

## 9: Electricity and electronics – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

Question	Year	Series	Paper number
3	2017	June	41
5	2017	June	41
6	2017	June	41

The mark scheme for each question is provided at the end of the document.

- 3 The digital transmission of speech may be illustrated using the block diagram of Fig. 3.1.

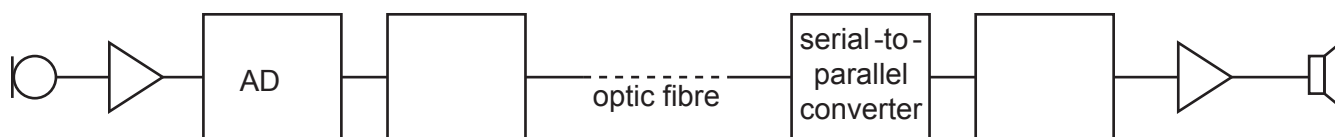


Fig. 3.1

- (a) (i) State what is meant by a *digital signal*.

.....  
 .....[1]

- (ii) State the names of the components labelled and on Fig. 3.1.

.....  
 .....[2]

- (iii) Describe the function of the AD .

.....  
 .....  
 .....[2]

- (b) The optic fibre has length m and the attenuation per unit length in the fibre is  $0.19 \text{ dB m}^{-1}$ .

The input power to the optic fibre is  $9.7 \text{ mW}$ . At the output from the optic fibre, the signal-to-noise ratio is  $2 \text{ dB}$ .

Calculate

- (i) In dB, the ratio

$$\frac{\text{input power to optic fibre}}{\text{noise power at output of optic fibre}},$$

ratio ..... dB [2]

(ii) the noise power at the output of the optic fibre.

noise power ..... [3]

[Total 10]

- 5 An  $\alpha$ -particle is travelling in a vacuum towards the centre of a gold nucleus, as illustrated in Fig. 5.1.



**Fig. 5.1**

The gold nucleus has charge  $79e$ .

The gold nucleus and the  $\alpha$ -particle may be assumed to behave as point charges.

At a large distance from the gold nucleus, the  $\alpha$ -particle has energy  $7.7 \times 10^{-13} \text{ J}$ .

- (a) The  $\alpha$ -particle does not collide with the gold nucleus. Show that the radius of the gold nucleus must be less than  $1.7 \times 10^{-14} \text{ m}$ .

[3]

- (b) Determine the acceleration of the  $\alpha$ -particle for a separation of  $1.7 \times 10^{-14} \text{ m}$  between the centres of the gold nucleus and of the  $\alpha$ -particle.

acceleration .....  $\text{ms}^{-2}$  [3]

- (c) In an  $\alpha$ -particle scattering experiment, the beam of  $\alpha$ -particles is incident on a very thin gold foil.

Suggest why the gold foil must be very thin.

.....  
 ..... [1]

[Total 7]

- 6 A comparator circuit is designed to switch on a mains lamp when the ambient light level reaches a set value.  
An incomplete diagram of the circuit is shown in Fig. 6.1.

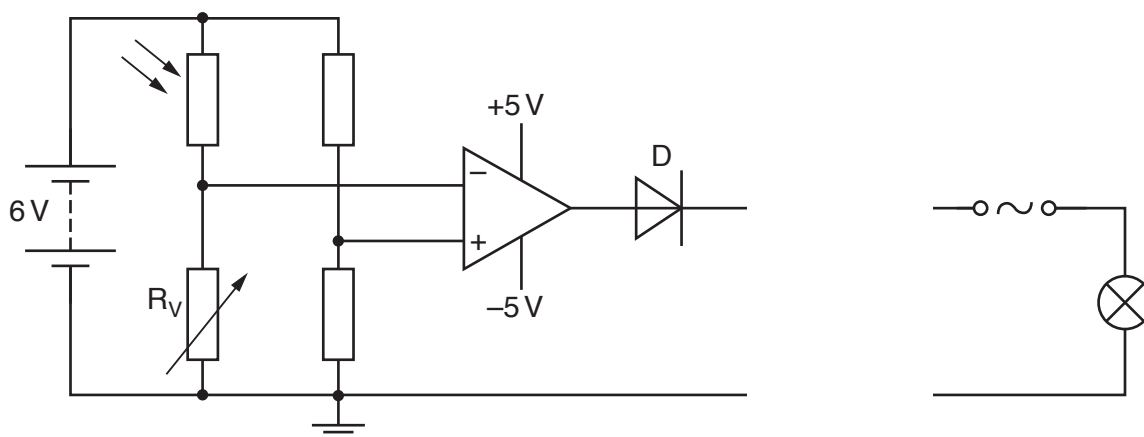


Fig. 6.1

- (a) (i) A relay is required as part of the output device. This is not shown in Fig. 6.1. Explain why a relay is required.

