Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1142/01

ELECTRONICS – ET2

A.M. WEDNESDAY, 21 May 2014

1 hour 15 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**6**	
2.	**6**	
3.	**7**	
4.	**6**	
5.	**8**	
6.	**5**	
7.	**8**	
8.	**7**	
9.	**7**	
Total	**60**	

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ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

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 total number of marks available for this paper is 60.

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.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

INFORMATION FOR THE USE OF CANDIDATES IN ET2

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.

Standard Multipliers

Prefix	Multiplier
T	$\times 10^{12}$
G	$\times 10^{9}$
M	$\times 10^{6}$
k	$\times 10^{3}$

Prefix	Multiplier
m	$\times 10^{-3}$
μ	$\times 10^{-6}$
n	$\times 10^{-9}$
p	$\times 10^{-12}$

Charging Capacitor

$$V_C = V_O(1 - e^{-t/RC})$$

$$t = -RC\ln\left(1 - \frac{V_C}{V_O}\right)$$

Discharging Capacitor

$$V_C = V_O\, e^{-t/RC}$$

$$t = -RC\ln\left(\frac{V_C}{V_O}\right)$$

Alternating Voltages

$$V_O = V_{rms}\sqrt{2}$$

Silicon Diode

$$V_F \approx 0.7\ V$$

Bipolar Transistor

$$h_{FE} = \frac{I_C}{I_B}$$

$$V_{BE} \approx 0.7\ V$$

MOSFETs

$$I_D = g_M V_{GS}$$

555 Monostable

$$T = 1.1\ RC$$

555 Astable

$$t_H = 0.7(R_A + R_B)C$$

$$t_L = 0.7R_BC$$

$$f = \frac{1.44}{(R_A + 2R_B)C}$$

Schmitt Astable

$$f \approx \frac{1}{RC}$$

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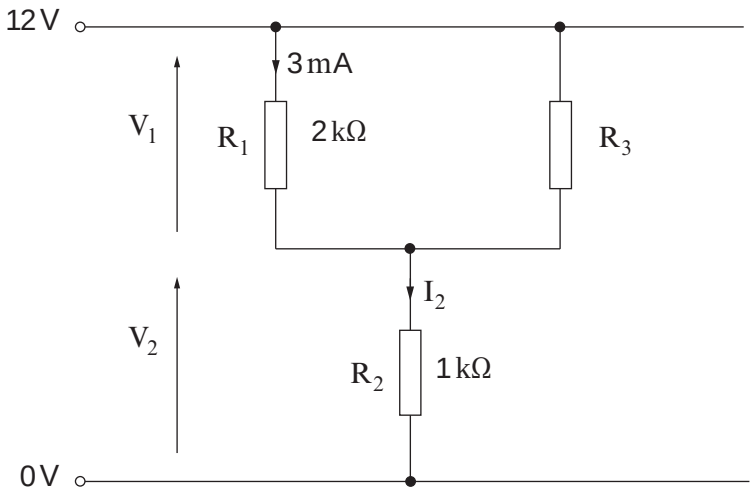
1. Use the information given in the circuit diagram to determine the values of the quantities listed below the diagram.



(a) V_1 ..... [1]

.....

(b) V_2 ..... [1]

.....

(c) I_2 ..... [1]

.....

(d) R_3 ..... [1]

.....

(e) The combined resistance of R_1 and R_3. [2]

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Turn over.

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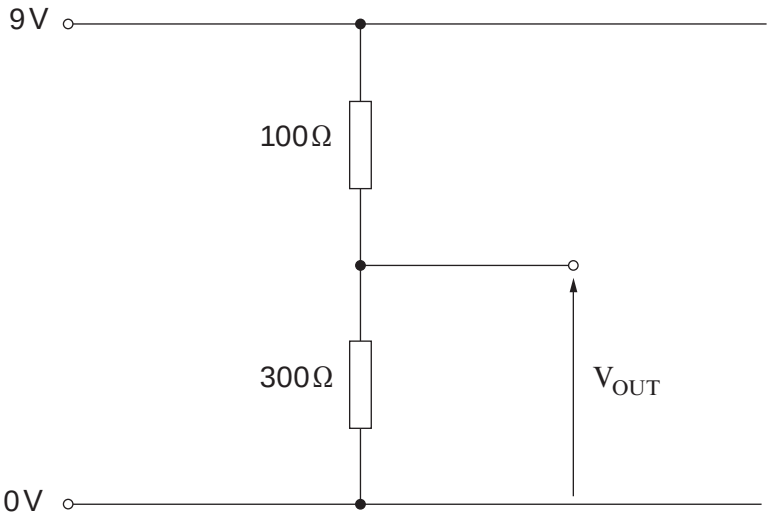
2. The following circuit is used as a voltage source.



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

(i) Calculate the open circuit voltage V_{OC}. [1]

.....

.....

(ii) Calculate the short circuit current I_{SC}. [1]

.....

