

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

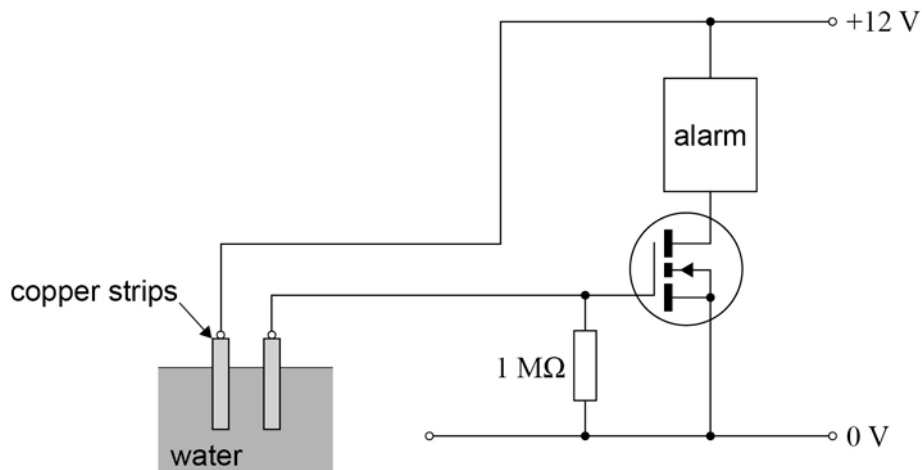
MOSFETs are commonly used in circuits where low power consumption is important to extend battery life.

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 MΩ 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 = _____ M Ω

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.

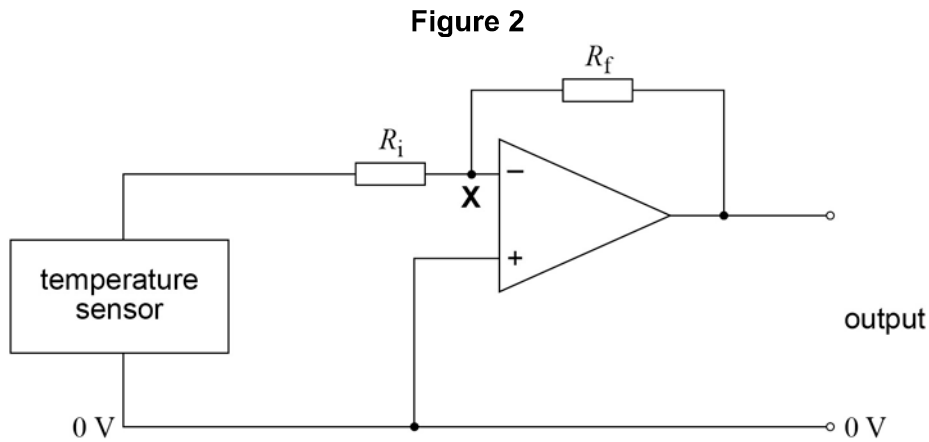
[1 mark]

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.



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 k Ω and the value of R_f is 270 k Ω .

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

[2 marks]

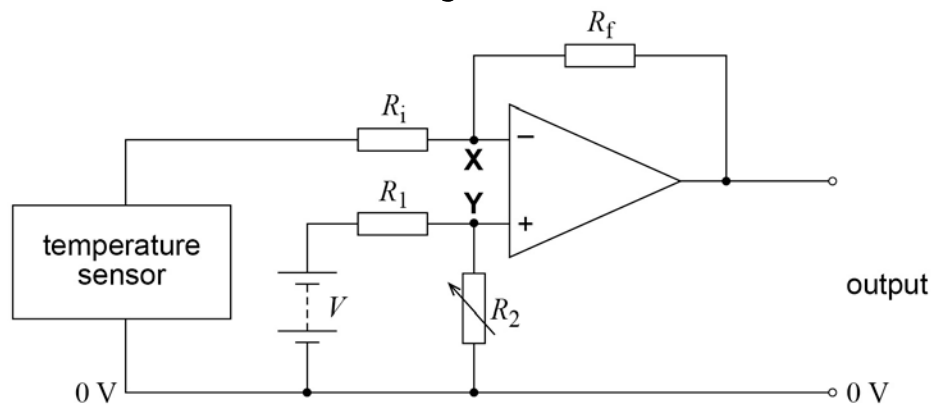
$V_{OUT} =$ _____ V

- 0 3 . 3** The circuit is powered by a $-15\text{ V} - 0 - +15\text{ V}$ supply. Explain why this circuit will not detect temperatures above $122\text{ }^{\circ}\text{C}$.

[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.

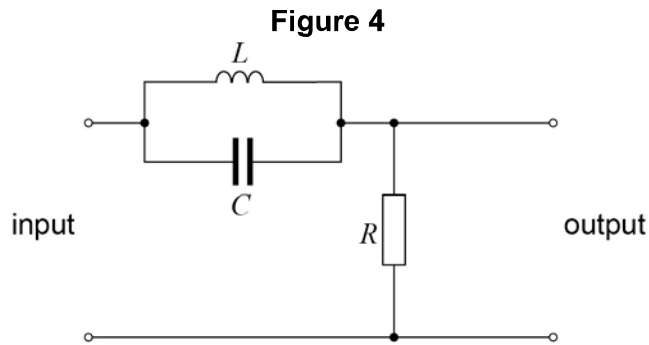
Explain how this circuit operates so that the heater switches off when the temperature reaches a pre-determined level.

[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.



0 4

. 1

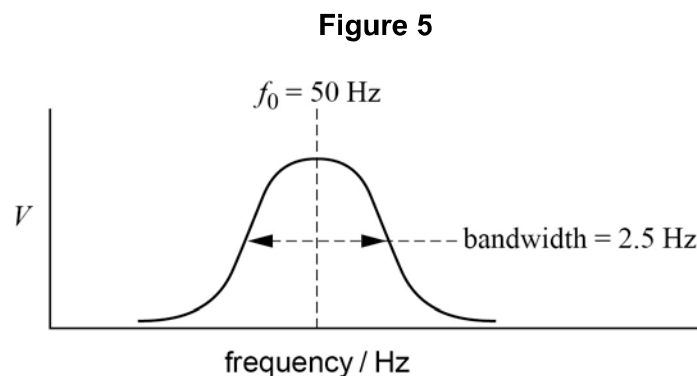
The engineer uses a 2.0 H inductor.

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.



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 6

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

$$Q = (A \cdot B) + (\bar{A} \cdot \bar{B})$$

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	\bar{A}	\bar{B}	A . B	$\bar{A} \cdot \bar{B}$	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

A ○ —

B ○ —

— ○ Q

END OF QUESTIONS

There are no questions printed on this page.