Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

C490UA0-1

S24-C490UA0-1

FRIDAY, 10 MAY 2024 – AFTERNOON

ELECTRONICS – Component 1

Discovering Electronics

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**6**	
2.	**10**	
3.	**16**	
4.	**12**	
5.	**12**	
6.	**5**	
7.	**13**	
8.	**6**	
Total	**80**	

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ADDITIONAL MATERIALS

A calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

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

The assessment of the quality of extended response (QER) will take place in question **8**.

INFORMATION SHEET

This information may be of use in answering the questions.

Resistor Colour Codes

Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet	7
Orange	3	Grey	8
Yellow	4	White	9

The fourth band colour gives the tolerance as follows:

GOLD ± 5%

SILVER ± 10%

Resistors E24 series values

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

Useful equations

$$P = \frac{V^2}{R}$$

$$G = 1 + \frac{R_F}{R_1}$$

$$V_{OUT} = \frac{R_2}{R_1 + R_2} V_{IN}$$

$$G = -\frac{R_F}{R_{IN}}$$

$$I_D = g_M(V_{GS} - 3)$$

$$V_{OUT} = -R_F\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \cdots\right)$$

$$I_C = h_{FE} I_B$$

$$T = 1.1RC$$

$$\overline{A + B} = \overline{A}.\overline{B}$$

$$f = \frac{1}{T}$$

$$\overline{A.B} = \overline{A} + \overline{B}$$

$$f = \frac{1.44}{(R_1 + 2R_2)C}$$

$$G = \frac{V_{OUT}}{V_{IN}}$$

$$\frac{T_{ON}}{T_{OFF}} = \frac{R_1 + R_2}{R_2}$$

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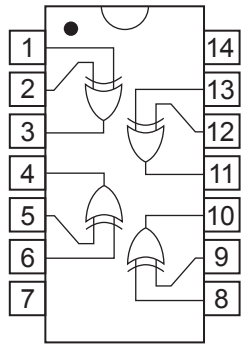
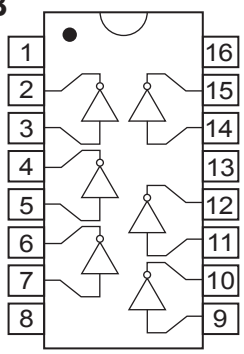
Answer **all** questions.

1. The diagram shows the pinout diagrams for some ICs (integrated circuits).

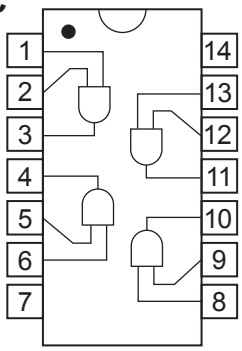
A



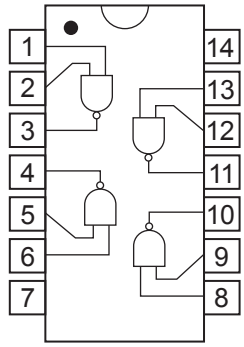
B



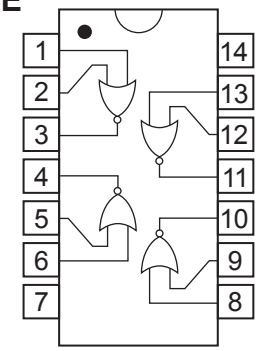
C



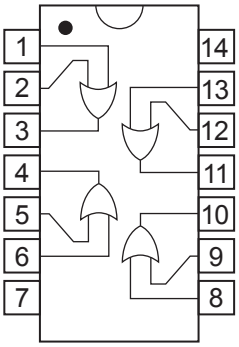
D



E



F



(a) Which IC (**A** to **F**) contains the following logic gates?

(i) NOT gates .....

(ii) NOR gates ..... [2]

(b) (i) Which IC (**A** to **F**) contains logic gates with the following truth table? [1]

B	A	Q
0	0	0
0	1	1
1	0	1
1	1	1

Answer: .....

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(ii) Which IC (**A** to **F**) contains logic gates with the following truth table? [1]

B	A	Q
0	0	0
0	1	0
1	0	0
1	1	1

Answer: .....

(c) Complete the following truth tables for:

(i) a logic gate in **D**; [1]

B	A	Q
0	0	
0	1	
1	0	
1	1	

(ii) a logic gate in **E**. [1]

B	A	Q
0	0	
0	1	
1	0	
1	1	

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2. (a) A number of electronic sub-systems are listed below.

