.26 MΩ and C = 1.70 μF.

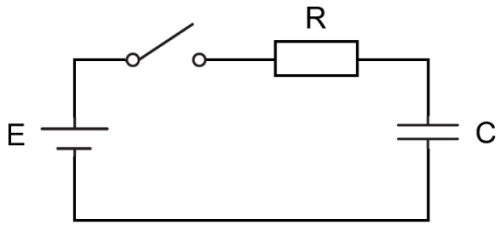

Fig. 5.1

(a) Calculate the time constant of the RC circuit.

…… [2]

(b) Find the maximum charge of the capacitor during charging.

…… [2]

(c) When the switch is closed, how long does it take for the potential difference across the capacitor to reach 8 V? You must show your working clearly.

…… [2]

6 The output of 555 timer is connected to an oscilloscope and the following waveform is captured in Fig. 6.1.

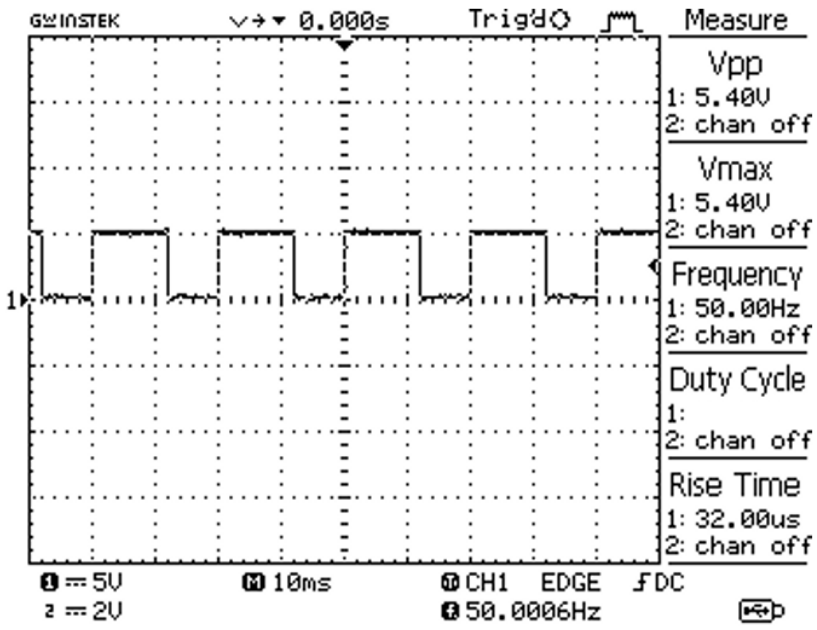

Fig. 6.1

(a) State the peak voltage of the waveform.

…… [1]

(b) Determine the ‘on time’ of the waveform.

…… [1]

(c) Determine the duty cycle of the waveform.

…… [2]

7 Fig. 7.1 shows an incomplete circuit diagram.
Connect an SPST switch and a general-purpose diode to Fig. 7.1 such that the user can set the light to be dim or bright.

Single pole single throw (SPST)	
General-purpose diode	

Table 7.1

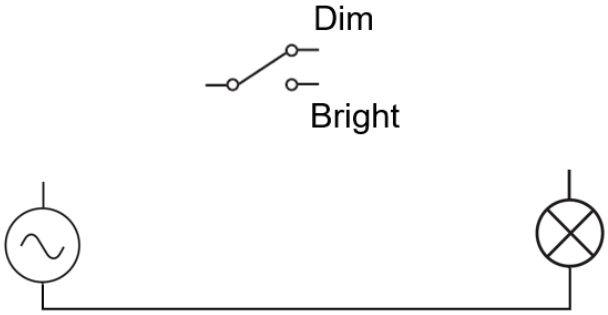

Fig. 7.1 [3]

8 Choose the correct type of Bipolar Junction Transistor for the switching circuits **A** and **B** shown in Fig. 8.1.

For each circuit, draw the transistor symbol inside the dotted circle and label its type on the dashed line.

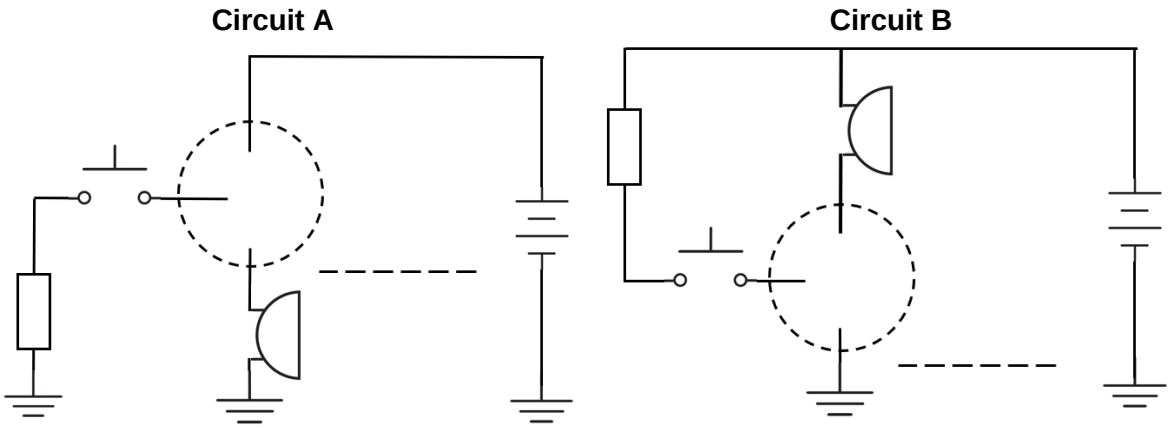

Fig. 8.1 [4]

