

Please write clearly in block capitals.

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Candidate number

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Candidate signature

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I declare this is my own work.

# A-level PHYSICS

Paper 3

Section B Electronics

Friday 5 June 2020

Afternoon

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 and 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.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- 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 scientific 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	
<b>TOTAL</b>	



J U N 2 0 7 4 0 8 3 B E 0 1

1B/M/Jun20/E8

**7408/3BE**

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ANSWER IN THE SPACES PROVIDED**

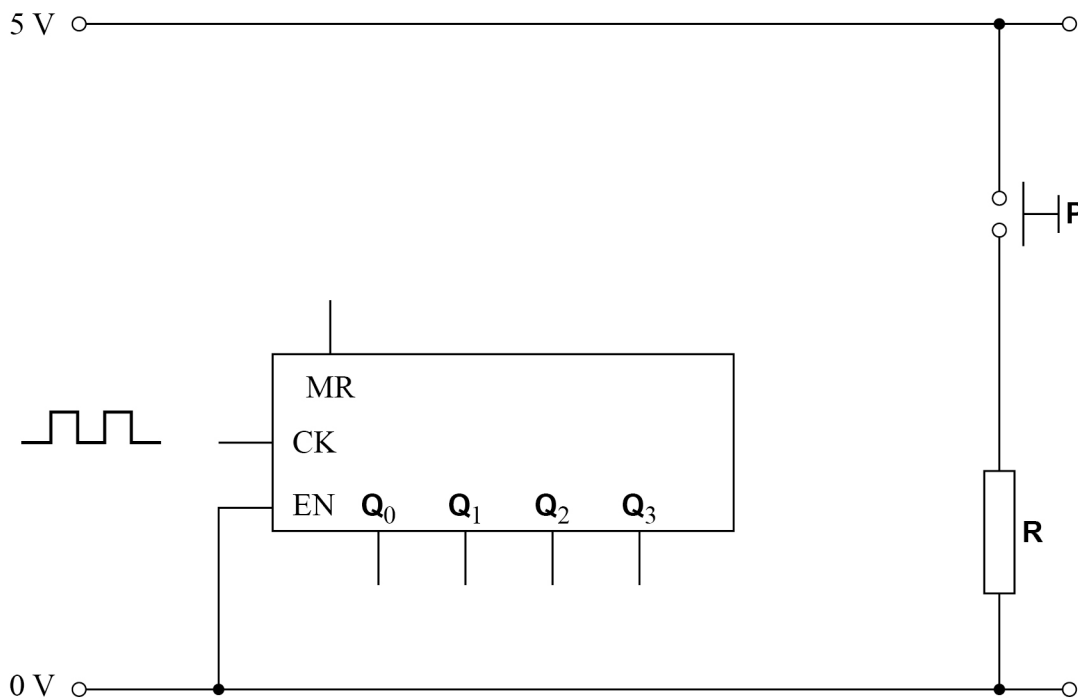
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**Section B**Answer **all** questions in this section.**0 1****Figure 1** shows part of a circuit that includes a 4-bit binary counter. The main inputs and outputs of the counter are shown.

The counter generates a sequence of binary codes representing the decimal numbers 0 to 7

Output  $Q_0$  is the least significant bit of the binary codes.**Figure 1**

The counter resets when the master reset pin MR receives a logic 1

The circuit requires the counter to reset when either one of two conditions is met.

**Condition 1** Manual reset using the switch **P** to reset the counter to 0**Condition 2** Automatic reset when an appropriate binary code is produced at the counter outputs. This will cause the counter to continually cycle through the decimal numbers 0 to 7**0 1 . 1**Complete **Figure 1** to show how both reset conditions can be met.Do **not** show the power line connections to the integrated circuit.**[3 marks]****Question 1 continues on the next page****Turn over ►**

