Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

A-level PHYSICS

Paper 3BE – Electronics

Specimen materials (set 2)

Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 50 minutes on this section.

Materials

For this paper you must have:
- a pencil
- a ruler
- a scientific calculator
- a Data and Formulae booklet.

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.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 35.
- You are expected to use a calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

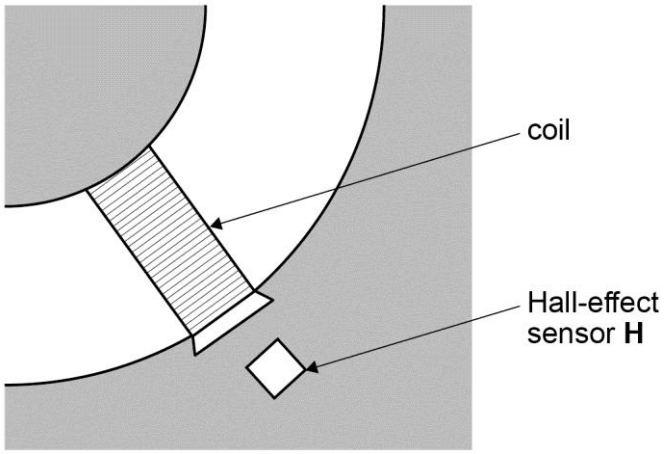
For examiner's use	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	

Section B

Answer **all** questions in this section.

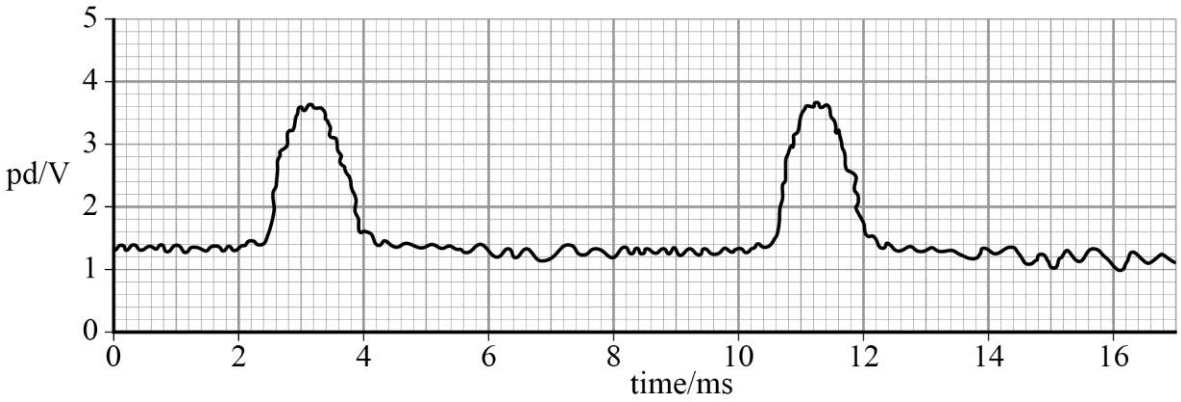
0 1 **Figure 1** shows part of the motor from a computer disk drive.

Figure 1



On each rotation a small magnet passes a Hall-effect sensor **H** which detects the change in magnetic field and produces an output potential difference (pd) that varies with time as shown in **Figure 2**.

Figure 2



0 1 . 1 Determine the speed of the motor in revolutions per second.

[2 marks]

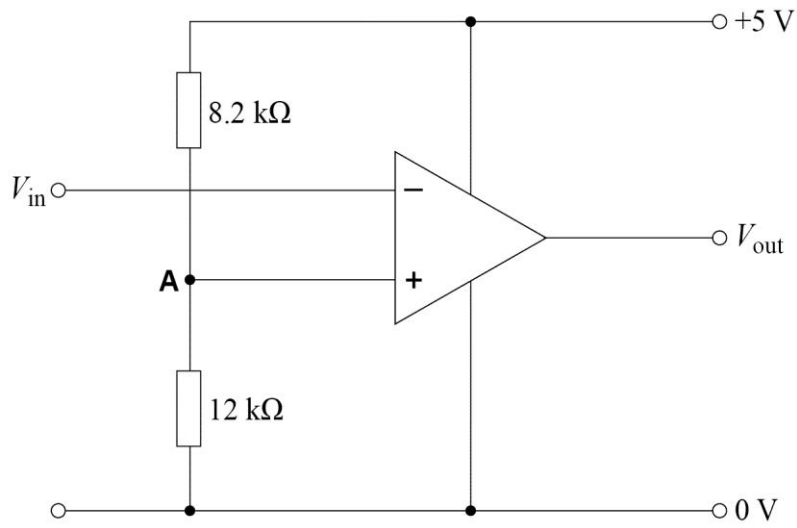
speed of motor = _____ rev s^{-1}

0 1 . 2 Explain why the output from the magnetic field sensor is unsuitable to be applied directly to the logic circuit of the motor controller.

