AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

AS
ELECTRONICS

Unit 1 Introductory Electronics

Tuesday 17 May 2016 Afternoon Time allowed: 1 hour

Materials

For this paper you must have:
- a pencil and a ruler
- a calculator
- Data Sheet (enclosed).

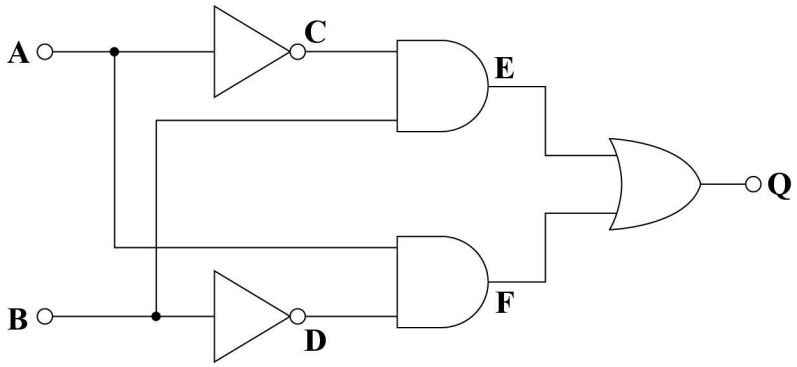
Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for each question are shown in brackets.
- The maximum mark for this paper is 67.

Answer **all** questions in the spaces provided.

1 The logic diagram in **Figure 1** shows how two inputs **A** and **B** produce an output **Q**.

Figure 1



1 (a) Complete the truth table shown in **Table 1** for this logic diagram.

[5 marks]

Table 1

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

1 (b) (i) Write the Boolean expression for point **E** in **Figure 1** in terms of inputs **A** and **B** only.

[1 mark]

E = _____

1 (b) (ii) Write the Boolean expression for point **F** in **Figure 1** in terms of inputs **A** and **B** only.

[1 mark]

F = _____

1 (b) (iii) Write the Boolean expression for the output **Q** in **Figure 1** in terms of inputs **A** and **B** only.

[2 marks]

Q = _____

1 (c) Circle the single logic gate that could be used to replace the function represented in **Figure 1**.

[1 mark]

AND EXOR NOR NAND OR

10

Turn over for the next question

2 The information below describes how smart washing machines warn people that there is too much washing in the drum and that the machine is overloaded.

- A load sensor detects the weight of washing in the drum and produces an output voltage.
- The load sensor output voltage increases as the weight of washing detected increases.
- When the weight of washing exceeds a preset maximum, a logic 1 is produced by a comparator circuit.
- The comparator output is gated together with a logic level audio frequency signal and a slow astable signal.
- The overall effect is to generate a pulsed tone, which warns of an overload.

2 (a) Using the following subsystems, draw a possible design for this system.

adjustable voltage reference **audio frequency generator**

comparator **driver** **load sensor**

loudspeaker **3-input logic gate** **slow astable**

[7 marks]

2 (b) (i) Name the subsystem most likely to contain a MOSFET.

[1 mark]

2 (b) (ii) Name the subsystem most likely to contain a potentiometer.

[1 mark]

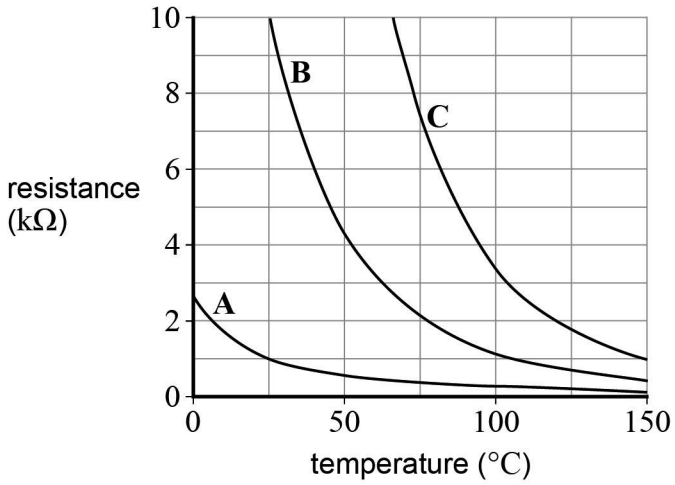
2 (b) (iii) Name the subsystem most likely to contain an operational amplifier.

[1 mark]

10

3 **Figure 2** shows the characteristic curves of three different NTC thermistors, **A**, **B** and **C**.

Figure 2



3 (a) (i) State what the letters NTC stand for.

[1 mark]

_____

3 (a) (ii) State how you can tell from the characteristic curves that **A**, **B** and **C** are NTC thermistors.

