SCHOOL OF SCIENCE AND TECHNOLOGY, SINGAPORE

SECONDARY 3
END-OF-YEAR EXAMINATION

ELECTRONICS

6063/01

25 September 2017 (Monday) **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 number of marks for this paper is **100**.

FOR EXAMINER'S USE	
Section A	**/ 40**
Section B	**/ 60**
TOTAL	**/ 100**

This document consists of **22** 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 1	Silver ± 10%
Brown 1	Brown 1	Brown 10	Gold ± 5%
Red 2	Red 2	Red 100	Red ± 2%
Orange 3	Orange 3	Orange 1k	Brown ± 1%
Yellow 4	Yellow 4	Yellow 10k	
Green 5	Green 5	Green 100k	
Blue 6	Blue 6	Blue 1M	
violet 7	violet 7	violet 10M	
Grey 8	Grey 8	Silver 0.01	
White 9	White 9	White 0.1	

STANDARD 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.

Bipolar Junction Transistor (BJT)

Current gain $\beta = \frac{\text{collector current}}{\text{Base current}}$

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

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

[Turn over

Section A

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

1 A DC electric motor used in the fan blower has an efficiency of 90%. The motor is running on 230 V power supply and delivers 400 W output.

(a) Calculate the current drawn by the motor. [2]

current=……

(b) Determine the power loss in the motor. [2]

power loss=……

(c) The power loss in the motor is mainly due to the winding resistance. Determine the resistance of the motor winding. [2]

resistance=……

(d) Determine the input electrical energy to the motor after operating for one hour. [2]

energy=……

[Total: 8 marks]

[Turn over

2 A sinusoidal waveform is shown in Fig. 2.1.

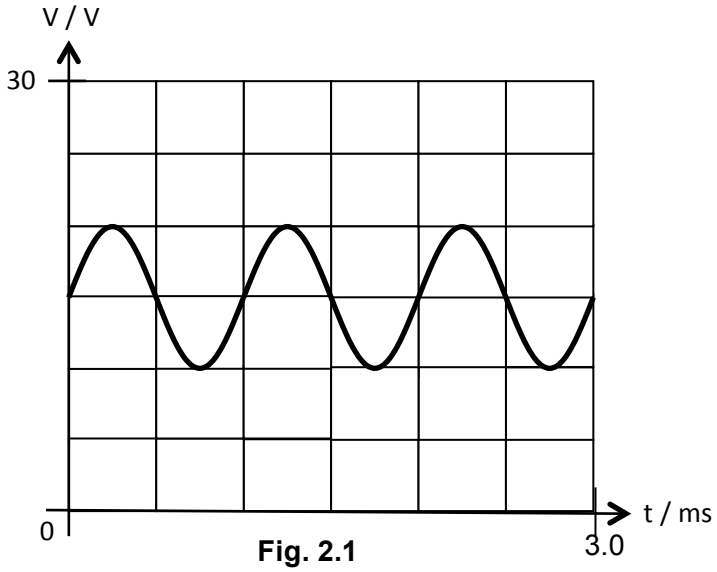

Fig. 2.1

(a) Calculate the frequency of the waveform. [2]

frequency =……

(b) Determine the peak-to-peak voltage Vpp. [1]

Vpp=……..

(c) Determine the dc level. [1]

dc level=……..

[Total: 4 marks]

[Turn over

3 Fig. 3.1, show a physical connection of three capacitors.

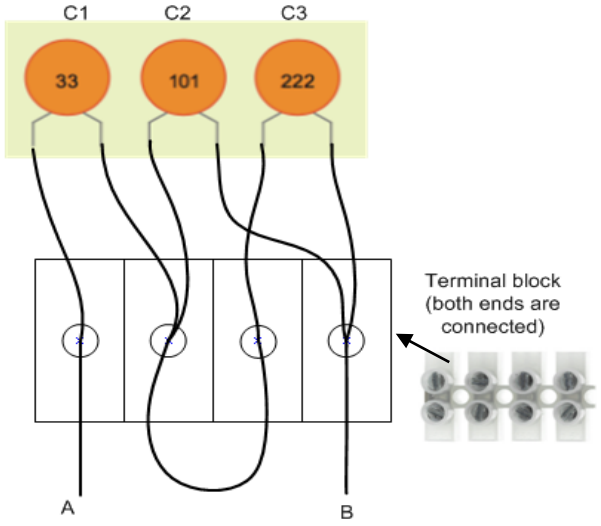

Fig. 3.1

(a) Complete the circuit diagram in Fig. 3.2 to represent this connection. [2]

