CAMBRIDGE TECHNICALS

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Examiners' report

ENGINEERING

05822–05825, 05873

Unit 4 Summer 2022 series

Version 1

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Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Unit 4 series overview

The vast majority of candidates found this paper accessible, however, although it followed a very similar format and structure to previous series there were far more instances of non-response from candidates, particularly those achieving the lowest overall marks.

Candidates were able to recall key definitions and diagrams with the higher ability able to apply their knowledge to explain and annotate.

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• had learned definitions and key information from the specification (e.g., definition of max power theorem, operating characteristics of a shunt wound motor) • noted when a question contained prefixes and subsequently used the correct power of ten • were able to recall circuit symbols of components and draw them in the correct location in circuit diagrams.	• attempted to give definitions (e.g., of rectification) in their own words • did not show full working out for calculations or performed incorrect algebraic manipulation of equations • did not complete any working out around “match the statement” or “complete the table” style questions even though calculation or understanding of truth table was required for these.

Question 1 (a)

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** to show the ammeter, voltmeter and necessary connections to complete the circuit.

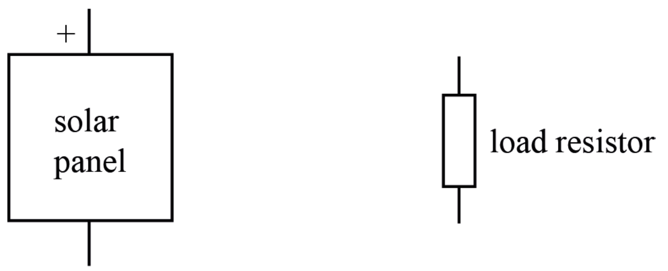

Fig. 1

[2]

The majority of candidates were able to successfully draw the voltmeter in parallel and ammeter in series with the most common mistake being to swap their locations or have both in series.

Question 1 (b)

(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]**

Ohm's Law was used well here. Some candidates missed the milli prefix leading to an incorrect response.

Assessment for learning

Prefixes.

Candidates should be aware of the common prefixes used in engineering and how to apply them in calculation.

Question 1 (c)

(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]**

The majority of candidates were able to select a power equation from the formula booklet however mistakes were often made when substituting values.

Question 1 (d) (i)

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

Fig. 2 shows the graph of power against resistance.

