GCSE ELECTRONICS Sample Assessment Materials

3. *(a)* Electronic sub-systems can be classed as either sensing, signal processing or output sub-systems.

For example, a transducer driver is a **signal processing** sub-system.

Here are five other sub-systems:

latch   lamp unit   NAND gate   switch unit   solenoid unit

Complete the table by adding the name of each sub-system in the correct column. [3]   AO 2

Sensing sub-system	Signal processing	Output sub-system
	transducer driver	

(b) Design an electronic system for road works on a motorway. The road works often go on for many miles so hazard warning lamps are placed alongside the road works to warn drivers of the dangers.
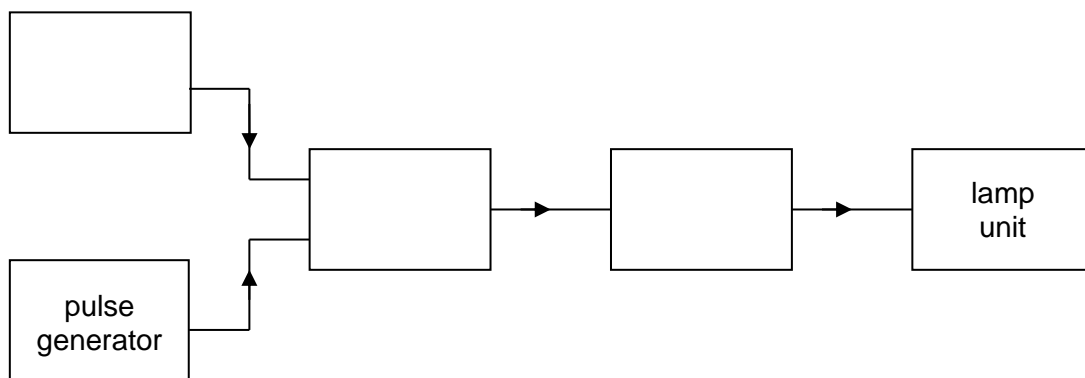
Specification for the system
The lamps:
- need to switch on when it gets dark
- flash on and off continuously
- switch off when it gets light.

The following sub-systems are available.

lamp unit   **OR gate**   **thyristor**   **light sensing unit**   **buzzer unit**

time delay   **temperature sensing unit**   **AND gate**   **MOSFET**

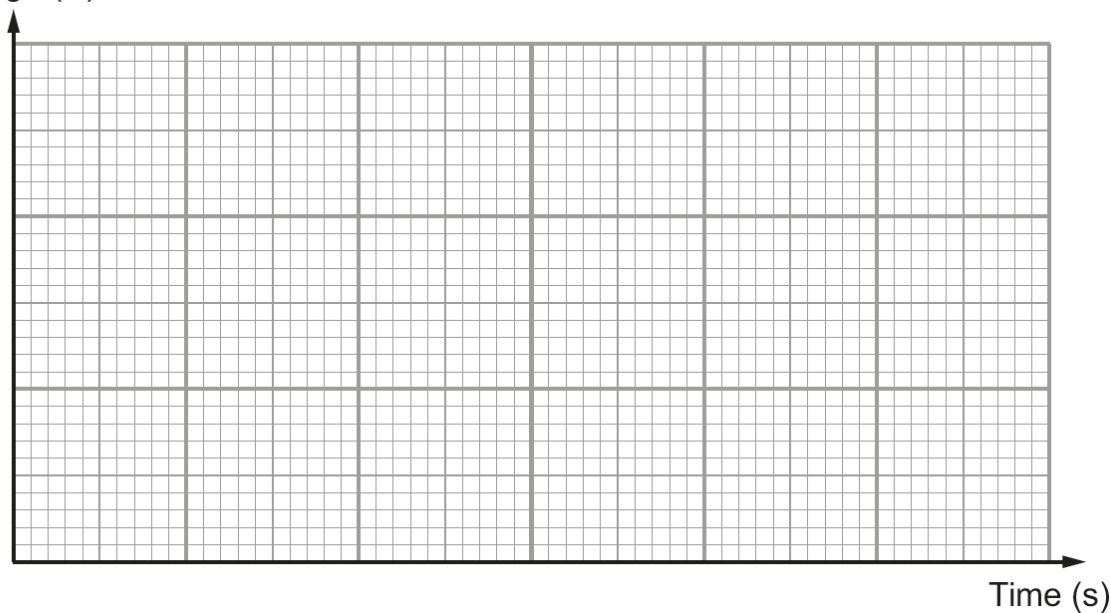Select the correct sub-systems to complete the block diagram design. [3]   AO 3

