CAMBRIDGE TECHNICALS

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CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 4 January 2021 series

Version 1

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 Unit 4 paper appeared accessible, with the majority of candidates attempting all questions. Candidates were able to recall key definitions and diagrams with the higher ability able to apply their knowledge to explain and annotate. As in previous series, the understanding and application of Kirchhoff's Laws appears difficult for most while the majority of candidates are confident with digital logic.

Candidates who did well on this paper generally did the following:	***Candidates who did less well on this paper generally did the following:***
• Read the questions carefully, particularly in Question 1 when the position of the switches was changing and Question 3 when the diagram had to be labelled. • Ensured prefixes were used correctly in calculations. • Had a clear understanding of circuits, e.g. rectification, generator, op-amp and so were not only able to construct successfully but could also access the questions where an explanation of their operation was required.	• Attempted to give definitions in their own words. • Did not highlight key information in the questions/annotate diagrams when performing calculation. • Did not show full working out for calculations.

Question 1 (a) (i)

1 The circuit diagram of a torch designed by a student is shown in Fig. 1.

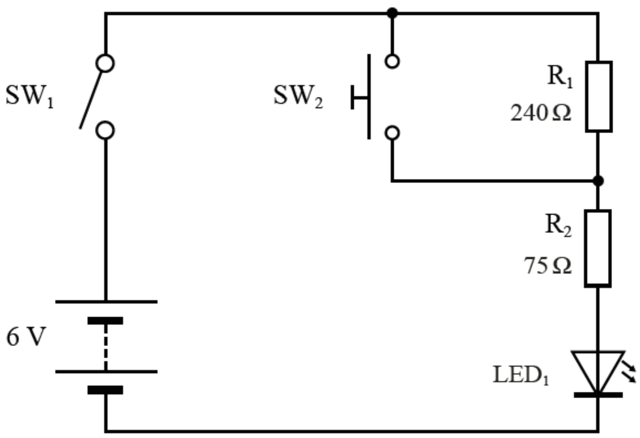

Fig. 1

(a) An ohmmeter is used to measure the resistance of R_1.

(i) Draw **on** Fig. 1 to show an ohmmeter connected to measure the resistance of R_1. **[1]**

This question was answered well by a high majority of candidates.

Question 1 (a) (ii)

(ii) A multimeter is used as an ohmmeter to measure the value of R_1.

Fig. 2a shows a multimeter with the dial in the off position.

Draw an arrow **on** Fig. 2b showing the correct position of the dial to measure the resistance of R_1 precisely.

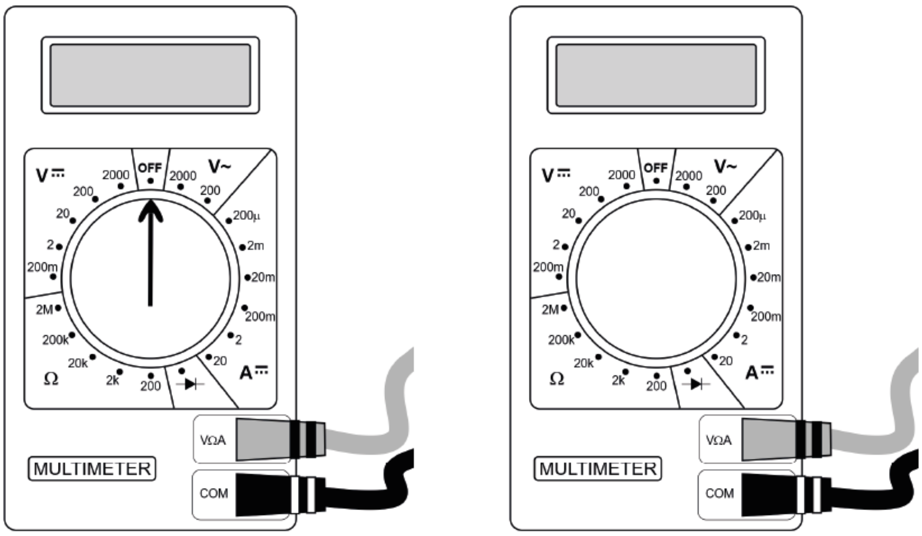

Fig. 2a **Fig. 2b**

[1]

This question was answered well by a high majority of candidates with the most popular incorrect responses being the dial pointing to either 200 Ohms or 200/2000 Volts.