.....

(iii) Calculate the equivalent resistance R_O. [1]

.....

.....

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(b) (i) Draw the equivalent circuit with a load resistance connected across the output terminals. [1]

(ii) Use the equivalent circuit to calculate the voltage drop across the output terminals when the load current is 20 mA. [2]

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Turn over.

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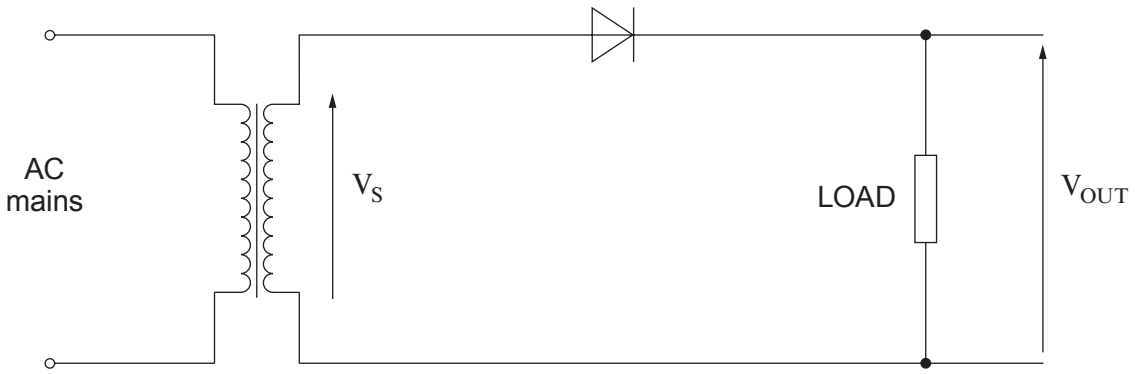
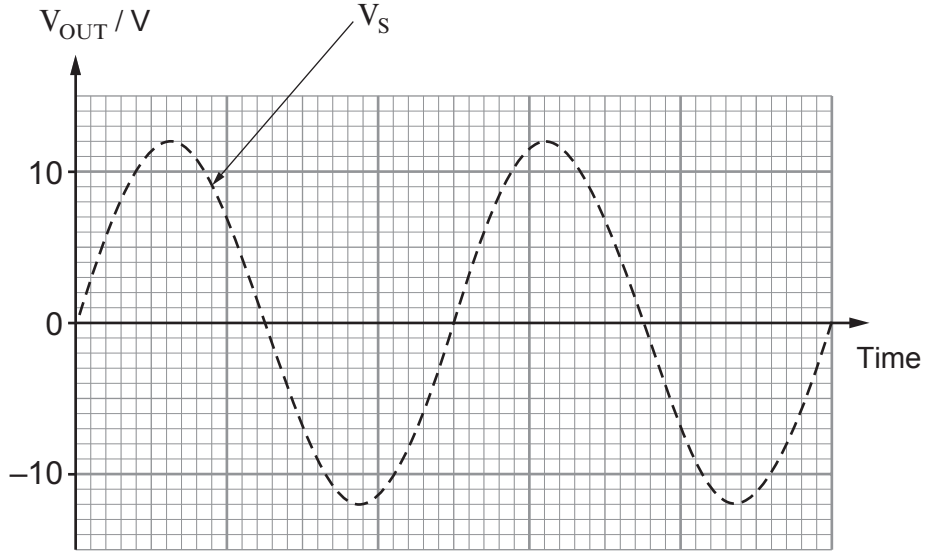
3. The following diagram shows part of the circuit of a half-wave rectified power supply.



(a) In the graph below, the voltage across the secondary windings of the transformer (V_S) is shown as a dotted waveform and has a **peak** voltage of 12 V.

(i) What is the **peak** value of the voltage V_{OUT}? ..... [1]

(ii) On the same graph, sketch the graph to show the output voltage V_{OUT} when a small current flows through the load **without a smoothing capacitor in the circuit**. [2]



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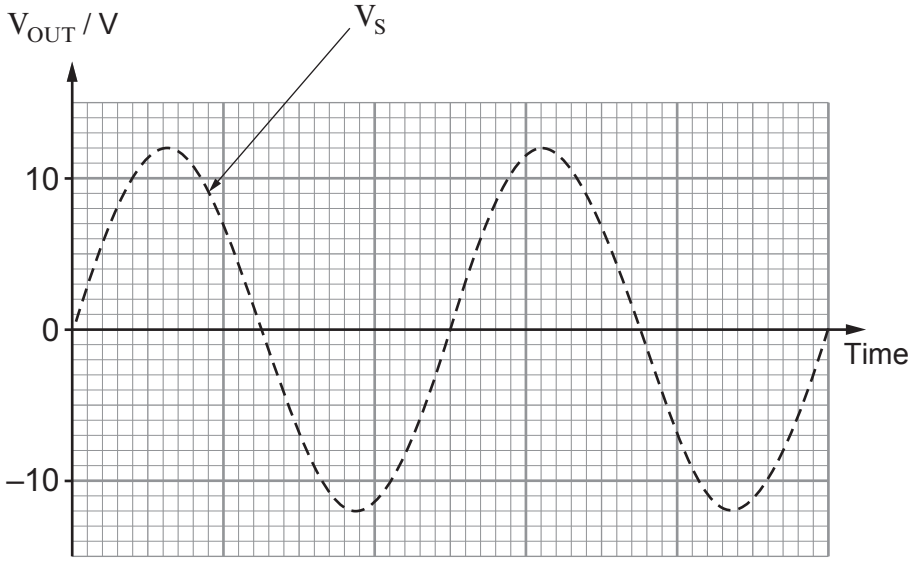
(b) (i) Add a smoothing capacitor to the circuit diagram opposite. [1]