[1 mark]

_____

_____

3 (b) A particular industrial process needs a thermistor that has a high sensitivity to small temperature variations in the 75–100 °C temperature range.

State with a reason which thermistor, **A**, **B** or **C**, should be used.

[2 marks]

Thermistor _____

Reason _____

_____

3 (c) Thermistor **A** is selected to monitor another stage in the process.

In this stage, an operational amplifier is used as a comparator to control a red LED and a green LED.

The circuit is designed to:

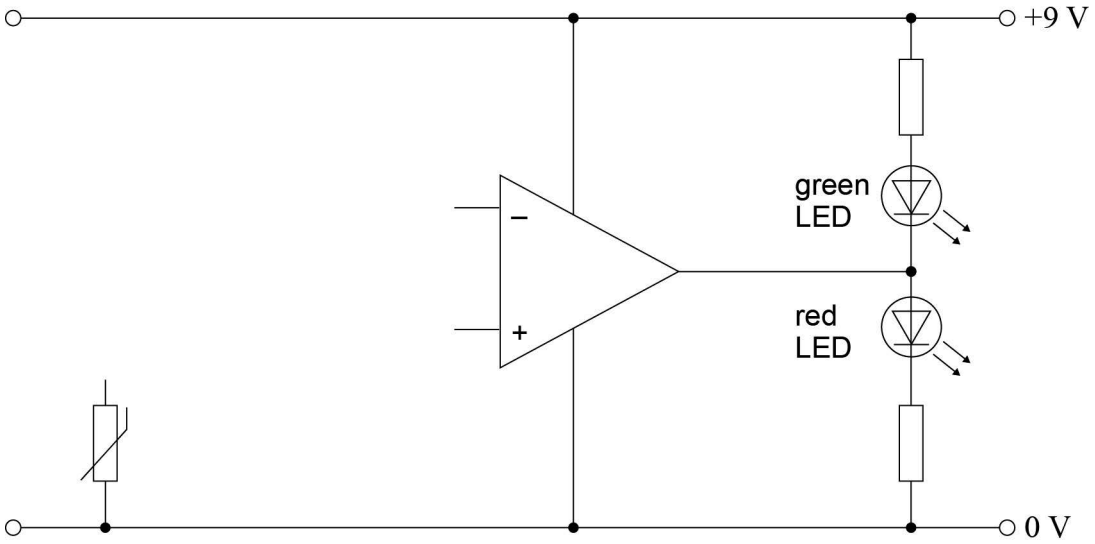
- only turn on the red LED when the temperature of a liquid is above 25 °C
- only turn on the green LED when the temperature of a liquid is below 25 °C.

Complete the circuit diagram in **Figure 3** showing the following:

- a 2 kΩ resistor, which together with the thermistor forms a voltage divider to produce a voltage that changes as the detected temperature changes
- two resistors arranged as a voltage divider to provide a fixed reference voltage
- suitable values for these two resistors
- correct connections from the voltage dividers to the operational amplifier inputs.

[5 marks]

Figure 3



3 (d) When the circuit was built and tested, the green LED performed as expected but the red LED stayed on dimly even when the temperature was below 25°C.

The LEDs used have the characteristics shown in **Table 2**.

Table 2

	Wavelength	**Minimum voltage to turn LED on**
Green	470–505 nm	2.5 V
Red	630–660 nm	1.7 V

Explain why the red LED did **not** switch off completely whereas the green LED did.

Use the information in **Table 2** and your knowledge of **real** operational amplifiers to help explain your answer.

[3 marks]

Turn over for the next question

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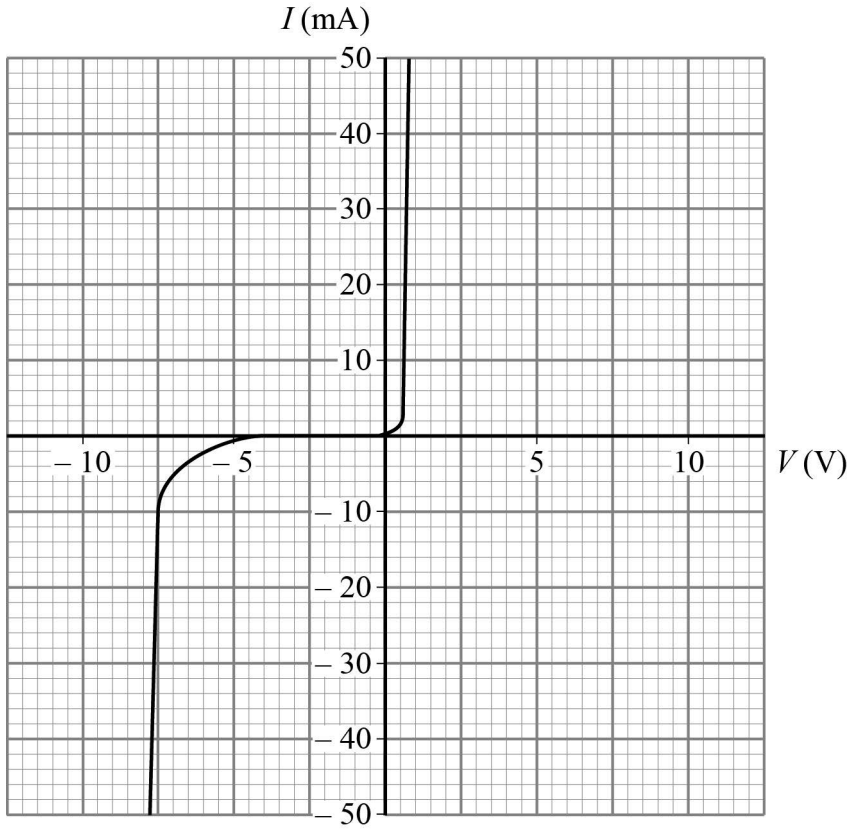
4 The graph in **Figure 4** shows part of the characteristic for a Zener diode.

