AQA

SPECIMEN MATERIAL

A-level
PHYSICS
(7408/3BE)

Paper 3 – Section B (Electronics)

Specimen 2014 Morning Time allowed: 2 hours

Materials
For this paper you must have:
- a pencil
- a ruler
- a calculator
- a data and formulae booklet
- a question paper / answer book for Section A.

Instructions
- Answer **all** questions.
- Show all your working.
- The total time for both sections of this paper is 2 hours.

Information
- The maximum mark for this section is 35.

Please write clearly, in block capitals, to allow character computer recognition.

Centre number

Candidate number

Surname

Forename(s)

Candidate signature

Section B

Answer **all** questions in this section.

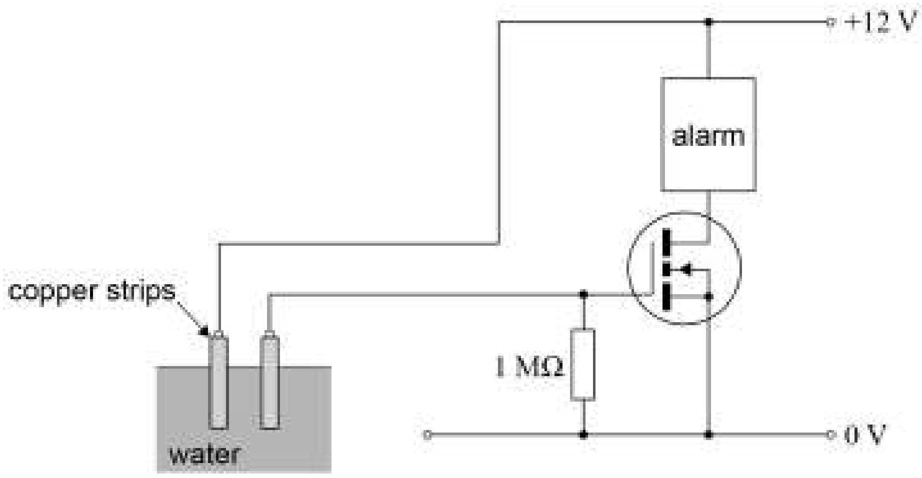
0 1 . 1 **MOSFETs are commonly used in circuits where low power consumption is important to extend battery life.**

State and explain the property of MOSFET devices that makes them useful in these circuits.

[2 marks]

Figure 1 shows an N-channel enhancement mode MOSFET, being used as part of a circuit for the water level alarm in a garden pond.
When the gap between the copper strips is filled with water the MOSFET turns on and the alarm sounds.

Figure 1



0 1 . 2 Explain the reason for the 1 $M\Omega$ resistor in this application.

[2 marks]

0 1 . 3 The circuit is tested by immersing the copper strips in the water, and bringing them closer together until the alarm sounds.
V_{th} for the MOSFET in **Figure 1** is 2.4 V.

Determine the resistance of the water between the copper strips when the alarm sounds.

[2 marks]

resistance = ____________________ MΩ

0 2 . 1 Describe what is meant by amplitude modulation (am).

[1 mark]

____

____

____

0 2 . 2 A radio wave has an unmodulated frequency of 120 kHz. It is amplitude modulated by a signal from an audio transducer of frequency 2.2 kHz.

Calculate the bandwidth of the modulated wave.

[1 mark]

bandwidth = ____________________ kHz

0 2 . 3 Explain why frequency modulation (fm) is not used for commercial radio transmissions in the medium and long wave bands.

[1 mark]

____

____

0 2 . 4 State and explain **one** advantage of transmitting digital signals using frequency modulation (fm) rather than amplitude modulation (am).

[2 marks]

____

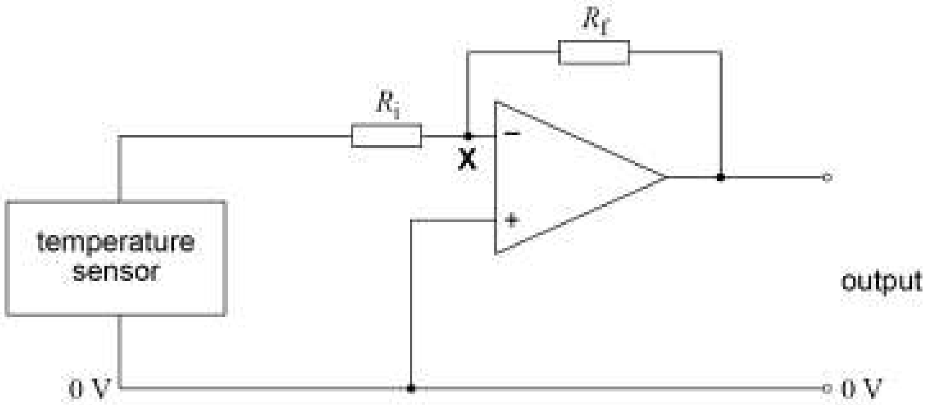
____

____

____

0 3 **Figure 2** shows a circuit that includes an ideal operational amplifier. A student uses this circuit to amplify the signal from the sensor before further processing by the system.

Figure 2



0 3 . 1 Point X in **Figure 2** is said to be a virtual earth.

Explain the meaning of the term virtual earth in this type of circuit.

[2 marks]

____

____

____

0 3 . 2 The temperature sensor produces a signal that changes by 10 mV for every degree Celsius change in temperature. The signal is 0 mV when the temperature of the sensor is 0 °C.

The value of R_i is 22 kΩ and the value of R_f is 270 kΩ.

Calculate the output voltage V_{OUT} of the circuit in **Figure 2** when the sensor is at a temperature of 50 ºC.