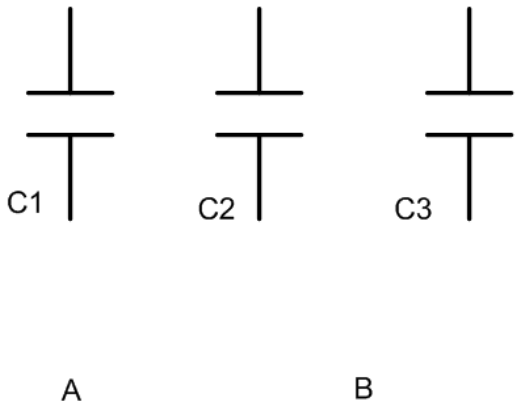

Fig. 3.2

[Turn over

(b) Fig. 3.3 shows three capacitors connected. The capacitors are initially uncharged. Given the effective capacitance (C_T) of the circuit is 10μF.

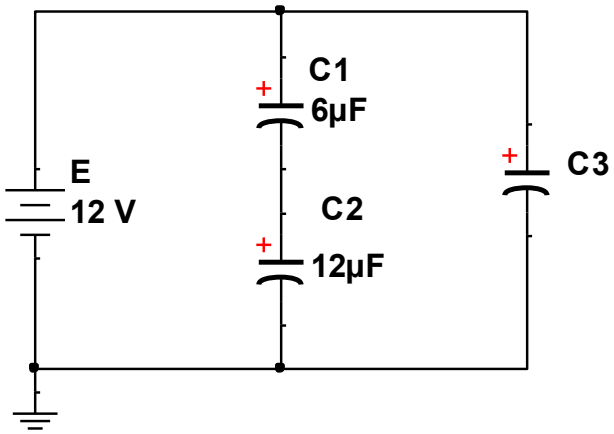

Fig. 3.3

(i) Calculate the effective capacitance of C1 and C2. [2]

effective capacitance of C1 and C2=……

(ii) Calculate the unknown capacitance C3. [2]

capacitance C3=……

(iii) Calculate the voltage across capacitor C2. [2]

voltage across C2=……

[Total: 8 marks]

[Turn over

4 Diodes are commonly used in circuit design.

(a) Describe the basic structure of the PN junction diode. [1]

……

……

……

(b) Explain how the PN junction diode is biased in the forward and reverse direction. [2]

……

……

……

(c) Fig. 4.1 shows a circuit connected using four diodes; D1, D2, D3 and D4.

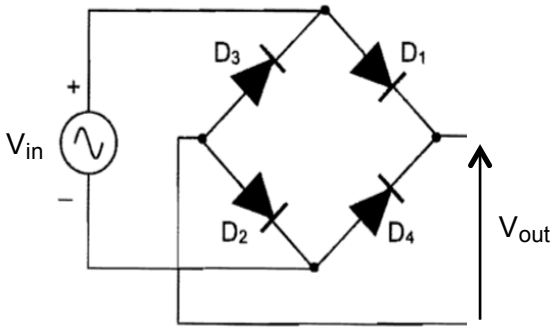

Fig. 4.1

(i) Identify the circuit shown on Fig. 4.1: ……..... [1]

[Turn over

(ii) The waveform of the input voltage V_{in} is shown on Fig. 4.2. On the same figure, draw the waveform of V_{out} using the ideal diode model. [2]

