Candidate Name	Centre Number	Candidate Number

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced Subsidiary/Advanced

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Uwch Gyfrannol/Uwch

382/01

ELECTRONICS

ET2

A.M. TUESDAY, 22 May 2007

(1½ hours)

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a calculator.

INSTRUCTIONS TO CANDIDATES

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.

INFORMATION FOR CANDIDATES

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

You are reminded of the necessity for good English and orderly presentation in your answers.

For Examiner's use only.	
1	
2	
3	
4	
5	
6	
7	
8	
Total	

Your attention is drawn to the Information for the use of candidates on page 2 of this paper.

No certificate will be awarded to a candidate detected in any unfair practice during the examination.

INFORMATION FOR THE USE OF CANDIDATES

Preferred Values for resistors
The figures shown below and their decade multiples and sub-multiples are the E24 series of preferred 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.

RC networks	$V_C = V_O\,(1 - e^{-t/RC})$	for a charging capacitor
	$V_C = V_O\,e^{-t/RC}$	for a discharging capacitor
	$t = -RC\,1n\left(1 - \frac{V_c}{V_o}\right)$	For a charging capacitor
	$t = -RC\,1n\left(\frac{V_c}{V_o}\right)$	For a discharging capacitor
Alternating Voltages	$V_o = V_{rms}\sqrt{2}$	
Silicon Diode	$V_F \approx 0{\cdot}7\ V$	
Bipolar Transistor	$h_{FE} = \frac{I_C}{I_B}$	Current gain
	$V_{BE} \approx 0{\cdot}7\ V$	in the on state
MOSFETs	$I_D = g_M V_{GS}$	
Operational amplifier	$G = -\frac{R_F}{R_{IN}}$	Inverting amplifier
	$G = 1 + \frac{R_F}{R_1}$	Non-inverting amplifier
	$V_{OUT} = -R_F\left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}\right)$	Summing amplifier
	$\text{Slew Rate} = \frac{\Delta V_{OUT}}{\Delta t}$	Slew rate
555 Monostable	$T = 1{\cdot}1\,RC$	
555 Astable	$t_H = 0{\cdot}7\,(R_A + R_B)C$	
	$t_L = 0{\cdot}7\,R_B C$	
	$f = \frac{1{\cdot}44}{(R_A + 2R_B)C}$	
Schmitt Astable	$f \approx \frac{1}{RC}$	

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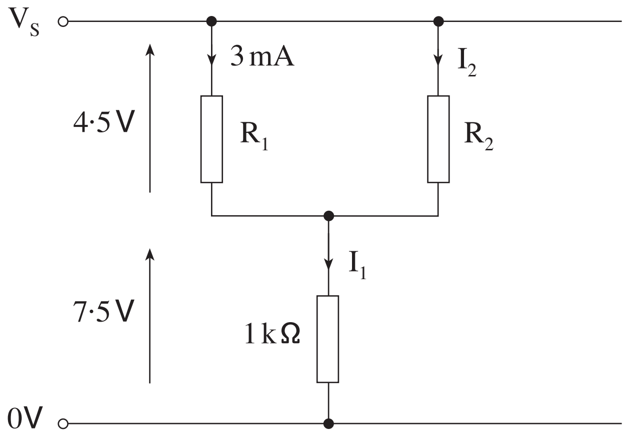
1. Use the information given in the circuit diagram to determine the values of the quantities listed below.



(a) V_S ....

....

(b) R_1 ....

....

(c) I_1 ....

....

(d) I_2 ....

....

(e) R_2 ....

....

(f) What is the effective resistance of the parallel combination R_1 and R_2?

....

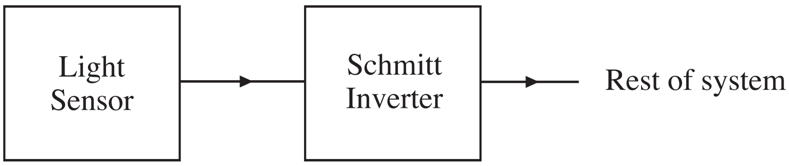
....