(c)   The pulse generator is constructed from a 555 IC which has a mark-space
        ratio of 3:1 and a frequency of 2 Hz. On the grid below:

    ▪ draw two cycles of the output of the astable   [3]   AO 1
    ▪ clearly label the mark and space
    ▪ add a suitable scale to the time axis.
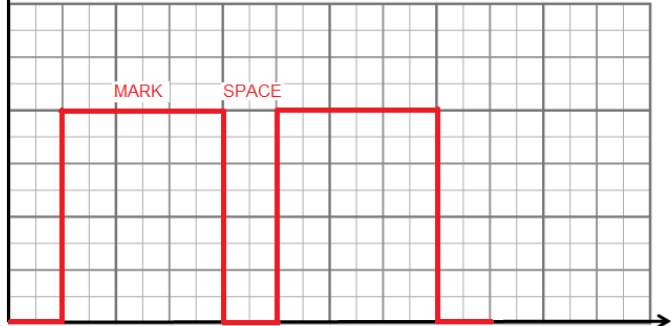
Voltage (V)

Time (s)

9

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
3	*a*		<table><tr><td>**Sensing subsystems**</td><td>**Signal processing**</td><td>**Output subsystems**</td></tr><tr><td>Switch Unit</td><td>Transducer driver</td><td>Lamp Unit</td></tr><tr><td></td><td>Latch</td><td>Solenoid Unit</td></tr><tr><td></td><td>NAND Gate</td><td></td></tr></table> each correct column (1) (no half marks)		3		3	
	b		each correct sub-system (1)			3	3	
	c		Correct Ratio (1) Correct identification of Mark & Space (1) Suitable time axis scale (1)	3			3	3
			Question 3 total	**3**	**3**	**3**	**9**	**3**

3.   A D-type flip-flop can be used as a one-bit counter.

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┌─────────────┐              ┌──────────────┐
│    Pulse    │──           ─│D          Q │─
│  Generator  │              │              │
└─────────────┘             ─│>CK           │
                             │              │
                             │            Q̄ │─
                             └──────────────┘
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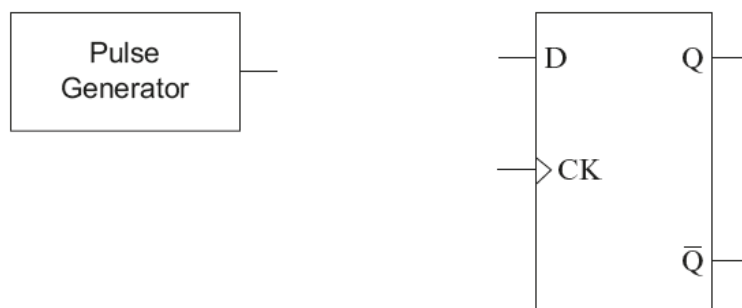
(a)   Complete the diagram of the one-bit counter: [2]   AO 1

   (i)   by adding the connections required on the diagram;

   (ii)   by connecting the pulse generator.

(b)   The D-type flip-flop is rising-edge triggered.

