CAMBRIDGE TECHNICALS

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CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 4 Summer 2023 series

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

This paper was accessible to the vast majority of candidates. However, there were several instances of no response among the less successful scripts, even although the style and format of the paper has not changed. Candidates were able to recall key definitions and diagrams and select equations from the formula booklet with the highest scoring being able to apply their knowledge and algebraic skill.

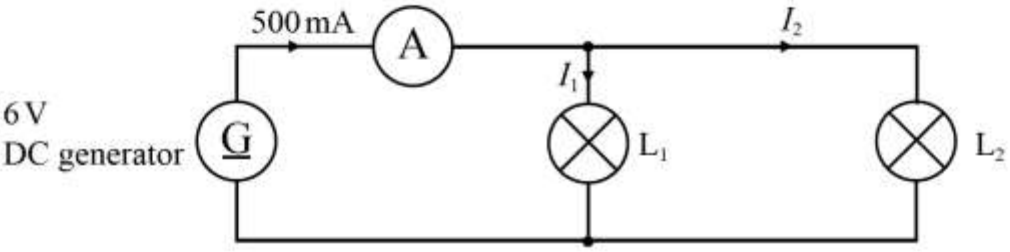
Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• had learned definitions and key information from the specification • had learned the circuit symbols for all components stated in the specification • noted when a question contained prefixes and subsequently used the correct power of ten • were able to apply prior knowledge from other units (10% of marks draw on knowledge from Units 1 and 2).	• did not have enough experience of past paper questions and exam technique thus missing out on marks involving recall of diagram and the giving of units where stated • were unfamiliar with the generator diagrams involving a load resistor rather than an open circuit representing an output voltage • attempted to give definitions (e.g. of rectification, AC and digital) in their own words rather than learning a textbook response.

Question 1 (a)

1 A bicycle has front and back lights powered by a 6 V DC generator of negligible internal resistance.

The front and back lights use filament lamps. A mechanic uses a multimeter to test the circuit while the bicycle wheel is turning the generator. **Fig. 1** shows the circuit diagram of the bicycle lighting system and the multimeter being used as an ammeter.

Fig. 1



(a) The multimeter is used as an ammeter to measure the current from the DC generator.

The current from the DC generator is designed to be 500 mA.

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

Draw an arrow **on Fig. 2b** to show the correct position of the dial to precisely measure the current from the DC generator.

Fig. 2a

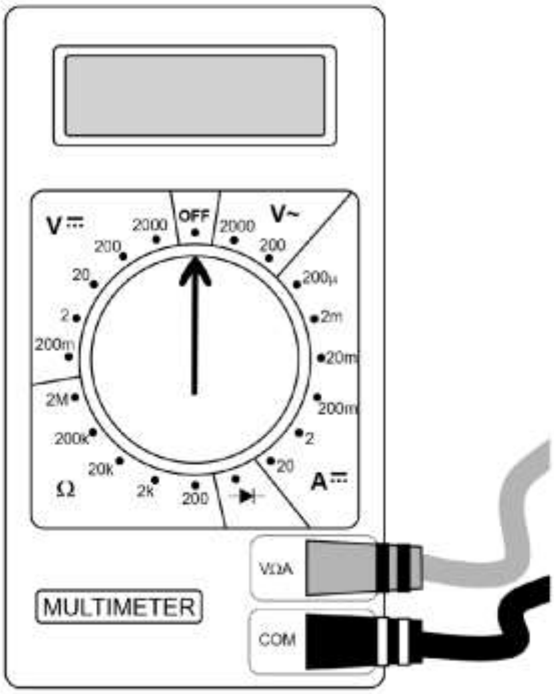
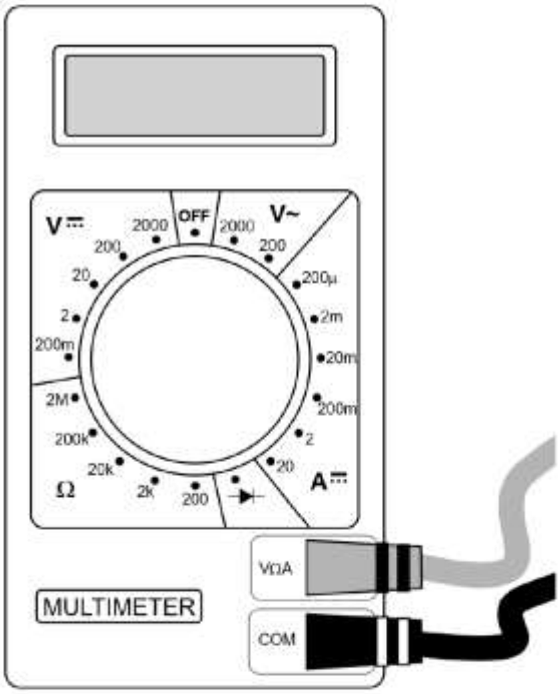