(ii) Use the next set of axes to sketch V_{OUT} for this modified circuit when a small current flows through the load. [1]



(c) The half-wave rectifier is replaced with a full-wave rectifier.

(i) What is the new **peak** value of the voltage V_{OUT}?

..... [1]

(ii) The frequency of the AC mains is 50 Hz. What is the frequency of the ripple voltage? [1]

.....

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Turn over.

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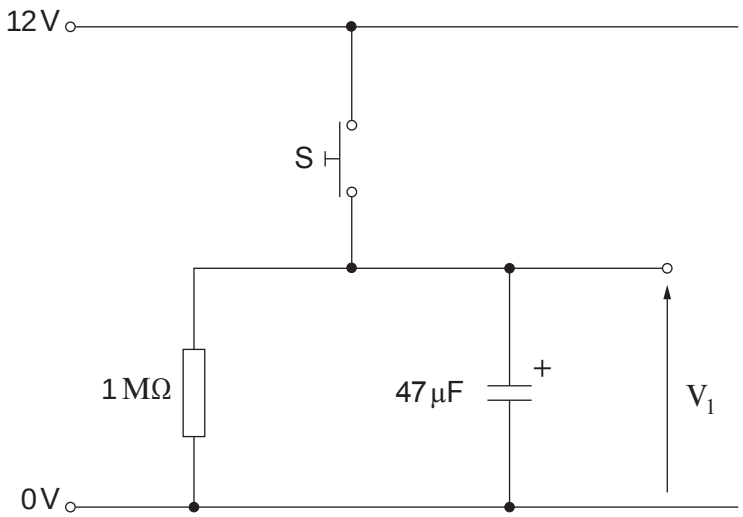
4. The following diagram shows a timing sub-system used in a monostable circuit.



(a) Switch S is closed and then released at time $t = 0$. Determine the time taken for V_1 to reach 6 V. [2]

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(b) Calculate the value of V_1 at time $t = 10$ s. [2]

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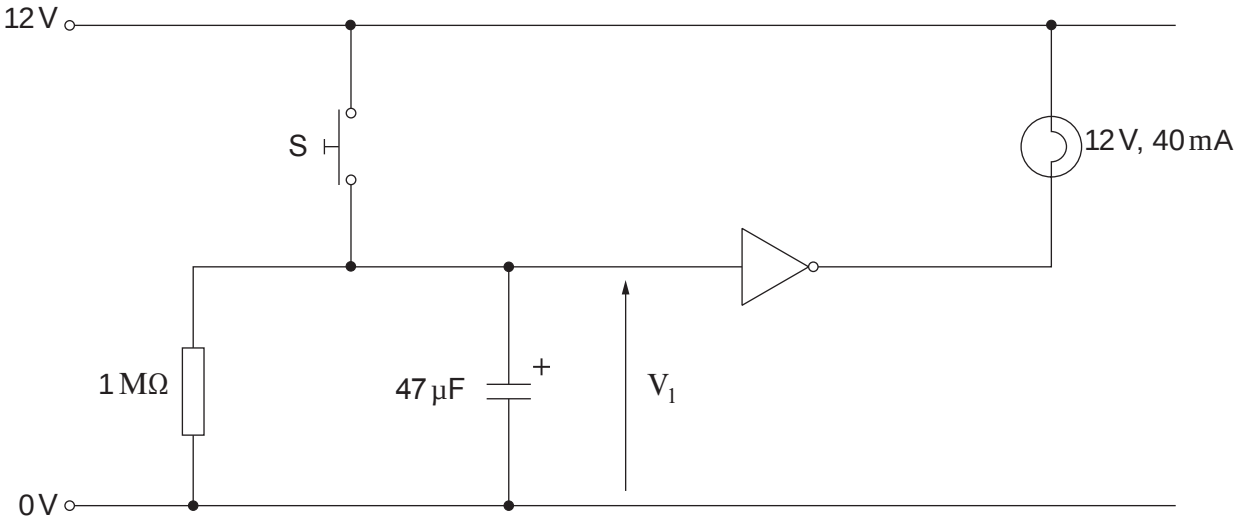
(c) Here is the circuit diagram for the monostable.

