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OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Friday 10 June 2022 – Afternoon

Level 3 Cambridge Technical in Engineering

05822/05823/05824/05825/05873

Unit 4: Principles of electrical and electronic engineering

Time allowed: 1 hour 30 minutes plus your additional time allowance

You must have:
the Formula Booklet for Level 3 Cambridge Technical in Engineering (with this document)
the Insert for FIG. 6
a ruler (cm/mm)
a scientific calculator

Please write clearly in black ink.

Centre number					
Candidate number					

First name(s) _____

Last name _____

Date of birth	D	D	M	M	Y	Y	Y	Y

READ INSTRUCTIONS OVERLEAF

INSTRUCTIONS

Use black ink. You can use an HB pencil, but only for graphs and diagrams.

Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.

Answer ALL the questions.

Where appropriate, your answer should be supported with working.

Give your final answers to a degree of accuracy that is appropriate to the context.

INFORMATION

The total mark for this paper is 60.

The marks for each question are shown in brackets [ ].

ADVICE

Read each question carefully before you start your answer.

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Answer ALL the questions.

1 When light shines on a solar panel it generates DC electricity.

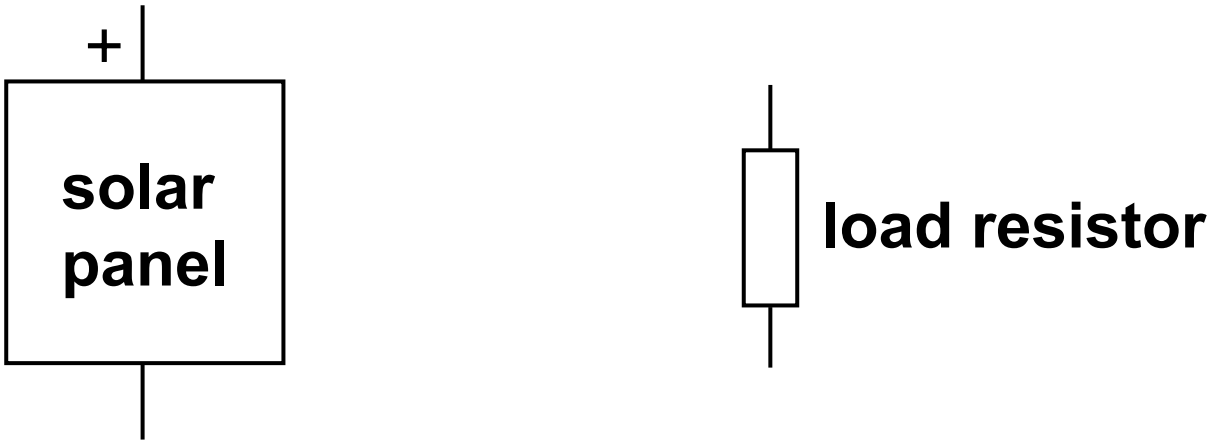
(a) The solar panel provides current to the load resistor.

An ammeter measures the current through the load resistor.

A voltmeter measures the voltage across the load resistor.

Draw ON FIG. 1 opposite to show the ammeter, voltmeter and necessary connections to complete the circuit. [2]

FIG. 1



(b) When a load resistor of 38 Ω is used in the circuit the current through the load resistor is 150 mA.

Calculate the voltage across the load resistor.

Voltage across load resistor =

_____ V [2]

(c) Calculate the power dissipated in a 38 Ω load resistor when the current through the load resistor is 150 mA.