[1 mark]

0 1 . 3 The signal from the magnetic field sensor is applied to the circuit shown in **Figure 3**.

Figure 3



Show that the potential of point **A** is about +3 V.

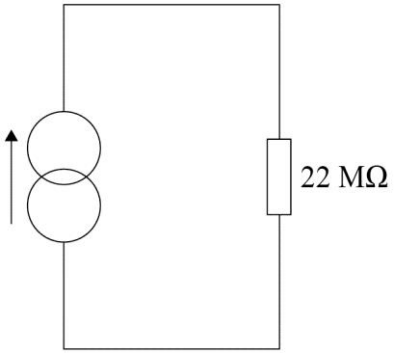
[1 mark]

0 1 . 4 Draw on **Figure 2** the waveform showing the variation with time of the output voltage V_{out} of the circuit shown in **Figure 3**.

[2 marks]

0 2 **Figure 4** shows a constant-current generator connected to a 22 MΩ resistor.

Figure 4



0 2 . 1 The output from the current generator is 5.0×10^{-10} A.

Show that the magnitude of the pd across the 22 MΩ resistor is about 10 mV.

[1 mark]

0 2 . 2 A student tries to measure this voltage with a digital voltmeter set on the 200 mV range. The resistance of the meter on this range is 1.0 MΩ.

Explain why the meter does **not** read 10 mV.

[2 marks]

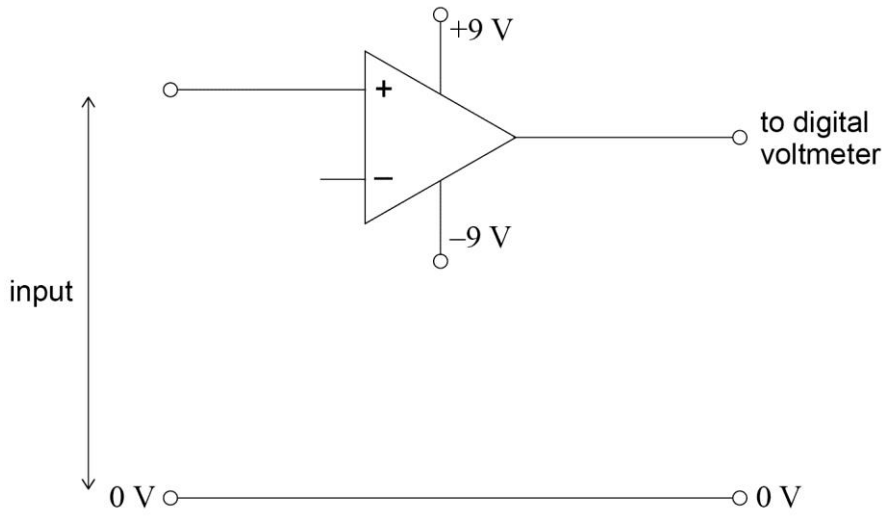
0 2 . 3 The student then decides to use a non-inverting operational amplifier to interface to the digital voltmeter.

Discuss the important property that makes this configuration a suitable choice.

[2 marks]

0 2 . 4 **Figure 5** shows a partly-drawn circuit diagram for the non-inverting amplifier.

Figure 5



Complete **Figure 5** to form a non-inverting amplifier by adding **two** labelled resistors and any connections that are needed.

[2 marks]

0 2 . 5 The values of the two resistors added to **Figure 5** are to give the non-inverting amplifier a voltage gain of 20. The resistance of the smaller of these two resistors is 500 kΩ.

Which of the following is the correct resistance for the other resistor?
Tick (✓) the correct answer in the right-hand column.

[1 mark]

	✓ if correct
1.0 MΩ	
9.5 MΩ	
10.0 MΩ	
10.5 MΩ	

0 2 . 6 Justify your choice of resistance value by calculation.

[1 mark]

9

0 3 A student needs to monitor the temperature of a pond using a remote link. To provide the link the student decides to use radio transmitter and receiver modules.

The radio modules available to the student are available with either amplitude modulation (AM) or with frequency modulation (FM).

0 3 . 1 Describe what is meant by amplitude-modulated and by frequency-modulated radio waves.

In your answer you should:

- indicate the principal features of each of these two types of modulation
- explain the differences between them
- refer to the advantages and disadvantages of using each type of modulation.

[6 marks]

0 3 . 2 The radio modules chosen by the student transmit a signal that is amplitude modulated having a carrier frequency of $434\,\text{MHz}$. The data sheet for the modules specifies quarter-wave aerials for both the transmitter and receiver.

Calculate the length of a quarter-wave aerial.