9 Fig. 9.1 shows a combinational logic circuit.

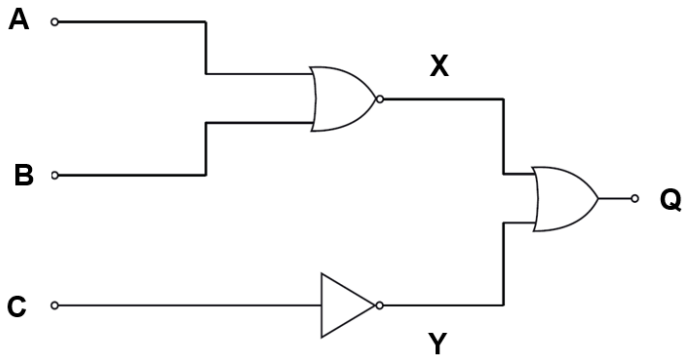

Fig. 9.1

(a) Fig. 9.2 shows a timing diagram of the circuit.
Complete the timing diagram of the circuit for X, Y and Q.

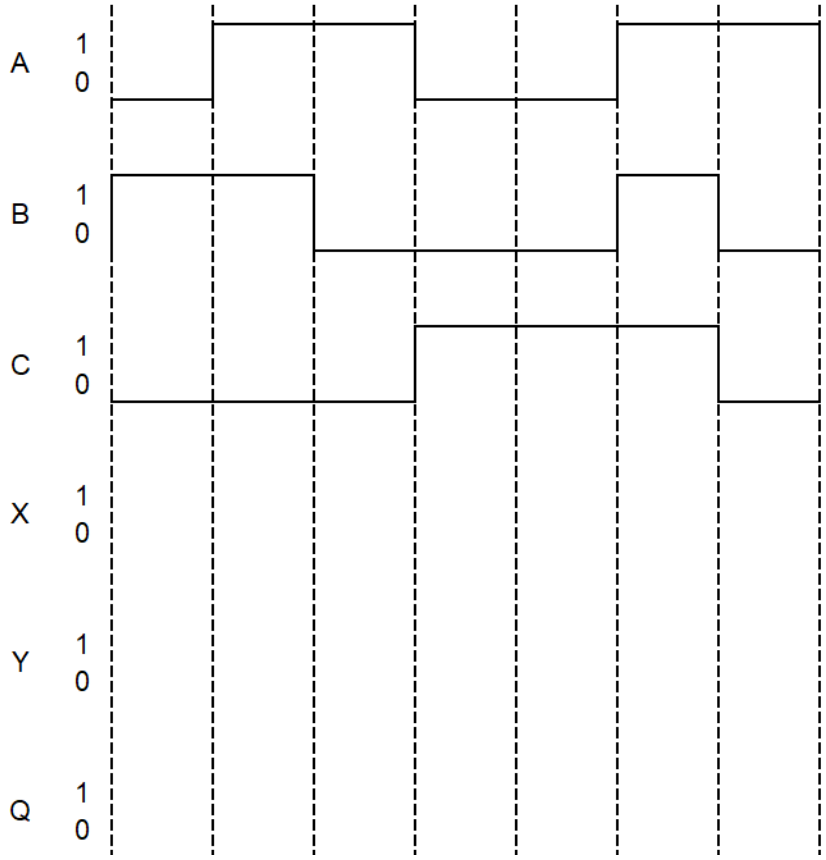

Fig. 9.2 [3]

(b) Write in terms of input A, B and C, the Boolean expressions for X, Y and Q.

X = ……

Y = ……

Q = …… [3]

10 Fig. 10.1 shows a circuit using AC input signal.

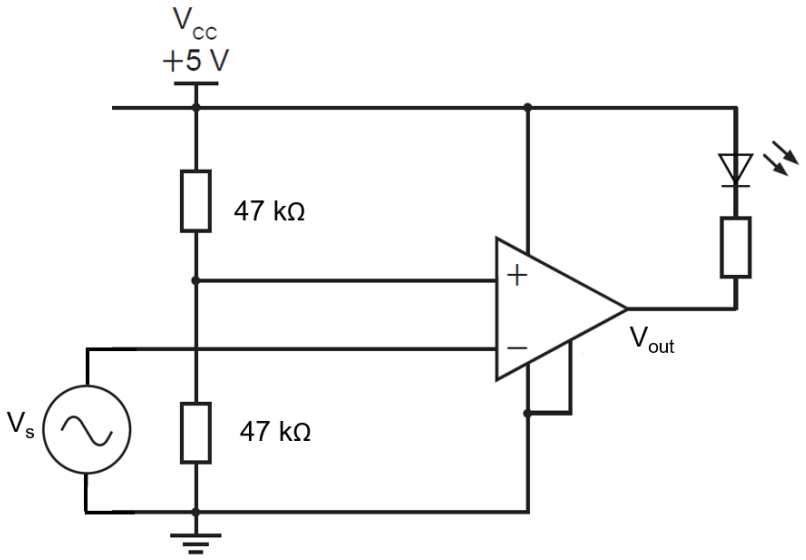

Fig. 10.1

The reference voltage is at the non-inverting input of the voltage comparator.
Fig. 10.2a shows an input waveform V_s applied at the inverting input.