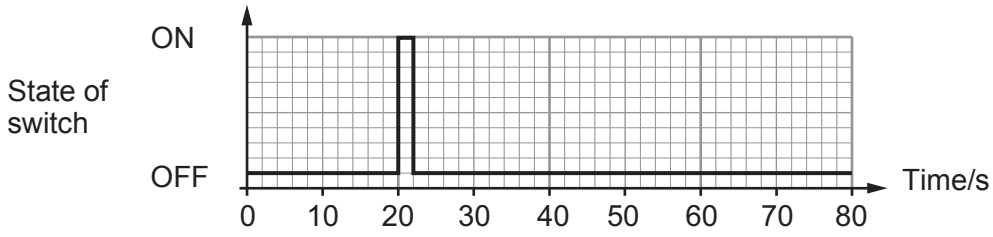


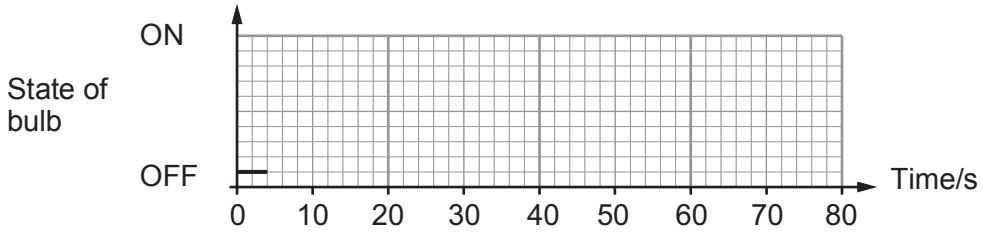
The CMOS inverting buffer (NOT gate) has the following parameters when connected to a 12 V power supply.

Parameter	*Value*
Input switching threshold	6 V
Input impedance	∞ (infinite)
Output current capability	60 mA

Switch S is closed (ON) for a short time and then opened (OFF) as shown in the first graph below. On the second axes, draw a graph to show how the state of the bulb changes.

[2]





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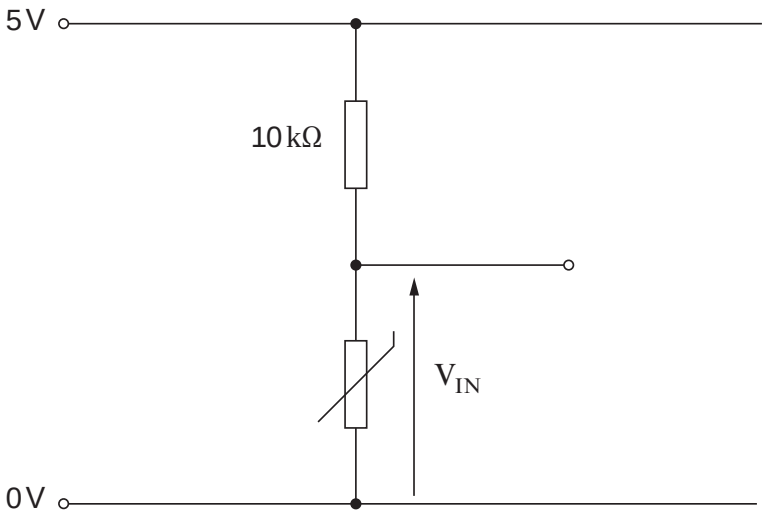
5. *(a)* The following temperature sensing unit is used as part of a boiler safety control system.



At 95°C the resistance of the thermistor is 2.3 kΩ. Calculate the value of V_{IN} at this temperature. [1]

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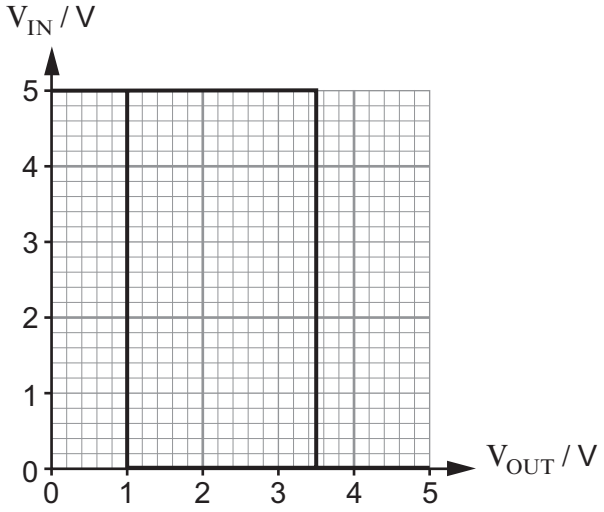
(b) A Schmitt inverter is used to *condition* the signal produced by the temperature sensing unit. The graph below shows the switching characteristic of the Schmitt inverter.



