Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

A-level PHYSICS

Paper 3
Section B Electronics

Thursday 29 June 2017 Morning

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.
- 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	
TOTAL	

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

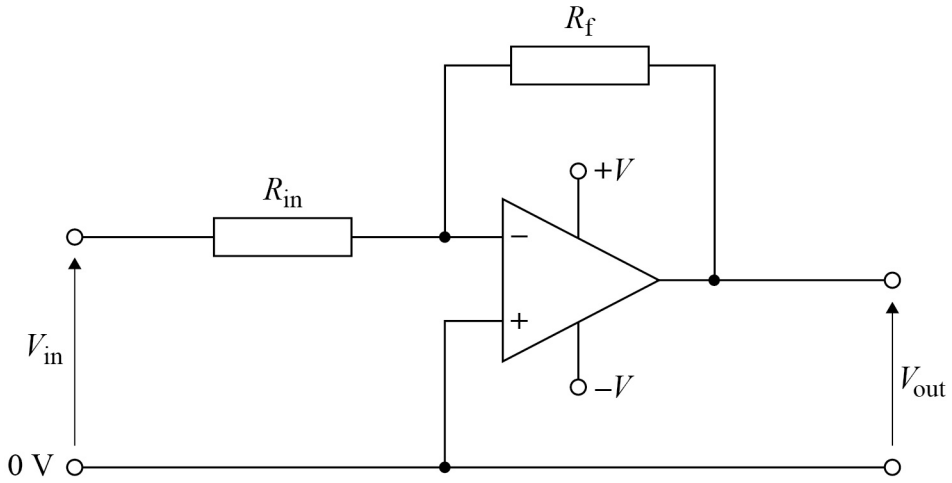
Do not write outside the box

Section B

Answer **all** questions in this section.

0 1 **Figure 1** shows an operational amplifier used as an inverting amplifier.

Figure 1



0 1 . 1 Label **Figure 1** with an **X** to show the point which is a virtual earth.

[1 mark]

0 1 . 2 Name the input pin shown by a (+) on the operational amplifier.

[1 mark]

0 1 . 3 Derive the expression for the inverting amplifier gain $\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$

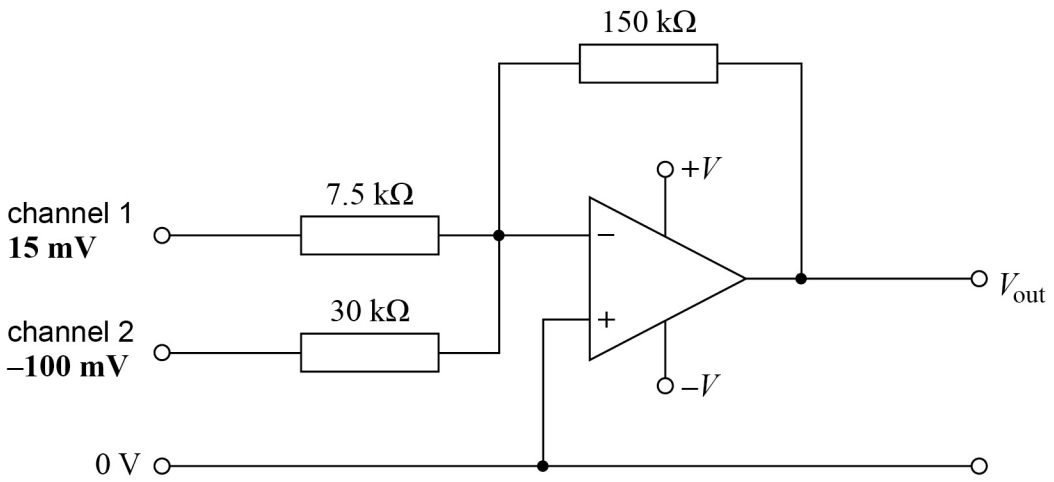
[2 marks]

Question 1 continues on the next page

Do not write outside the box

0 1 . 4 **Figure 2** shows the inverting amplifier modified to make a summing amplifier that is to form part of a two-channel audio mixer.

Figure 2



Calculate the voltage gain produced by channel 1.