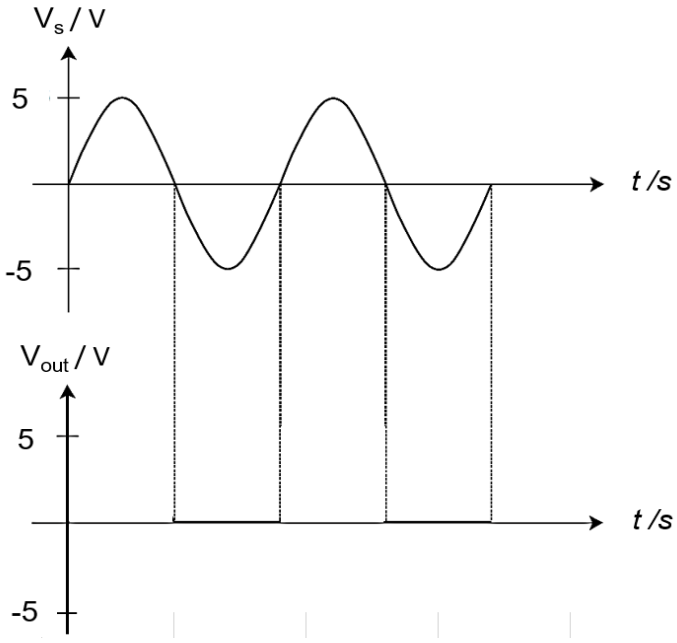

Fig. 10.2a

Fig. 10.2b

(a) Draw the reference voltage on Fig. 10.2a. Indicate its voltage value. [1]

(b) Draw the voltage signal waveform at V_{out} on Fig. 10.2b. Indicate its voltage value and necessary signal/line trace from Fig. 10.2a. [2]

Section B

Answer **all** questions in this section.

11 The system diagram shown in Fig. 11.1 is to be used to generate intermittent on/off sound as part of a shop display alarm.
The logic gate circuit is used to achieve an on/off sequence that has different ON time for each sound.

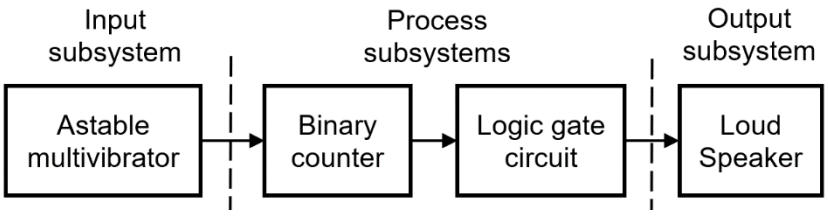

Fig. 11.1

Fig. 11.2 shows a 555 timer being connected to operate as an astable multivibrator part of the system.

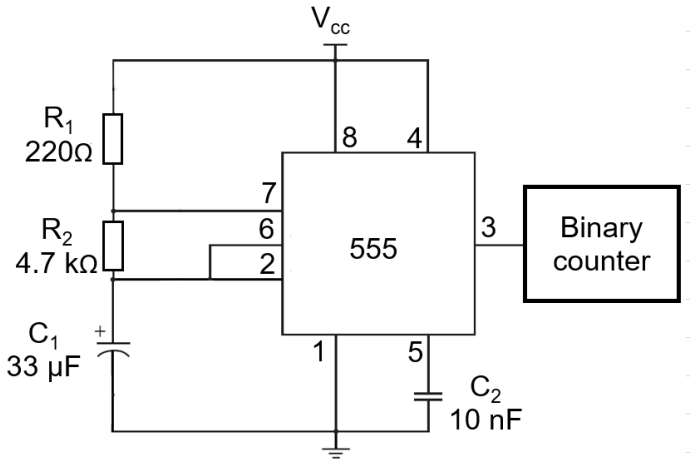

Fig. 11.2

(a) Calculate the on/off frequency of the astable multivibrator.

…….. [3]

(b) Explain why it is impossible for the circuit in Fig. 11.2 to achieve 50% duty cycle.

……..

……..

…….. [2]

(c) Fig. 11.3 shows how the signal from the astable multivibrator causes the loudspeaker output to change.