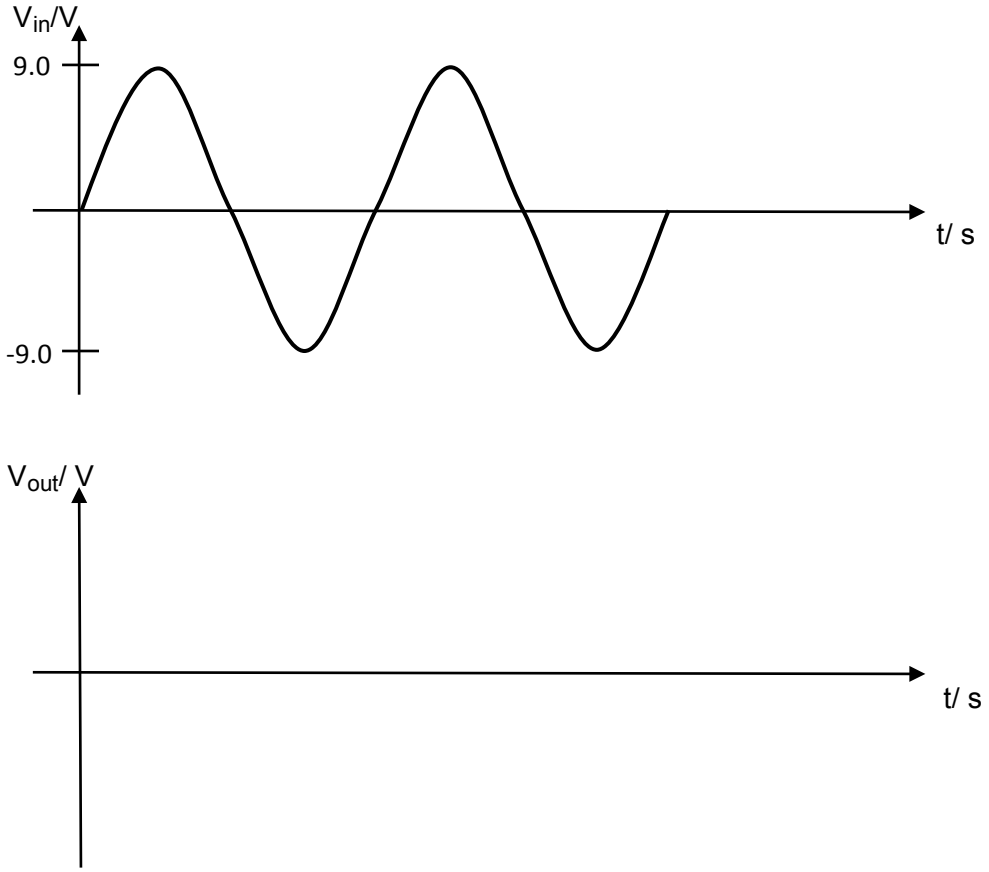

Fig. 4.2

[Total: 6 marks]

[Turn over

5 Fig. 5.1 shows a common emitter amplifier. The transistor has a V_{BE} = 0.7 V and β_{dc} =100. Collector current I_C = 1.30 mA.

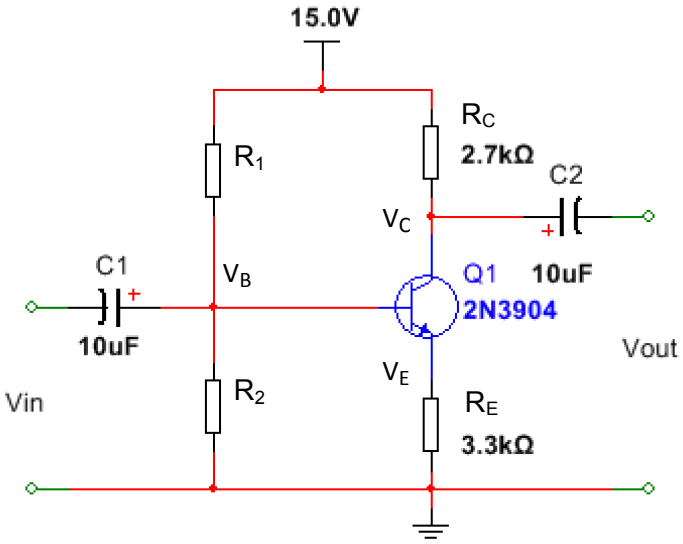

Fig. 5.1

(a) Determine the emitter voltage V_E. [2]

V_E=……

(b) Determine the base voltage V_B. [2]

V_B=……

(c) Determine the voltage gain Av. [2]

Av=……

(d) If all the resistors in the circuit are increased by a factor of 10, state and explain the change, if any, in the voltage gain Av. [2]

……

……

……

[Total: 8 marks]