Fig. 2b



[1]

Many candidates gave responses between settings, not seeming to realise how the multimeter worked. Perhaps more hands-on experience of using a multimeter would reinforce the idea of discrete settings. The most common error was to select 200mA although selections of voltage and other settings were occasionally seen.

Question 1 (b) (i)

(b) The power dissipated by L_1 is 0.6 W.

(i) Calculate the energy dissipated by L_1 in 5 minutes.

energy dissipated by L_1 = ... J **[2]**

The majority of responses calculated the correct answer with the most common error being not converting the time to seconds.

Question 1 (b) (ii)

(ii) Calculate the current, I_1.

current, I_1 = ... A **[1]**

The power equation was used well here by many candidates; however several responses were seen incorrectly assuming the current was the same throughout the circuit, thus giving a response of 500mA, or that the current would split in half, thus answering 250mA.

Question 1 (b) (iii)

(iii) Calculate the resistance of L_1.

resistance of L_1 = ... Ω **[1]**

This question was well attempted with the majority of candidates using Ohm's Law to find an answer based on their previous responses and information from the question.

Question 1 (c)

(c) Calculate the resistance of L_2.

resistance of L_2 = ... Ω **[2]**

Many responses did not apply Kirchoff's Law to the circuit to obtain I_2, instead using their I_1 in Ohm's Law. Successful responses were more likely to have annotated their diagram and may have also noticed that 2 marks were given for this response indicating a two-step process.

Question 1 (d)

(d) Calculate the power dissipated by L_2.

power dissipated by L_2 = ... W **[1]**

This question was well attempted by the majority of candidates.

Question 2 (a)

2 An inductor and resistor are connected in series to an alternating current (AC) generator.

(a) Explain what is meant by alternating current.

[2]

Many candidates confidently stated changing direction but less successful responses were seen including fluctuating or varying current or an attempt to describe a sine wave which could not be credited. Fewer responses then went on to describe this change as happening repeatedly over a period of time for the second mark point. Candidates referring to positive and negative current had to qualify this with reference to direction as the response could also be referring to charge.

Question 2 (b)

(b) Draw a circuit diagram of the inductor and resistor connected in series to an alternating current (AC) generator.

Label all components.

[2]

Inductor symbols were not well known with several instances of capacitors, resistors, transformers or other drawn in their place. Similarly, the AC generator was often seen drawn as an armature, DC supply or ammeter. Although the majority of candidates attempted to draw the components in series there were many instances of incomplete circuits to represent a voltage output or the inclusion of an additional component, most commonly a cell.