Power dissipated in the load resistor =

_____ W [1]

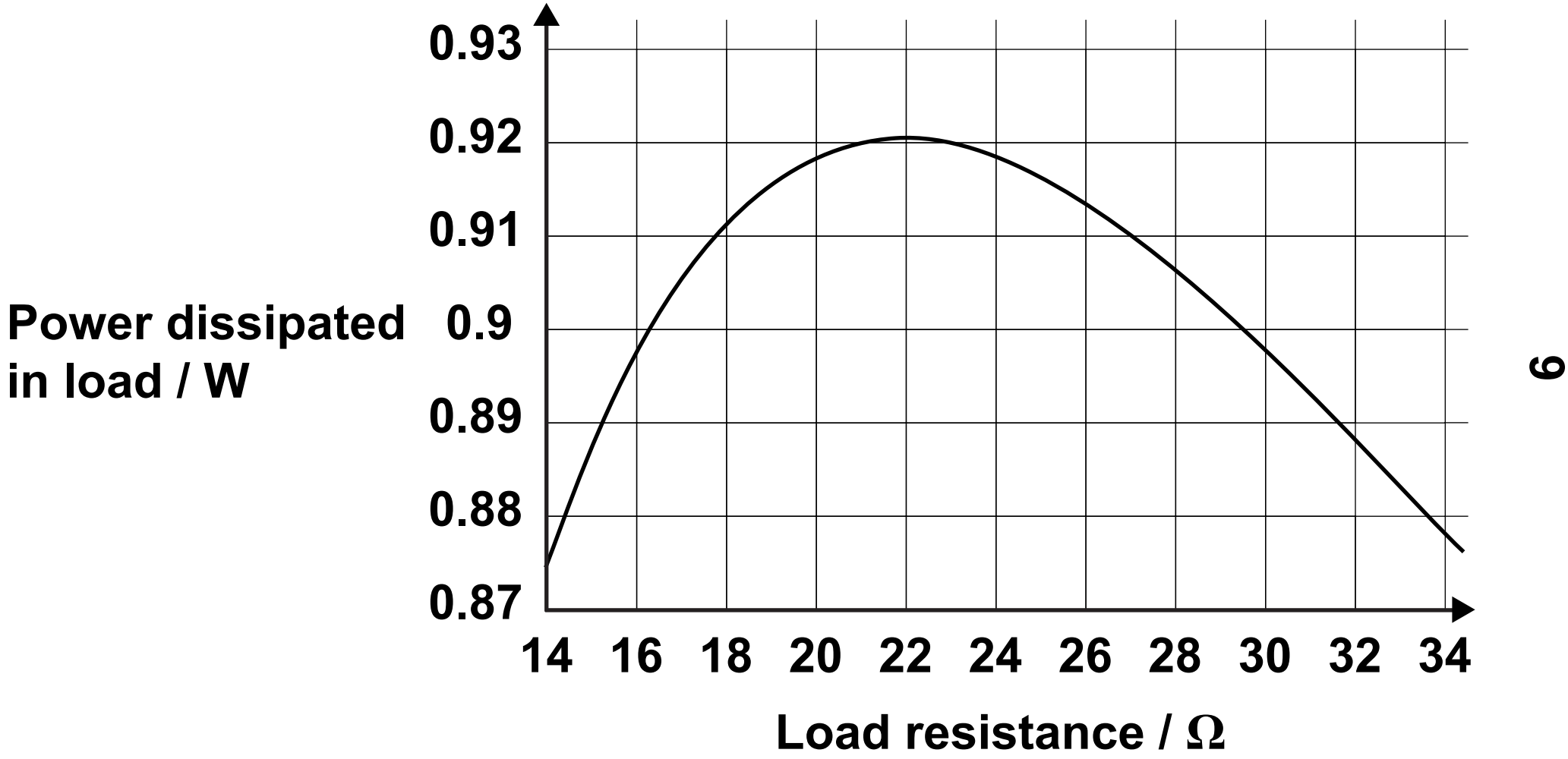
(d) An engineer measures the voltage and current for different values of load resistor and calculates the power for each measurement.

FIG. 2 opposite shows the graph of power against resistance.

(i) Calculate the current from the solar panel when the load resistance is 27 Ω.

Current = _____ A [3]

FIG. 2


Power dissipated in load / W
0.93
0.92
0.91
0.9
0.89
0.88
0.87
14
16
18
20
22
24
26
28
30
32
34
Load resistance / Ω

(ii) State the internal resistance of the solar panel.