AND gate	**Transducer driver**	**Lamp unit**
Moisture sensing unit	**Latch unit**	**Motor unit**
Light sensing unit	**Pressure sensing unit**	**NOR gate**

Write each sub-system into the correct column in the table below. [3]

Input sub-systems	Processing sub-systems	Output sub-systems

(b) A tropical fish tank needs controlled conditions to keep plants and fish healthy.

SPECIFICATION

- The water is maintained at a constant temperature by a high-power heater.
- It must be possible to switch off the heater so that maintenance can be carried out.
- To stimulate plant growth, the LED lights in the tank cover switch on during daylight hours but must turn off at night.
- During daylight hours only, a low-power motor drives a pump which circulates water through a filter to keep the water clear.

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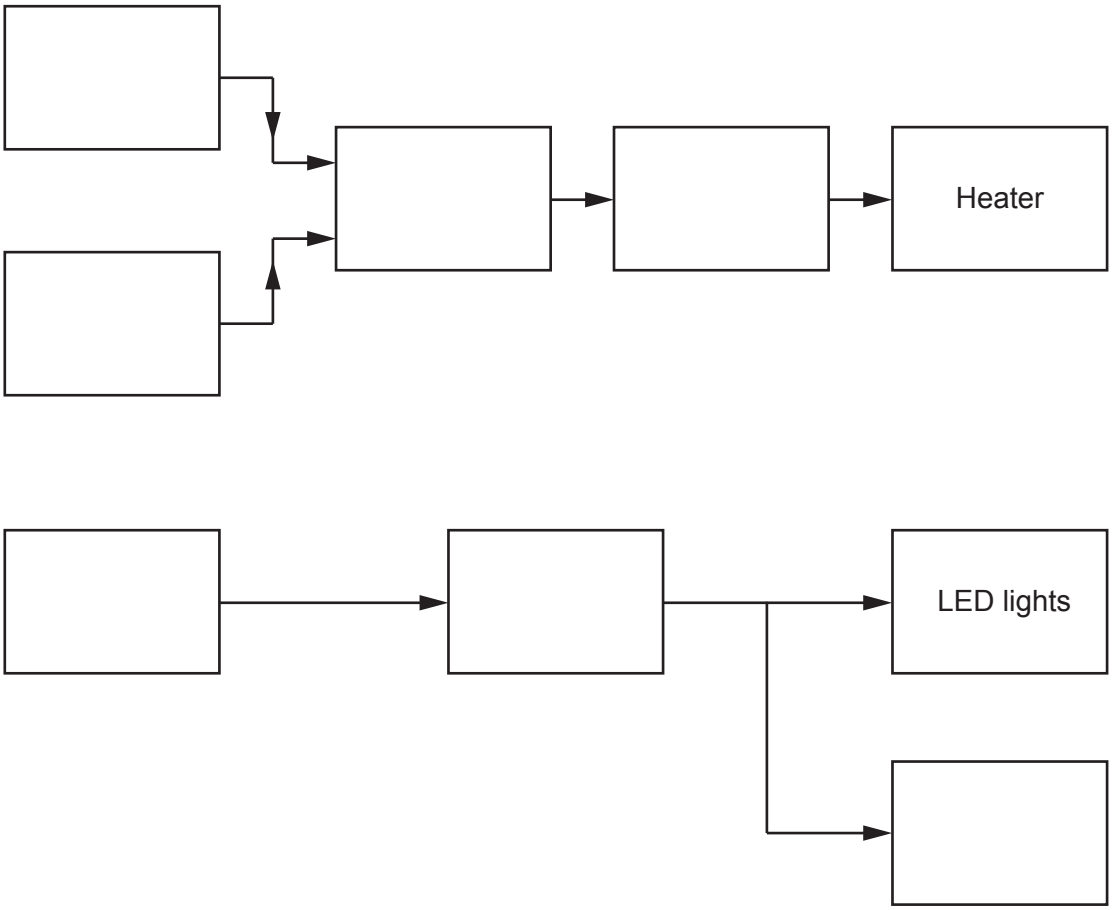
The following sub-systems are available.