(i) Determine the input switching threshold for: [2]

an increasing input voltage; .....

a decreasing input voltage. .....

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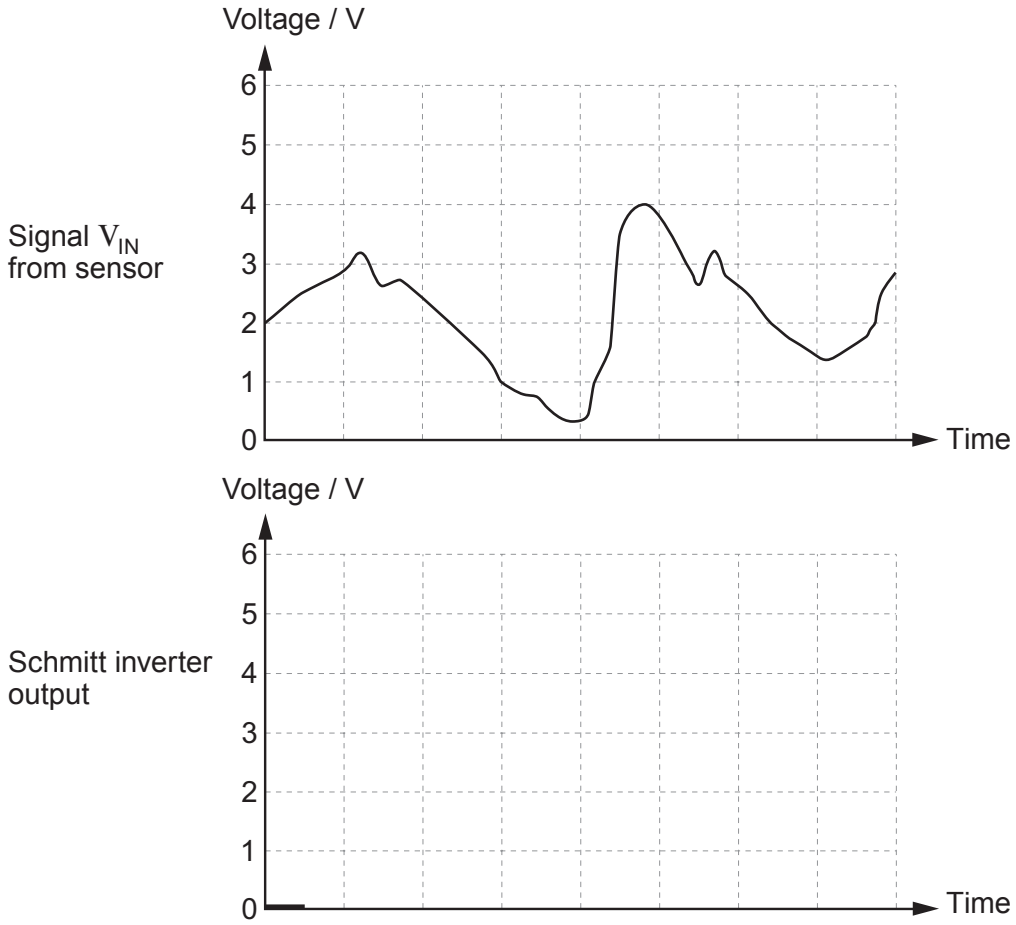
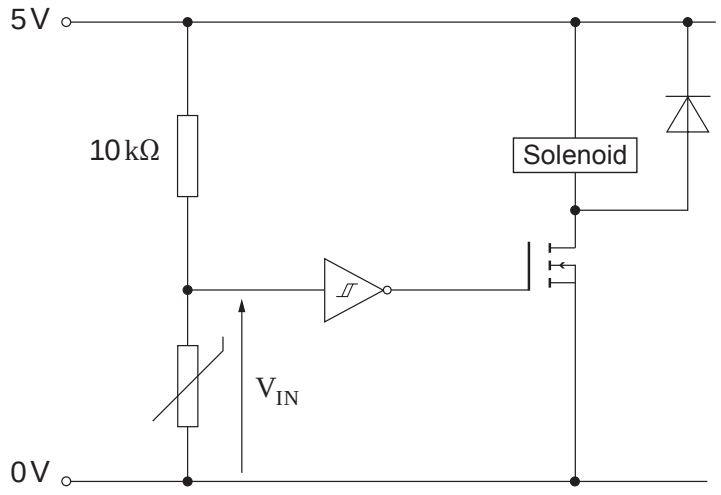
(ii) The signal V_{IN} produced by the sensing sub-system changes with temperature. Complete the graph to show the signal obtained at the output of the Schmitt inverter. [3]



(c) A MOSFET and solenoid are added to complete the boiler safety control system. When the boiler temperature approaches 95°C, the solenoid operates and cuts off the gas supply.