Internal resistance of the solar panel =

_____ Ω [1]

(iii) Explain your answer to part (d)(ii).

_____

_____

_____

_____

_____ [2]

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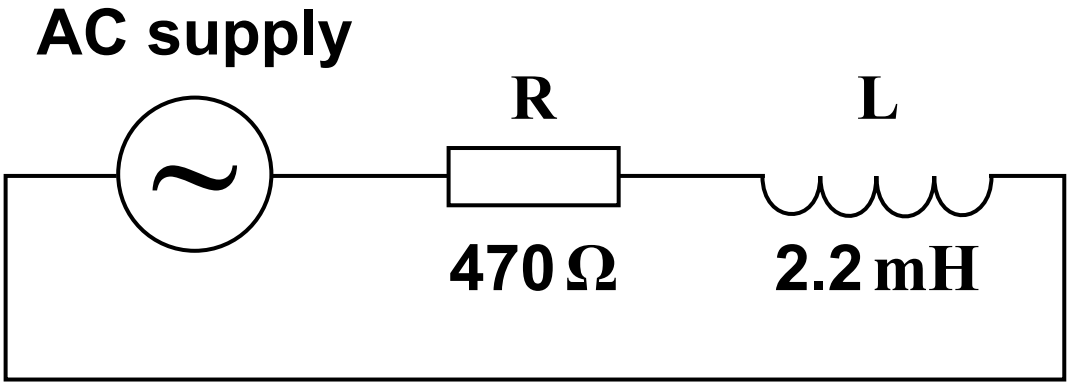
2 FIG. 3 shows a series RL circuit connected to an AC supply.

FIG. 3



(a) The AC supply has a frequency (f) of 20 kHz.

(i) Calculate the reactance (X_L) of the inductor at a frequency of 20 kHz.

X_L = _____ Ω [2]

(ii) Calculate the impedance (Z) of the series RL circuit at a frequency of 20 kHz.

Z = _____ Ω [2]

(b) A $7.2\,\mathrm{nF}$ capacitor (C) is connected in series with the $470\,\Omega$ resistor (R) and the $2.2\,\mathrm{mH}$ inductor (L) to form a series RLC circuit connected to the AC supply.

(i) Draw a diagram of the series RLC circuit and AC supply.

Label the components in the circuit with their values.

[1]

(ii) State the value of the 7.2 nF capacitor (C) in farads.

$C =$ _____ F [1]

(iii) Complete the table opposite to show how the impedance of the RLC series circuit changes with frequency. [4]

Frequency f/Hz	Reactance of inductor X_L/Ω	Reactance of capacitor X_C/Ω	Impedance of series RLC circuit Z/Ω
25000	346	884	
40000	553		470
50000		442	

3 The diagram of a DC motor connected to a battery is shown in FIG. 4 opposite.

(a) Put a (ring) around the name of the DC motor shown in FIG. 4. [1]

permanent magnet series-wound

shaded pole shunt-wound

(b) Suggest why this type of motor is suitable for a fan.