OR gate	**Temperature sensing unit**	**Light sensing unit**	**Motor unit**
Input voltage unit	**Latch unit**	**Pulse generator**	**Switch unit**
MOSFET	**Transistor switch unit**	**AND gate**	**NOT gate**

The sensing units behave as follows:

- The input voltage unit can be set to produce a voltage anywhere between zero and the maximum voltage.
- The light sensing unit outputs a low voltage in the dark.
- The temperature sensing unit provides a decreasing output voltage as the temperature rises.

Select the correct sub-systems to complete the block diagrams. [7]



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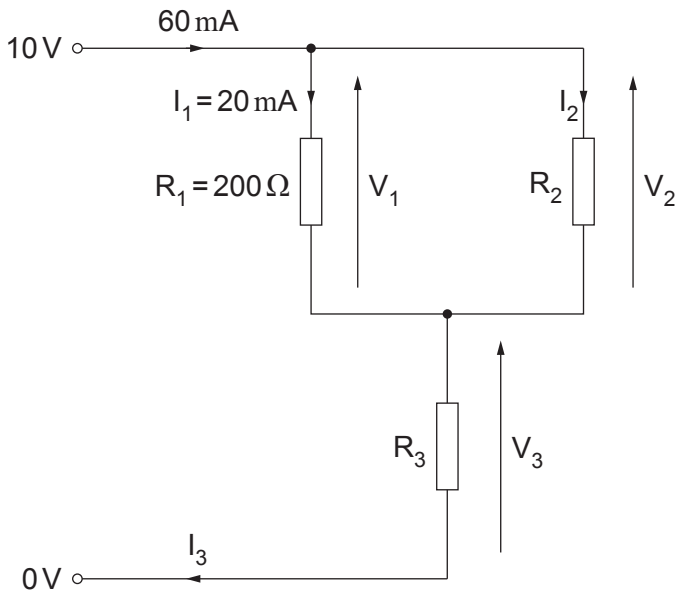
3. The diagram shows part of a circuit.



(a) (i) What is the colour code on resistor R_1? The tolerance band colour has been completed. [3]

....Silver.....

(ii) Calculate the power dissipated in resistor R_1. [3]

.....

.....

.....

.....

(b) (i) Determine the values of the following: [2]

I_2 = ...

I_3 = ...

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(ii) Calculate the value of V_1. [3]

.....

.....

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(iii) Determine the values of the following: [2]

V_2 = ...

V_3 = ...

(iv) Calculate the value of R_2. [3]

.....

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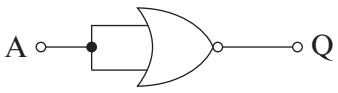
4. (a) Look at the suggested truth table for a NOR gate connected as shown.



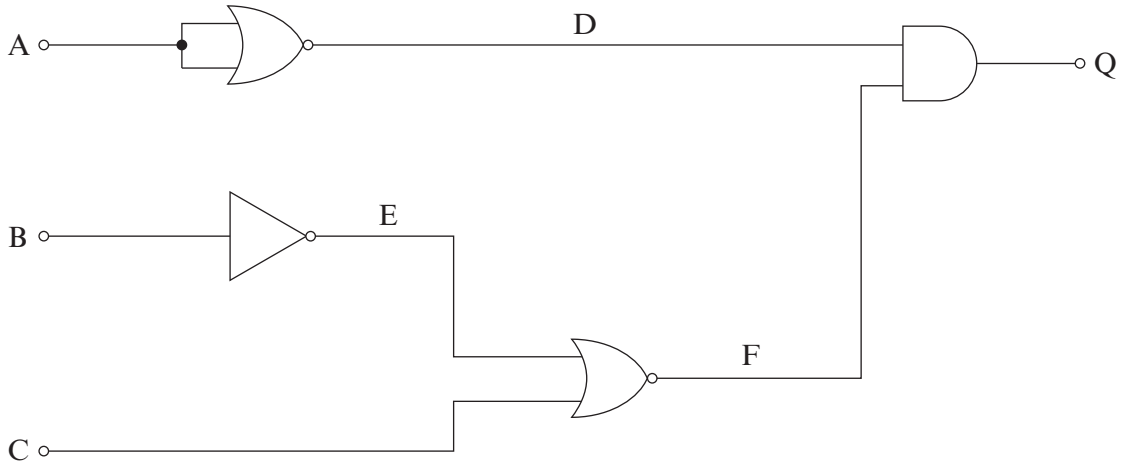
Inputs		Output
A	A	Q
0	0	1
0	1	0
1	0	0
1	1	0

(i) **Draw lines** through the two rows of the truth table that cannot occur. [1]

(ii) What single logic gate does this NOR gate system behave as? [1]

.....

