Cambridge Technicals
Engineering

Unit 4: Principles of electrical and electronic engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825

Mark Scheme for January 2020

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

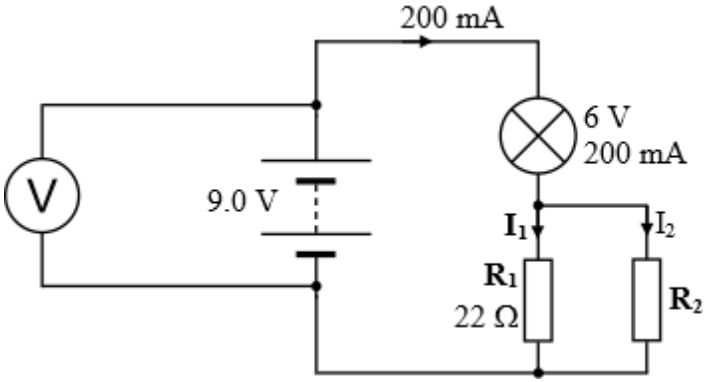
Annotations

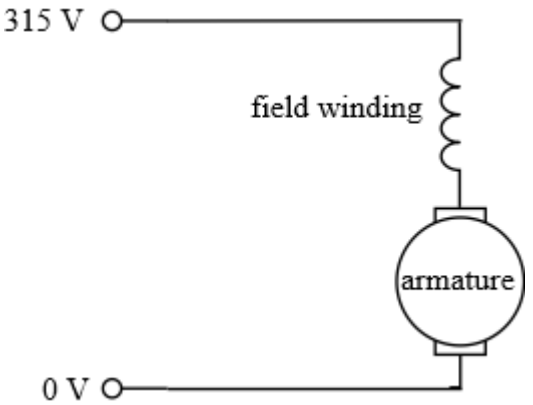
Annotation	***Meaning***
tick	Correct response
cross	Incorrect response
Omission mark (carat)	Incomplete response
ECF	Error carried forward
BOD	Benefit of doubt
NBOD	No benefit of doubt
RE	Rounding error

Subject-specific marking instructions

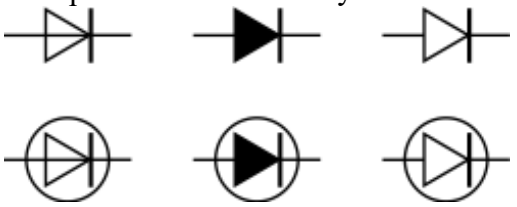
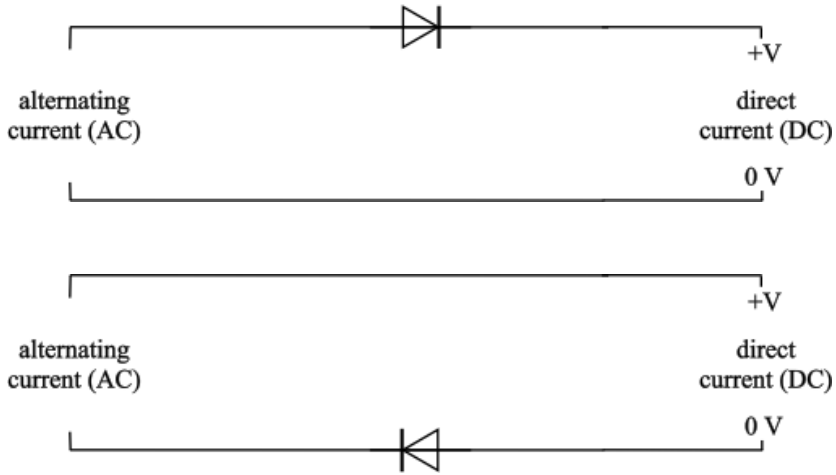
- In all numerical calculation questions a correct response will gain all marks unless specified otherwise.
- Rounding of answers should be to the same number of significant figures as the data in the question, or, otherwise, an answer will be correct provided it rounds to the correct answer.
- Symbols used in circuit diagrams must identify relevant components uniquely and unambiguously.