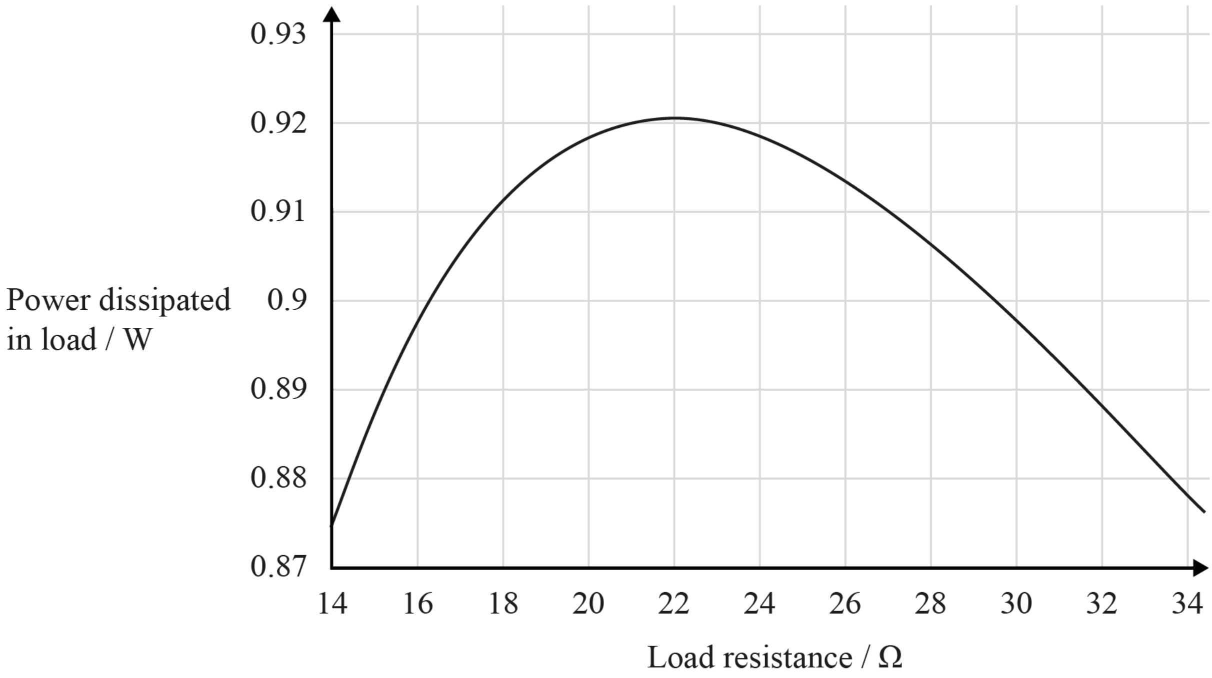

Fig. 2

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

Current = ... A **[3]**

Although the majority of candidates were able to read the power dissipated in the load for a resistance of 27 Ohms many were unable to carry on from there to calculate the current.

Question 1 (d) (ii)

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

Internal resistance of the solar panel = ... Ω **[1]**

This question was not well attempted with many students stating 14 Ohms as the starting resistance showing a lack of recall of maximum power theorem.

Assessment for learning

The specification should be fully covered including section 1.3 (maximum power transfer theorem) so that students are familiar with this.

Question 1 (d) (iii)

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

....

....

....

....

.... **[2]**

Those that had gained the mark in Question 1d (ii) in general were able to gain 1 mark here for stating that this was the peak of the graph or the point at which the power was at a maximum. However, few candidates were able to state that maximum power theorem stated that there would be maximum power transferred across the load when the internal resistance was equal to the load resistance.

Question 2 (a) (i)

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

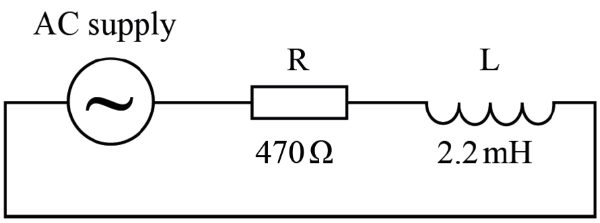

Fig. 3

(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]**

Most candidates were able to gain 1 mark for the use of the reactance equation, but many used incorrect powers of ten due to misunderstanding of the prefixes.

Question 2 (a) (ii)

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

Z = ... Ω **[2]**

Although the majority of candidates attempted to use an equation a significant minority multiplied the squared terms rather than adding them perhaps attempting to recall the formula instead of using the formula booklet.

Assessment for learning

Formula Booklet

Formulae should not be memorised and recalled in the exam. Instead, the equations should be selected from and copied out of the formula booklet provided.

Question 2 (b) (i)

(b) A 7.2 nF capacitor (C) is connected in series with the 470 Ω resistor (R) and the 2.2 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]

The majority of candidates were able to draw this circuit with the most common errors being either not labelling the components with their values as required by the question or using an incorrect symbol for the AC supply or capacitor.

Question 2 (b) (ii)

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

C = ... F **[1]**

Although the majority of candidates gave a response in standard form a significant minority attempted to give a decimal response which led to error perhaps due to the number of zeros after the decimal point.

Question 2 (b) (iii)

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

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	

[4]

Very few candidates gained full marks in this question. Those that did well used a logical approach shown by their working out and calculation around the answer grid.

Question 3 (a)

3 The diagram of a DC motor connected to a battery is shown in **Fig. 4**.

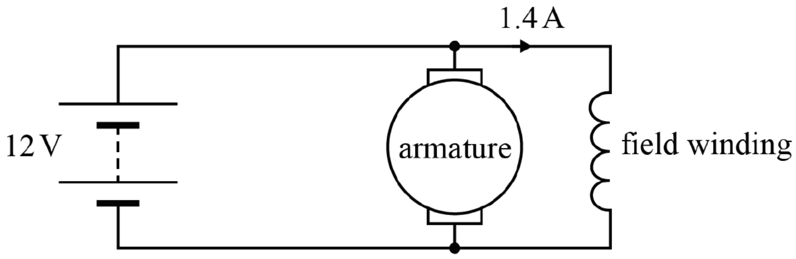

Fig. 4

(a) Put a (ring) around the name of the DC motor shown in **Fig. 4**.

permanent magnet **series-wound** **shaded pole** **shunt-wound**

[1]

This question was answered well but a significant minority selected the incorrect response of series-wound.