The solenoid is rated at 5 V, 3 A. Calculate the minimum value of g_M required to allow the MOSFET to provide a load current of 3 A. [2]

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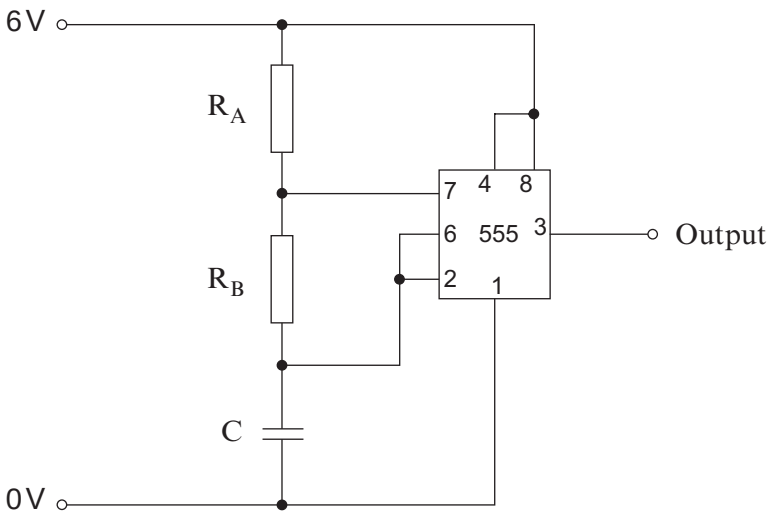
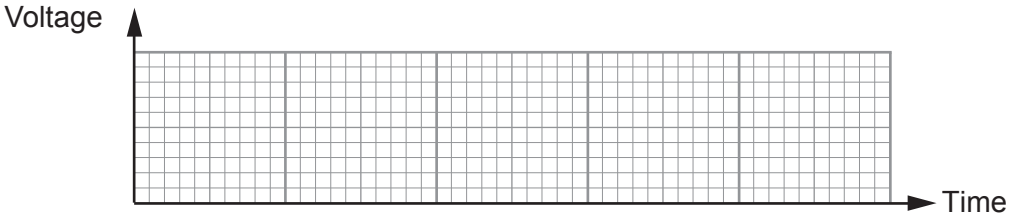
6. The diagram shows a 555 astable circuit.



(a) The output signal has a mark:space ratio of 3:1. Sketch one cycle of the output signal. Label the ***mark*** T_1 and the ***space*** T_2. [2]



(b) The *space* T_2 has a duration of 20 ms. Calculate the value of resistor R_B that will produce the *space* T_2 when C = 2.2 μF. [2]

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(c) Determine the value of resistor R_A. [1]

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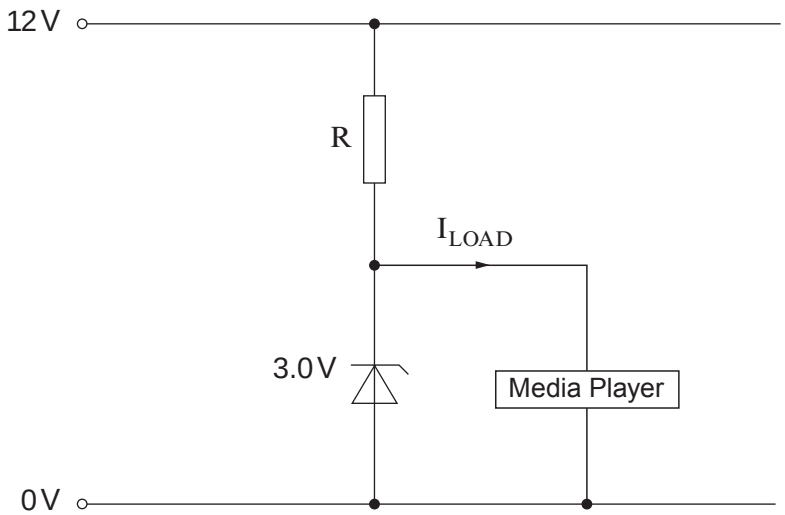
7. A simple 3 V regulated power supply is required for a portable media player to be used with a 12 V car battery.



The zener diode requires a **minimum** current of 8 mA to maintain the zener voltage.

(a) The power supply should be able to supply load currents up to 250 mA. Calculate the ideal value of resistor R. [3]

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(b) Select the preferred value of resistor that you would use from the E24 series. Give a reason for your choice. [1]

.....

.....