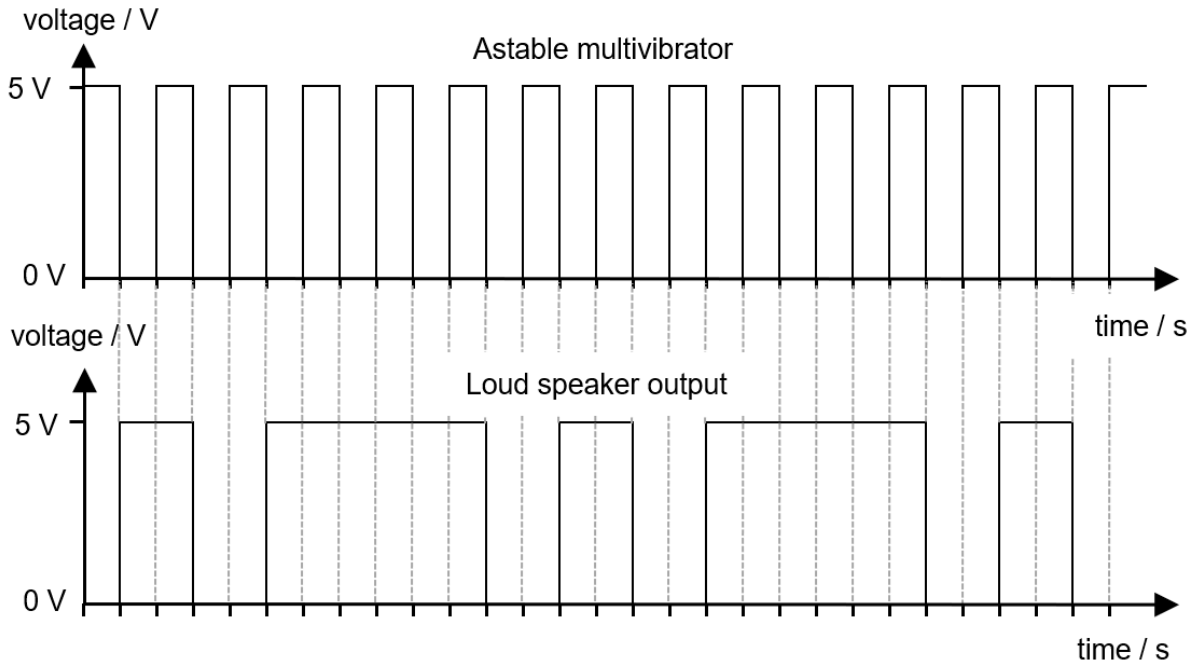

Fig. 11.3

(i) Using the frequency of the astable multivibrator found in **part 11(a)**, label at least 3 values on the time axis of the astable multivibrator chart in Fig. 11.3. [1]

(ii) State the type of signal edge trigger from the astable required to change states in the loudspeaker output.

…….. [1]

(d) Table 11.1 shows the truth table for the binary counter and loudspeaker output. The binary counter resets on the 6th pulse from the astable multivibrator.

Table 11.1

Binary counter output				Output
Count	Q_C	Q_B	Q_A	X
0	0	0	0	0
1	0	0	1	1
2	0	1	0	0
3	0	1	1	1
4	1	0	0	1
5	1	0	1	1
6 - reset	1	1	0	

(i) Karnaugh maps are used to simplify logic systems.
Complete the Karnaugh map in Fig. 11.4 using the information from the truth table in Table 11.1.

C \ AB	00	01	11	10
0				
1				

Fig. 11.4 [2]

(ii) Using the information from Fig. 11.4, write the Boolean expression for the logic gate circuit.

……. [2]

(iii) Using your answer from **part 11(d)(ii),** complete the circuit diagram in Fig. 11.5 showing the logic gate arrangement connecting the binary counter to the loudspeaker.

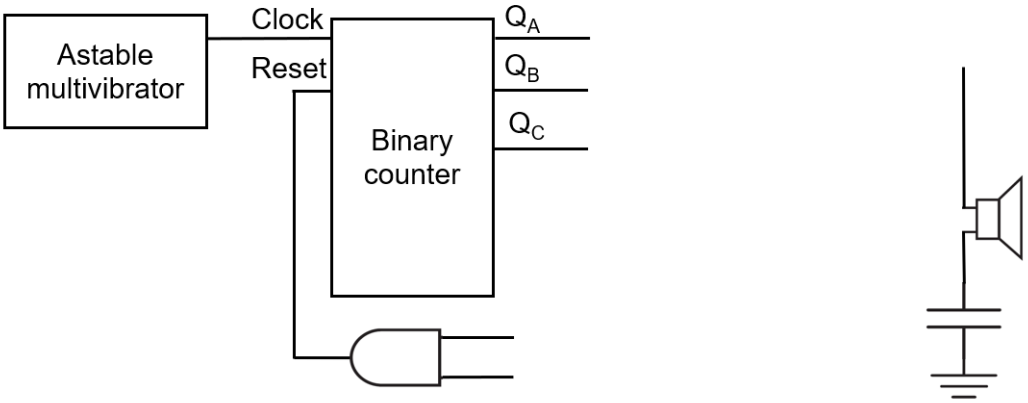

Fig. 11.5 [3]

(iv) Connect the AND gate used to reset the binary counter in Fig. 11.5 to its necessary input signal pins. [1]

12 Fig. 12.1 shows a system diagram for a volleyball match scoring system.

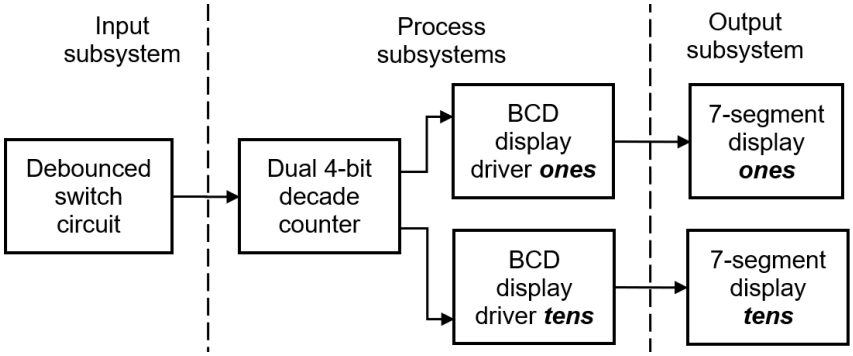

Fig. 12.1

(a) As occasionally contact bounce can cause the counter to register more than one switch operation, contact bounce can be removed by adding an S-R latch circuit.