[Turn over

6 Fig. 6.1 shows a logic circuit.

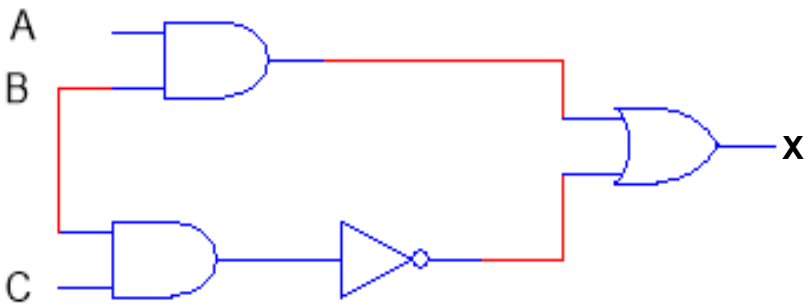

Fig. 6.1

(a) Write down the output Boolean expression for the logic circuit in Fig.6.1. [2]

(b) Implement the logic circuit in Fig. 6.1 using NAND gates only. [4]

[Total: 6 marks]

[Turn over

Section B

Answer **all** questions.

Write your answers in the spaces provided.

7 Fig. 7.1 and Fig. 7.2 show two circuits connected to two light bulbs each. The voltage and power ratings of the light bulbs are as indicated.

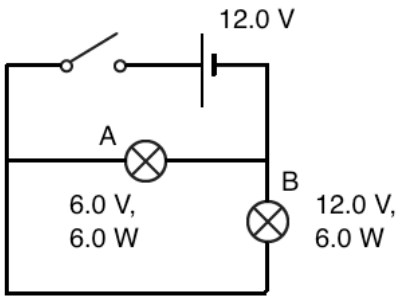

Fig. 7.1

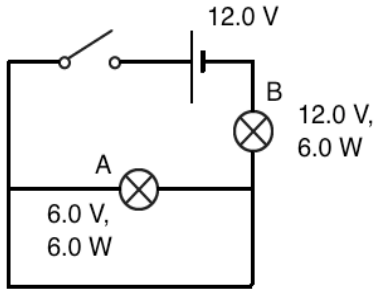

Fig. 7.2

(a) When the switch is closed, state and explain the brightness of light bulb A. [4]

Brightness of bulb A	Fig. 7.1	Fig. 7.2
(Not lit, normal brightness, very bright)		
Reasons		

[Turn over

(b) Fig 7.3 shows a resistive circuit with two voltmeters V1, V2 connected.

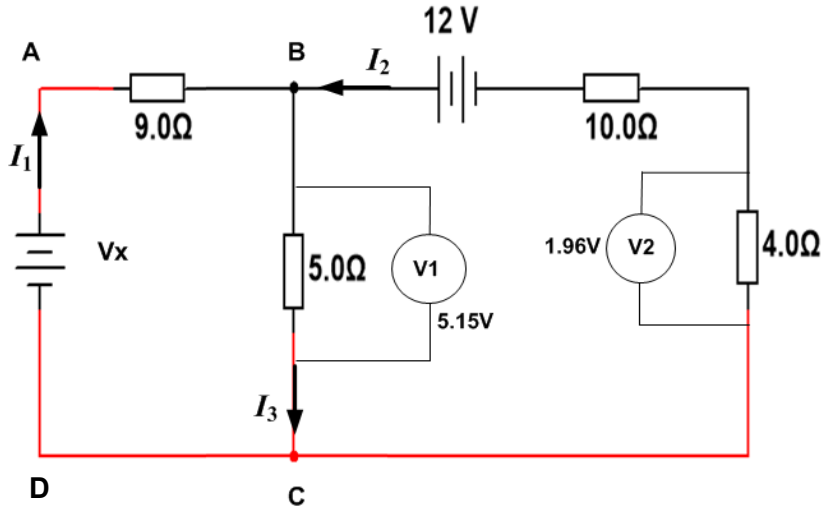

Fig. 7.3

(i) Determine the current I_2 [1]

current I_2=.....

(ii) Determine the current I_3 [1]

current I_3=.....

(iii) Determine the current I_1 [2]

current I_1=.....

(iv) Apply Kirchhoff's Voltage Law KVL to write the branch equation for the loop ABCDA. [1]

KVL Loop ABCDA:.....