(c) The output of the car battery varies, and can reach 14.5 V. The battery output is now 14.5 V. Calculate:

(i) the voltage across the zener diode; ..... [1]

(ii) the voltage across resistor R; ..... [1]

(iii) the power dissipated in resistor R. [2]

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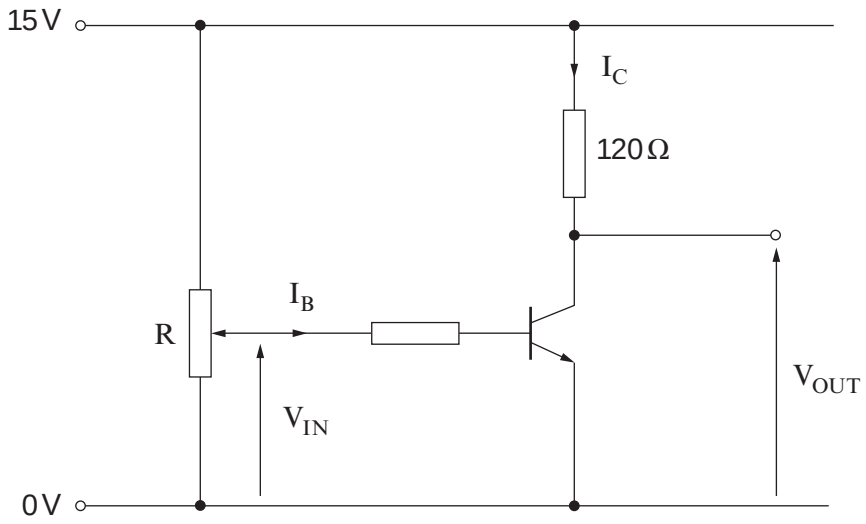
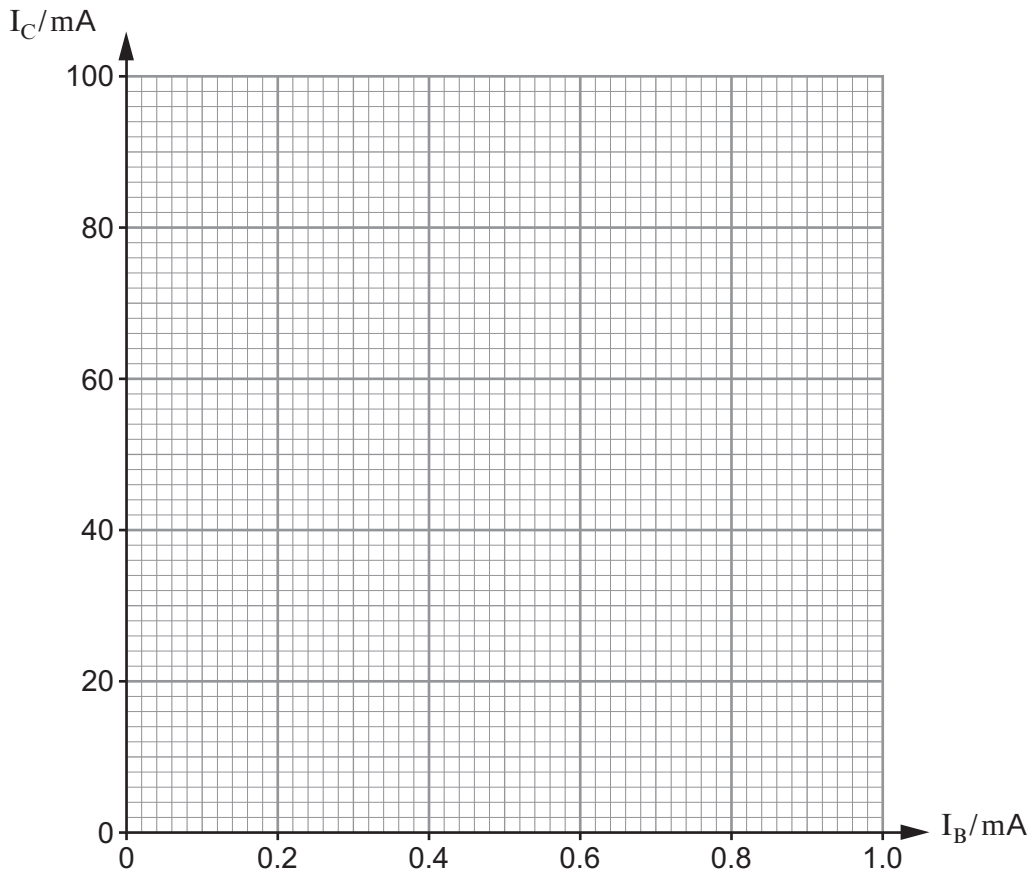
8. The following circuit is set up to investigate a transistor switching circuit.



Potentiometer R is varied and readings of V_{IN}, V_{OUT}, I_B and I_C are taken.

(a) As the base current is increased from 0.2 to 0.8 mA the collector current increases from 16 to 64 mA and the transistor does not saturate.