0 1 2

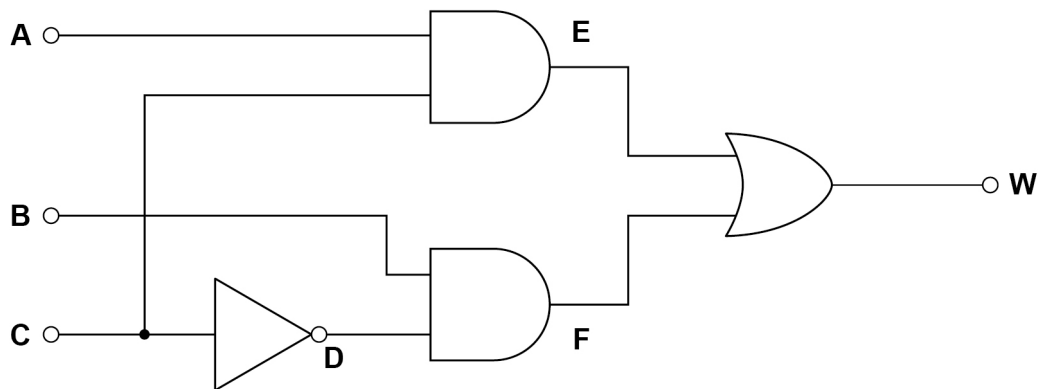
A logic system is designed to identify prime numbers.

The binary codes from the counter are now applied to the inputs **ABC** of the logic system shown in **Figure 2**.

Input **A** takes the least significant bit of the binary code from the counter.

Output **W** becomes logic state 1 when a prime number 2, 3, 5 or 7 is detected.  
Otherwise output **W** is at logic 0

**Figure 2**



Write the Boolean algebra expression for output **W** in terms of the inputs **A**, **B** and **C**.  
The expression must contain only the four logic gate operations shown in **Figure 2**.

**[2 marks]**

**W** = \_\_\_\_\_



**0 1 . 3** Complete **Table 1**, the truth table for the logic system in **Figure 2**.

[1 mark]

**Table 1**

Decimal number	C	B	A	D	E	F	W
0	0	0	0	1	0		0
1	0	0	1	1	0		0
2	0	1	0	1	0		1
3	0	1	1	1	0		1
4	1	0	0	0	0		0
5	1	0	1	0	1		1
6	1	1	0	0	0		0
7	1	1	1	0	1		1

**0 1 . 4** The logic system in Question **01.2** is replaced with one that gives an output **S** using the same binary input codes **CBA**.

The Boolean algebra equation for output **S** is

$$S = \overline{A} \cdot (B + C)$$

Deduce which decimal numbers 0 to 7 will cause **S** to become logic 1

[1 mark]

Question 1 continues on the next page

Turn over ►



**0 1 . 5** Complete **Figure 3** by drawing the logic system for **S**.

You must use only the logic gate operations given in  $S = \overline{A} \cdot (B + C)$

[2 marks]

**Figure 3**

**A** ○ —

**B** ○ —

**C** ○ —

— ○ **S**



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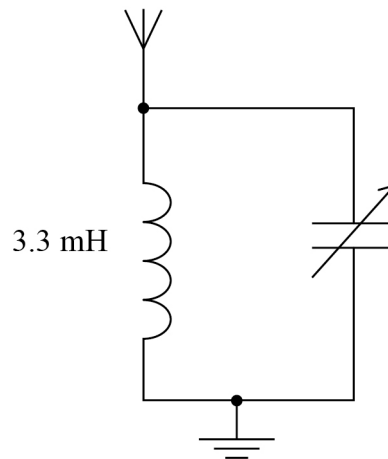


0 2

**Figure 4** shows the filter circuit that forms the first stage in an amplitude modulated (AM) radio receiver.

The circuit contains a 3.3 mH inductor and a variable capacitor.

**Figure 4**



0 2

1

The circuit is tuned to receive a radio station transmitting at a frequency of 1053 kHz.

Calculate the value of the capacitance needed to receive this station.

**[1 mark]**

capacitance = \_\_\_\_\_ pF





0 2 . 2

The circuit is retuned to receive a different radio station by setting the variable capacitor to a value of 9.3 pF.