[Turn over

(v) Determine the unknown power supply Vx. [2]

Vx=……

(vi) Calculate the power dissipated in the 5.0 Ω resistor. [2]

Power =……

(vii) If a short length of wire is connected across the junction BC; what is the voltmeter V2 reading. [2]

Reading voltmeter V2=……

[Total: 15 marks]

[Turn over

8 Fig. 8.1 shows three circuits found in a dc power supply. In circuit A, V_{in} is connected to a rectifier D1. V_{in} is an ac signal with a peak voltage of 9.0 V.

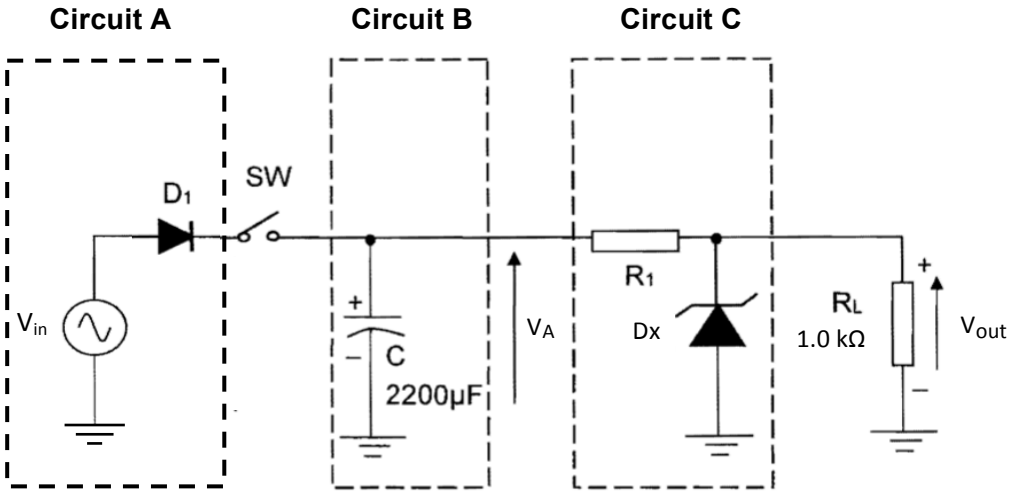

Fig. 8.1

(a) When the switch SW is closed, circuit A is connected to the capacitor C in circuit B. Fig. 8.2 shows the charging cycle of the capacitor C. Assuming the capacitor is initially uncharged.

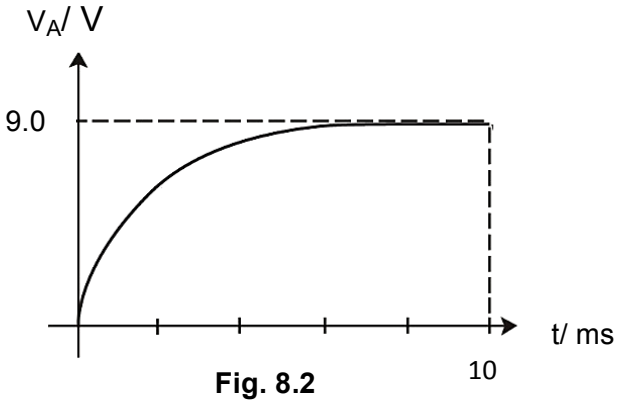

Fig. 8.2

(i) State the function of capacitor C used in circuit B. [1]

……

……

(ii) From Fig. 8.2, estimate the time taken for the capacitor to be fully charged. [1]

time taken=……

(iii) Estimate one time constant. [1]

time constant =……

[Turn over

(iv) Determine the voltage across the capacitor after one time constant. [1]

voltage =……..

(b) Fig. 8.3 shows a circuit C connected to load R_L. The Zener diode Dx has a reverse breakdown voltage of 5.1 V and a power rating of 1.3 W.