Question 1 (a) (iii)

(iii) Explain why switch SW_1 must be in the off position and switch SW_2 should not be pressed when the ohmmeter is being used to measure the resistance of R_1.

....

....

....

.... **[2]**

Many candidates struggled with this question. However, those who had understood that they were being asked to give different reasons for the opening of SW_1 and the not pressing of SW_2 were able to answer successfully. It was clear that some centres had fully taught the operation of the ohmmeter/multimeter but without a clear link to the question (and which switch was being considered) candidates were commonly only given 1 of the potential 2 marks, with many discussing voltage and current without linking back to how this may affect the reading of the resistance of R_1.

Question 1 (b) (i)

(b) LED_1 in Fig. 1 has a voltage of 3.6 V across it when it is glowing.

You can assume that the battery has negligible internal resistance.

(i) Calculate the voltage across the two resistors R_1 and R_2 when switch SW_1 is turned on and SW_2 is **not** pressed.

voltage across R_1 and R_2 = ... V **[1]**

A small number of candidates were successful in this question regarding Kirchhoff's Second Law. It would be useful for centres to consolidate the teaching of this topic.

	AfL	Careful reading of question. In questions such as these, when there are 2 switches that may be on or off, it is important that candidates read the question carefully to make sure they fully understand the effect of the switches on the circuit before performing any calculations. Candidates with well annotated diagrams were more successful on this series of questions showing a clear understanding of the question to be helpful.

Question 1 (b) (ii)

(ii) Calculate the current through LED_1 when switch SW_1 is turned on and SW_2 is **not** pressed.

current through LED_1 = ... A **[2]**

A majority of candidates realised that they had to add the values of the two resistors. However, rather than using the previously calculated voltage, many used 6V in their Ohm's Law calculation. It would be useful for centres to consolidate the teaching of this topic.

Question 1 (b) (iii)

(iii) Calculate the current through the LED_1 when switch SW_1 is turned on and SW_2 **is** pressed.

current through LED_1 with SW_2 pressed = ... A **[1]**

This question relied on a strong understanding of DC circuits and as such many candidates struggled. Candidates had to identify that the LED would continue to have a voltage of 3.6V across it while the pressing of SW_2 would create a short circuit.

	AfL	Short Circuits Although short circuits are not explicitly included in the specification they are an opportunity for candidates to apply their knowledge of Kirchhoff's Second Law and so they should be given the opportunity to explore simple circuits including short circuits.

Question 1 (b) (iv)

(iv) Calculate the power dissipated in resistor R_2 when SW_1 is turned on and SW_2 is pressed.

Give the units for your answer.

power dissipated in R_2 = ... **[2]**

The majority of candidates were able to select an appropriate power equation but were less successful identifying the values of current, voltage or resistance to use in the context of the question. Candidates seemed to be unclear as to the interaction between Ohms Law, Kirchhoff's Laws and the power equations. The majority of candidates identified the correct units with a few either neglecting to give a unit or giving the most common incorrect choice of the Joule.

Question 2 (a)

2 (a) State what is meant by 'alternating current (AC)'.

....

....

.... **[1]**

This was one of the least successful questions on the paper. Candidates were able to show some understanding of AC current but often the terminology used was not clear enough to be given the mark.

	AfL	Recall of definition Definitions of key terms should be taught and learnt using the specification for guidance. Candidates relying on writing a definition in their own words often lack the clarity required.

Question 2 (b) (i)

(b) An alternating current (AC) signal is a sine wave of frequency 250 kHz and amplitude 20 V.

A graph of the alternating current signal is shown in Fig. 3.