**Table 2** shows the capacitance range of four variable capacitors **W**, **X**, **Y** and **Z**.

Comment on the suitability of these capacitors for this application and state your preference.

[2 marks]

**Table 2**

Capacitor	Range / pF
<b>W</b>	2–9
<b>X</b>	3–10
<b>Y</b>	4.5–20
<b>Z</b>	10–50

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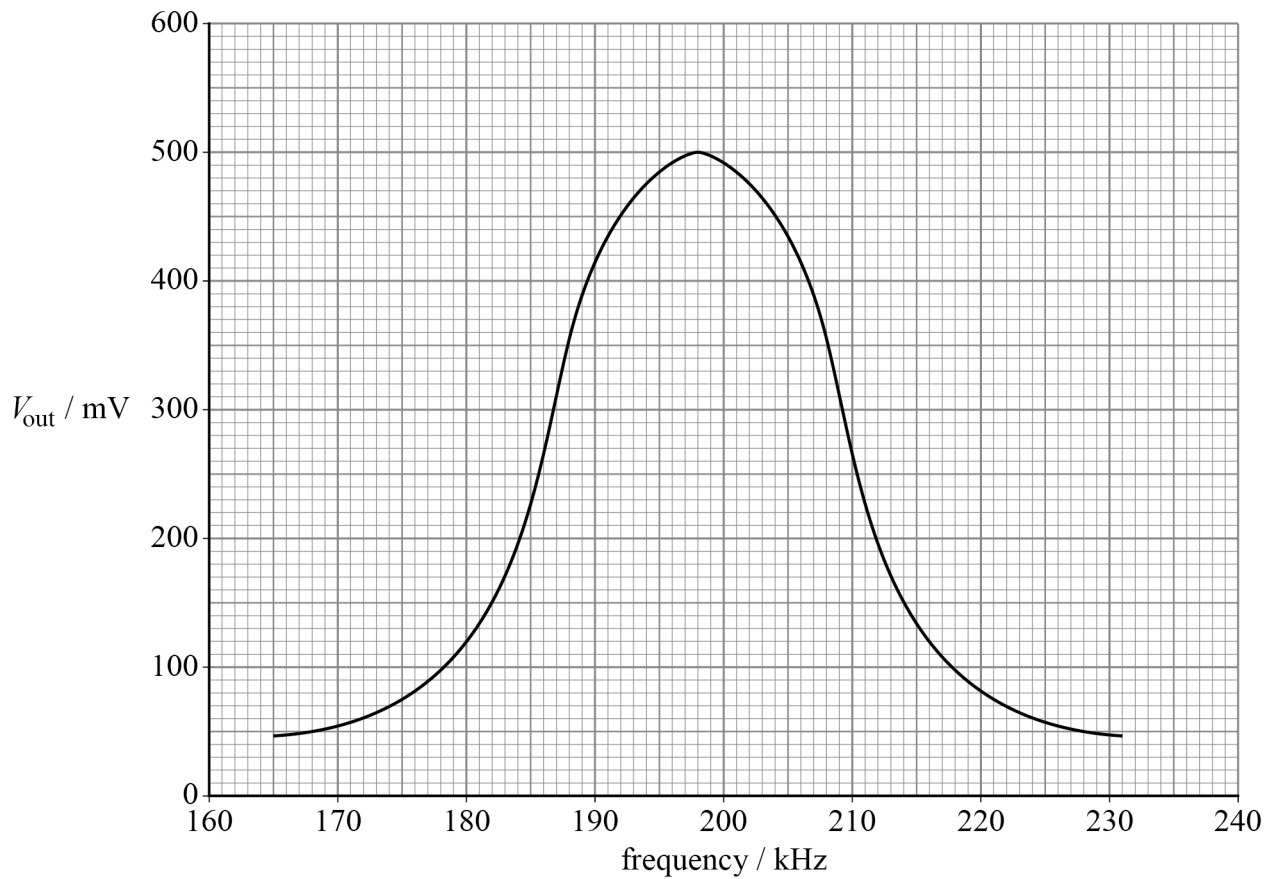
**Question 2 continues on the next page**

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**0 2 . 3** Figure 5 shows part of the frequency response curve for a different filter circuit.