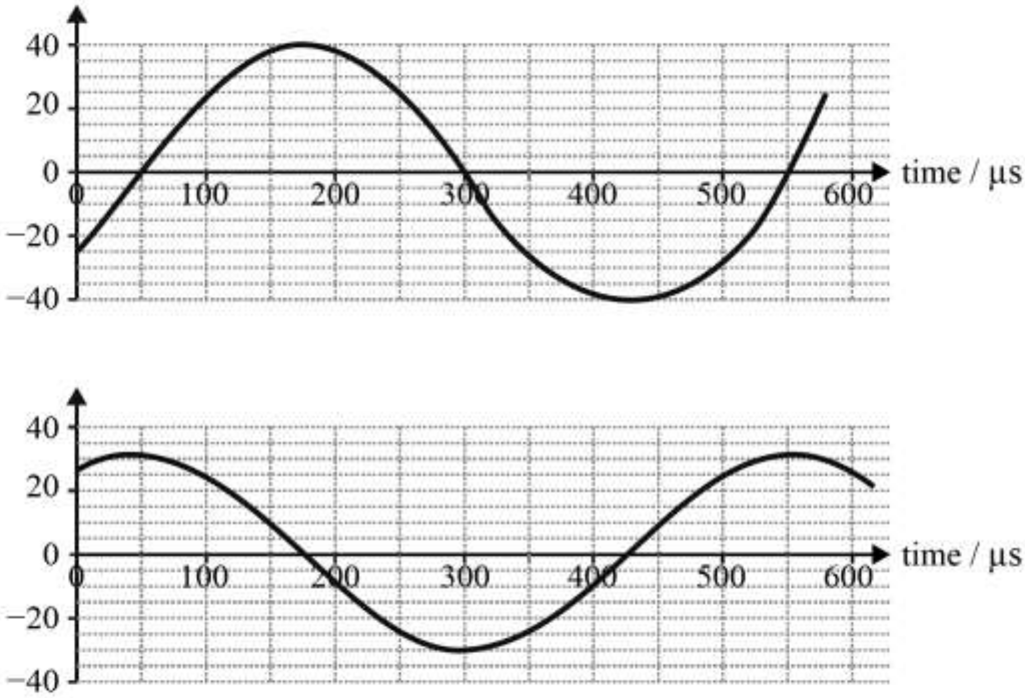
Assessment for learning

Circuit symbols should be learned for all components mentioned in the specification.

Question 2 (c) (i)

(c) Graphs of voltage against time for the voltage across the resistor V_R and the voltage across the inductor V_L are shown in **Fig. 3**.

Fig. 3



(i) Find the amplitude of V_R from the graph in **Fig. 3**.

amplitude of V_R = ... V **[1]**

The majority of candidates successfully read the amplitude from the figure with a significant minority giving peak to peak voltage.

Question 2 (c) (ii)

(ii) Find the period of V_R from the graph in **Fig. 3**.

period of V_R = ... μs **[1]**

Although most candidates appeared to understand the definition of the period many attempted to estimate the time from the peak to peak or trough to trough value. Candidates should be encouraged to calculate the period using the points where the wave cuts the time axis as this gives a value which is much easier to read. A minority of responses calculated the correct period but then halved the value or misread the scale.

Question 2 (c) (iii)

(iii) Calculate the frequency of V_R.

frequency of V_R = ... Hz **[2]**

Many candidates struggled with the conversion of microseconds and selecting the formula connecting frequency with time period.

Assessment for learning

Prefixes should be learned by candidates.

Question 2 (c) (iv)

(iv) Calculate the phase difference between V_R and V_L in degrees.

phase difference between V_R and V_L = ... ° **[2]**

Many responses found the correct phase difference but did not then convert this into a value in degrees.

Question 2 (c) (v)

(v) Calculate the phase difference between V_R and V_L in radians.

phase difference between V_R and V_L = ... rad **[1]**

A minority of candidates were able to select the correct equation from the formula booklet and apply it to their value for Question 2(c)(iv).

Question 3 (a)

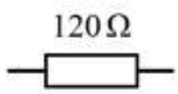
3 An engineer is testing a series-wound self-excited DC generator connected to a 120 Ω resistor.

The resistance of the armature is 25 Ω and the resistance of the field winding is 18 Ω.

(a) Draw the circuit diagram of a series-wound self-excited DC generator **on Fig. 4** and show how it is connected to the resistor.

Label the field winding and the armature.

Fig. 4



[2]

As with Question 2(a) there were many incorrect components drawn. The 120Ω resistor being the load seemed to confuse candidates with many leaving gaps in the circuit for a voltage output or drawing in an additional DC or AC supply.

Question 3 (b) (i)

(b) When the generator is connected to the 120 Ω resistor the voltage at the output is 8.2 V.

(i) Calculate the current in the 120 Ω resistor.

current in the 120 Ω resistor = ... A **[1]**

The vast majority of candidates answered successfully using the correct equation with a minority including the armature and field winding resistance in their calculation.

Question 3 (b) (ii)

(ii) Calculate the EMF, E, in the armature.

Give the units of your answer.