(b) A logic system is shown below:



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Complete the following truth table for the logic system. [4]

C	B	A	D	E	F	Q
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

(c) (i) **Redraw** this logic circuit using NAND gates only. [4]

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(ii) **Cross out** all redundant NAND gates. [1]

(iii) State an advantage of converting a logic system to NAND gates only. [1]

.....

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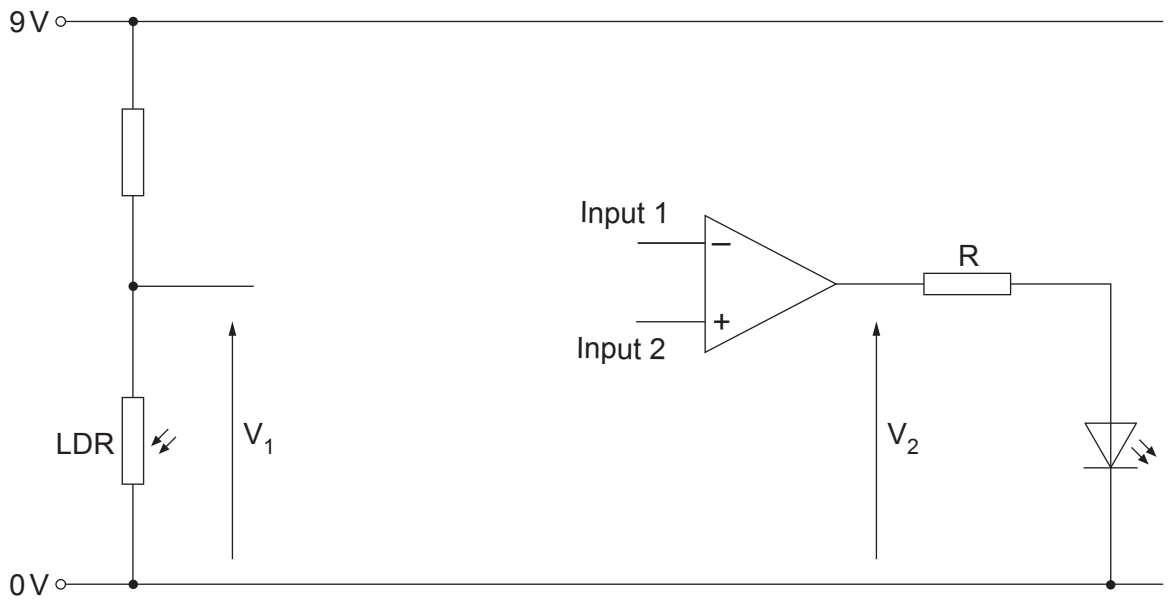
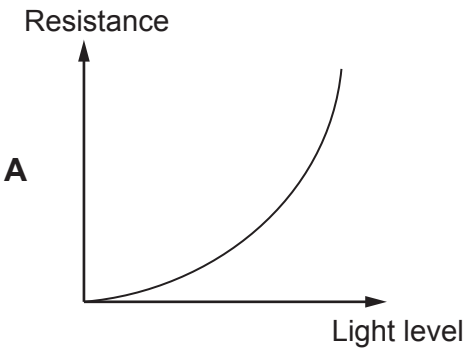
5. A cricket umpire uses a light meter which shows when the light level is too low for play to continue safely. An incomplete circuit diagram for this is shown below.



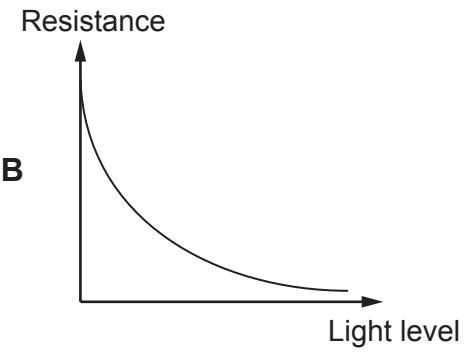
(a) Which of the following graphs **A**, **B**, **C** or **D** best shows the way in which the resistance of the LDR changes as the light level increases? [1]

.....