   On the graphs below:

   (i)   Label a rising-edge on the pulse generator output.   [1]   AO 1

   (ii)   The Q output is initially at logic level 1. Complete its signal.   [2]   AO 2

   (iii)   Draw the signal at the $\overline{Q}$ output.   [1]   AO 1
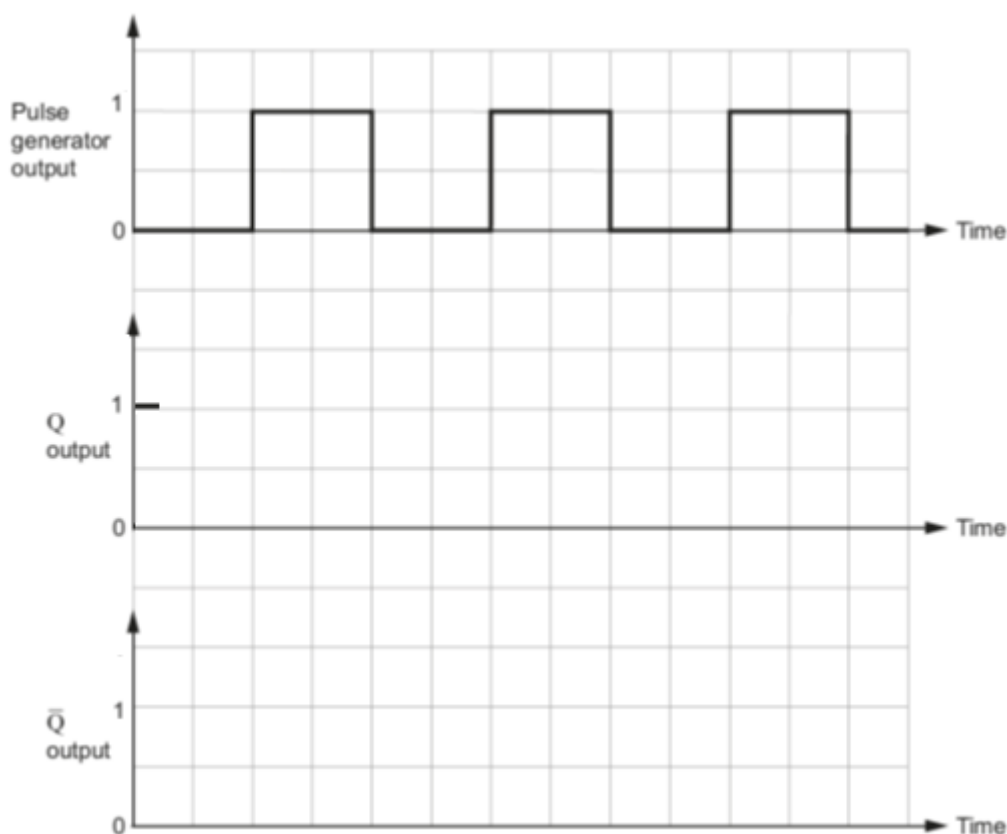
(c) The pulse generator is made from the following 555 circuit sub-system.

9V o ─── R_A 1kΩ ─── R_B 22kΩ ─── 555 (pins 4, 8, 7, 6, 3, 2, 1) ─── Output

C = 10 nF

0V o ───

AO 1
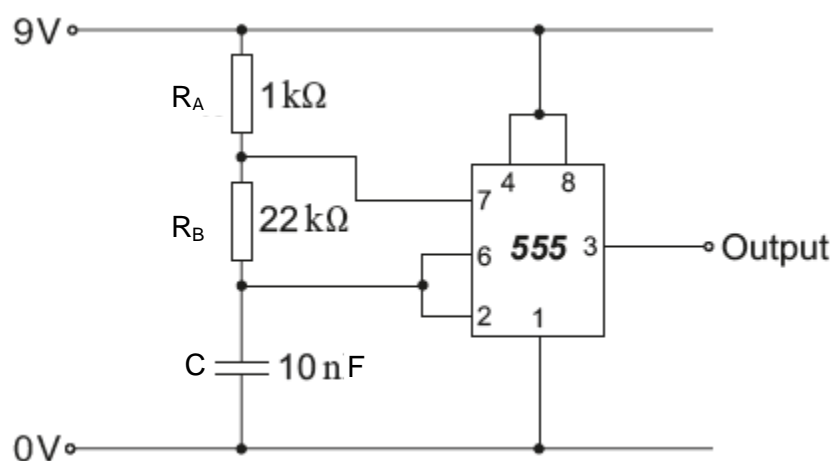
Select and use a formula to calculate the output frequency.   [3]