[1 mark]

voltage gain (channel 1) = _____

0 1 . 5 The mixer is tested using the input signals to channels 1 and 2 with the amplitudes shown in **Figure 2**.

Calculate the amplitude of the output voltage V_{out} produced in the test.

[2 marks]

V_{out} = _____ V

Do not write outside the box

0 1 . 6 Describe how the function of the audio mixer could be improved by changing the two input resistors from fixed values to variable values.

[1 mark]

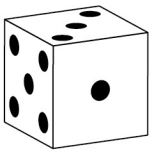
8

Turn over for the next question

Do not write outside the box

0 2 A die, where dots on the faces of a cube indicate the numbers 1 to 6, is shown in **Figure 3** and is used in many games.

Figure 3



A student makes an electronic version of this by feeding pulses from a pulse generator into a 4-bit binary counter.

The circuit uses the first three outputs of the counter A (least significant bit), B and C.

By feeding the outputs from the counter through logic gates, the seven LEDs shown in **Figure 4** can be made to display the numbers 1 to 6 in sequence.

Figure 4

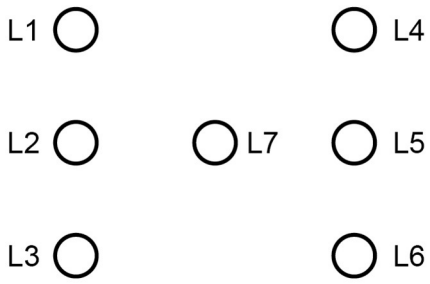
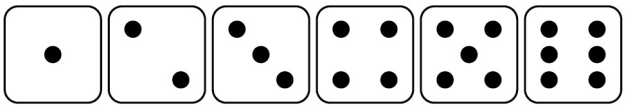


Figure 5 shows the sequence of numbers.

Figure 5



The black dots show which LEDs are lit for each of the numbers 1 to 6.

Do not write outside the box

The partially completed truth table in **Table 1** shows which of the LEDs (L1 to L6) are ON (logic 1) and which are OFF (logic 0) during the counting sequence.

Table 1

Number shown on die	Logic inputs			Logic outputs						
	C	B	A	L1	L2	L3	L4	L5	L6	L7
1	0	0	0		0	0	0	0		1
2	0	0	1		0	0	0	0		0
3	0	1	0		0	0	0	0		1
4	0	1	1		0	1	1	0		0
5	1	0	0		0	1	1	0		1
6	1	0	1		1	1	1	1		0
Reset 6 → 1										

0 2 . 1 Complete **Table 1** to show the logic outputs for the lamps L1 and L6.

[2 marks]

0 2 . 2 Deduce the **simplest** Boolean expression that can be used to show how output L7 can be controlled by the logic inputs.

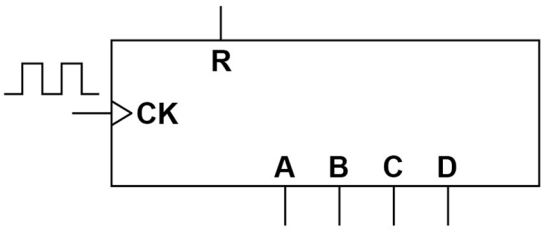
[1 mark]

Question 2 continues on the next page

Do not write outside the box

0 2 . 3 **Figure 6** shows some of the input and output pins of the 4-bit binary counter.

Figure 6



The data sheet for the counter indicates that the counter resets when the reset pin **R** is taken from logic 0 to logic 1.

Draw on **Figure 6** the logic gate needed and the connections required from the outputs to the reset pin **R** on the counter so that the counter cycles as required.