Question 3 (b)

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

....

....

.... **[1]**

This question showed some confusion between series and shunt wound motors with a minority of candidates giving a clear, confident, and correct response. The majority of candidates that scored the mark mentioned that the fan would operate at a constant speed.

Question 3 (c)

(c) When the voltage (V) across the armature is 12 V and the motor is turning quickly the current through the armature (I_a) is 2.2 A. The armature resistance (R_a) is 0.9 Ω.

Calculate the EMF (E) generated in the armature.

Give the units for your answer.

E = ... **[3]**

Many candidates incorrectly selected the generator equation rather than the motor. Of the minority that successfully selected the equation many rearranged incorrectly.

Question 3 (d)

(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]**

This question was handled successfully by a majority of candidates.

Question 3 (e) (i)

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

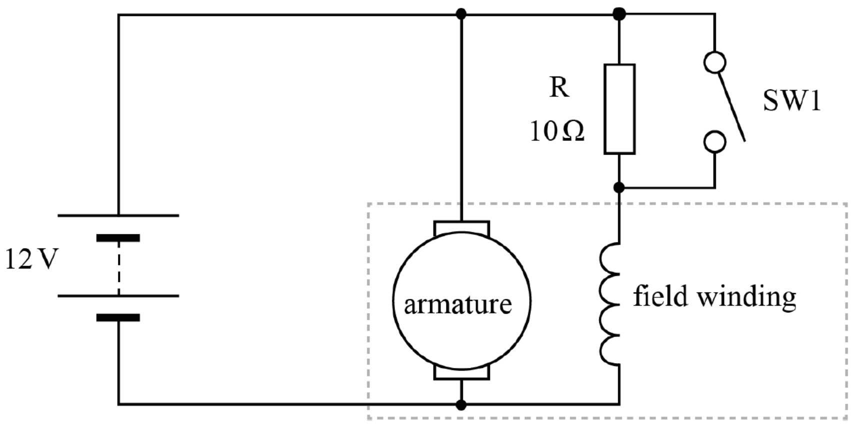

Fig. 5

(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.

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

....

[3]

Few candidates were able to show their understanding of speed control.

Question 3 (e) (ii)

(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]**

A very small minority of candidates were able to answer this question correctly with almost all who attempted the question using just the 10 Ohms for resistance and not adding their response for 3d in series.

Question 4 (a)

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 in **Fig. 6** of a stabilised power supply for the wireless router.

Choose from the terms below.

relay **smoothing circuit** **stabilising circuit** **transformer** **XOR gate**

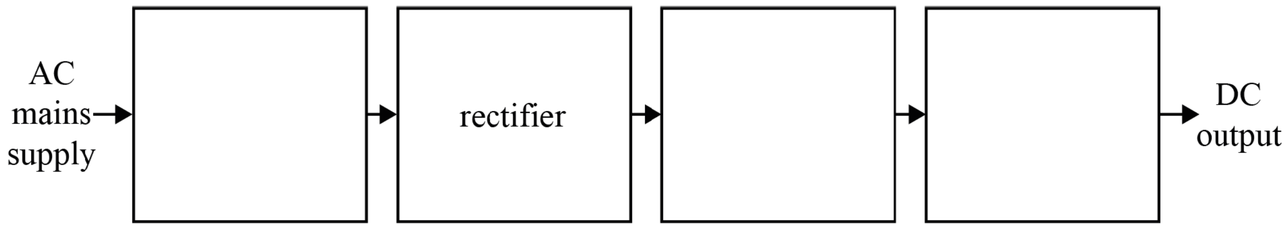

Fig. 6

[3]

This was generally well answered with the majority of incorrect responses coming from swapping the positions of the smoothing circuit and stabilising circuit.

Question 4 (b)

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

....

....

.... **[2]**

Very few candidates were able to confidently state that the function of the rectifier is to change alternating current into direct current with many instead explaining the role of the diode in half wave and full wave rectification. Some candidates attempted to sketch voltage time or current time graphs to aid their explanation but without labelled axes and a clear description marks could not be awarded.