Figure 4



4 (a) (i) Estimate from the graph in **Figure 4** the Zener voltage of this Zener diode.

[1 mark]

4 (a) (ii) Estimate from the graph in **Figure 4** the minimum current at which this Zener diode should be used.

[1 mark]

4 (b) A student designs a 5 V power supply with a USB socket for use in her car.

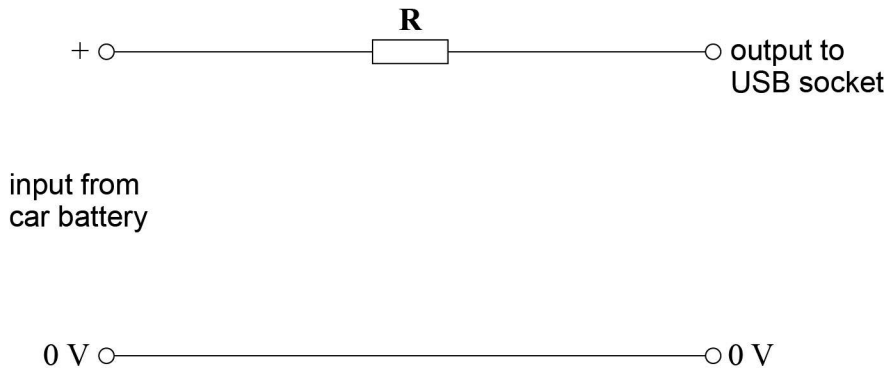
The power supply runs off the car's battery and contains a simple voltage regulator.

The regulator includes a resistor and a 5.1 V Zener diode.

Draw on **Figure 5** the Zener diode in the correct position to complete the voltage regulator circuit.

[3 marks]

Figure 5



Question 4 continues on the next page

4 (c) The power supply must be capable of providing a current of $500\ \text{mA}$ to any device that is plugged into it.

The chosen Zener diode needs $5\ \text{mA}$ to maintain the $5.1\ \text{V}$ Zener voltage.

4 (c) (i) Assume that the car's battery voltage is $12\ \text{V}$.

Calculate the theoretical value of resistor **R** needed for the regulator circuit.

[3 marks]

4 (c) (ii) Select a suitable resistor value for **R** from the E24 series.

Give a reason for your choice.

[3 marks]

E24 series resistor value _____

Reason _____

4 (c) (iii) Calculate the maximum power that would be dissipated by the Zener diode.

[3 marks]