[2 marks]

Do not write outside the box

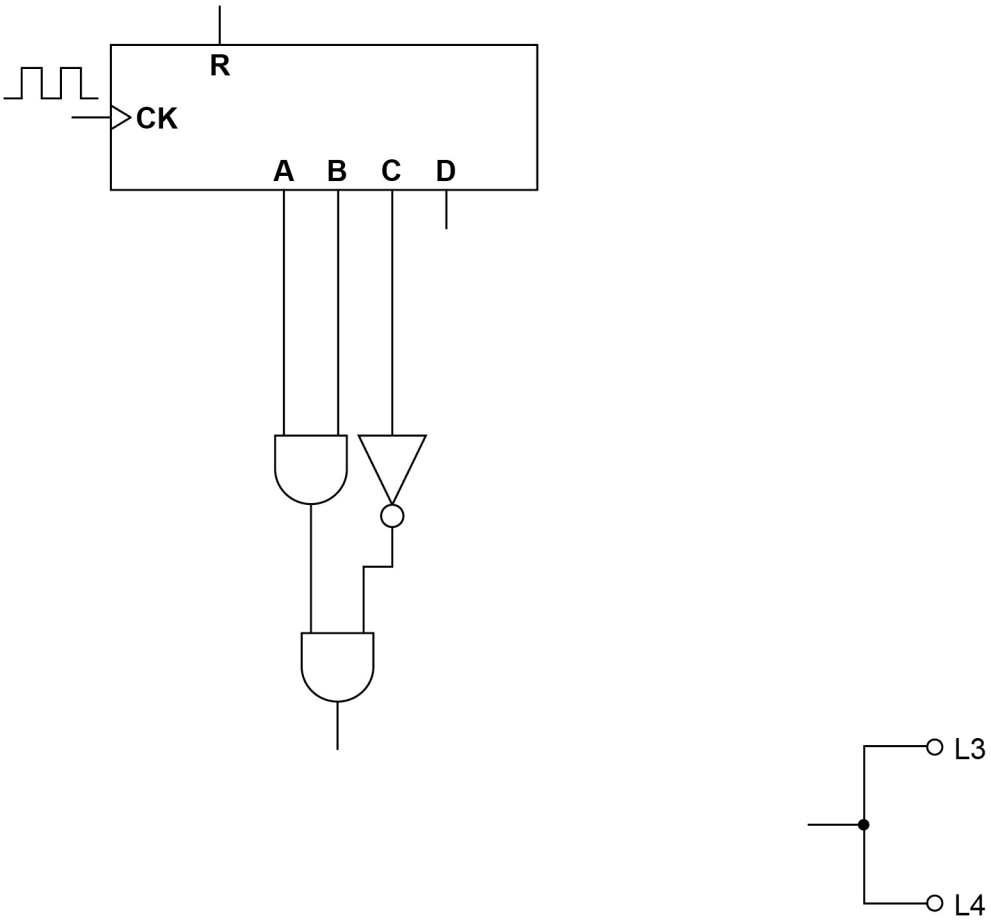
0 2 . 4 The output of both L3 and L4 can be written as **(A . B . $\overline{C}$) + ($\overline{B}$. C)**

Figure 7 shows part of a logic circuit needed to represent this Boolean expression.

Complete the logic circuit in **Figure 7** by adding AND, OR and NOT gates.

[3 marks]

Figure 7



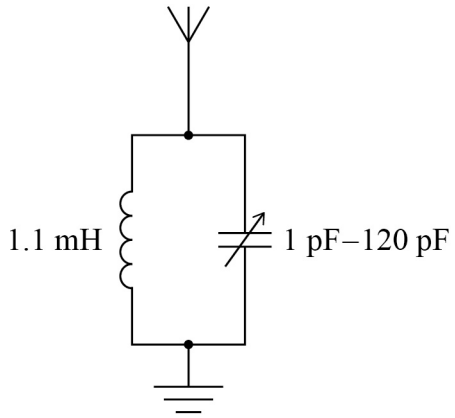
8

Turn over for the next question

Do not write outside the box

0 3 **Figure 8** shows the first-stage filter circuit for a simple AM receiver. The circuit can be adjusted to resonate at 910 kHz so that it can receive a particular radio station.

Figure 8



0 3 . 1 Calculate the value of the capacitance when the circuit resonates at a frequency of 910 kHz.