Question			Answer	Marks	Guidance
1	(a)		P = VI = 6 x 0.2 = 1.2 (W)	1	
1	(b)		3 minutes = 180 s E = P Δt (Evidence of using correct equation) = 1.2 x 180 = 216 (Correct calculation) J or Joules (Correct units)	1 1 1	Ecf for P from 1(a) Synoptic mark from Unit 2: 3.8 Accept alternative calculation consistent with units. Accept valid units of energy (J, Ws, Wmin, Whr) provided consistent with calculation. Synoptic mark from Unit 2:1.1
1	(c)		9 - 6 = 3 (V)	1	
1	(d)		$I_1 = \frac{3}{22} = 0.136\ A = 136\ (mA) = 140\ (mA)\ (2\ s.f.)$	1	Ecf for their 1 (c)
1	(e)		$I_2 = 200 - I_1 = 0.064A$ $R_2 = \frac{V\ across\ R_2}{I_2} = 47\ (\Omega)$	1 1	Evidence of calculating I_2 ie award use of Kirchoff I (ecf for their I_1) Correct calculation using Ohm's law and their 1(c) ecf I_2
1	(f)		$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{22} + \frac{1}{47} = 0.0667$ $\frac{1}{0.0667} = 15\ (\Omega)$ ±1 Ω (i.e. 14 Ω to 16 Ω)	 1	Ecf for their R_2 from 1 (e)

Question			Answer	Marks	Guidance
1	(g)		Voltmeter connected across battery	1	
2	(a)	(i)		1 1 1	Indication of AC power supply with value shown 3 components in series and correct symbol for resistor with value shown Correct symbol for capacitor with value shown Symbols clear enough that they couldn't be mistaken for another component eg length of capacitor lines
2	(a)	(ii)	f = 250 kHz = 250000 Hz C = 220 pF = 2.2 x 10^{-10} F $\frac{1}{2\pi fC} = \frac{1}{2\pi \times 250000 \times 2.2 \times 10^{-10}} = 2900\ (\Omega)$	1 1 1	Correct conversion to Hz Correct conversion to F (ecf from value for f and C)

Question			Answer	Marks	Guidance
2	(a)	(iii)	$Z = \sqrt{R^2 + {X_C}^2} = \sqrt{4700^2 + 2900^2}$ Correct values in equation. Z = 5519 = 5500 (Ω) (2 s.f.)	1 1	Allow ecf from 2aii
2	(a)	(iv)	$(\cos \phi) = \frac{4700}{5519} = 0.852$ $\cos^{-1}(0.852) = 31.6° \pm 1$	1 1	Allow ecf from 2aiii Correct calculation of arc cos Synoptic mark from unit 1:4.7
3	(a)		Diagram with labelled field winding, labelled armature and no other parts (with exception of a load resistor) and current supplied to armature. Field winding and armature in series with power supply.	1 1	 Accept any unambiguous labelled symbols

Question			Answer	Marks	Guidance
3	(b)		Valid comment about torque or turning force Valid comment about conditions e.g. starting from rest/low speed E.g. Series wound motor develops high torque (wtte) At low speed (wtte) Or Shunt wound motor has low torque (wtte) On starting (wtte)	1 1	
3	(c)	(i)	Resistance of motor = $R_a + R_f = 0.42 + 0.63 = 1.05\ (\Omega)$	1	
3	(c)	(ii)	$I_a = \frac{V-E}{R_a+R_f}$ $I_a = \frac{315-141}{1.05} = 165.71 = 166\ (A)\ (3\ s.f.)$	1 1	evidence of correctly rearranging formula Synoptic mark from unit 1: 1.3 correct substituting and calculating. ecf for their 3ci
3	(c)	(iii)	Current increases Up to 2 marks for explanation: EMF decreases Link to motor equation i.e. I increases as E decreases due to R/V staying the same	1 1 1	Must be correct to be awarded explanation marks.