(i) Complete the graph below to show how the ammeter readings change as I_B is increased from 0 to 1 mA. The transistor does not saturate. [1]



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(ii) Determine the current gain (h_{FE}) of the transistor. [1]

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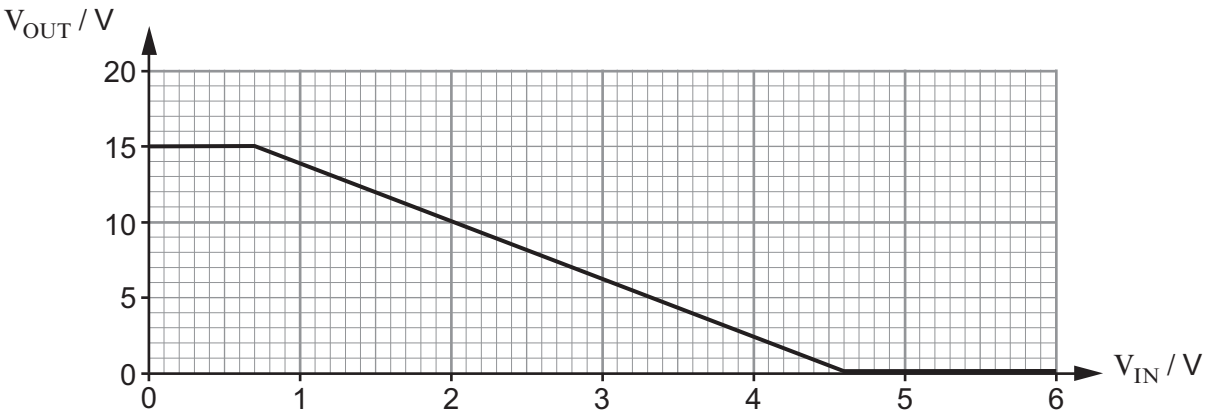
(b) A second graph was drawn to show how V_{OUT} changed as V_{IN} was increased from 0 to 6 V.



Use the graph to determine:

(i) the minimum value of V_{IN} required to saturate the transistor;

..... [1]

(ii) the value of V_{OUT}, when V_{IN} = 3.1 V.

..... [1]

(c) V_{IN} = 3.1 V and the load resistor = 120 Ω.

Calculate the collector current and the power dissipated in the transistor. [3]

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TURN OVER FOR THE LAST QUESTION.

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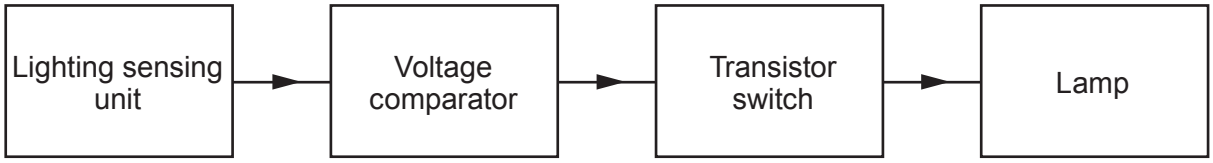
9. A system is required to turn on a 12 V, 2 A lamp automatically at night.

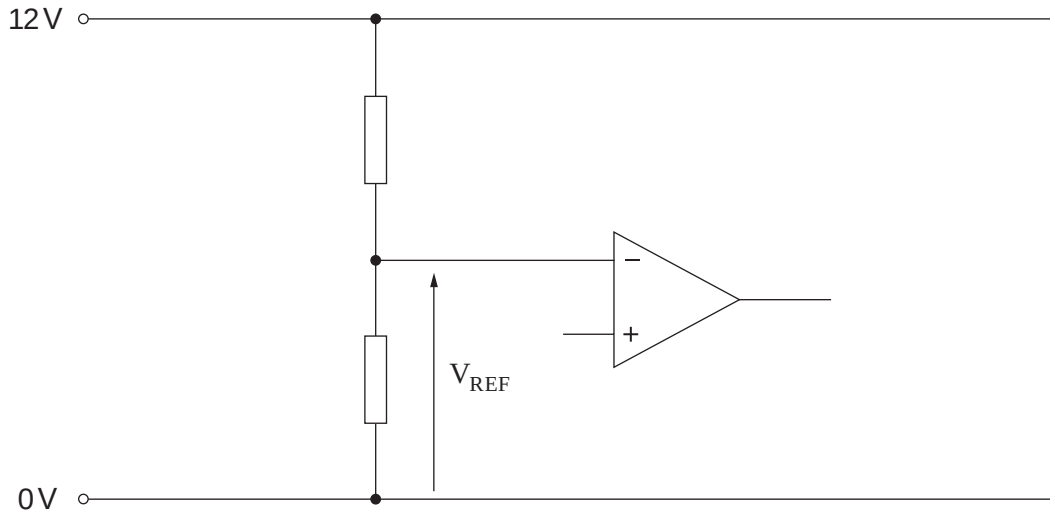


The specification for the system is:

- the system requires a 12 V power supply;
- the light level at which the lamp comes on should be adjustable;
- the lamp is capable of being driven directly from the transistor switch output;
- the voltage comparator reference voltage is 3 V.

Complete the circuit diagram for the system by adding:

- the component values required to provide a reference voltage, V_{REF} = 3 V;
- the light sensing sub-system;
- a facility for adjusting the light level at which the lamp comes on;
- the transistor switch;
- the output sub-system. [7]



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