_____

_____

_____ [1]

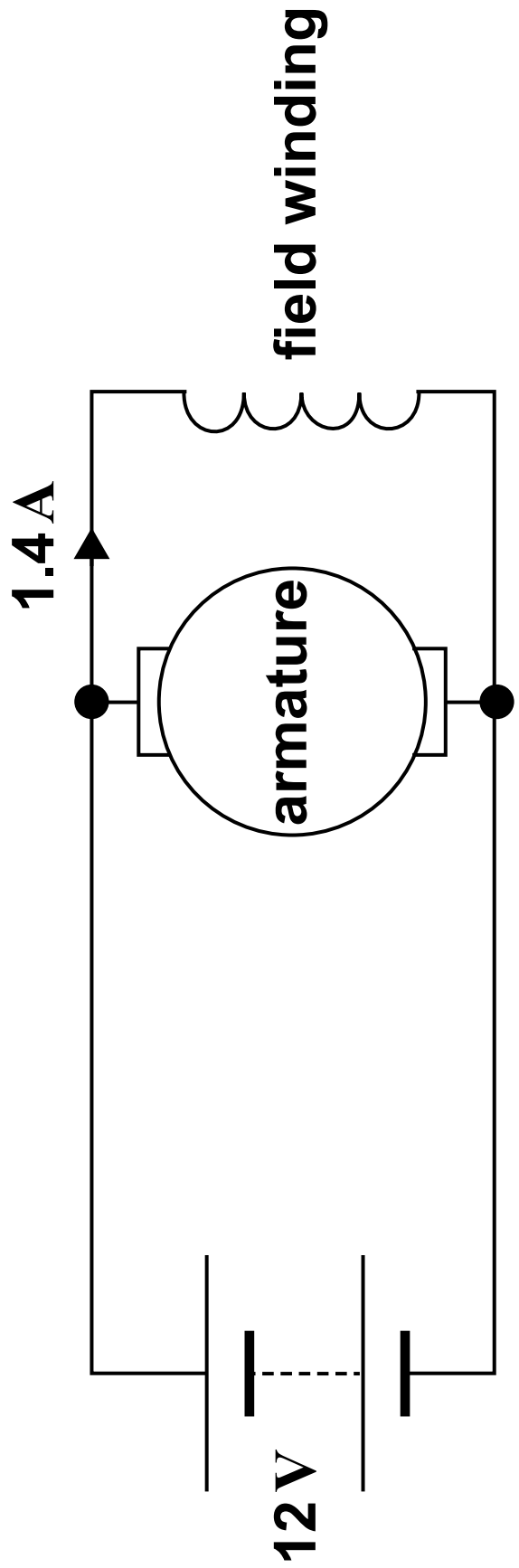


FIG. 4

(c) When the voltage (V) across the armature is $12\,\mathrm{V}$ and the motor is turning quickly the current through the armature (I_a) is $2.2\,\mathrm{A}$. The armature resistance (R_a) is $0.9\,\Omega$.

Calculate the EMF (E) generated in the armature.

Give the units for your answer.

E = _____ [3]

(d) When a 12 V supply is connected to the motor the current in the field winding is 1.4 A.

Calculate the resistance of the field winding (R_f).

R_f = _____ Ω [1]

(e) FIG. 5 opposite shows a switch and resistor added to the circuit of FIG. 4 so that the fan can run at two different speeds.