[7]

2. *(a)* A Schmitt inverter can be used to *condition* the signal produced by an analogue sensor. Here is part of the data sheet for a Schmitt inverter:

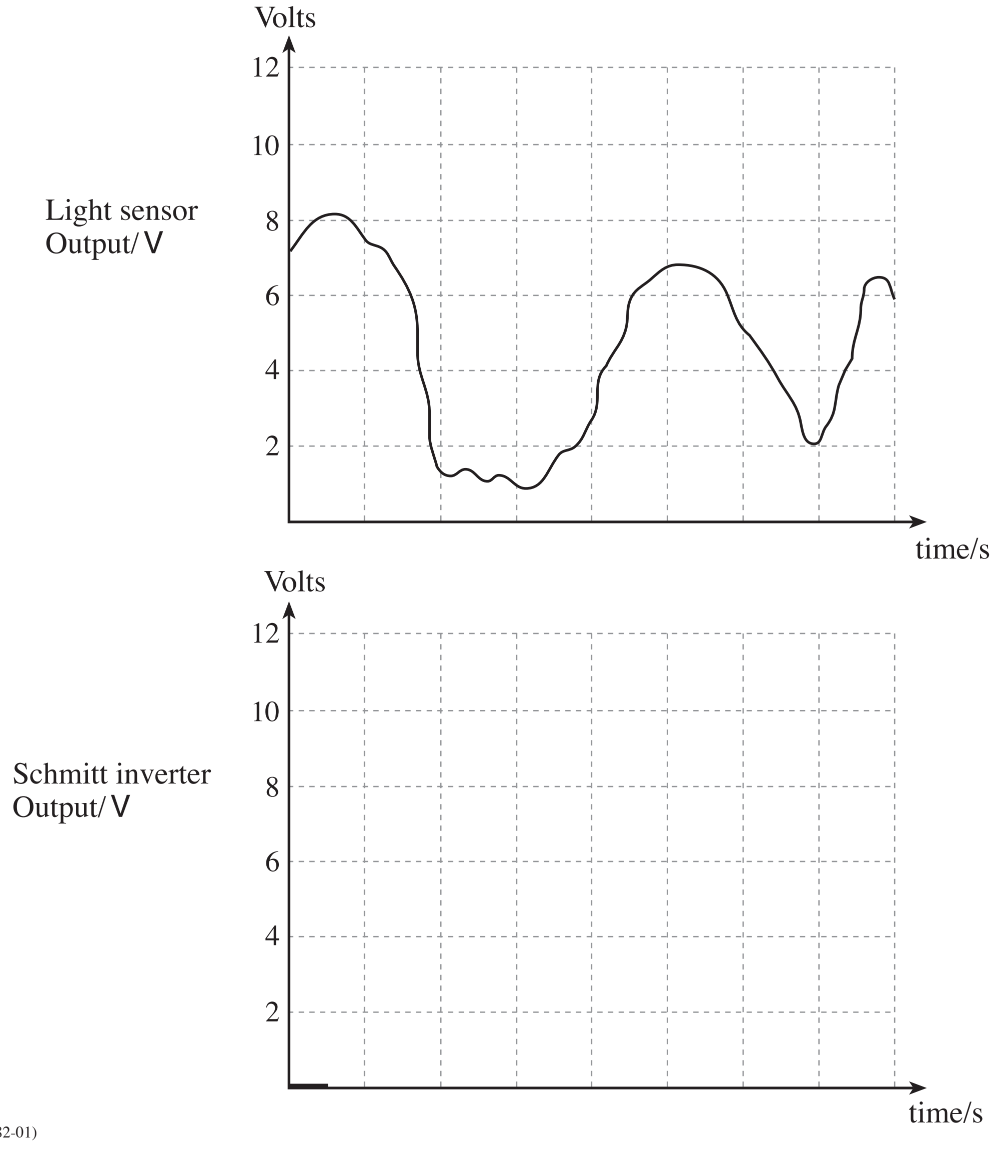
> When connected to a 10 V supply:
>
> - Logic 0 = 0 V
> - Logic 1 = 10 V
> - The output changes from logic 1 to logic 0 when a **rising** input voltage reaches 3 V
> - The output changes from logic 0 to logic 1 when a **falling** input voltage reaches 1 V

The Schmitt inverter is connected as follows in an electronic system:



The upper graph shows the light sensor output.

Complete the lower graph to show the signal obtained at the output of the Schmitt inverter.