EMF generated in the armature, E = ... **[3]**

Candidates that showed full working were more likely to gain marks. If the correct equation was selected the most common error was to incorrectly add the load resistance onto the field winding and armature resistances to find the total resistance, with some candidates just using R_a or R_f instead of calculating R_t. The question explicitly asked for the units, which was marked independently of the answer, however this was left blank by many candidates or an incorrect unit selected.

Question 3 (c) (i)

(c) When the 120 Ω resistor is replaced by a power supply, the series-wound DC generator works as a series-wound DC motor.

(i) State the difference between a motor and a generator.

....

....

....

.... **[2]**

This was well attempted by the vast majority of candidates, however a minority incorrectly mixed up the definitions of the two devices or referenced chemical or physical energy.

Question 3 (c) (ii)

(ii) When the motor is operating from a supply of 24 V the EMF in the armature is 17 V.

Calculate the current in the armature, I_a.

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

Candidates who selected the correct equation from the formula sheet were typically successful.

Question 3 (c) (iii)

(iii) The engineer needs a motor to make a conveyer belt move at a fairly constant speed regardless of the load on the conveyor belt. A series-wound self-excited DC motor is not the best choice of motor for this application.

Suggest a better choice of DC motor for the conveyor belt. Explain your answer. Refer to the characteristics of the motor.

....

....

.... **[2]**

Although many responses referenced the shunt-wound (or alternative correct response) as a better choice, the explanation was not always clear. Fewer responses referred to the limitations of the series-wound motor in terms of its speed being much higher with reduced load or matching the performance of the shunt-wound (it's speed not being strongly dependant on load) to the specification of a constant speed requirement.

Question 4 (a)

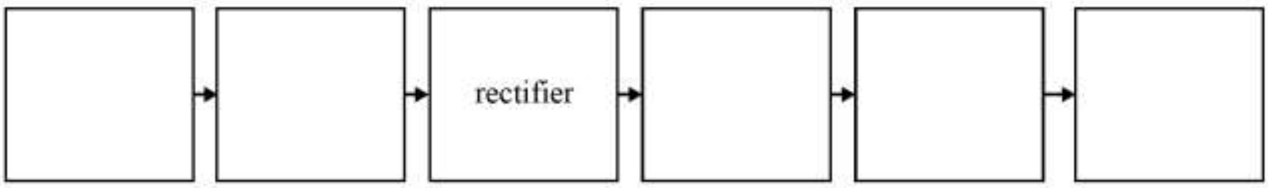
4 A stabilised power supply is used to provide the steady 19 V DC supply for a laptop computer from the 230 V AC mains supply.

(a) Complete the block diagram of a stabilised power supply shown in **Fig. 5**.

Choose from the terms below.

3-wire Delta	**AC input**	**DC output**	**smoothing circuit**	**stabilising circuit**	**transformer**

Fig. 5



[5]

This question was successfully attempted by the majority of candidates with the most common error being to transpose the smoothing and stabilising circuits.

Question 4 (b)

(b) State the function of the rectifier.

....

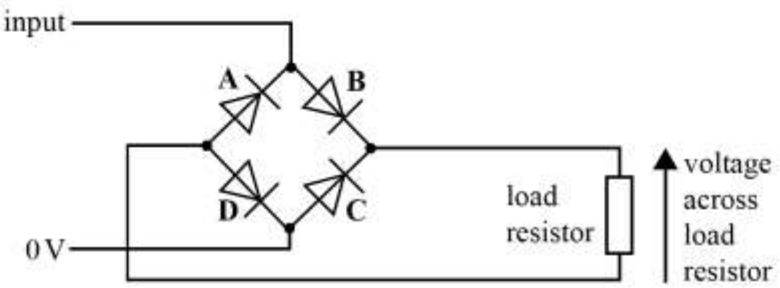
.... **[1]**

This question was well attempted but a significant minority used the stem of the question referring to the fact that it rectifies current or attempted to describe a voltage-time graph.

Question 4 (c) (i)

(c) A rectifier is shown in **Fig. 6**.

Fig. 6



(i) Complete the sentences below about the rectifier in **Fig. 6** using the most appropriate term in each gap.

Choose terms from the following list.

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

A and B **A and C** **A and D** **all** **B and C** **B and D** **C and D** **no**

When the voltage at the input is 24 V, ... diodes are conducting.

When the voltage at the input is 0 V, ... diodes are conducting.