[2 marks]

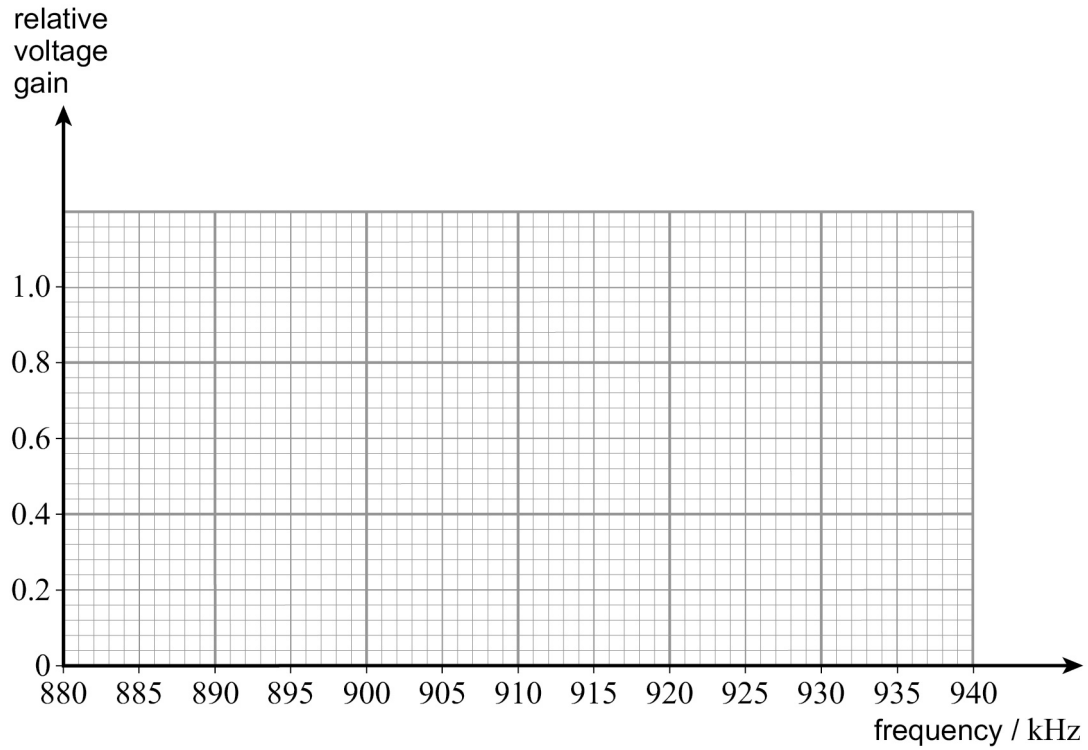
capacitance = _____ pF

Do not write outside the box

0 3 . 2 Draw on **Figure 9** an ideal response curve for the resonant circuit, labelling all relevant frequency values based upon a 10 kHz bandwidth.

[3 marks]

Figure 9



0 3 . 3 The *Q*-factor for the practical tuning circuit has a smaller value than the ideal one assumed in question **03.2**.

Discuss the changes the listener might notice when tuning to this station due to the practical *Q*-factor being smaller.

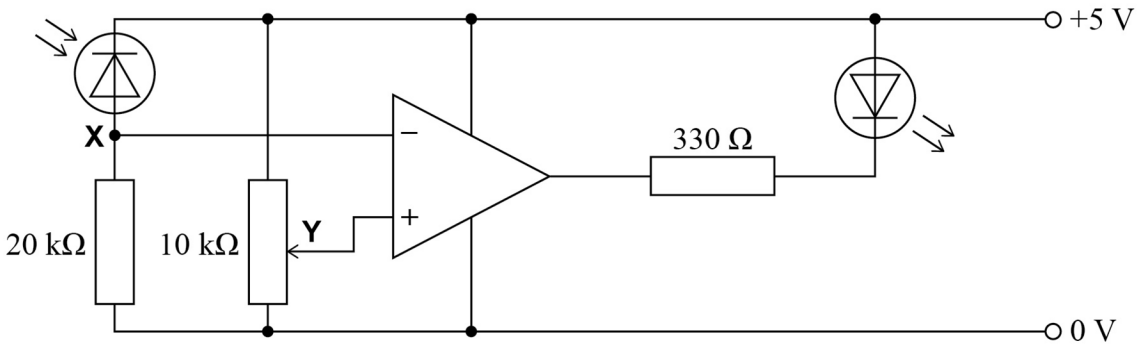
[2 marks]

7

Do not write outside the box

0 4 A photodiode forms part of a light meter used for checking light levels in an office. **Figure 10** shows the circuit diagram for the light meter.