Complete Fig. 12.2 to show how two NOR gates can be wired to create an S-R latch for the switch circuit.

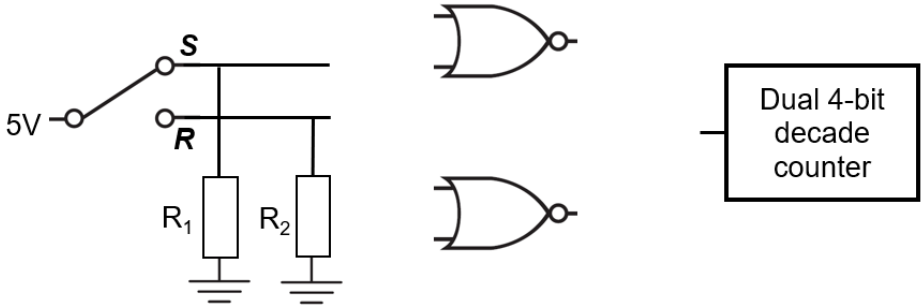

Fig. 12.2 [3]

(b) Give the full name the type of switch used in this circuit.

…….. [1]

(c) Explain why there is a need to place resistors R_1 & R_2 after the switch.

……..

…….. [1]

(d) Fig. 12.3 shows how a dual 4-bit decade counter 74LS390 connected to the debounced switch circuit, push button S_2, and a 7-segment display module.

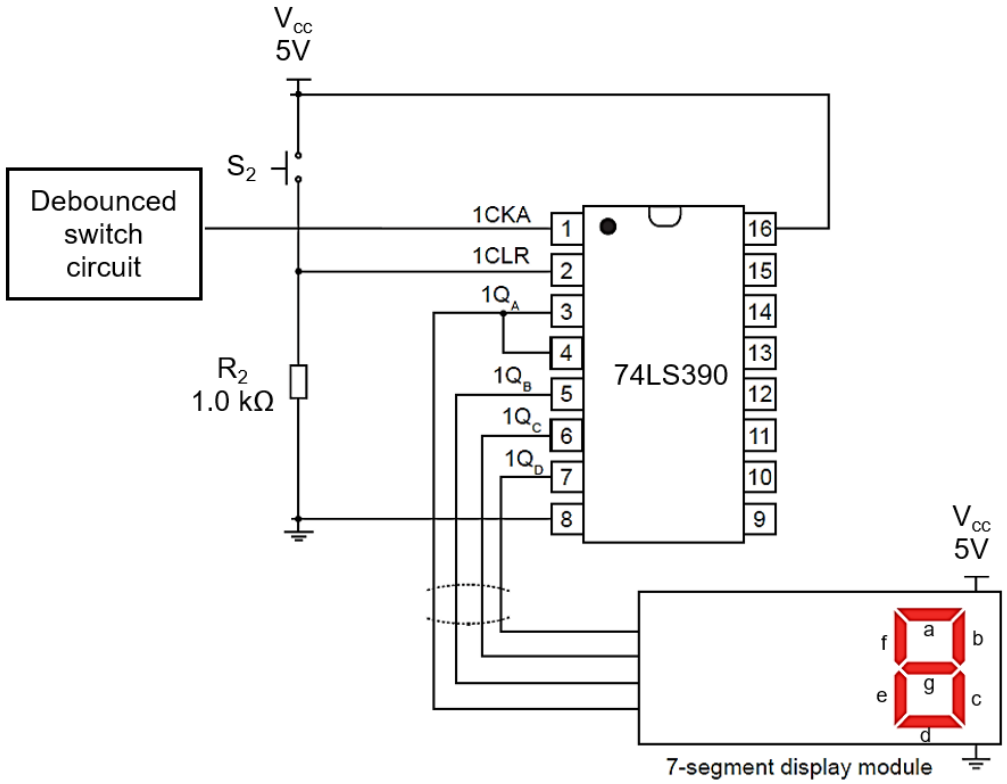

Fig. 12.3

Describe what happens to the 7-segment display when

(i) the debounced switch in Fig. 12.2 switches from position S to position R,

……

…… [1]

(ii) when push button S_2 is pressed.

……

…… [1]

(e) Complete **Table 12.1** to show how a number is displayed in the 7-segment display.

Table 12.1

Display number	BCD code				7 bit binary code						
	Q_D	Q_C	Q_B	Q_A	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
5					1	0	1	1	0	1	1
	0	1	1	1							

[3]

(f) Complete the timing diagram of the 74LS390 counter IC in Fig. 12.4.
The output at the start is 0010_{BCD}.