**Figure 5**



Determine the bandwidth of the filter circuit.

**[2 marks]**

bandwidth = \_\_\_\_\_ kHz



0 2 . 4

Calculate the  $Q$  factor of the filter circuit in Question 02.3.

[1 mark]

 $Q$  factor = \_\_\_\_\_

0 2 . 5

The radio station is tuned using a different filter circuit with a very low  $Q$  factor.State and explain **one** effect of this change on the sound heard by a listener.

[1 mark]

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**0 3**

Pulse code modulation (PCM) is used to encode live music as an uncompressed digital audio file.

Sampling of the analogue signal is carried out at 44.1 kHz.

A 16-bit system is used to encode each of the two channels that make up the stereo signal.

**0 3 . 1**

Explain why the sampling frequency used is suitable for this task.

**[2 marks]**

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**0 3 . 2**

Calculate the number of quantisation levels available on a 16-bit encoding system.

**[1 mark]**

number of quantisation levels = \_\_\_\_\_



0 3 . 3

A recorded piece of stereo music lasts for 3.5 minutes.

Calculate the size, in megabytes, of the digital file needed to store this recording.

**[2 marks]**

file size = \_\_\_\_\_ megabytes

0 3 . 4

The music file is used by a call centre to play as background music while a phone call is on hold. However, the telephone network is designed to use a bandwidth of 0.3 kHz – 3.4 kHz.

Compare the quality of the music heard by the telephone caller with that of the original file heard when played directly from a compact disc.

**[2 marks]**

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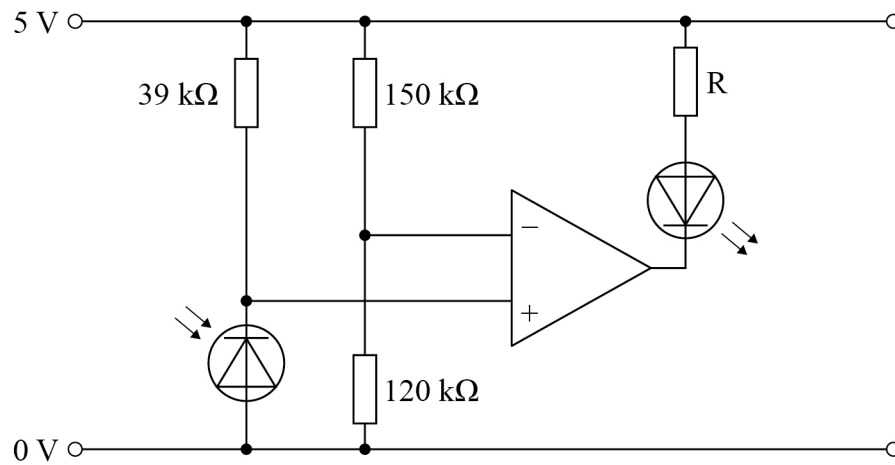
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0 4

**Figure 6** shows a circuit containing a photodiode and an ideal operational amplifier. This circuit is used to monitor the intensity of monochromatic radiation.

**Figure 6**

0 4 . 1

What is the configuration of the operational amplifier circuit shown in **Figure 6**? Tick (✓) **one** box.