Figure 10



0 4 . 1 State the mode in which the photodiode is being used in **Figure 10**.

[1 mark]

0 4 . 2 In which mode is the operational amplifier being used in **Figure 10**?

Tick (✓) the correct box.

[1 mark]

Non-inverting amplifier ☐

Comparator ☐

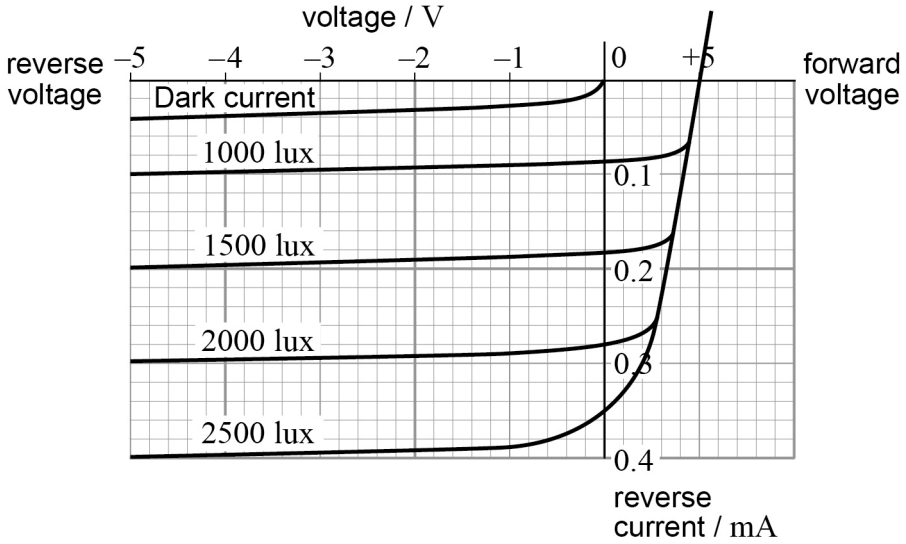
Summing amplifier ☐

Difference amplifier ☐

Do not write outside the box

0 4 . 3 **Figure 11** shows an extract from a data sheet of the characteristics for a photodiode under different light levels measured in lux.

Figure 11



For a particular lighting condition, the current through the photodiode in **Figure 10** was 0.10 mA.

Estimate, using the information in **Figure 11**, the light level needed to cause this reverse current through the photodiode.

[1 mark]

light level = _____ lux

0 4 . 4 Calculate the voltage at point **X** in the circuit shown in **Figure 10** for the light level in question **04.3**.

[1 mark]

voltage = _____ V

Question 4 continues on the next page

Do not write outside the box

0 4 . 5 The $10\ \text{k}\Omega$ linear potential divider shown in **Figure 10** is set to give $1.75\ \text{V}$ at point **Y**.
Assume that the operational amplifier has ideal characteristics.

Deduce whether the output LED would be switched ON or OFF when the current through the photodiode is $0.10\ \text{mA}$.

[2 marks]

6

Do not write outside the box

0 5 Discuss how longwave (LW), shortwave (SW) and microwave links can be used to communicate beyond the visible horizon.

For each link, you should give:

- a typical carrier frequency that is used
- an explanation of how the signals travel from the transmitter to the receiver
- a typical use.

You may use a diagram to help make clear aspects of your answer.

[6 marks]

Extra space is available on the next page if needed

6

END OF QUESTIONS

Copyright Information

For confidentiality purposes, from the November 2015 examination series, acknowledgements of third party copyright material will be published in a separate booklet rather than including them on the examination paper or support materials. This booklet is published after each examination series and is available for free download from www.aqa.org.uk after the live examination series.

Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and AQA will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team, AQA, Stag Hill House, Guildford, GU2 7XJ.

Copyright © 2017 AQA and its licensors. All rights reserved.