When the voltage at the input is −24 V, ... diodes are conducting.

[3]

The path of current flow in a full wave rectifier was not well understood. However the majority of responses were able to achieve the second mark point for no diodes conducting when the voltage input is 0 V.

Question 4 (c) (ii)

(ii) The input voltage to the rectifier is shown in **Fig. 7a**.

Show how the full wave bridge rectifier operates by drawing the voltage across the load resistor on the grid in **Fig. 7b**.

Fig. 7a

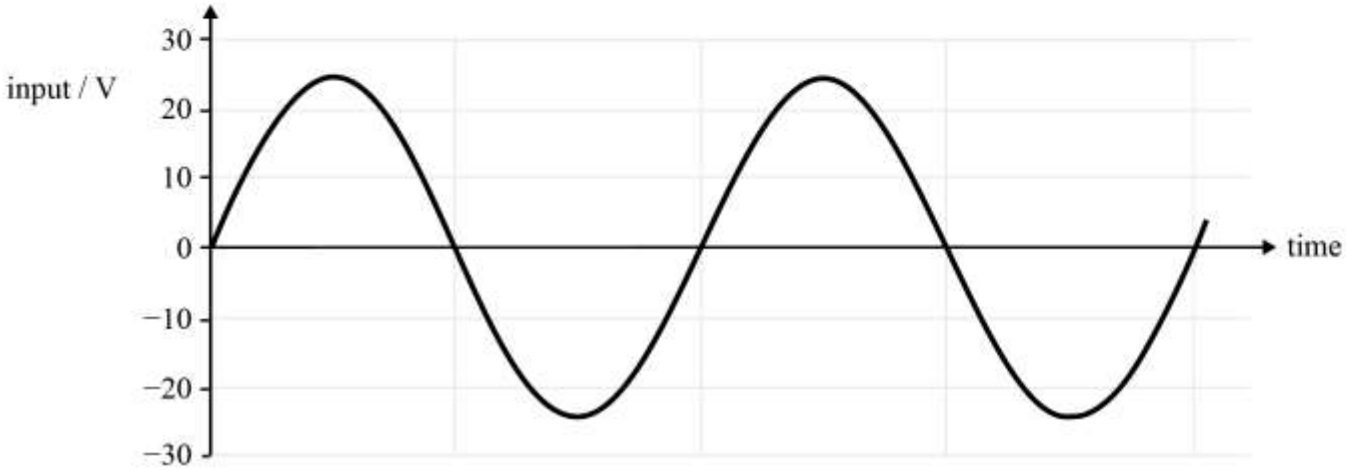
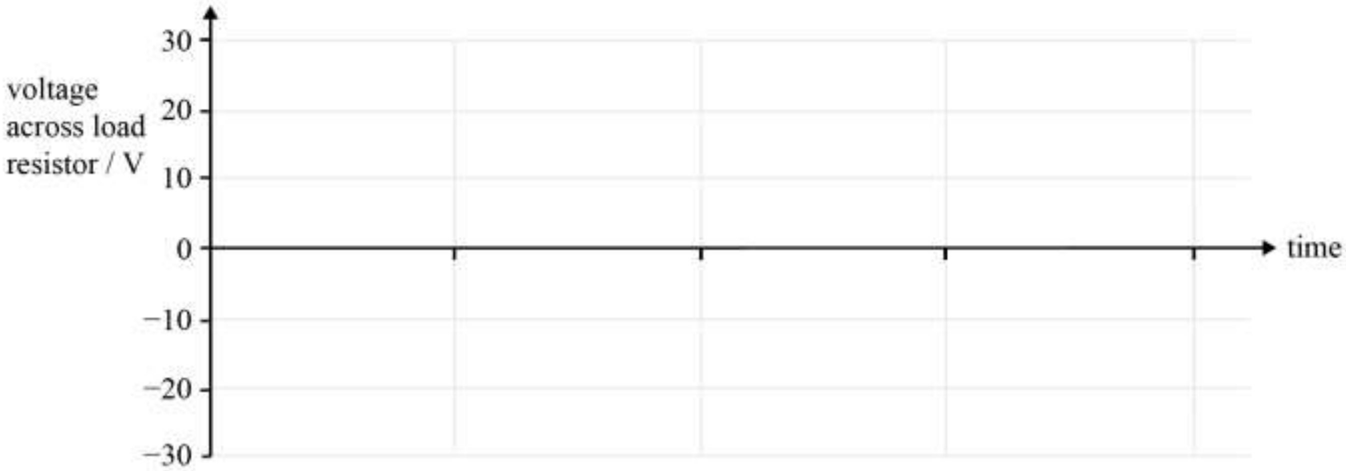