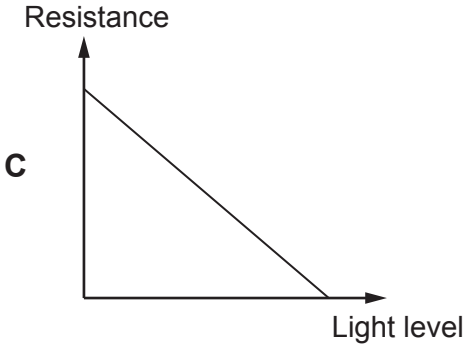
A



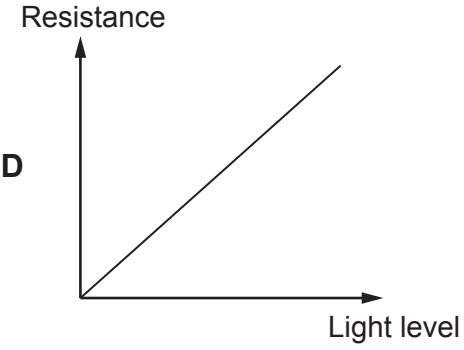
B



C



D



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(b) What happens to the voltage V_1 as the resistance of the LDR increases? [1]

.....

(c) The output V_2 of the comparator saturates at 8.4 V and 0 V.

Complete the table to show:

- The output V_2 for the given values of the input voltages.
- If the LED is **on** or **off**. [2]

Input 1 (V)	Input 2 (V)	Output V_2 (V)	LED
5.1	7.3		
7.5	7.1		

(d) **Complete the circuit diagram** by adding:

- a voltage divider to provide a variable reference voltage for the comparator;
- any other connections so that the LED lights when the light level is too low for play. [4]

(e) When the LED is on, the current through it is 12.5 mA and the forward voltage drop across it is 2.2 V.

(i) What is the voltage drop across resistor R when V_2 = 8.4 V? [1]

.....

(ii) What is the current flowing through resistor R when V_2 = 8.4 V? [1]

.....

(iii) Calculate the ideal resistance for resistor R. [2]

.....

.....