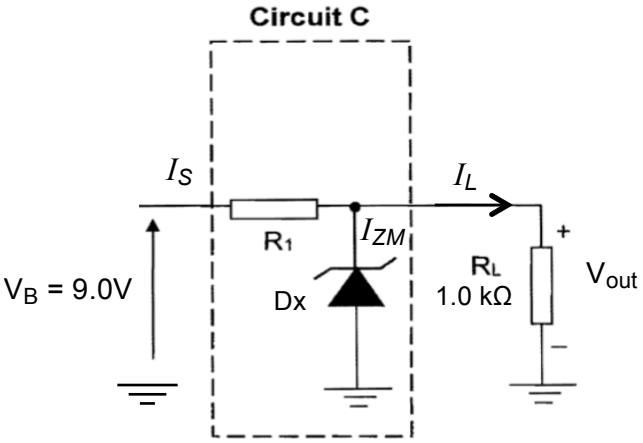

Fig. 8.3

(i) State the function of the zener diode Dx in circuit C. [1]

……..……..…

……..……..…

(ii) In the datasheet, the maximum safe current I_{ZM} refers to the amount of current the zener diode is able to handle without exceeding its power rating. Calculate the maximum safe zener current I_{ZM}. [2]

I_{ZM}=……..

(iii) Determine the load current I_L. [2]

I_L=……..

[Turn over

(iv) Determine the resistance R_1. [3]

R_1=.....

(v) Sketch and label the I-V characteristic curve of the zener diode. [2]

(c) The student connected two diodes Dy and Dz in series to produce a variety of different voltages at the output as shown in Fig. 8.4.

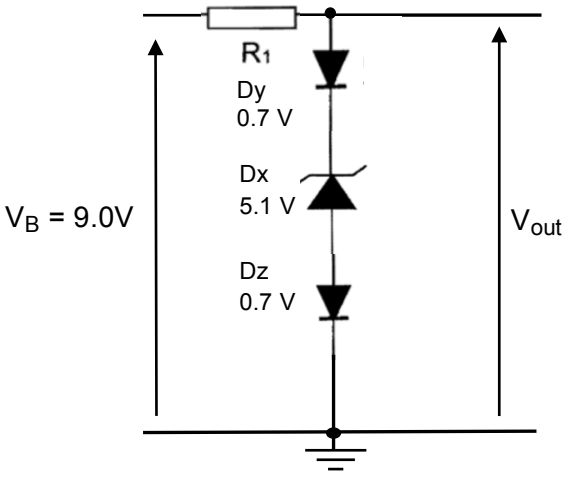

Fig. 8.4

Determine the voltage reference V_{out}. [1]

V_{out} =.....

[Total: 15 marks]

[Turn over

9 A student designs a new automated lighting system that turns on the light automatically along the corridor when light level is too low. She decided to use light dependent resistor to detect the light intensity of the surrounding and transistors to turn on the lights along the corridor.

(a) The student tested the light dependent resistor separately from the rest of the circuit and collected results in Table 9.1. She connected the light dependent resistor in a circuit shown in Fig. 9.1.

Brightness level along the corridor	R_{LDR} / Ω
High	1.0 k
Low	16 k

Table 9.1

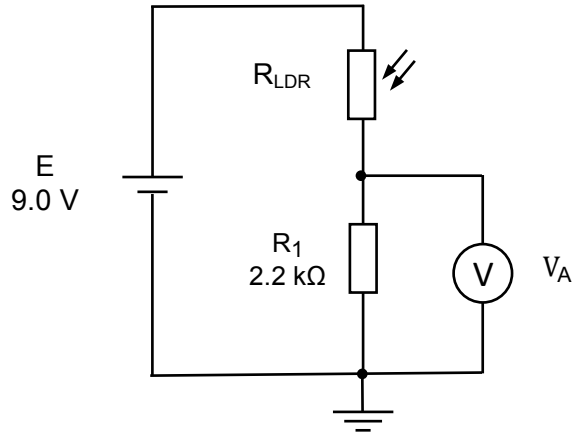

Fig. 9.1

Determine the change in voltage V_A as the brightness level along the corridor decreases from high to low. [3]

V_A changes from…… to ……

[Turn over

(b) Next, the student tested the process and output of the system. She connected a transistor into a switching circuit as shown in Fig. 9.2. In this configuration, the transistor turns on the LED when the input voltage Vin is 5.0 V.