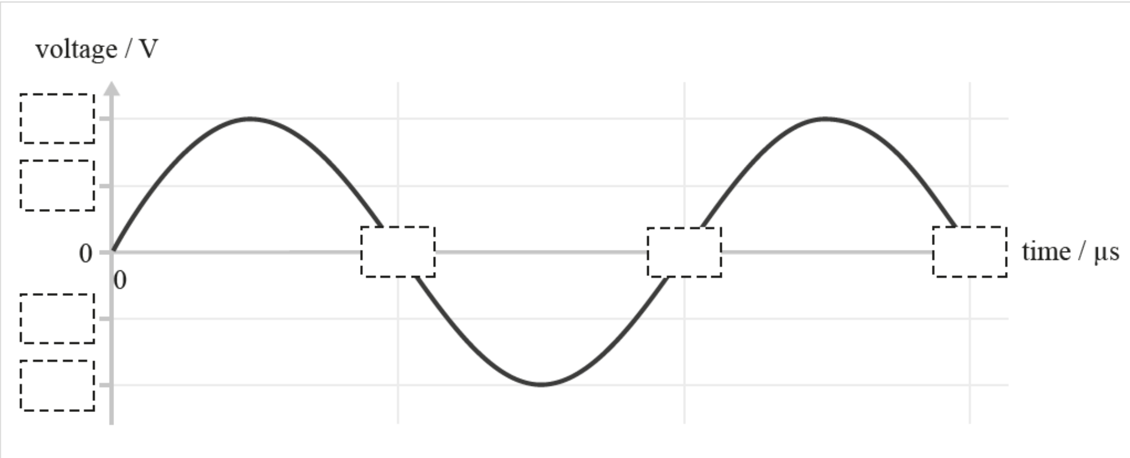

Fig. 3

(i) Calculate the period of the sine wave.

T = ... µs **[2]**

To be successful in this question, candidates need to remember and understand that the period is the reciprocal of the frequency. Candidates that were aware of this relationship, which is not given in the formula booklet, were often successful. However, a significant amount did not take into account the kilo prefix for the frequency or were unable to convert their answer into microsecond as on the answer line.

Question 2 (b) (ii)

(ii) Complete the labelling of the axes **on** Fig. 3 by filling the boxes $\boxed{}$ with the correct times and voltages.

[4]

The majority of candidates were able to achieve 2 marks for the labelling of the voltage axis. However, the relationship between the period and where that value would appear on the time axis of the diagram was not well understood.

Question 2 (b) (iii)

(iii) Calculate the angular frequency, ω, using the formula $\omega = 2\pi f$.

ω = ... rad s^{-1} **[2]**

Full marks were given to approximately half of candidates, with the majority losing marks by either neglecting to include the kilo prefix for frequency or being confused by the unit in rads^{-1} and attempting a conversion.

Question 2 (b) (iv)

(iv) The sine wave has an amplitude $V = 20$ V.

Calculate the voltage, v, of the sine wave at $t = 2.2\,\mu$s using the formula $v = V \sin \omega t$.

v = ... V **[2]**

This question was not well attempted, but successful candidates correctly applied the micro prefix for time and set their calculators to find the sin of a value in radians.

Question 3 (a)

3 (a) Describe the difference between a motor and a generator.

....

....

.... **[2]**

The majority of candidates answered this question well by giving the definition from the specification. Candidates who attempted to explain rather than recall a definition often used incorrect terminology.

Question 3 (b) (i)

(b) A shunt-wound self-excited DC generator is used to charge a battery.

(i) Draw a diagram of a shunt-wound self-excited DC generator.
Label all the parts and the output terminals.

[4]

Candidates struggled when drawing generator diagrams. Many motors were drawn instead and often the question was not well read as parts and/or output terminals remained unlabelled.

Question 3 (b) (ii)

(ii) The shunt-wound self-excited DC generator has a field winding resistance of $R_f = 18\,\Omega$ and armature resistance of $R_a = 0.12\,\Omega$.

Calculate the current (I_f) in the field winding when the generator is producing an output voltage of $V = 16\,\text{V}$.

$I_f =$ .... A **[1]**

This question was well answered by candidates.

Question 3 (b) (iii)

(iii) Calculate the current in the armature, I_a, when the DC generator is producing an output voltage, V, of 16.0 V and an EMF, E, of 18.8 V.

$I_a =$ .... A **[2]**

Rearrangement of this equation was problematic for many candidates. Another common error included incorrect substitution of values.

Question 3 (b) (iv)

(iv) State why the output current from the generator is less than the armature current.

....

....

....**[1]**

This question caused difficulty, many candidates could improve their understanding of the operation of a generator.

Question 4 (a)

4 (a) Fig. 4 shows a three phase 4-wire power supply.

Add labels **on** Fig. 4 to identify the three phase wires and the neutral wire.