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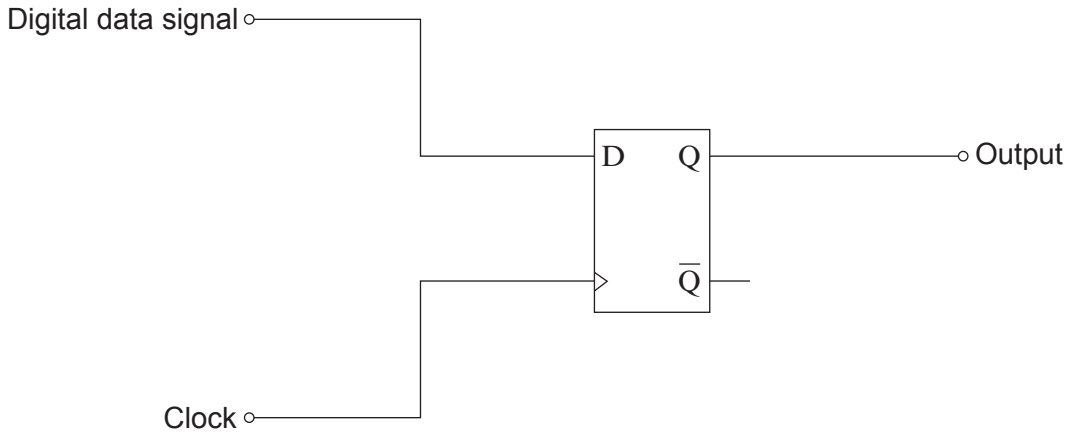
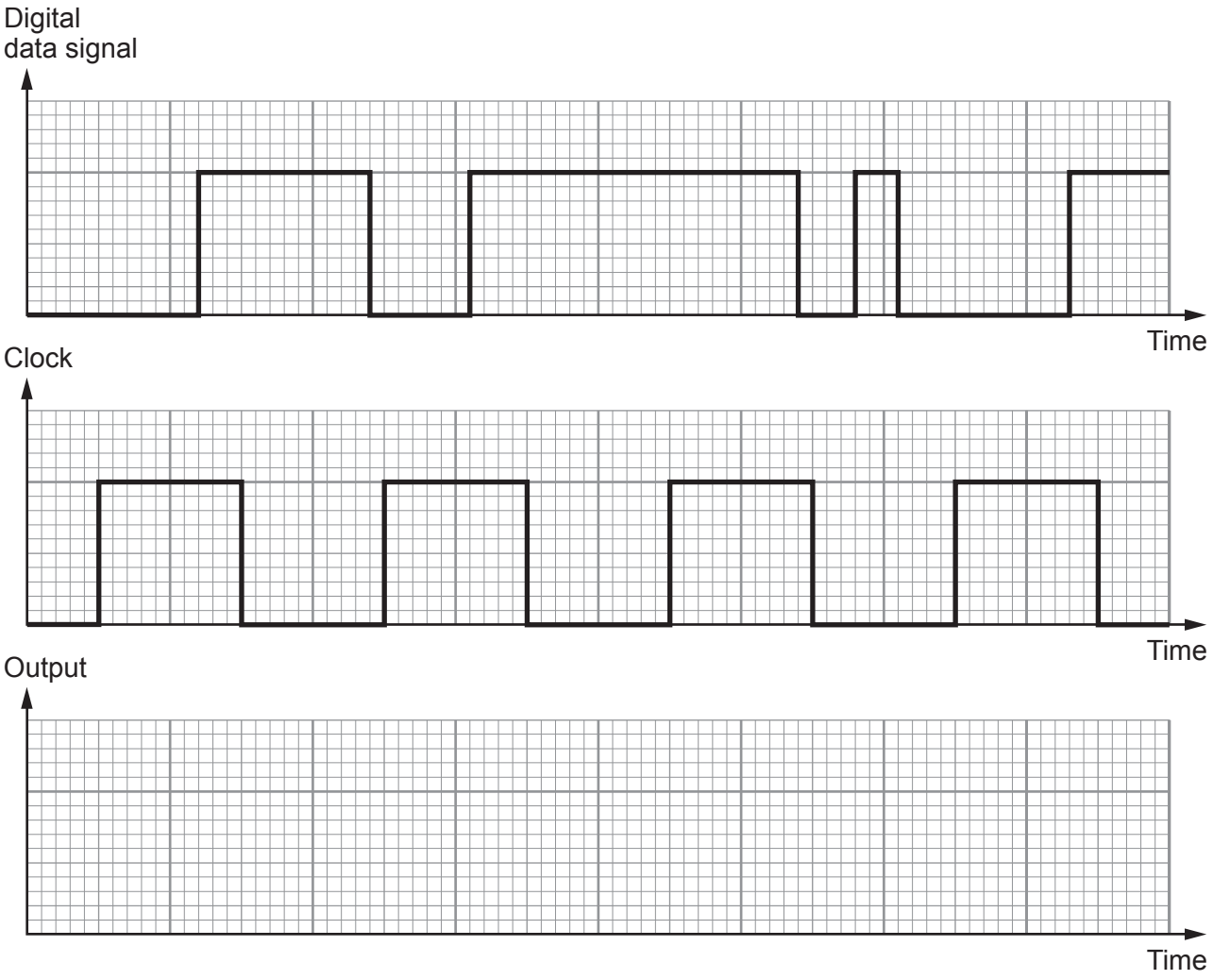
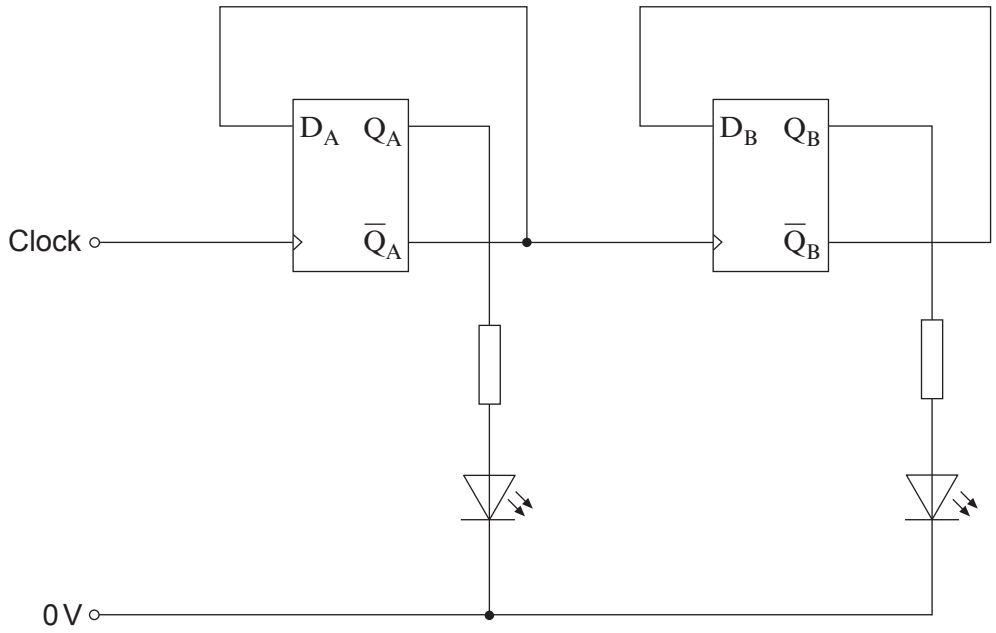
6. The following diagram shows a D-type flip-flop being used for data transfer. The D-type is rising-edge triggered.