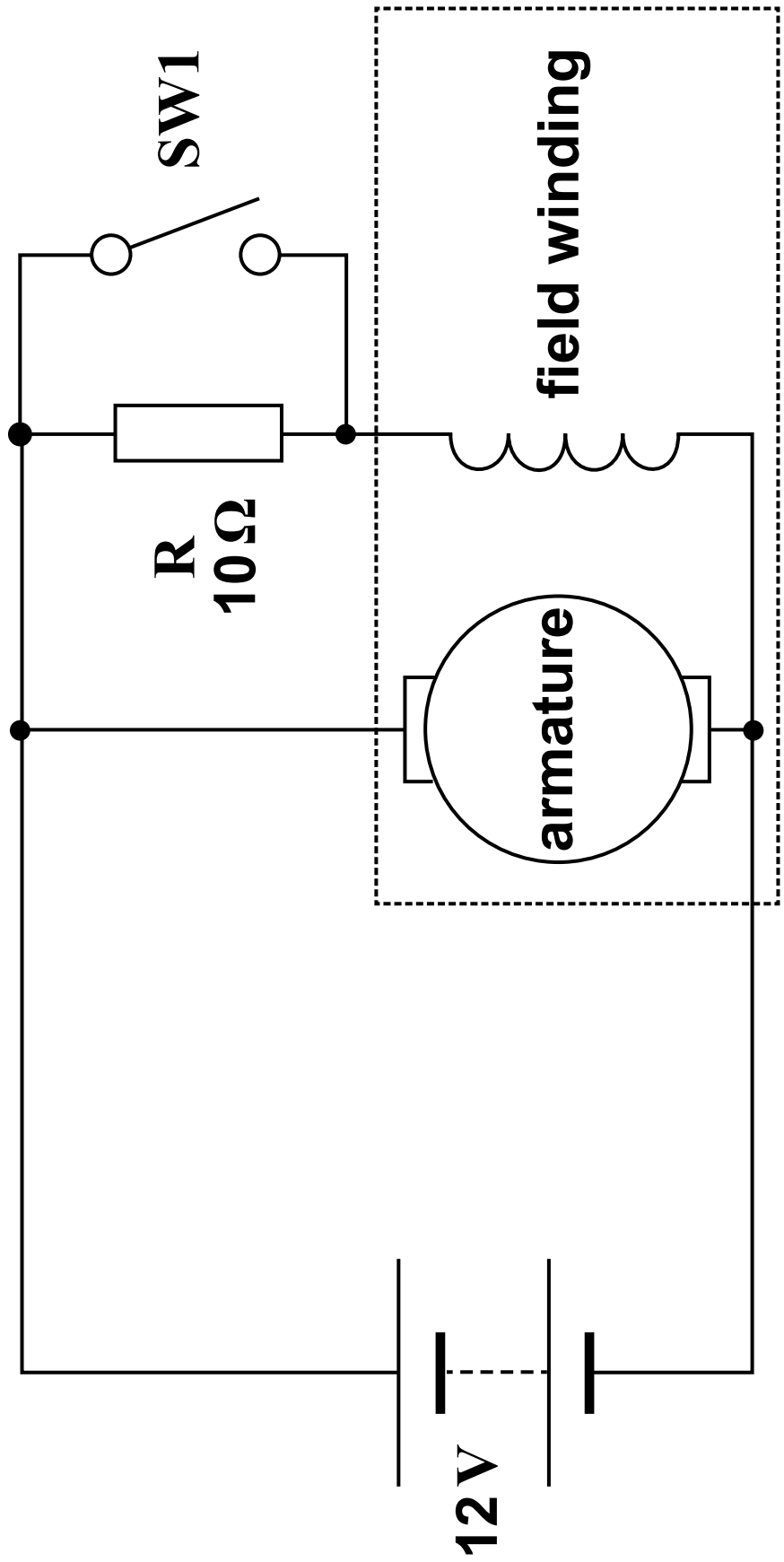


FIG. 5

(i) Complete the sentences in the paragraph below by choosing the most appropriate words from the list.

Use each word once, more than once or not at all. [3]

constant	increased
reduced	zero

When the switch SW1 is closed the current in the field winding is 1.4 A and the motor spins. When the switch SW1 is opened the resistor, R, is in series with the field winding. Therefore, the current in the field winding (I_f) is _____ and the magnetic flux (ϕ) in the motor is _____ .

This means that the speed of the motor is _____ .

(ii) Calculate the current in the field winding (I_f) when the switch, SW1, is open so that the resistor, R, is in series with the field winding.

I_f = _____ A [2]

4 A wireless router is used to provide internet access for people in an office. The wireless router requires a low voltage DC power supply.

(a) Complete the block diagram ON FIG. 6 on the Insert of a stabilised power supply for the wireless router.

Choose from the terms in the Insert. [3]

(b) Describe the function of the rectifier in a stabilised power supply.