.....  
 .....  
 .....[2]

- (ii) On Fig. 6.1, draw the symbol for a relay connected in the circuit as part of the output device. [2]

- (b) Describe the function of

- (i) the variable resistor  $R_v$ ,

.....  
 .....[1]

- (ii) the diode D.

.....  
 .....[1]

(c) State whether the lamp will switch on as the light level increases or as it decreases. Explain your answer.

.....

.....

.....

.....

.....[3]

[Total: 9]

Question	Answer	Marks
3 (a) (i)	signal consists of (a series of) 1s and 0s <b>or</b> offs and ons <b>or</b> highs and lows	1
3 (a) (ii)	component X: parallel-to-serial converter	1
	component Y: DAC/digital-to-analogue converter	1
3 (a) (iii)	sample the (analogue) signal	1
	at regular intervals and converts the analogue number to a digital number	1
3 (b) (i)	attenuation in fibre = $84 \times 0.19$ (= 16 dB)	1
	ratio = $16 + 28$ = 44 dB	1
3 (b) (ii)	ratio / dB = $10 \lg (P_2 / P_1)$	1
	$44 = 10 \lg (\{9.7 \times 10^{-3}\} / P)$ <b>or</b> $-44 = 10 \lg (P / \{9.7 \times 10^{-3}\})$	1
	power = $3.9 \times 10^{-7} \text{ W}$	1
	Total: 10	
5 (a)	(loss in) kinetic energy of $\alpha$ -particle = $Qq / 4\pi\epsilon_0 r$ <b>or</b> $7.7 \times 10^{-13} = Qq / 4\pi\epsilon_0 r$	1
	$7.7 \times 10^{-13} = 8.99 \times 10^9 \times 79 \times 2 \times (1.60 \times 10^{-19})^2 / r$	1
	$r = 4.7 \times 10^{-14} \text{ m}$ $r$ is closest distance of approach so radius less than this	1
5 (b)	force = $Qq / 4\pi\epsilon_0 r^2 = 4u \times a$	1
	$8.99 \times 10^9 \times 79 \times 2 \times (1.60 \times 10^{-19})^2 / (4.7 \times 10^{-14})^2 = 4 \times 1.66 \times 10^{-27} \times a$	1
	$a = 2.5 \times 10^{27} \text{ m s}^{-2}$	1
5 (c)	so that single interactions between nucleus and $\alpha$ -particle can be studied <b>or</b> so that multiple deflections with nucleus do not occur	1
	Total: 7	

Question	Answer	Marks
6 (a) (i)	lamp needs 'high' power/'large' current/'large' voltage	1
	op-amp can deliver only a small current/small voltage	1
6 (a) (ii)	correct symbol for relay coil connected between output and earth	1
	switch between mains supply and lamp	1
6 (b) (i)	vary light intensity at which lamp is switched on/off	1
6 (b) (ii)	so that relay operates for only one current/voltage direction <b>or</b> so that relay/lamp operates for either dark or light conditions	1
6 (c)	when light level increases, LDR resistance decreases	1
	( $R_{\text{LDR}}$ low,) so $V^- > V^+$ , so $V_{\text{OUT}}$ negative/−5 V (must be consistent with previous mark)	1
	OR	
	when light level decreases, LDR resistance increases	(1)
	( $R_{\text{LDR}}$ high,) so $V^- < V^+$ , so $V_{\text{OUT}}$ is positive/+5 V (must be consistent with previous mark)	(1)
	lamp comes on as light level decreases <b>or</b> lamp goes off as light level increases	1
Total: 9		

Notes about the mark scheme are available separately.