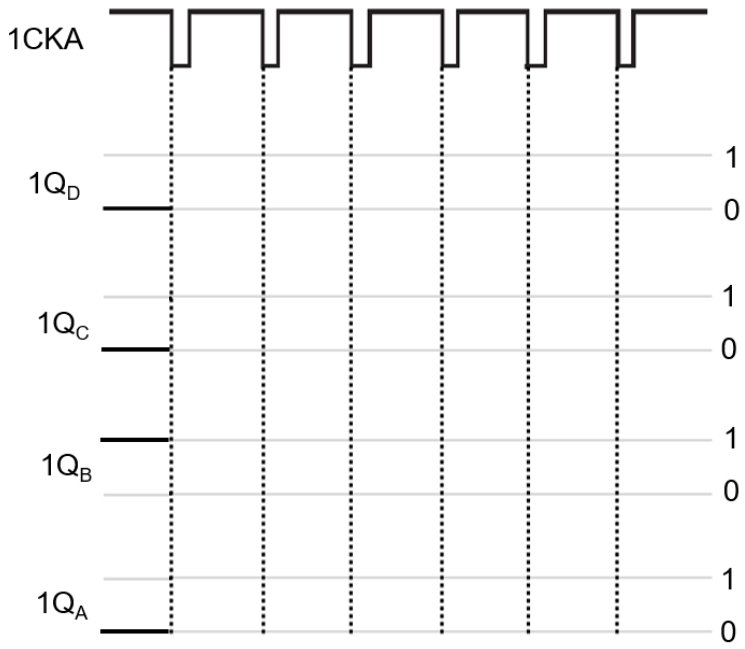

Fig. 12.4 [2]

(g) The volleyball match scoring system allows the display of scoring up till 99.
Draw on Fig. 12.5, the correct connections from the second 7-segment display to the 74LS390 decade counter so that it is able to count from 0 to 99.

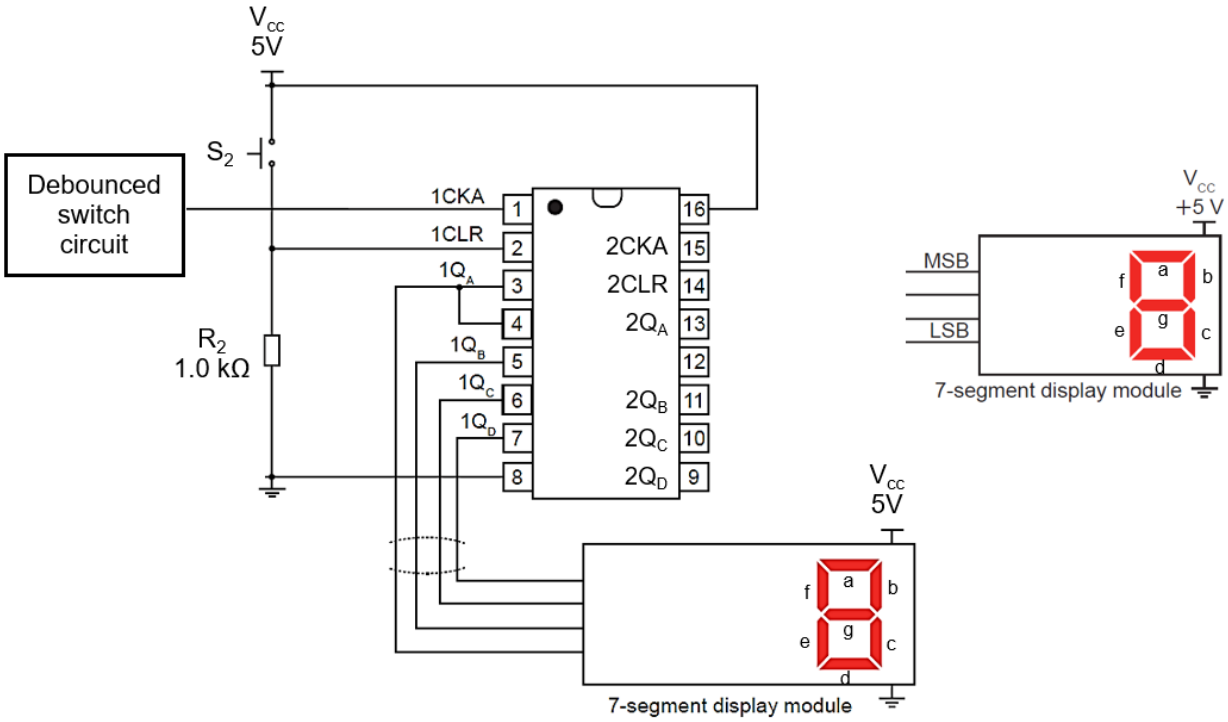

Fig 12.5 [3]

13 Certain medicines are maintained at a temperature between −6 °C and 16°C.
Fig. 13.1 shows the system diagram of a circuit being developed to monitor the temperature of the medicines.