[3]

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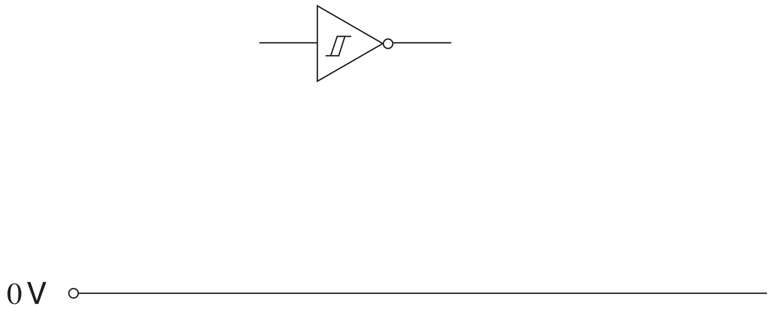
(b) A Schmitt inverter can also be used as part of an astable circuit.

(i) Complete the circuit diagram for the astable circuit.

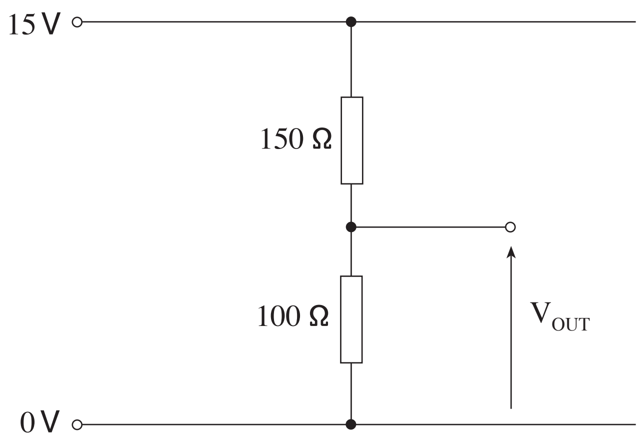


[2]

(ii) Draw a sketch to illustrate the output waveform produced by the astable. Your sketch should show clearly how an astable waveform differs from a monostable waveform.

[2]

3. The following circuit is used as a voltage source.



(a) Thevenin's theorem is used to produce an equivalent circuit.

(i) Calculate the open circuit voltage V_{OC}.

....

....

(ii) Calculate the short circuit current I_{SC}.

....

....

(iii) Calculate the equivalent resistance R_O.

....

....

[3]

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(b) (i) Draw the equivalent circuit with a load resistance connected across the output terminals.

(ii) Use the equivalent circuit to calculate the voltage across the load resistance when the load current is 30 mA.

....

....

[3]

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4. The following diagram shows part of a half-wave rectified power supply.

(a) Complete the circuit by adding:

(i) a diode to produce the half-wave rectification,

(ii) a capacitor to smooth the output. [2]

(b) The rms value of the secondary voltage V_S is 20 V. Calculate the **peak value** of

(i) the secondary voltage,

....

....

(ii) the voltage V_{OUT}.

....

[2]

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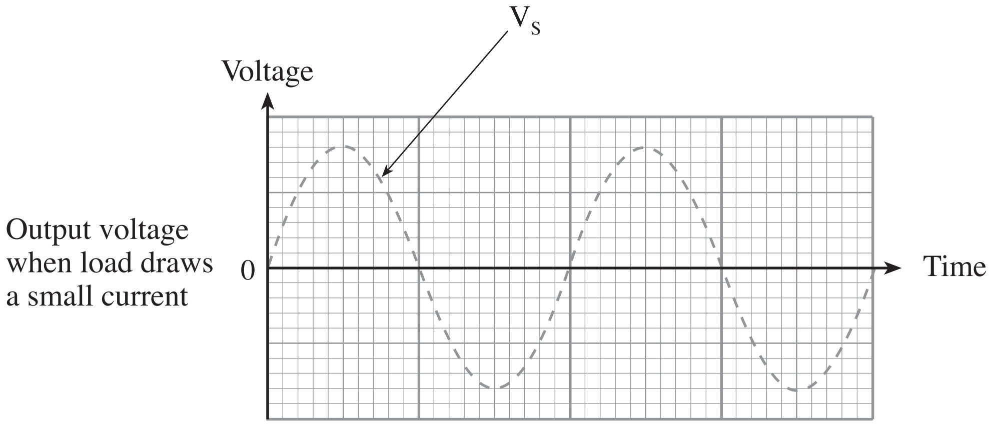
(c) On the axes provided below, sketch the graph to show the voltage V_{OUT} when