Question 4 (c)

(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.

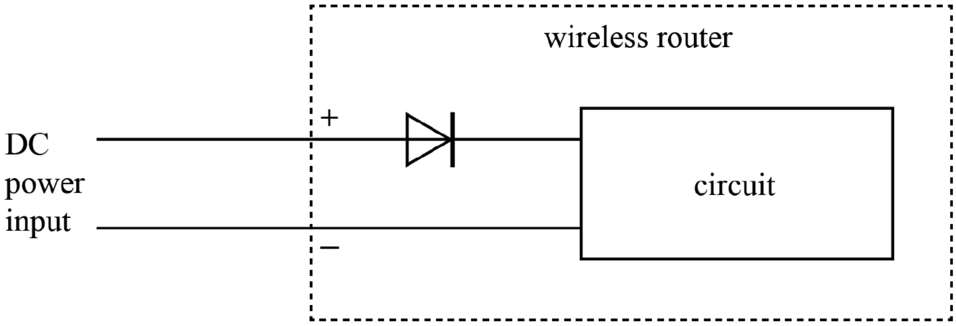

Fig. 7

State how the diode protects the wireless router.

....

....

.... **[1]**

Candidates were unable to clearly state that the diode only conducted when in forward bias (and did not conduct when in reverse bias) and so only allowed current to flow in one direction. If the DC power input was connected the wrong way round current would not flow and the router would be protected. Descriptions of clockwise and anticlockwise current often led to a clear response but there was much mention of "backflow of current" or "positive/negative current" which was unclear and some mention of voltage flow which was incorrect.

Question 4 (d)

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

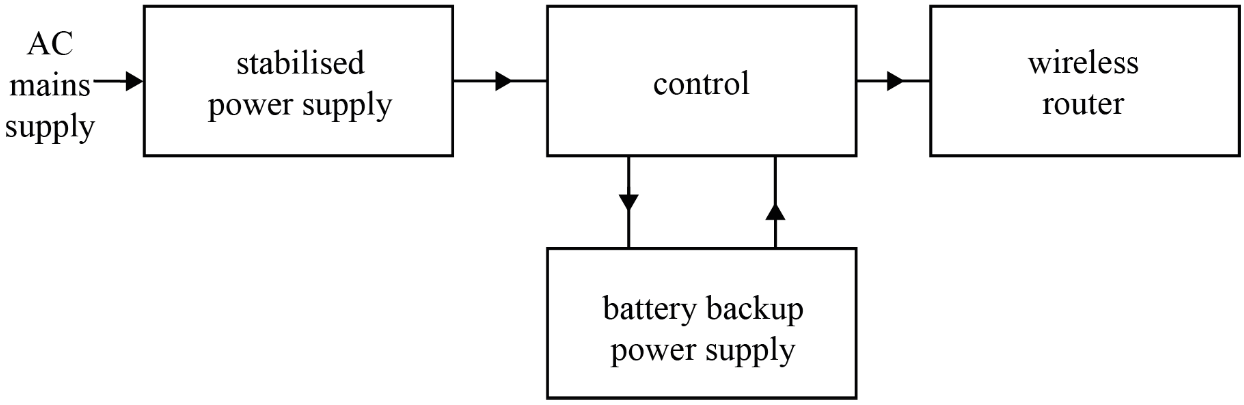

Fig. 8

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]

Candidates generally performed well in this application of knowledge question, however a significant minority incorrectly selected "limiting the current" as something a stabilised or backup power supply would achieve.

Question 5 (a)

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

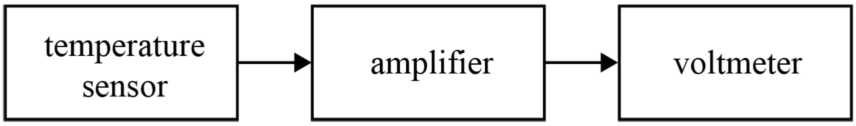

Fig. 9

(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]**

Although many candidates achieved the mark for conversion to volts many reversed the input and output voltage values. A number of candidates did not give a negative response for voltage gain even though this was the correct response here.

Question 5 (b) (i)

(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]**

Although most candidates stated the name of a taught op-amp (inverting, non-inverting or summing) there were many no responses or an attempt to name a device.