AO 2

frequency = ...Hz

9

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
3	a							
		i	Connection required from D to $\overline{Q}$ (1)					
		ii	Connection from pulse generator to CK (1)	2			2	
	b	i						
		ii						
		iii						
			Notes: i) Allow a mark for any correct rising edge identified (1)	1				
			ii) Falling edge on first rising edge (1)		1			
			Transitions on remaining two rising edges (1)		1			
			iii) $\overline{Q}$ output as the inverse of Q, allow e.c.f. for incorrect Q (1)	1			4	

Question			Marking details	Marks available				Maths
				AO1	AO2	AO3	Total	
3	c		Selection of $f = \dfrac{1.44}{(R_1 + 2R_2)C}$ (1)	1				
			Substitution of $f = \dfrac{1.44}{(1000+44000) \times 10 \times 10^{-9}}$ (1)		1			
			$f = 3\,200\,\text{Hz}$ (1)		1		3	2
			Question 3 Total	**5**	**4**	**0**	**9**	**2**

8. Here is the circuit diagram for a temperature sensing unit and the characteristic curve for the thermistor.
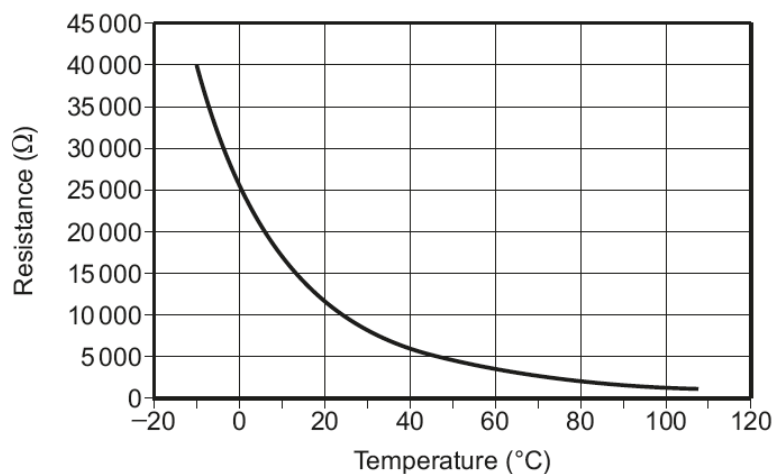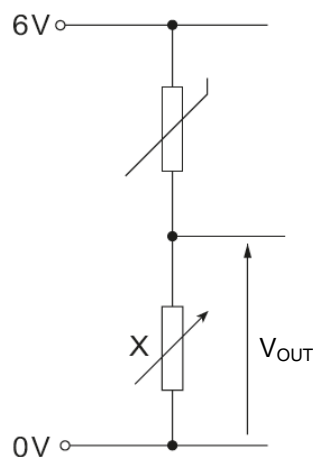
(a) (i) State the resistance of the thermistor at 0 °C. [1] AO 2

....

(ii) The variable resistor is set at a resistance of 5 kΩ. Calculate V_{OUT} at 0 °C. [3] AO 1 AO 2

V_{OUT} = ... V

(b) What happens to V_{OUT} when the temperature increases? [1] AO 2

....

....

(c) At 40 °C, V_{OUT} needs to be 5.4 V. Determine the new resistance of the variable resistor at 40 °C. [4]

AO 1

AO 2

resistance = ... $k\Omega$

(d) The temperature sensor is now connected to a MOSFET. When the temperature is 40 °C a fan is switched on which produces cool air. The fan draws a current of 3 A.

(i) Determine the minimum value of g_M for the MOSFET. [2]

AO 2
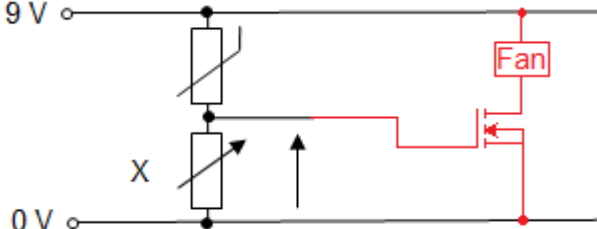
g_m = ... S

(ii) Complete the circuit diagram below to show the final design of the cooling system. [2]