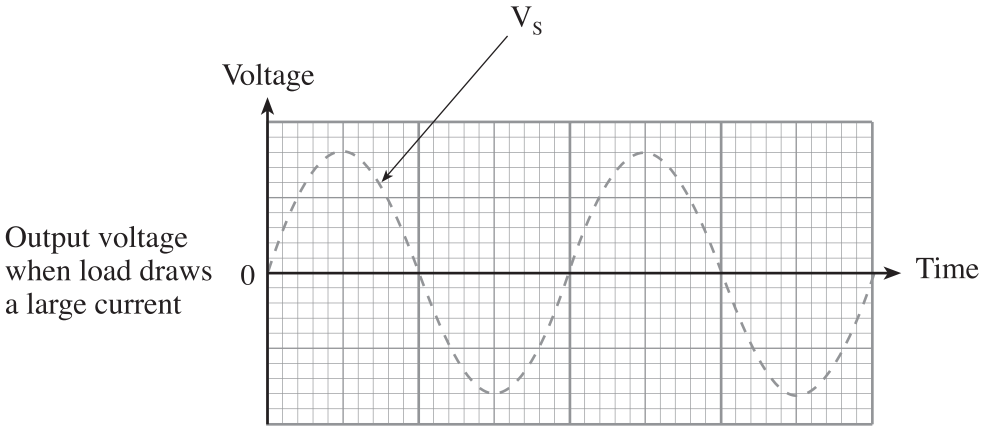
(i) the load draws a small current,

(ii) the load draws a large current .

Label the axes with any relevant voltages.

The voltage across the secondary windings of the transformer is shown as a dotted waveform.





[3]

Turn over.

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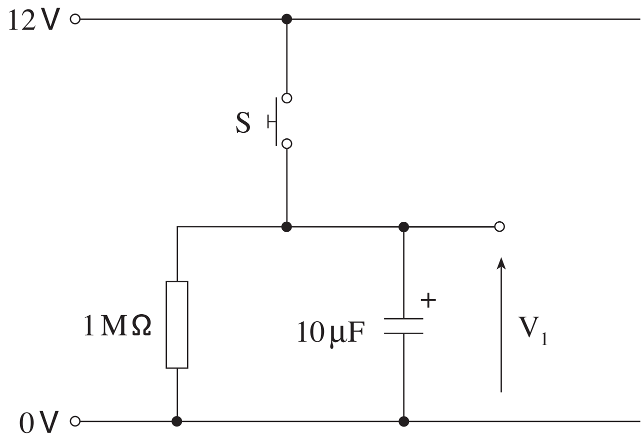
5. The following diagram shows a timing sub-system used as part of a simple monostable circuit.



(a) Calculate the time constant of the timing sub-system.

....

....
[2]

(b) Switch S is momentarily closed at time t = 0.

(i) Determine the time taken for V_1 to reach 6 V.

....

....

....
[2]

(ii) Calculate the value of V_1 at time t = 3s.

....

....

....
[2]

(iii) Estimate the time taken for V_1 to reach 0 V.

....
[1]

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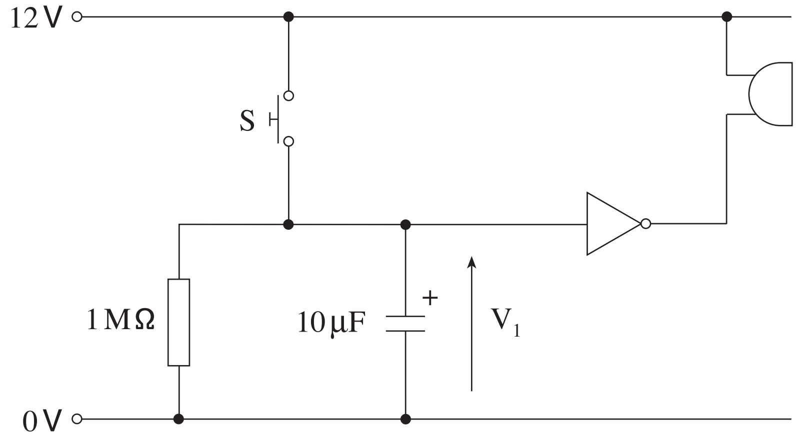
(c) Here is the circuit diagram for the complete monostable.



The CMOS inverting buffer (NOT gate) has the following parameters when connected to a 12 V power supply:

Parameter	*Value*
Input switching threshold	6 V
Input impedance	∞ (infinity)
Logic 0 output voltage level	0 V
Logic 1 output voltage level	11 V
Output current capability	50 mA

Describe what you would observe:

(i) Before switch S is closed.

....

(ii) Immediately after switch S is closed and then released.

....