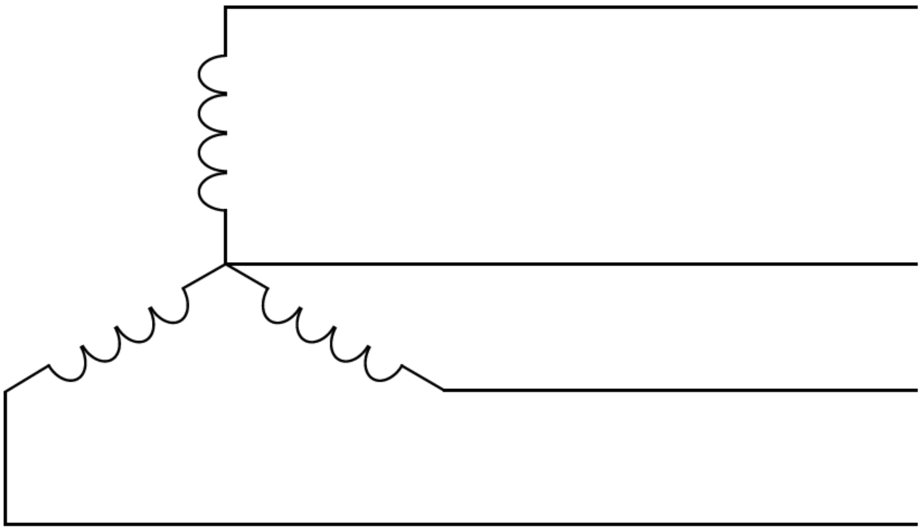

Fig. 4

[2]

The majority of candidates were able to label the diagram correctly, with almost all identifying the neutral wire.

Question 3 (b)

(b) Complete the paragraph below using the most appropriate word in each gap.

Choose words from the following list.

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

delta **line** **phase** **single** **star** **three**

Most local electricity supplies in the UK use a three phase 4-wire system with three phase wires and a neutral wire. A three phase 4-wire supply is called a .... connected system. The voltage between one of the phase wires and the neutral wire is called the .... voltage. The voltage between two phase wires is called the .... voltage.

[3]

Candidates struggled with this question, many needed to improve their understanding of three phase systems.

Question 4 (c) (i)

(c) Most electronic equipment requires a low voltage direct current supply.

(i) A transformer can produce a low voltage AC from the high voltage AC input.

Complete Fig. 5 to show how a high voltage AC supply can be converted to a low voltage rectified output using four diodes to make a full wave bridge rectifier.

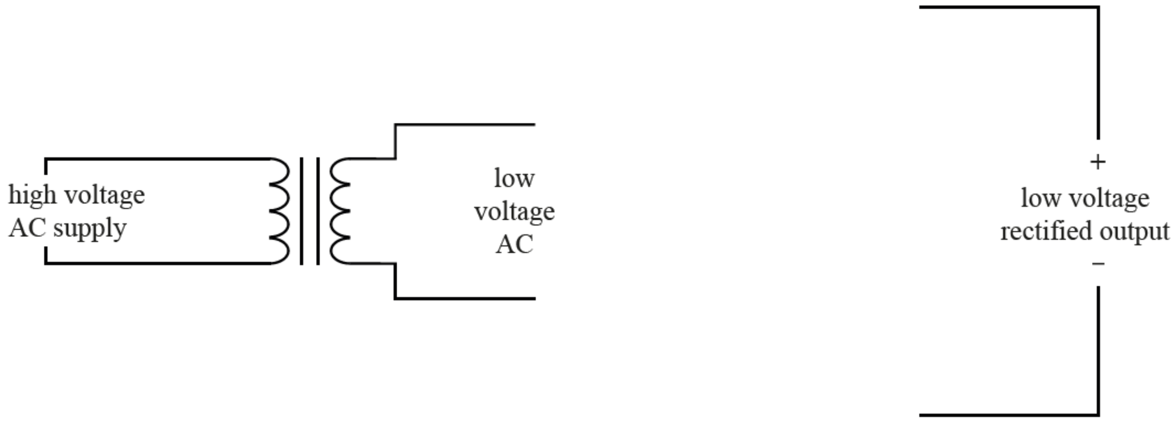

Fig. 5

[3]

Many candidates were able to construct a four diode bridge rectifier. However, some made connection errors so that the diodes achieved only half wave or no rectification, showing that although familiar with the diagram, they were not confident in their understanding.