(a) The digital data and clock signals are shown below. **Complete the output graph**. The output is initially low. [2]



(b) The diagram shows two D-type flip-flops connected as a 2-bit counter.



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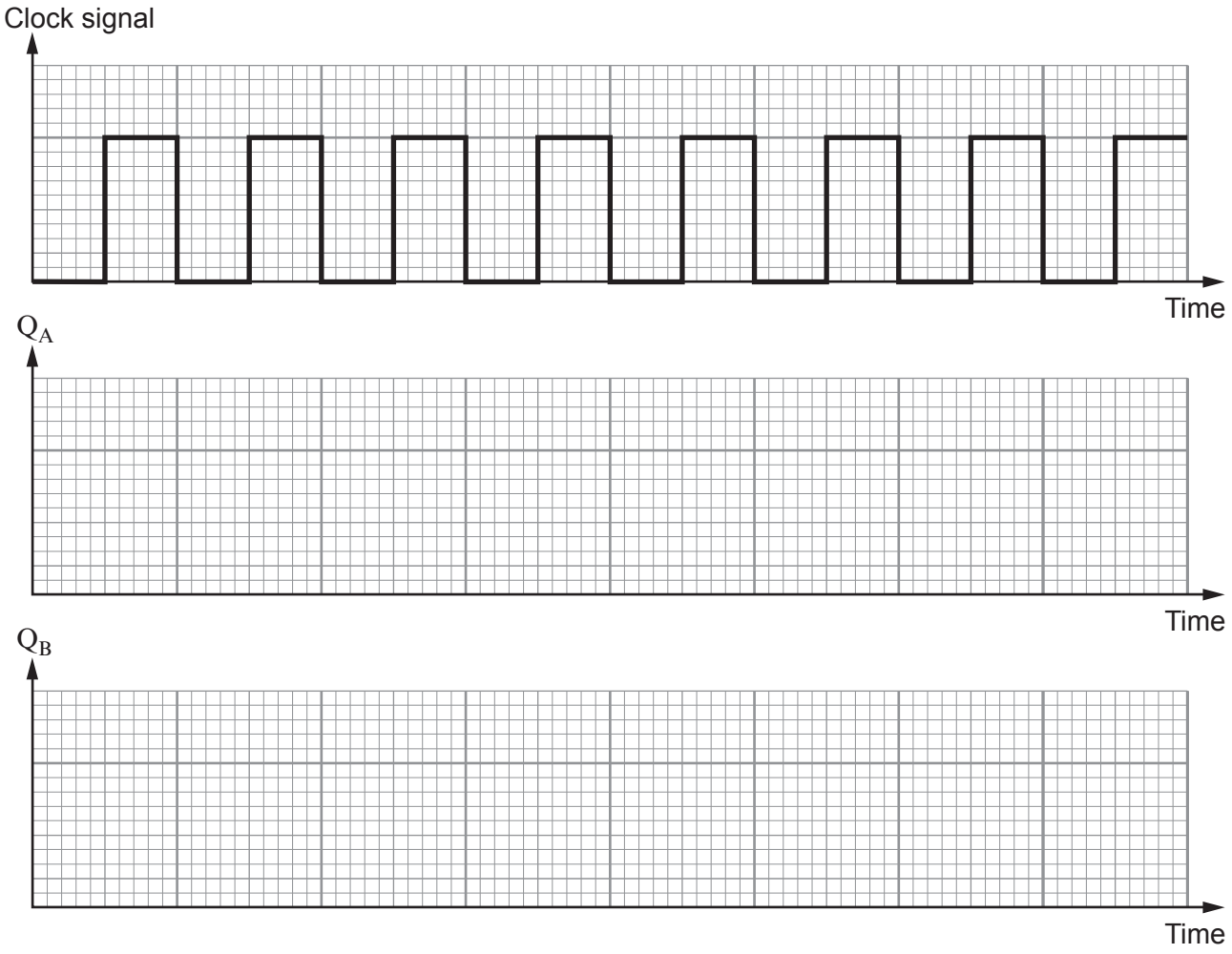
Complete the graphs below for Q_A and Q_B. Both outputs are initially at logic 0. [3]