Fig. 7b



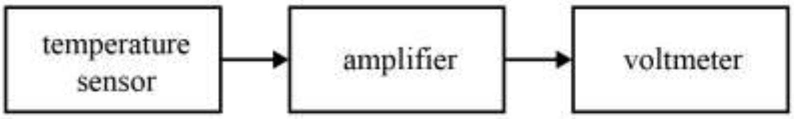
[2]

The wave was drawn correctly by the majority of candidates with a minority drawing half wave rectification or drawing with a different period.

Question 5 (a) (i)

5 The block diagram of a system for measuring temperature is shown in **Fig. 8.**

Fig. 8



(a) The equation for voltage gain of a non-inverting op-amp amplifer is:

$$\text{Voltage gain} = \frac{V_{\text{out}}}{V_{\text{in}}} = 1 + \frac{R_F}{R_2}$$

(i) When the voltage from the temperature sensor is 2.2 V the voltmeter reads 5.5 V.

Calculate the voltage gain of the amplifier.

voltage gain of the amplifier = ... **[1]**

The majority of candidates correctly calculated 2.5 with a minority giving the reciprocal or adding/ subtracting 1 from their final answer.

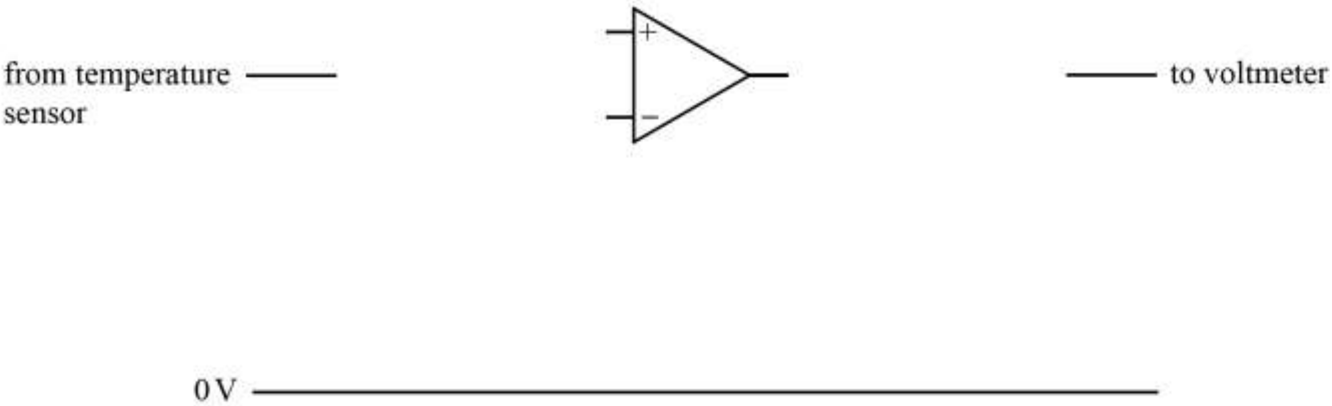
Question 5 (a) (ii)

(ii) The system in **Fig. 8** uses a non-inverting amplifier.

Complete the circuit diagram in **Fig. 9** of a non-inverting amplifier.

Label the components with suitable values.

Fig. 9



[5]

Many candidates appeared familiar with this op-amp circuit. However, a significant amount of positive feedback was seen along with instances of the inverting and non-inverting inputs being connected which lost candidates marks. Although the question clearly stated for components to be labelled, a minority of candidates gave resistor values on their circuit.

Question 5 (b)

(b) The current from the temperature sensor must be low to obtain an accurate reading.

State the property of an op-amp that ensures the current from the sensor is low.

....