(iii) During the next 20 seconds after S is released.

Hint: Use the information from b(i) as part of your answer.

....

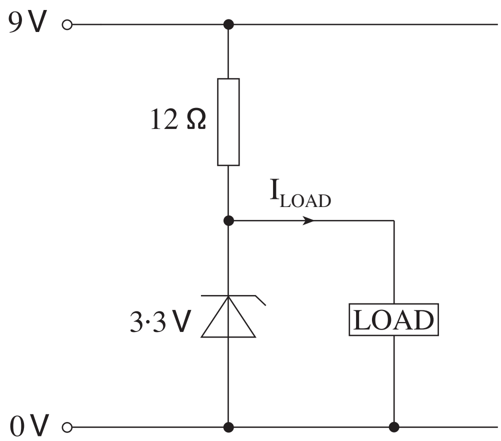
....

....

[3]

Turn over.

6. The following diagram shows a simple stabilised power supply. The zener diode requires a **minimum** current of 8 mA to maintain the zener voltage.



(a) The zener current is greater than 8 mA. Calculate the value of the current through the 12 Ω resistor.

....

....
[2]

(b) Calculate the minimum power rating required for the zener diode.

....

....
[2]

(c) What is the maximum load current that the power supply can provide whilst still maintaining the zener voltage?

....
[1]

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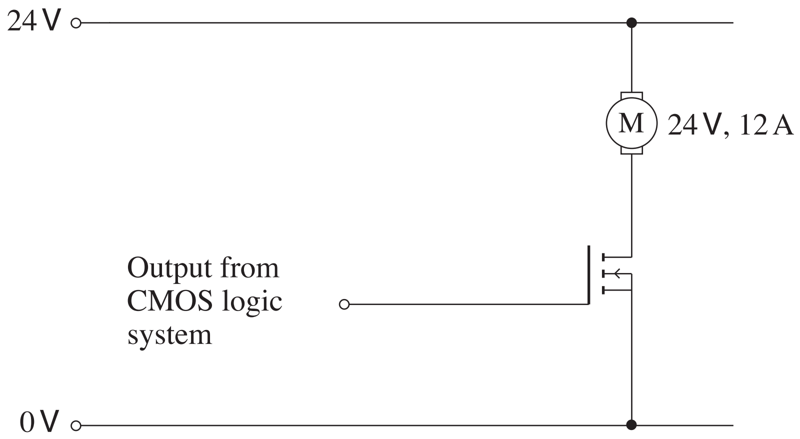
7. The circuit below shows a MOSFET being used to interface a CMOS logic system to a motor rated at 24 V, 12 A.



An extract from the data sheet of the MOSFET is shown below.

V_{GS} / V (max)	I_D / A (max)	P_{TOT} / W (max)	g_M / S (typical)	r_{DSon} / Ω
15	15	90	1·2	0·15

(a) Add a protective diode to the circuit diagram. [1]

(b) Calculate the minimum value of V_{GS} required to enable the motor to operate at its rated current.

....

....

[2]

(c) Calculate the power dissipated in the MOSFET when the motor is operating at its rated current.

....

....

[2]

(d) The maximum output current available from the logic system is 30 mA. Explain why an npn transistor would be unsuitable for this application.

....

....

[2]

Turn over.