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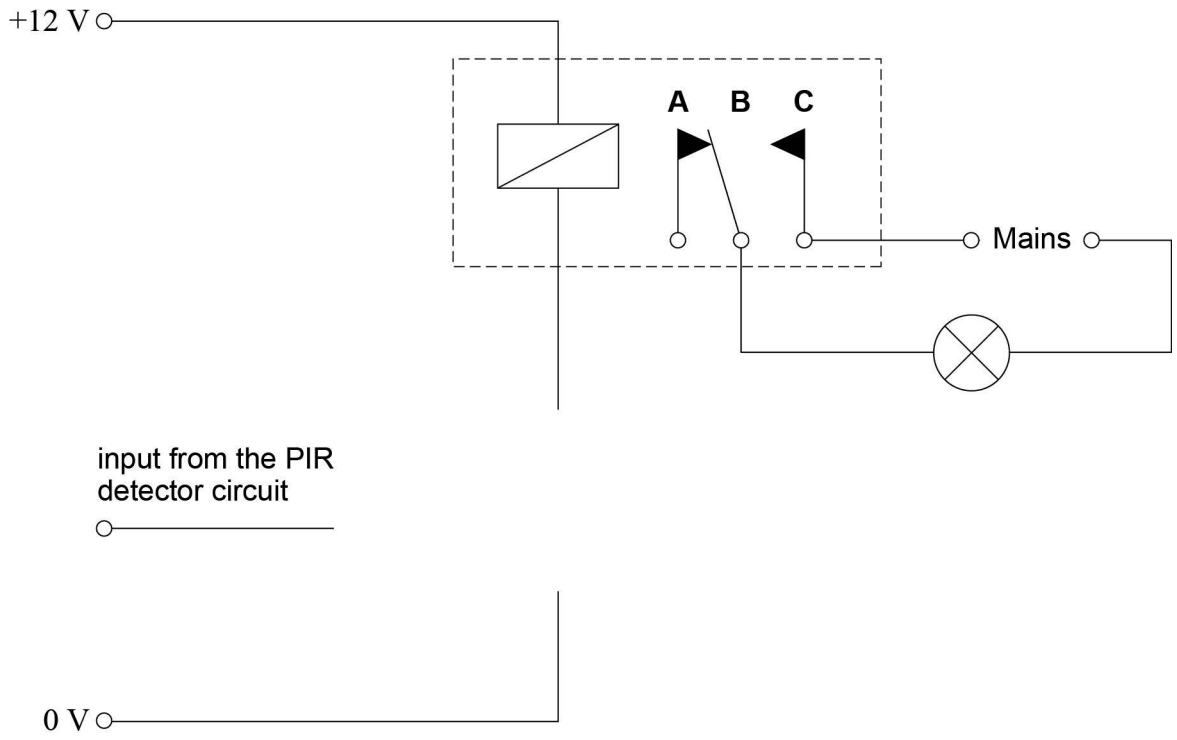
5 **Figure 6** shows the relay circuit stage for an outdoor security light. The light is powered by the mains and activated by a Passive Infrared (PIR) detector. The relay (in the dotted box) is shown in its unpowered state.

Figure 6



5 (a) (i) Draw on **Figure 6** an npn bipolar transistor together with its input resistor, so it can act as a driver for the relay.

[2 marks]

5 (a) (ii) Draw on **Figure 6** the diode needed to protect the transistor.

[2 marks]

5 (a) (iii) Explain why diode protection is needed **and** how the diode achieves this.

[2 marks]

5 (b) The relay coil has a resistance of $160\ \Omega$ and must be used on a $12\ \text{V}$ supply to operate correctly. The PIR detector circuit can only supply $0.5\ \text{mA}$.

Show that the current gain (I_c / I_b) for the transistor must be at least 150 for the circuit to work.

[3 marks]

5 (c) Tick (✓) the box next to the row of information in **Table 3** that best describes the relay being used in this application.

[1 mark]

Table 3

Contact A	Contact B	Contact C	Configuration	
NC	COM	NO	SPST	
COM	NC	NO	SPDT	
NC	COM	NO	SPDT	
NO	COM	NC	SPDT	
NO	COM	NC	SPST	

5 (d) State **one** advantage of using an n-channel MOSFET instead of the npn bipolar transistor as the driver in **Figure 6**.

[1 mark]

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6 A small company has a total of 60 shares that are held by three shareholders.

- Mr **A**ndrews holds **10** shares (voting button **A**).
- Mrs **B**rown holds **20** shares (voting button **B**).
- Mrs **C**larke holds **30** shares (voting button **C**).

At a board meeting, each shareholder may vote to cast **all** their shares in support of the plan being discussed by pressing their voting button.

For the plan to be passed, **at least 30 shares** in total must be cast.

A student has been asked to design a logic system that will turn on an LED to indicate when at least 30 shares have been cast in favour of a plan.

6 (a) The logic system works as follows:

- When a voting button is pressed, a logic 1 is produced.
- When at least 30 shares are cast, a logic 1 is produced at output **Q**.

Complete the truth table shown in **Table 4** for this logic system.

[1 mark]

Table 4

C	B	A	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	

6 (b) Explain how the following expression for **Q** represents the correctly completed truth table in part **6 (a)**.

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

[2 marks]

6 (c) Show that the expression for **Q** in part **6 (b)** can be simplified to $Q = (A.B) + C$

You may use either Boolean algebra **or** a Karnaugh map to show how you have arrived at your answer.

[3 marks]

6 (d) **Figure 7** shows the inputs and output for a logic diagram.
When completed it will represent the expression $Q = (A.B) + C$

6 (d) (i) Complete **Figure 7** using the **minimum** number of 2-input logic gates to correctly represent the expression for **Q**.

[2 marks]

Figure 7

6 (d) (ii) Complete **Figure 8** to correctly represent the expression **Q** using **NAND** gates only.

[2 marks]

Figure 8

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END OF QUESTIONS

There are no questions printed on this page

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