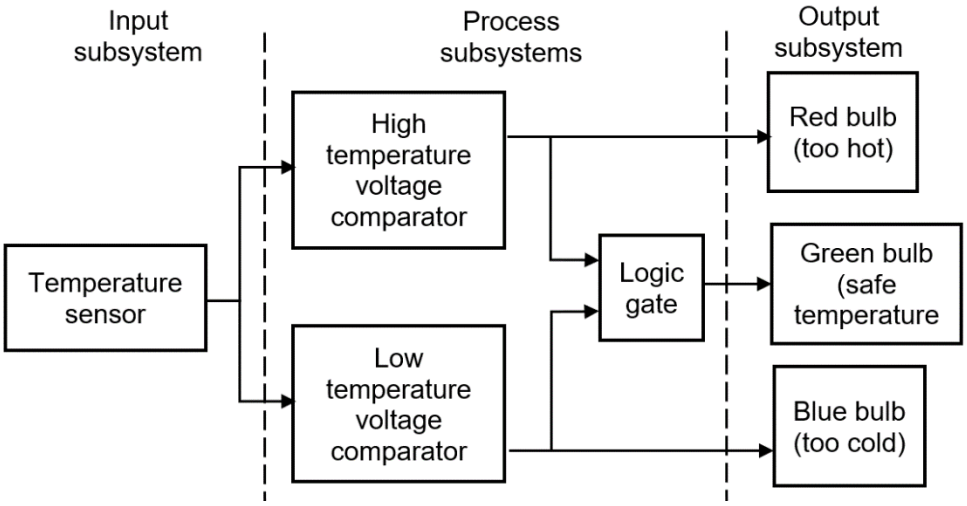

Fig. 13.1

(a) Fig. 13.2 shows the resistance chart for the temperature sensor.
Using this chart, complete Table 13.1 to show the component's resistance for the lower and upper temperatures.

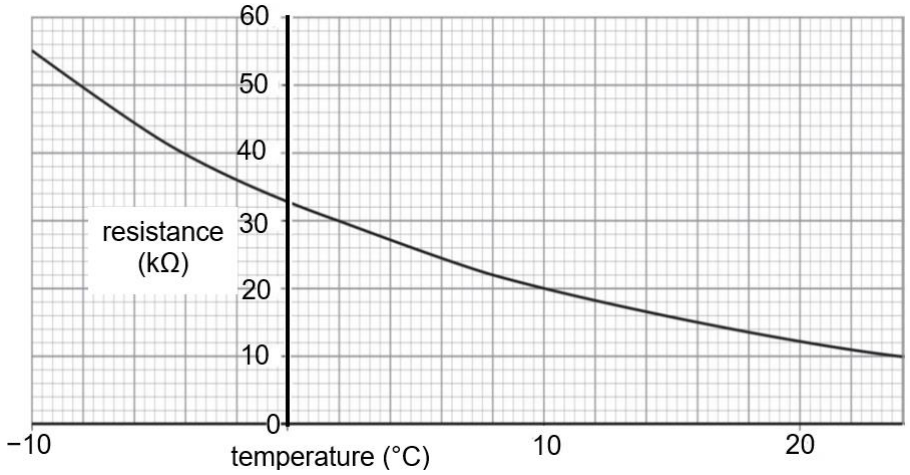

Fig. 13.2

Table 13.1

Temperature (°C)	Resistance (kΩ)
-6	
16	

[2]

(b) State the type of temperature sensor used in Fig. 13.1. Explain your answer.

……...

……...

……... [2]

(c) Fig. 13.3 shows the comparator circuit for the low temperature sensor subsystem shown in Fig. 13.1.

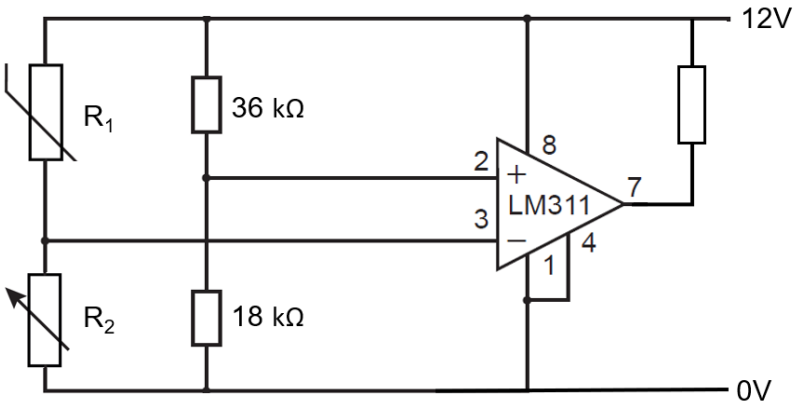

Fig. 13.3

(i) Show that the non-inverting input of the voltage comparator is 4V.

[1]

(ii) Calculate the required resistance of R_2, to give 3.9 V at pin 3 of the voltage comparator when the temperature drops to – 6°C.
Use your answer from **part 13(a)** for the resistance value of the sensing component at −6 °C.
Your answer must include unit.

……. [3]

(iii) What is the OUTPUT STATE at pin 7 of the voltage comparator when the temperature drops to – 6°C?

……. [1]

(iv) Complete the circuit in Fig. 13.3 so that a blue bulb lights when the temperature drops below – 6°C.

Include any additional components. [2]

(d) Complete Fig. 13.4 to show the logic gate that would provide the logic function needed to light a green blub to indicate the safe temperature range of -6°C to 16°C.

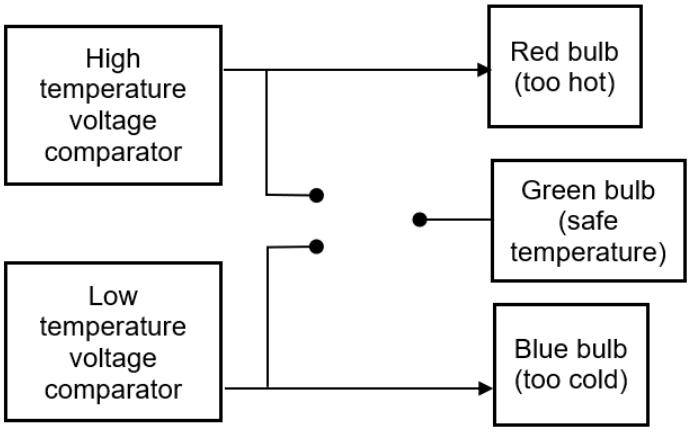

Fig. 13.4

[1]

(e) LEDs are replacing incandescent bulbs for the lighting of domestic houses.
State one advantage for the use of LEDs compared to incandescent bulbs.