Question 4 (c) (ii)

(ii) Fig. 6a shows the low voltage AC signal from the transformer.

Show how the full wave bridge rectifier operates by drawing the low voltage rectified output **on** the axes in Fig. 6b.

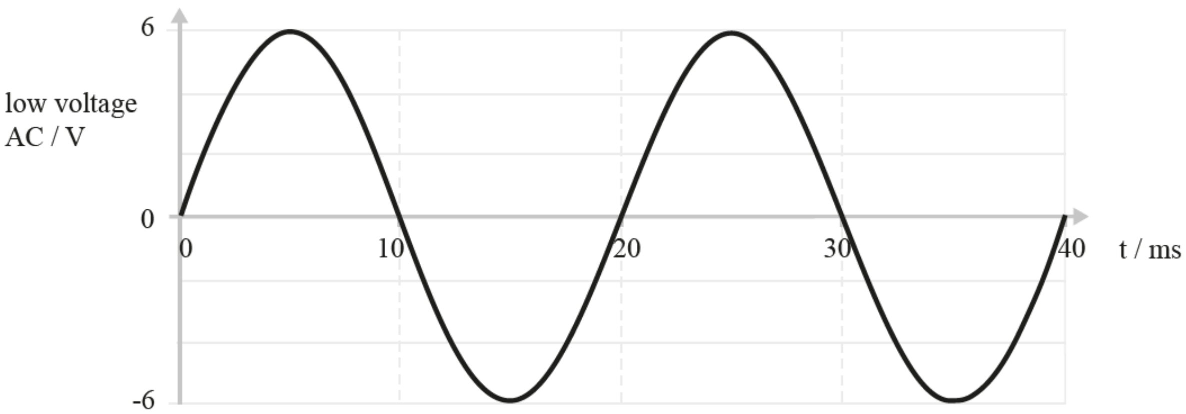

Fig. 6a

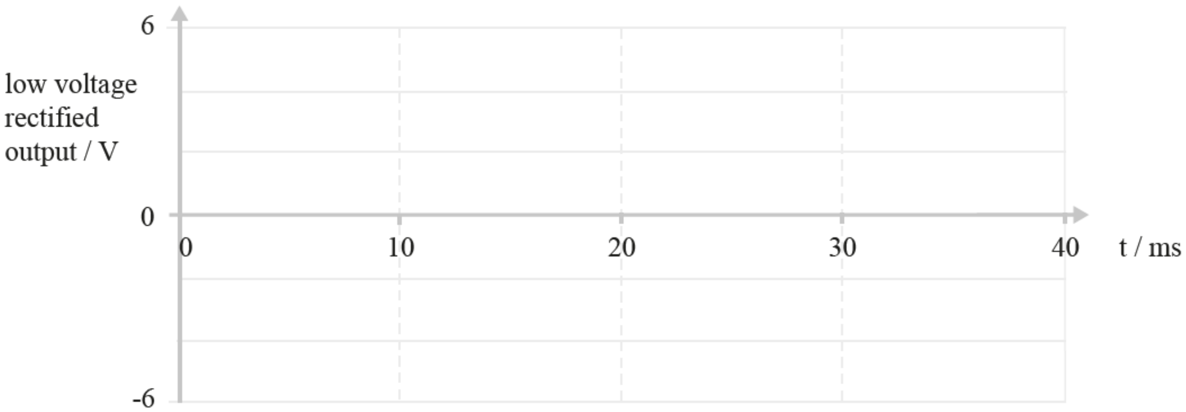

Fig. 6b

[2]

A minority of candidates were successful in their response, but many candidates struggled with rectification as shown on a voltage time graph.

Question 5 (a)

5 (a) An operational amplifier (op amp) of Voltage Gain = −12 is used to amplify the voltage from a sensor attached to the input of the amplifier, producing an input voltage, $V_{in} = 0.3$ V.

Calculate the output voltage V_{out}.

Use the formula: Voltage Gain = $\frac{V_{out}}{V_{in}}$

V_{out} = ... V **[2]**

Most candidates were able to gain full marks for this question.

Question 5 (b)

(b) An inverting op-amp amplifier is used to amplify the signal.

Calculate suitable values for the input resistor R_{in} and the feedback resistor R_F to provide a Voltage Gain = −12.