Question 5 (b) (ii)

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

Label any components added and include their values.

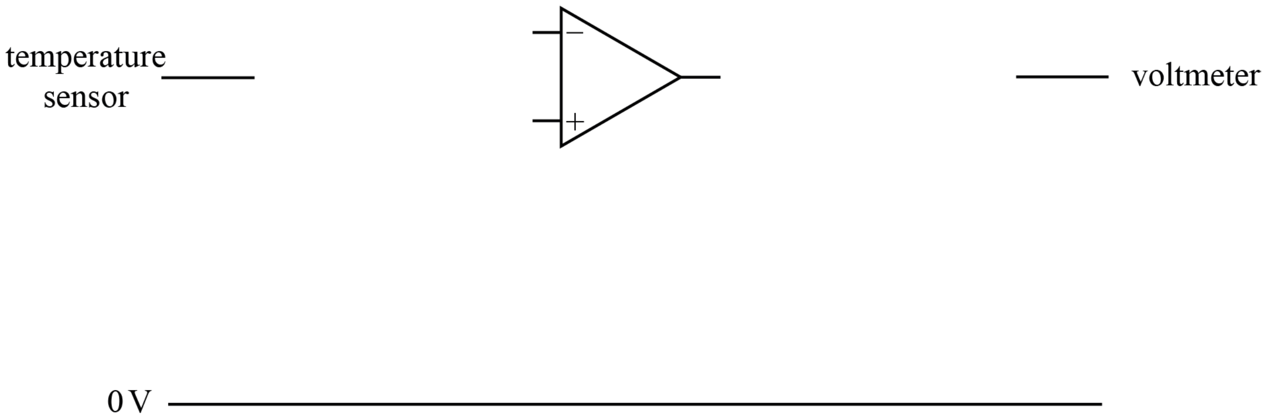

Fig. 10

[5]

Although very similar to questions set in previous years many candidates were unable to complete the diagram for an inverting op-amp. Only a very small minority attempted to include component values for the resistors in order to give the required gain calculated in Question 5a, although those that did almost always achieved full marks for the question.

Question 6 (a)

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

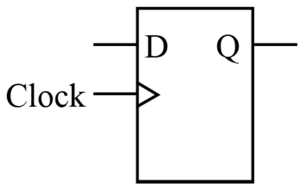

Fig. 11

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

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

Clock	**changed from high to low**	**changed from low to high**	**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.

[4]

Candidates found it difficult to apply their knowledge rather than just recall the function of devices in this 'cloze' style question. This question was a good differentiator of the level of candidate understanding.

Question 6 (b)

(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.

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

[3]

Candidates that scored highly on this question tended to draw the truth tables for the gates around the question which is a good method to help select the correct response. The statements had to be read carefully as "only high" is not the same as "high."

Question 6 (c)

(c) **Fig. 12** shows a logic gate circuit.

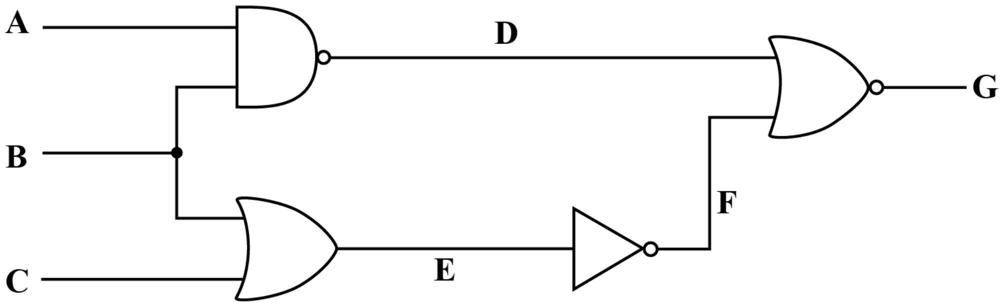

Fig. 12

Complete the truth table for this circuit.

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				

[4]

The majority of candidates were able to gain the mark column F as the NOT gate appears to be the most understood, closely followed by column E for the OR gate. However, candidates seemed to struggle more with the NAND and NOR gates. Candidates should make sure they are familiar with the truth tables for all gates listed on the specification.

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