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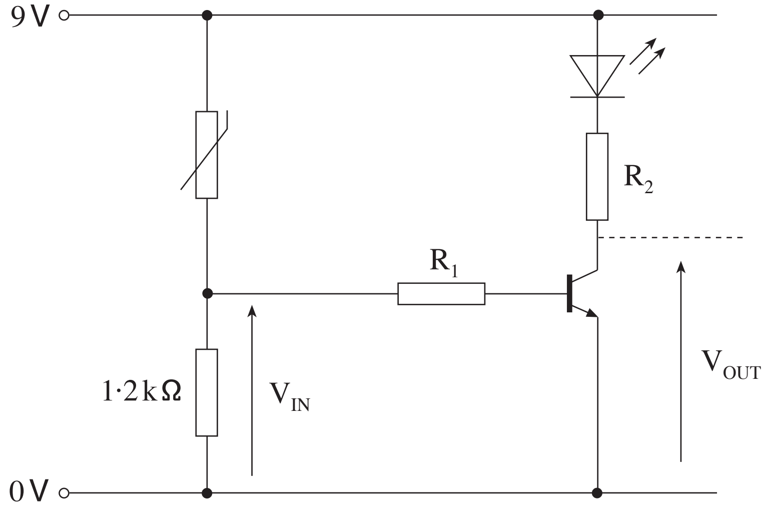
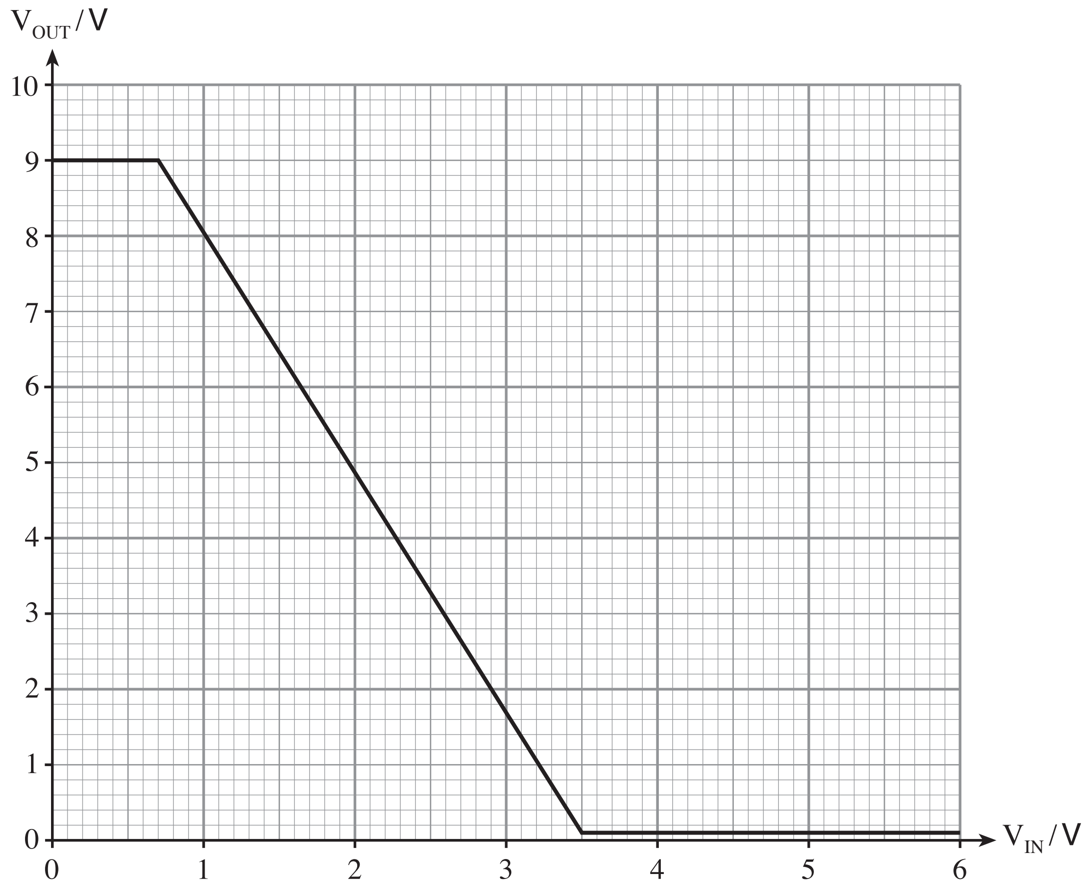
8. The LED in the following temperature sensing circuit should light up when the temperature in a refrigerator rises above 4°C.



(a) The temperature is gradually increased. The graph shows how V_{IN} and V_{OUT} change.



Use the graph to determine the minimum value of V_{IN} required to saturate the transistor

V_{IN} .... [1]

(b) The forward voltage drop across the LED is 2 V.

(i) Calculate the minimum value for resistor R_2 required to limit the current through the LED to maximum of 30 mA when the transistor is saturated.

....

....

.... [2]

(ii) Select the preferred value for resistor R_2 that you would use from the E24 series.

.... [1]

(c) The thermistor has a resistance of 3·9 kΩ at 2°C.

(i) Calculate the value of V_{IN} at this temperature.
Assume that the base current is small enough to be ignored in this calculation

....

.... [2]

(ii) Use the graph given in part *(a)* to determine the value of V_{OUT} at this temperature.

....

.... [1]

(iii) Calculate the value of the current through the LED at this temperature.
Assume the voltage across the LED is 2 V.

....

....

....

.... [2]

(d) Give two benefits of replacing the transistor with a comparator in this application.

....

....

....

.... [2]