[2 marks]

length of aerial = _____ m

0 3 . 3 The output from the temperature sensor in the pond is connected to an astable oscillator. The frequency f (in Hz) of the astable varies with temperature θ (in °C) according to the equation

$$f = 7.3(6\theta + 273)$$

During the course of the year the temperature of the pond varies between $4°\text{C}$ and $22°\text{C}$. The highest frequency produced by the astable is $3.0\,\text{kHz}$.

Calculate the lowest frequency in kHz produced by the astable.

[1 mark]

lowest frequency = _____ kHz

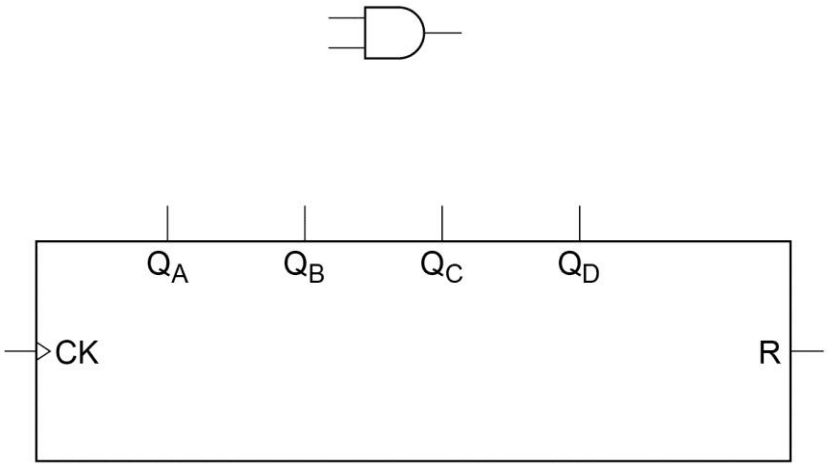
0 3 . 4 Deduce the maximum bandwidth required by the AM carrier wave produced by the radio transmitter as the signal from the astable is transmitted.

[2 marks]

0 4 . 1 Draw connections on **Figure 6** to show how the 4-bit binary counter could be used to form a binary coded decimal (BCD) counter.

[2 marks]

Figure 6



An automatic bread maker has 10 discrete processes. These are shown in the following table. The processes are controlled by the BCD counter.

Process number	Process	Action
0	OFF	add ingredients
1	mix ingredients	motor on
2	warm ingredients	heater on
3	add yeast	add ingredients
4	mix dough	motor on
5	warm ingredients	heater on
6	mix dough	motor on
7	warm ingredients	heater on
8	cook	heater on
9	switch heater OFF	alert that bread is cooked

0 4 . 2 Identify and write down the process numbers from the table that correspond to each of the actions when the heater is on. Convert each of these numbers into their binary values.

[1 mark]

0 4 . 3 Show, by reference to the labelled terminals on the counter in **Figure 6**, that the Boolean expression for the conditions when the heater is on is

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

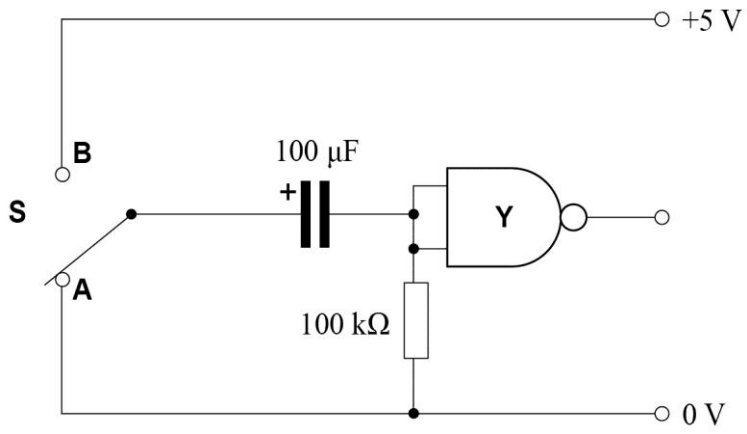
[2 marks]

5

Turn over for the next question

0 5 A student experiments with the circuit shown in **Figure 7.**

Figure 7



Y is a NAND gate for which an input of less than 2.5 V is logic state 0 and input greater than 2.5 V is logic state 1.

Switch **S** is set to position **A** for a long time so that the capacitor is uncharged.

0 5 . 1 Explain why the output of **Y** is logic state 1.

[1 mark]

0 5 . 2 When **S** is moved to position **B**, the capacitor charges through the 100 kΩ resistor.

Show that the capacitor will be charged to 2.5 V after about 7 s.

[2 marks]

0 5 . 3 Suggest an application for a circuit such as that shown in **Figure 7**.

[1 mark]

END OF QUESTIONS

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