[2 marks]

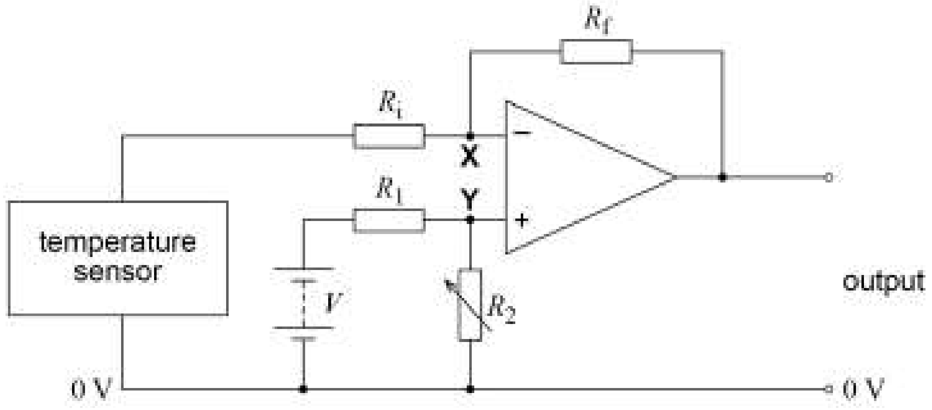
V_{OUT} = ____________________ V

0 3 . 3 The circuit is powered by a -15 V - 0 - +15 V supply. Explain why this circuit will not detect temperatures above 122 ºC.

[2 marks]

0 3 . 4 A student suggests a modification to the circuit in **Figure 2** to form a difference amplifier circuit for a thermostat. The modified circuit is shown in **Figure 3**.

Figure 3



The output controls a circuit that switches the heater off when the output is positive.

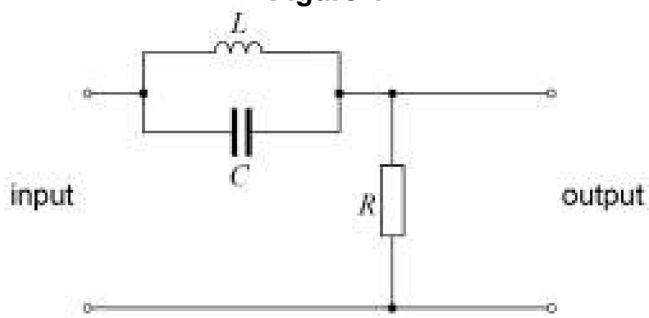
Explain how this circuit operates so that the heater switches off when the temperature reaches a pre-determined level.

[3 marks]

0 4 An engineer uses copper cable to connect an intercom system between her office and workshop. The signals have to travel a long distance and she finds that interference (hum) from the mains supply is a problem.
She reduces the interference using a filter tuned to the frequency of the mains supply. The mains frequency is 50 Hz.

Figure 4 shows her solution which is based on a parallel L–C resonant circuit.

Figure 4



0 4 . 1 The engineer uses a 2.0 H inductor.

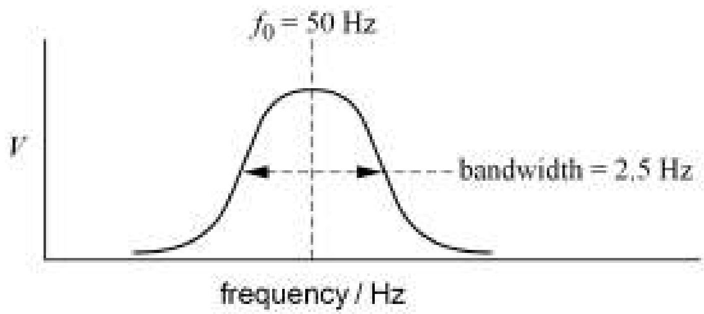
Calculate the required value for C for the filter to operate at 50 Hz.

[2 marks]

capacitance = ________________ F

Figure 5 is the response curve for the inductor-capacitor circuit which shows how the pd V across the inductor-capacitor circuit varies with frequency.

Figure 5



Question 4 continues on the next page

0 4 . 2 Calculate, from the graph, the Q factor of the inductor-capacitor circuit.

[1 mark]

Q factor = _______________

0 4 . 3 The inductor is replaced to one that has an inductance of 8.0 H and a lower resistance than that of the original inductor. The capacitor is not changed. Describe how this change affects the response curve of the inductor-capacitor circuit.

[2 marks]

___

___

___

___

0 5 Compare the advantages and disadvantages of optic fibre and copper wire for transmitting information.

[6 marks]

0 6 The Boolean equation for a particular logic circuit with inputs A and B and output Q is:

$$\mathbf{Q} = (\mathbf{A}.\mathbf{B}) + (\overline{\mathbf{A}}.\overline{\mathbf{B}})$$

0 6 . 1 **Table 1** shows intermediate logic signals for the circuit, and the overall output, Q, for all combinations of the inputs A and B.

Complete the missing two entries in the truth table.

[1 mark]

Table 1

A	B	$\overline{A}$	$\overline{B}$	A . B	$\overline{A}$. $\overline{B}$	Q
0	0	1	1	0	1	
0	1	1	0	0	0	0
1	0	0	1	0		0
1	1	0	0	1	0	1

0 6 . 2 Complete the diagram in **Figure 6** to show the logic circuit that has the same function as the Boolean equation given in part 6**.** Your circuit should contain only **two** AND gates, **two** NOT gates, and **one** OR gate.

[3 marks]

Figure 6

END OF QUESTIONS

There are no questions printed on this page.