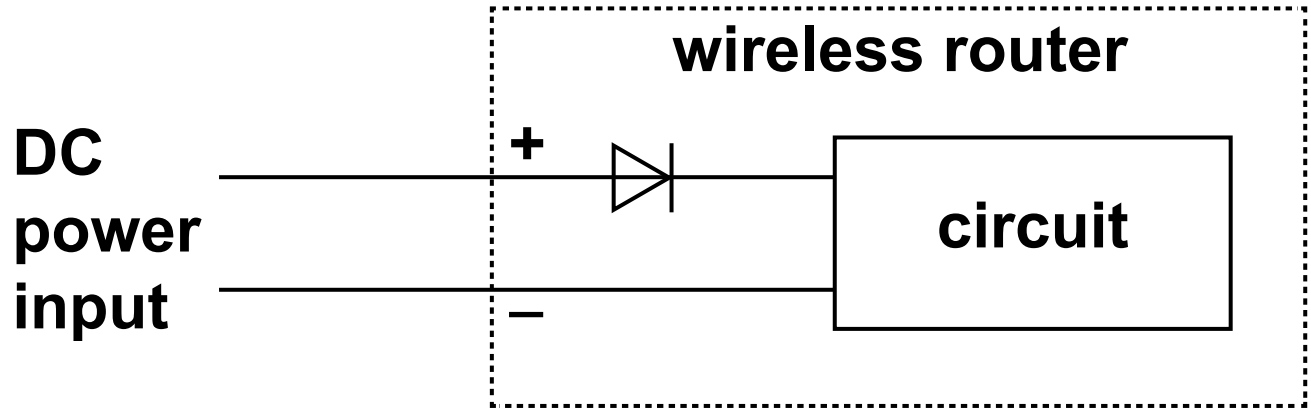
_____

_____

_____ [2]

(c) The circuit diagram in FIG. 7 shows how a diode is used to protect the circuit in the wireless router from being damaged due to being connected the wrong way around.

FIG. 7



State how the diode protects the wireless router.

_____

_____

_____ [1]

(d) FIG. 8 opposite shows the wireless router connected to the AC mains supply and a battery backup power supply.

Complete the sentences in the paragraph below by choosing the most appropriate phrases from the list.

Use each phrase once, more than once or not at all.

being charged	limiting the current	powering the wireless router	rectifying the supply

When the AC mains supply is not working, the battery backup power supply is

_____ .

When the AC mains supply is working, the stabilised power supply is

_____

and battery backup power supply is

_____ .

[3]

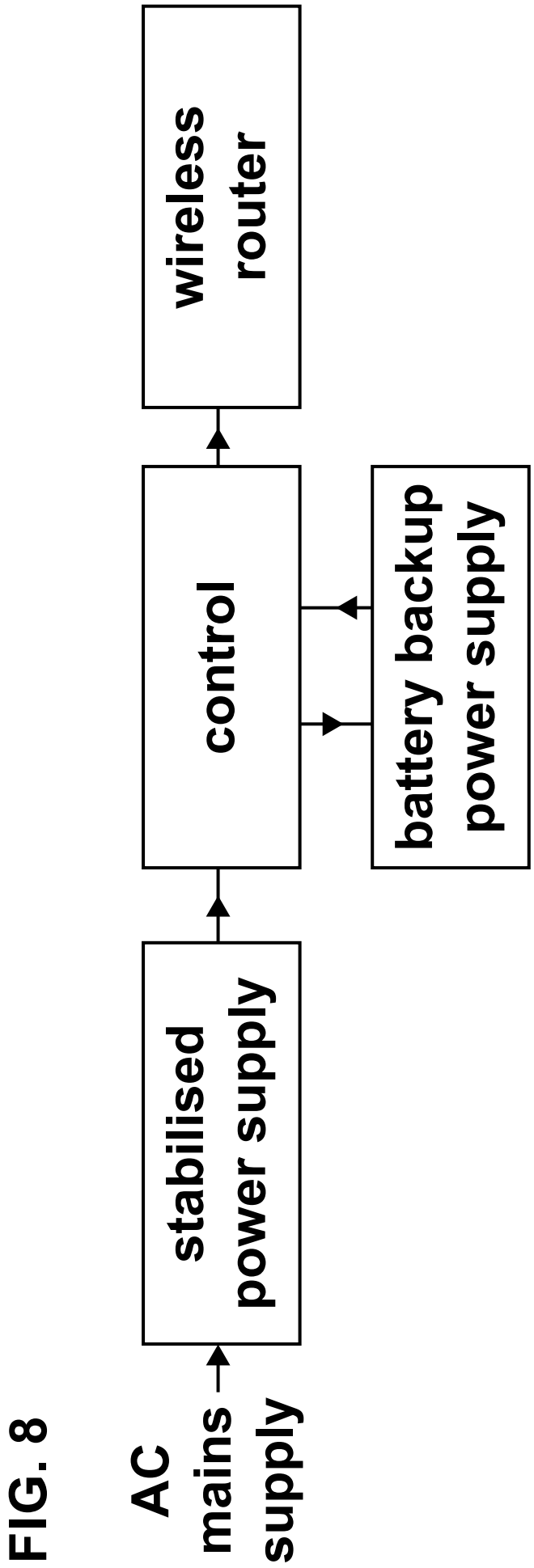
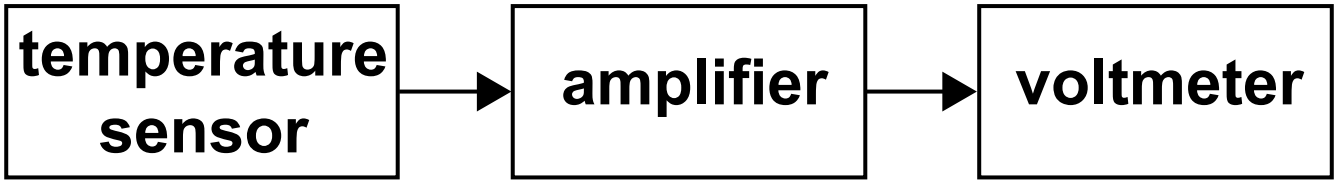