Use the formula: Voltage Gain = $-\frac{R_F}{R_{in}}$

R_F = ... Ω

R_{in} = ... Ω

[2]

The majority of candidates were able to answer this question successfully, with incorrect responses usually due to giving negative values for R_F.

Question 5 (c)

(c) Complete the circuit diagram in Fig. 7 of an op-amp inverting amplifier.

Label the resistors $\mathbf{R_F}$ and $\mathbf{R_{in}}$ and the **input** and **output** of the amplifier.

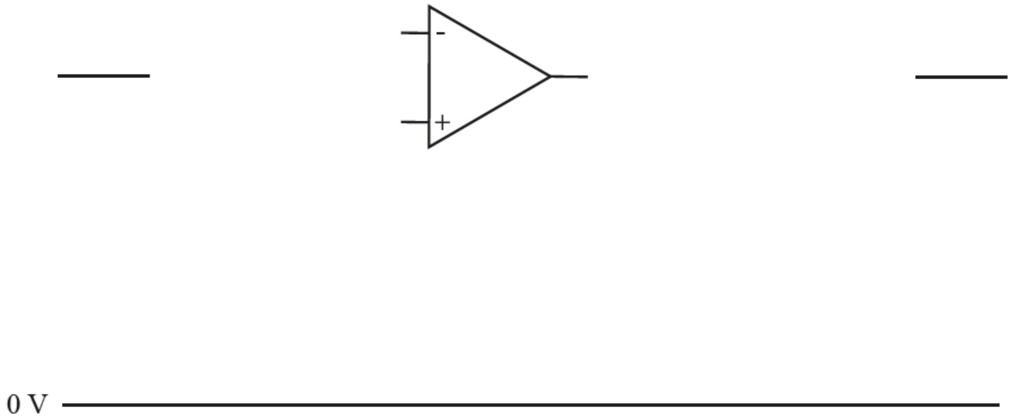

Fig. 7

[7]

Candidates appeared fully aware of the op-amp diagram but struggled to make the correct connections and find the correct location for the resistors.

Question 6 (a)

6 **(a)** Draw the circuit symbol for a NAND gate.

Label the inputs **A** and **B** and label the output **Q**.

[1]

The majority of candidates answered correctly with little ambiguity of symbol. A minority did not read the question carefully, omitting the labels A, B and Q and thus were not given the mark.

Question 6 (b)

(b) Complete the truth table for a NAND gate.

A	B	Q

[2]

The majority of candidates answered correctly.

Question 6 (c)

(c) Put a ring around the correct Boolean expression for a NAND gate.

$\mathbf{Q = A + B}$ $\mathbf{Q = \overline{A + B}}$ $\mathbf{Q = A \cdot B}$ $\mathbf{Q = \overline{A \cdot B}}$ $\mathbf{Q = A \oplus B}$

[1]

The majority of candidates were able to identify the correct Boolean expression.

Question 6 (d)

(d) Fig. 8 shows a logic gate circuit.

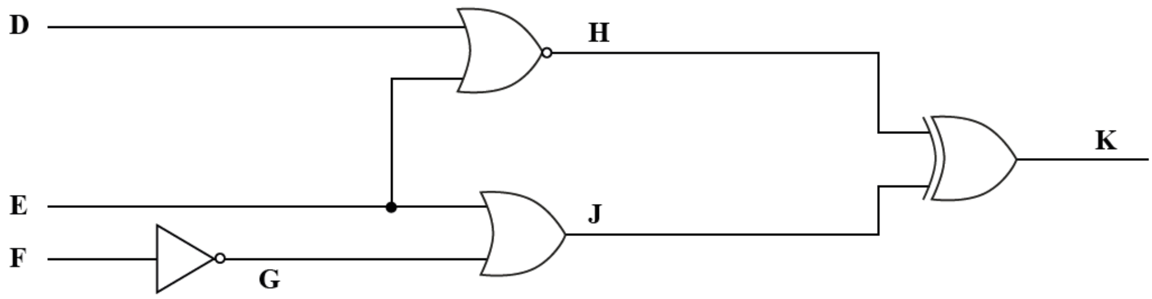

Fig. 8

Complete the truth table for the circuit in Fig. 8.

D	E	F	G	H	J	K
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 gained marks from this question with the NOT gate particularly well understood. The NOR and OR gate in particular proved challenging for candidates.

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