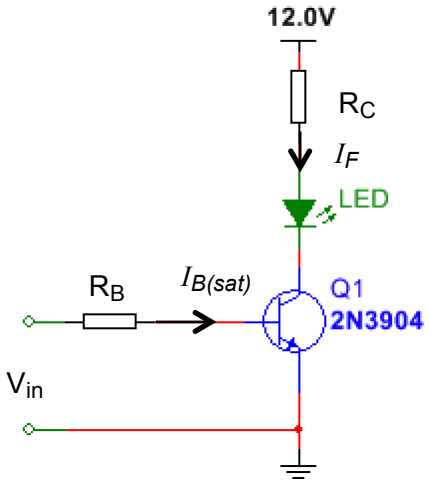

Fig. 9.2

Specifications of components

Transistor/ 2N3904	LED	Resistor R_C
$V_{CE(sat)}$ = 0.2 V	V_F = 2.0 V	2.2 kΩ
V_{BE} = 0.7 V	I_F = 4.5 mA	
β_{dc} = 80		

Table 9.2

(i) Determine the base current $I_{B(sat)}$ is needed to turn on the LED. [2]

$I_{B(sat)}$=……

(ii) Determine the resistance R_B. [2]

R_B =……

(iii) Suggest a suitable value from the E24 series resistor for R_B such that the transistor is still operating in saturation. [1]

……

[Turn over

(iv) The student then set up a train of square wave at input voltage V_{in} to test the circuit as shown in Fig. 9.3.

Not drawn to scale

Fig. 9.3

Describe what will happen to the LED when a train of square wave with a frequency of 5.0 Hz is connected to the input voltage V_{in} of the circuit in Fig. 9.2. [2]

.....

.....

.....

(c) Through her tests, the student realises the light intensity provided by LED in Fig. 9.2 is insufficient to light up the corridor. Fig. 9. 4 shows part of her modified design, using a Darlington pair to drive component X and a 24 V high power lamp.

Transistor specification: BC 547

β_{dc} = 100 for each transistor

$V_{CE(sat)}$ for the Darlington pair = 0.9 V

(i) Complete the circuit in Fig 9.4 to show the connection of the Darlington pair. [2]

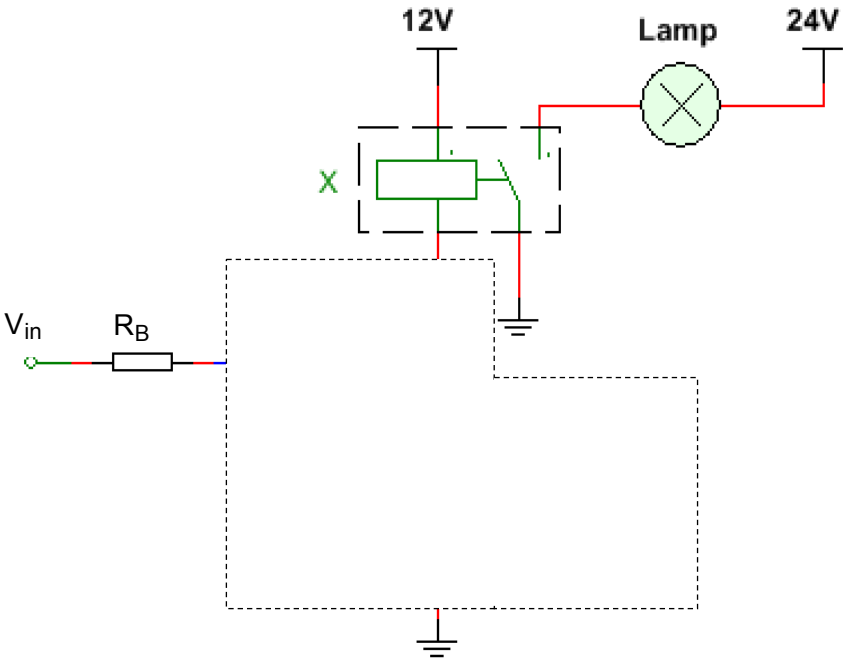

Fig. 9.4

[Turn over

(ii) Name the component X in Fig. 9.4. [1]

……..…….……..……..……

(iii) Determine the dc current gain of the Darlington pair. [2]

dc current gain: ……..……..

[Total: 15 marks]

[Turn over

10 **(a)** Using a calculator, perform the conversion and complete the table below. [2]

Decimal	Binary	BCD
	10010011	

(b) Give one advantage of digital signals that makes it suitable for long distance data transmission. [1]

……

……

(c) A home alarm system consists of two infrared sensors installed at the front door (S1) and windows (S2). The circuitry for each sensor produces a HIGH voltage (logic '1') when the sensor detects infrared light.