AO 3

13

Question			Marking details	Marks available			Total	Maths
				AO1	AO2	AO3		
8	a	i	$25\,000\,\Omega$ (accept $25\,\text{k}\Omega$) $\pm 500\,\Omega$		1		1	
		ii	Correct equation (1) $\quad V_{OUT} = \dfrac{R_2}{R_1+R_2} \times V_{IN}$	1				
			Substitution / correct multipliers (1) $\ V_{OUT} = \dfrac{5k}{5k+25k} \times 9$	1				
			Answer (1) $\ = 1.5\,\text{V}$ (accept alternative solutions of ratios or using current divider)		1		3	2
	b		the output voltage increases.		1		1	
	c		Correct equation (1) $\ V_{OUT} = \dfrac{R_2}{R_1+R_2} \times V_{IN}$	1				
			Substitution / correct multipliers (1) $\ 5.4 = \dfrac{R_2}{6k+R_2} \times 9$					
			Manipulation (1) $\ 5.4(6k + R_2) = 9R_2$ $\qquad\qquad\qquad 32.4k + 5.4R_2 = 9R_2$ $\qquad\qquad\qquad 32.4k = 9R_2 - 5.4R_2$ $\qquad\qquad\qquad\qquad R_2 = \dfrac{32.4k}{4.6}$		1			
					1			
			Answer (1) $\ = 9\text{k}\Omega$		1		4	3
	d	i	Selection and manipulation $\quad I_D = g_M(V_{GS} - 3)$ $\qquad\qquad\qquad 3 = g_M \times (5.4\text{-}3)$ $\qquad\qquad\qquad g_M = \dfrac{3}{(5.4-3)} \quad (1)$					
			Answer $\ = 1.25\,\text{S}$ $\qquad\qquad\qquad\qquad\qquad (1)$		2		2	2
		ii	Correct components (1) Correct connection of components (1)			2	2	2
			Question 8 total	3	8	2	13	9

10. The following flowchart represents the function of a control system.
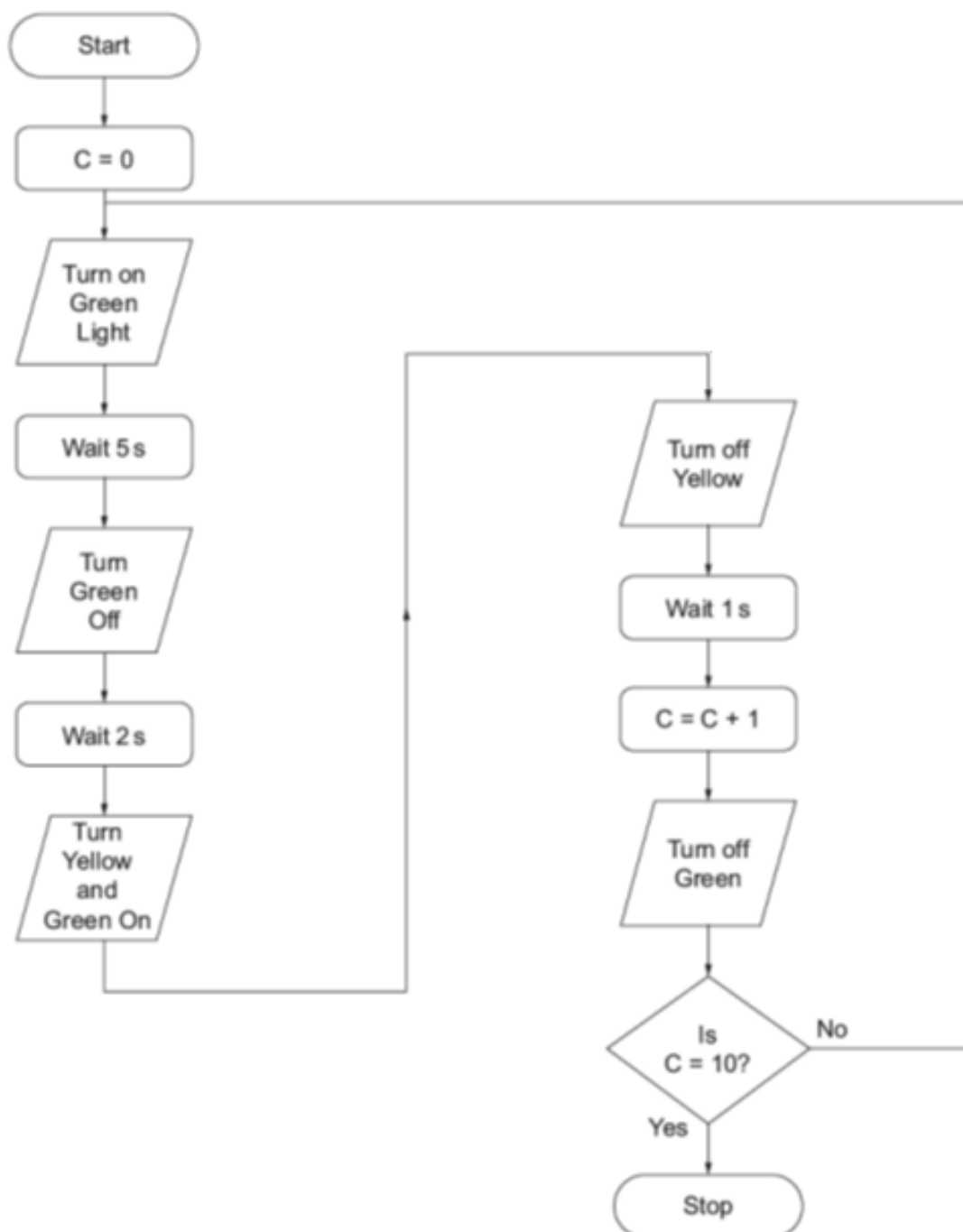
The specification for the system is:

- The light sequence starts when limit switch A is pressed
- The light sequence must operate as follows:
  - The green light is switched on for 5 seconds before being switched off
  - 2 seconds later the yellow and green lights are switched on
  - After 3 seconds the yellow light is switched off
  - 1 second later the green light is switched off
- The light sequence must repeat 12 times

Evaluate the function of the system shown in the flowchart against the specification and suggest any improvements required to fully meet the specification. [6 QER]   AO 3

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END OF PAPER

6

Question			Marking details	Marks available				
				AO1	**AO2**	**AO3**	**Total**	**Maths**
10			Indicative content: Evaluation identifies the three functions which do not meet the requirements of the specification: • there is no reference to limit switch A to initiate the sequence • the system does not wait for 3 seconds before switching the yellow light off • the light sequence repeats 10 times rather than 12 times as required The candidate has provided suggestions for improvement: • decision command to check switch A • to include a 3 second delay after the yellow light is switched on • to change the number in the count from 10 to 12					
			5-6 marks The candidate's evaluation identifies all three shortfalls of the system and details how those can be successfully overcome, including the amendments needed and their position in the flowchart. *There is a sustained line of reasoning which is coherent, substantiated and logically structured. The information included in the response is relevant to the argument.*					

Question			Marking details	Marks available				Maths
				AO1	AO2	AO3	Total	
			3-4 marks The candidate's evaluation identifies two shortfalls of the system and details how those can be successfully overcome, specifying the location of those amendments in the flowchart. *There is a line of reasoning which is partially coherent, supported by some evidence and with some structure. Mainly relevant information is included in the response but there may be some minor errors or the inclusion of some information not relevant to the argument.* **1-2 marks** The candidate's evaluation identifies one shortfall of the system and details how that can be successfully overcome, specifying the location of the amendment in the flowchart. *There is a basic line of reasoning which is not coherent, supported by limited evidence and with very little structure. There may be significant errors or the inclusion of information not relevant to the argument.* **0 marks** No attempt made or complete misunderstanding of the program. *Response not creditworthy or not attempted.*			6		
			Question 10 total	**0**	**0**	**6**	**0**	**0**
	22		**TOTAL**	**35**	**35**	**10**	**80**	**22**

Eduqas GCSE Electronics SAMs from 2017/ED
25/11/16