AC mains supply
stabilised power supply
control
battery backup power supply
wireless router

FIG. 8

5 The block diagram of an electronic thermometer is shown in FIG. 9.

FIG. 9



(a) When the temperature sensor produces 30 mV the voltmeter shows −3 V.

Calculate the voltage gain of the amplifier.

Voltage gain of amplifier = _____ [2]

(b) An op-amp amplifier is used for the amplifier in FIG. 9.

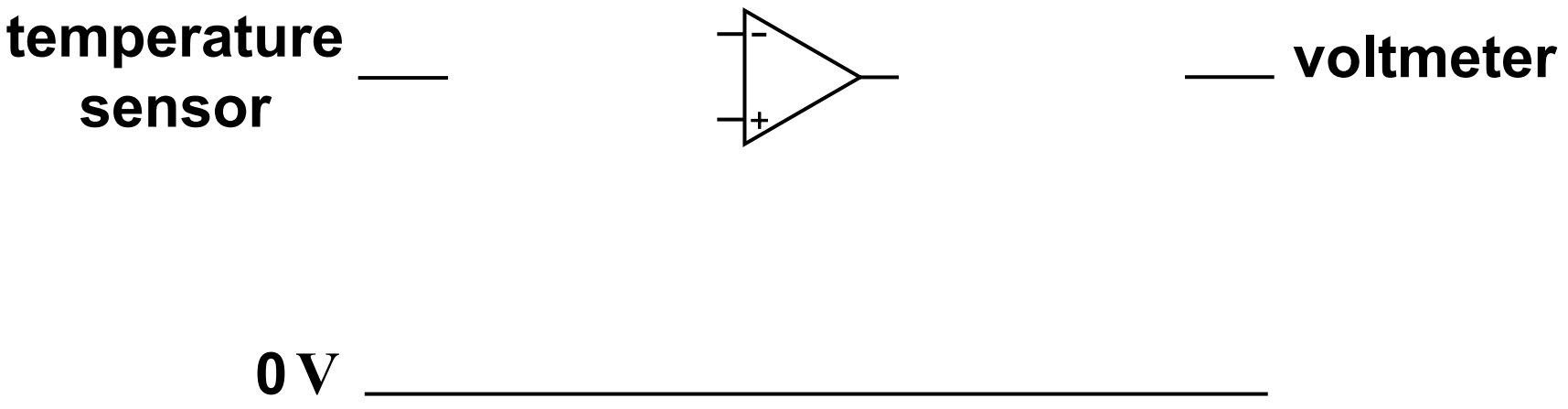
(i) Name the type of op-amp amplifier circuit used in FIG. 9.