The alarm (A) requires a HIGH voltage (logic '1') input to activate when either sensors S1 or S2 are not receiving any infrared light. The house owner (H) can de-activate the alarm with a key inserted (logic '1').

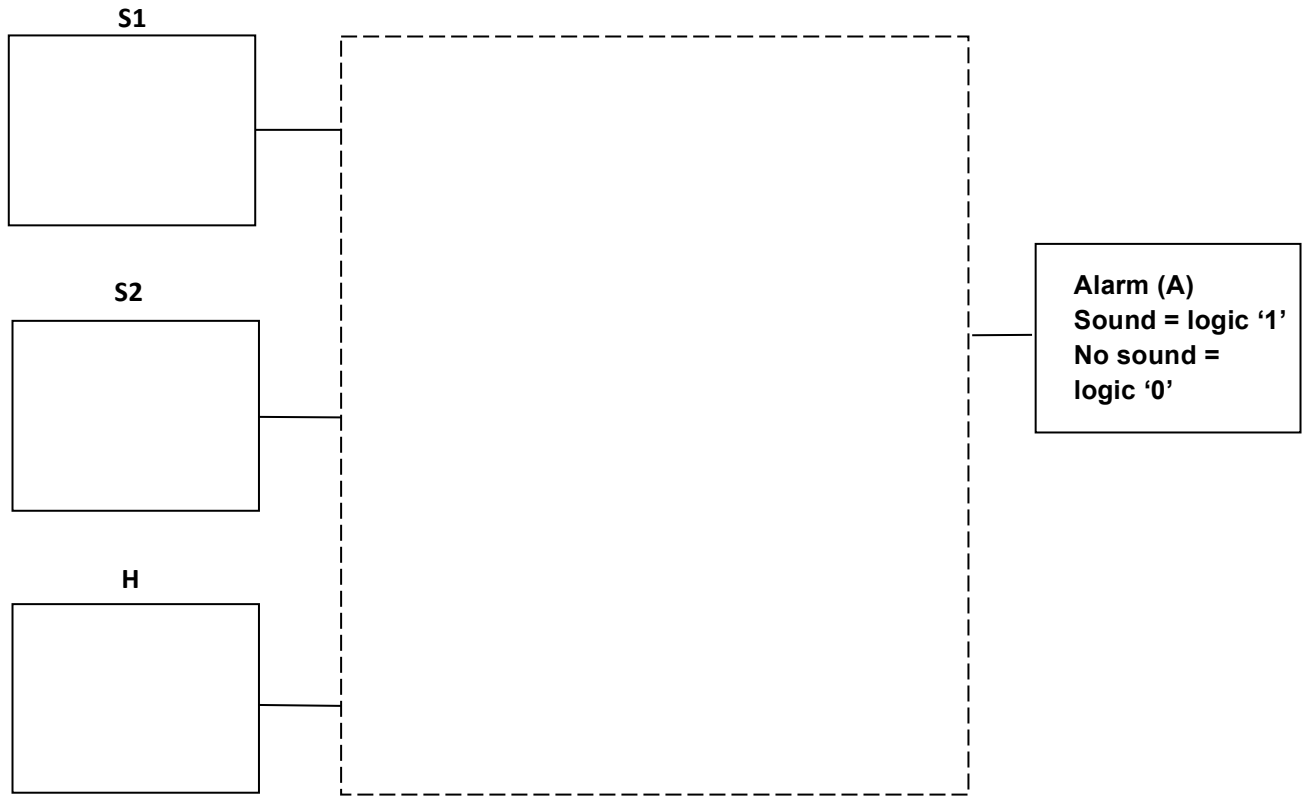

Fig. 10.1

(i) Fill in the conditions for the blocks S1, S2 and H in Fig 10.1 [3]

(ii) Using suitable **NOT** and **AND** gates with two-inputs, draw the connection in the dotted box as shown in Fig. 10.1 to implement this system. [3]

[Turn over

(iii) Complete the truth table below. [3]

H	S1	S2	A
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

(iv) Write down the SOP Boolean output (A) expression. [3]

[Total: 15 marks]

END OF PAPER

[Turn over