**[1 mark]**

comparator

☐

differential amplifier

☐

inverting amplifier

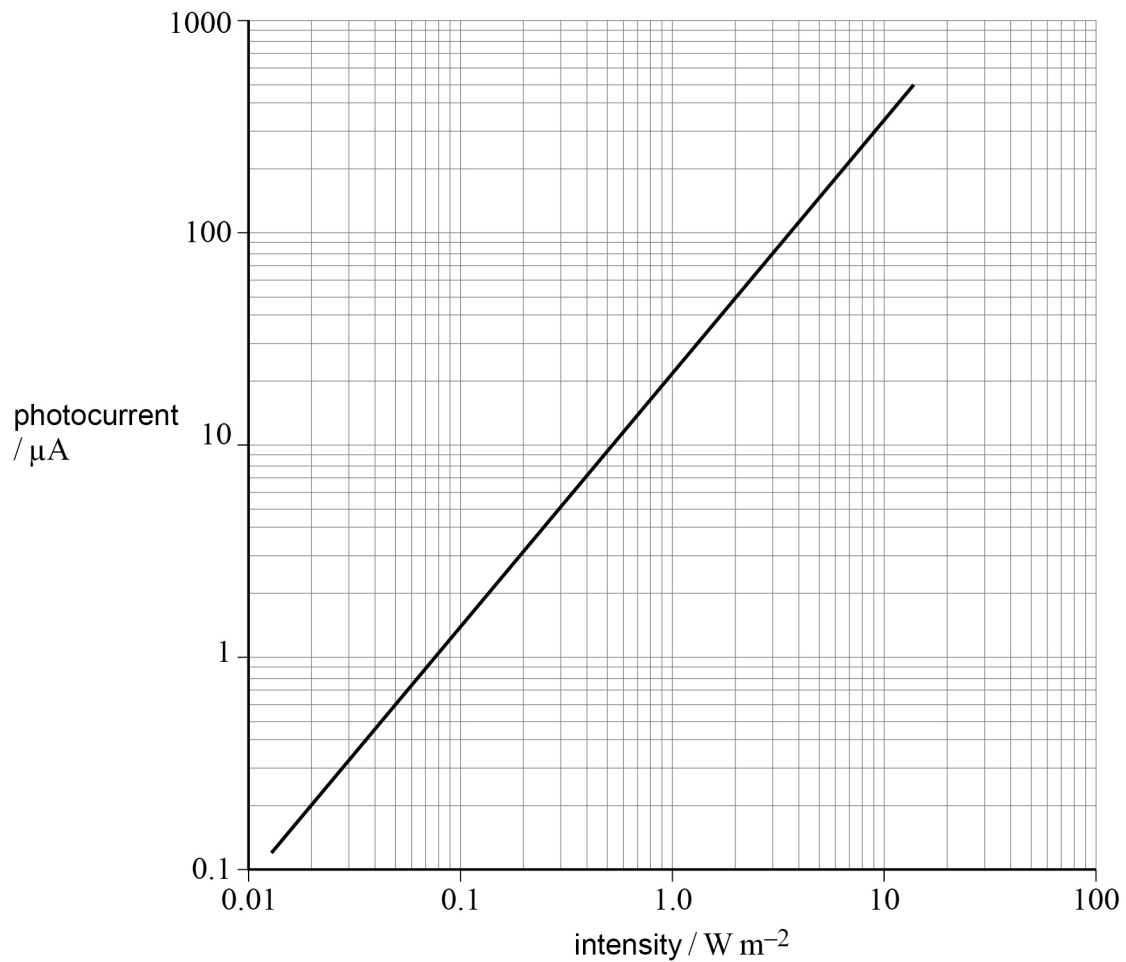
☐

non-inverting amplifier

☐

0 4 . 2

**Figure 7** shows the variation of photocurrent with intensity for the monochromatic radiation incident on the photodiode.

**Figure 7**

Radiation of intensity  $3.0 \text{ W m}^{-2}$  is incident on the photodiode.

Show that the voltage at the non-inverting terminal ( $V_+$ ) of the operational amplifier is 1.9 V.

**[3 marks]**

**Question 4 continues on the next page**

**Turn over ►**



0	4	.	3
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The intensity of radiation incident on the photodiode remains at  $3.0 \text{ W m}^{-2}$ .

Deduce whether the light-emitting diode (LED) in **Figure 6** is on or off.

**[2 marks]**

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6

END OF QUESTIONS



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