_____ [1]

(ii) **Complete FIG. 10 opposite to show the diagram for the amplifier circuit named in part (b)(i).**

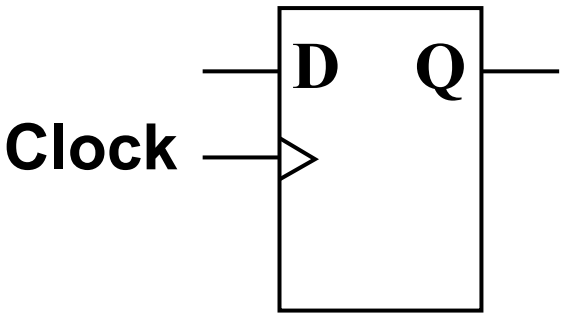
Label any components added and include their values. [5]

FIG. 10



6 The circuit symbol for a D type flip-flop is shown in FIG. 11.

FIG. 11



(a) Complete the paragraph opposite by choosing the most appropriate terms from the list.

Each term may be used once, more than once or not at all. [4]

	changed from high to low	changed from low to high	
Clock			
D	held high	held low	Q

A rising edge triggered D-type flip-flop is triggered when the

_____

connection is

_____ .

To make Q high, the

_____

connection is

_____

whilst the D-type flip-flop is triggered.

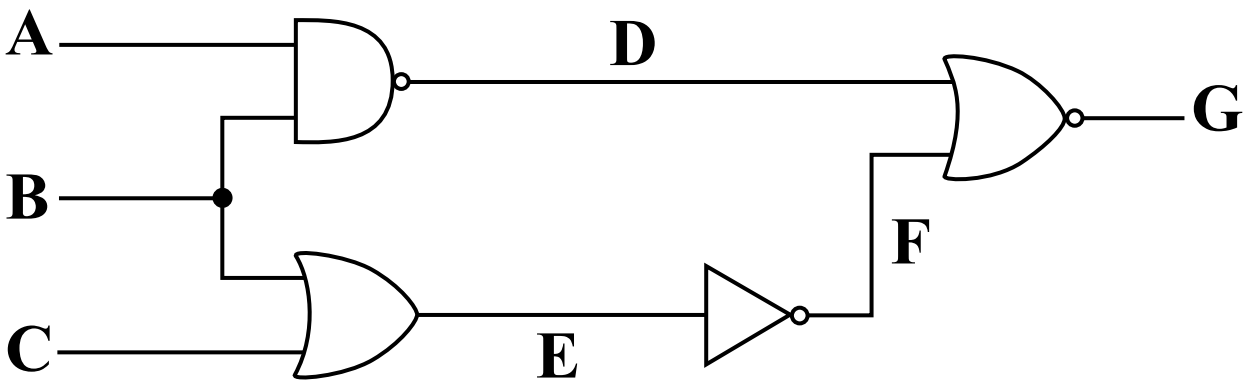
(b) Draw a line to join each statement about logic gates to the most appropriate name of logic gate.

There will be some logic gates without a connecting line. [3]

Statements about logic gates	Name of logic gate
	AND gate
The output is only high when all the inputs are low.	NAND gate
The output is only high when only one of the inputs is high.	NOR gate
The output is only low when all the inputs are high.	OR gate
	XOR gate

(c) FIG. 12 shows a logic gate circuit.

FIG. 12



Complete the truth table for this circuit. [4]

A	B	C	D	E	F	G
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined pages. The question numbers must be clearly shown – for example, 3(b) or 4(b).