.... **[1]**

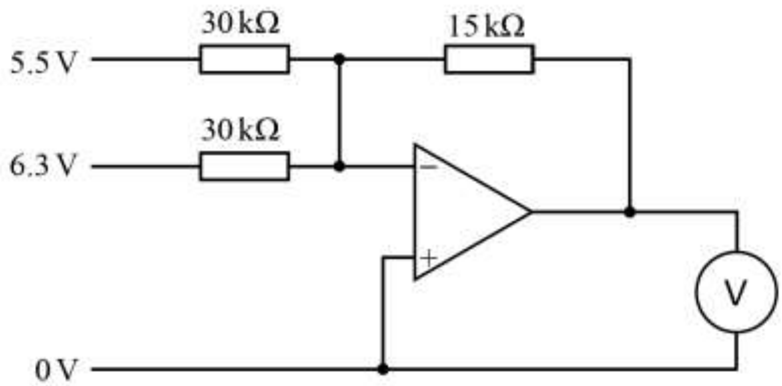
A minority of candidates successfully answered this question. Many were not given the mark because they didn't clarify that the high impedance/resistance was at the op-amp input.

Question 5 (c)

(c) The circuit in **Fig. 10** shows a summing amplifier being used to combine the signals from two temperature sensors.

Calculate the voltage shown on the voltmeter in **Fig. 10**.

Fig. 10



voltage shown on voltmeter = ... V **[3]**

Many candidates were given a mark for adding together the two voltages. However, of those that went on to successfully recall and use the formula, a minority gave the voltage shown as having a negative value.

Question 6 (a)

6 This question is about digital electronic circuits.

(a) State the meaning of **digital** in the term **digital electronic circuits**.

....

.... **[1]**

The majority of candidates were able to give an appropriate definition however this was often given as a longer explanation in their own words rather than a concise technical definition.

Assessment for learning

Definitions of key terms in the specification should be learned.

Question 6 (b)

(b) This is the truth table of a logic system with inputs **F** and **G** and output **P**.

F	G	P
0	0	0
0	1	1
1	0	0
1	1	0

Draw a circuit using logic gates to obey this truth table.

You may use any logic gates in your design.

Label the inputs **F** and **G**. Label the output **P**.

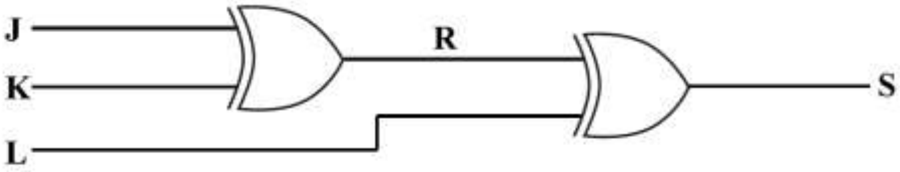
[2]

A minority of candidates attempted to answer the question using one logic gate. Of those that drew circuits with several gates the majority gained the first mark for inverting one of the inputs. Although the examples given in the mark scheme were most common, several candidates provided alternative responses, often with supporting logic tables, which were also given full marks.

Question 6 (c) (i)

(c) A logic circuit is shown in **Fig. 11**.

Fig. 11



(i) Name the type of logic gate used in **Fig. 11**.

.... **[1]**

The majority of candidates answered this successfully with NOR and OR being the most common incorrect responses.

Question 6 (c) (ii)

(ii) Put a (ring) around the Boolean expression for the first logic gate in **Fig. 11**.

$\mathbf{R = J + K}$ $\mathbf{R = \overline{J + K}}$ $\mathbf{R = J \cdot K}$ $\mathbf{R = \overline{J \cdot K}}$ $\mathbf{R = J \oplus K}$

[1]

Most candidates were able to identify the correct Boolean expression.

Question 6 (c) (iii)

(iii) Complete the truth table for the logic circuit in **Fig. 11**.

J	K	L	R	S
0	0	0		

[3]

Many candidates were able to state all of the input combinations, with the most successful strategy being to count up from 0 in binary. Candidates that that gave their inputs in an undefined order were more likely to make a duplication and omit a combination. Some were then able to successfully complete the outputs at R and S although a significant number missed out on marks by not making it clear what their response was.

Overlapping 1 and 0 could not be given and candidates should clearly score out a response before replacing it with a clear alternative, next to the crossed out response, when changing an answer.

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