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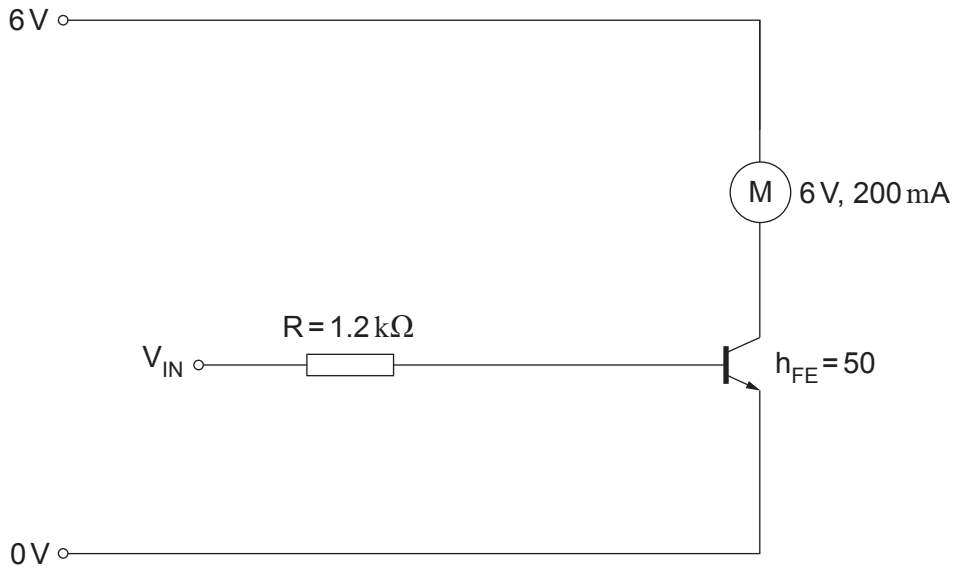
7. A transistor switching circuit that drives a small motor is shown below.



The transistor is just saturated.

(a) Calculate the base current flowing through the 1.2 kΩ resistor. [4]

(b) Calculate the voltage across the 1.2 kΩ resistor. [2]

(c) Calculate the value of V_{IN}. [2]

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(d) Calculate the power dissipated in the motor. [3]

.....

.....

.....

.....

(e) **Add a component to the circuit diagram** to protect the transistor from damage when the transistor switches off. [2]

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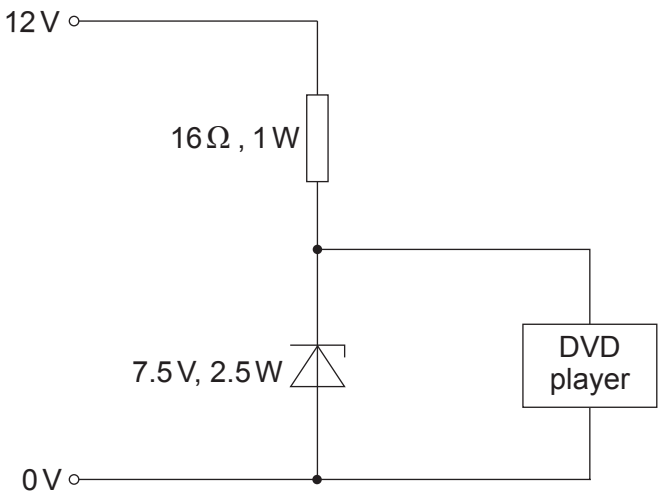
8. A regulated power supply is required to power a portable DVD player from a 12 V power socket in a car. The DVD player requires an operating voltage of 7.5 V and a maximum current of 250 mA.

A proposed circuit design is shown below. The 7.5 V zener diode requires a minimum holding current of 15 mA.



Evaluate the design and its suitability for the task given. Your evaluation should be supported with relevant calculations. Suggest any modifications required. [6 QER]

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