……...

……... [1]

(f) Describe with reasons, one further feature that could be considered when developing the design.

……...

……...

……... [2]

14 **(a)** Fig. 14.1 shows a part of a light dependent resistance sensor circuit using a bipolar junction transistor for a mobile robotics system that a company is developing for their children's toy range.

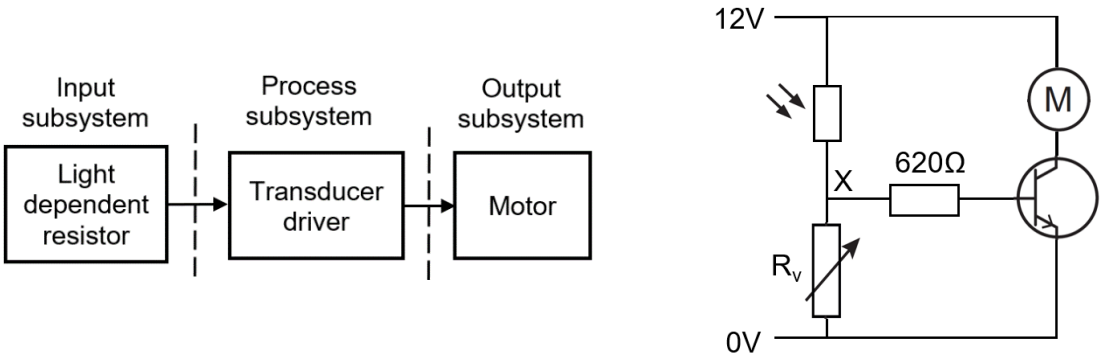

Fig. 14.1

(i) The DC motor used in Fig. 14.1 has a current rating of 140 mA and the transistor has a DC current gain (β) of 35.
Calculate the minimum base current required to run the motor at its rated value.

……. [2]

(ii) Using your answer from **part 14(a)(i)**, calculate the voltage drop across the 620 Ω resistor.

……. [2]

(iii) Calculate the voltage required at point X to saturate the transistor.
Take V_{BE} to be 0.7 V.

……. [1]

(iv) Calculate the power dissipated in the motor.

……. [1]

(v) Give a reason why resistor R_v needs to be adjustable.

……. [1]

(b) A BJT is also able to amplify signals. Fig. 14.2 shows a circuit diagram of a common-emitter transistor amplifier circuit.

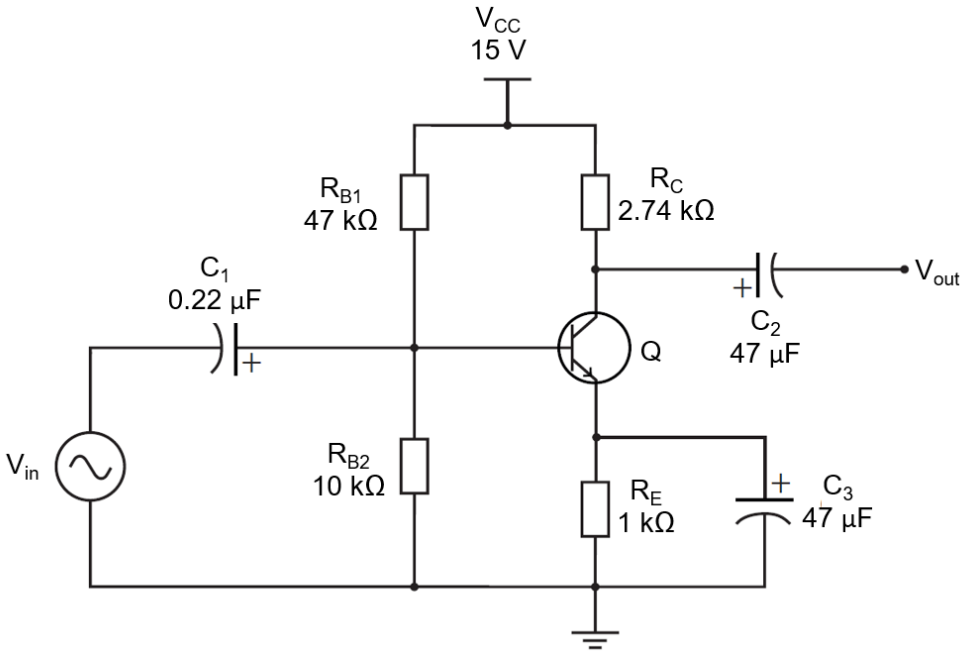

Fig. 14.2

Assume the base-emitter voltage, V_{BE} = 0.7 V.

Calculate

(i) V_B,

…… [1]

(ii) V_E,

…… [2]

(iii) I_E,

…… [1]

(iv) $V_{C.}$

…… [3]

(v) Explain the purpose of placing capacitor C_3 parallel to resistor R_E.

……

…… [1]

END OF PAPER