Question			Answer	Marks	Guidance
4	(a)	(i)	Correct diode symbol  used anywhere in diagram	1	Accept alternative diode symbol 
			Diodes achieve rectification	1	Award this mark even if polarity of output is incorrect
			Connections are made so that rectifier produces correct polarity half-wave rectified dc	1	Must obtain rectification mark for this mark
			Correct answers for 3 marks: 		

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>4</td><td>(a)</td><td>(ii)</td><td>Comment about diode only conducting in one direction

Comment about only half of ac wave being conducted to output</td><td>1

1</td><td>Diode only conducts/allows current to flow/allows appropriate wave cycle through (or wtte) in one direction
So only allows positive part of AC signal (allow description of current flow that makes it clear correct polarity is achieved) through to the output (or wtte)</td></tr>
<tr><td>4</td><td>(b)</td><td></td><td>Maintains constant/little change in voltage/current (wtte)

Regardless of the load on the output (wtte)</td><td>1

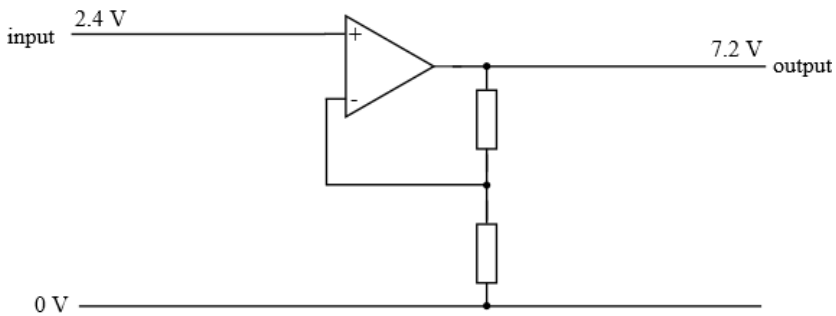
1</td><td>Do not allow power

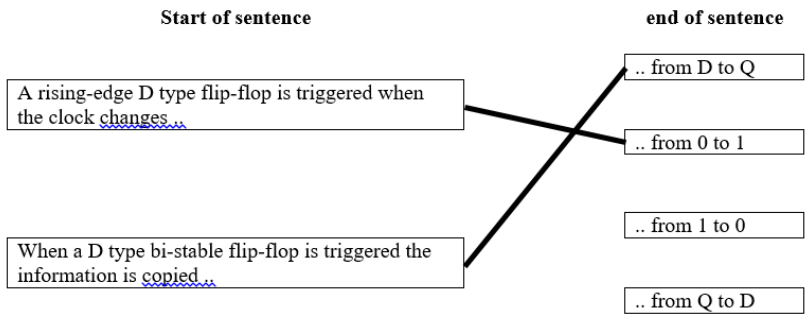
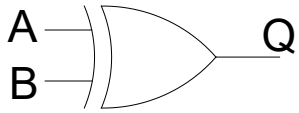
Accept ‘regardless of current drawn’ if constant or little change in voltage</td></tr>
<tr><td>4</td><td>(c)</td><td></td><td>Fuses are used to protect power supplies and electrical devices. A fuse is connected in series with the power supply and the electrical device. If a fault occurs in the electrical device and it draws too much power then high current flows through the fuse causing it to get very hot and melt. After the fuse has melted no current is supplied to the electrical device and it stops operating.</td><td>1

1

1</td><td></td></tr>
<tr><td>5</td><td>(a)</td><td></td><td>One mark for each correct answer

<table><tr><th>Ideal op-amp</th><th>Real op-amp</th></tr><tr><td>infinite (1)</td><td>very high</td></tr><tr><td>infinite (1)</td><td>high (1)</td></tr><tr><td>zero</td><td>low (1)</td></tr></table></td><td>4</td><td>Allow symbol for infinite</td></tr>
</table>

Question			Answer	Marks	Guidance
5	(b)	(i)		1	Allow arrow from 0V up to positive rail
5	(b)	(ii)	**non-inverting amplifier**	1	
5	(b)	(iii)	$\boldsymbol{Voltage\ Gain = \frac{7.2}{2.4} = 3.0}$	1	Synoptic mark from unit 1: 1.3 Ignore units
5	(b)	(iv)	Resistors in ratio 2:1 Larger value labelled on top resistor Units in Ω [or kΩ]	1 1 1	 Synoptic mark from unit 2: 1.1

Question			Answer	Marks	Guidance
6	(a)		1 mark for each correct line  	2	
6	(b)		 	1	Gate **and** labels are needed for the mark

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td>(c)</td><td></td><td>
<table>
<tr><th>A</th><th>B</th><th>Q</th></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
</table>
All combinations of A and B (any order)
Q correct</td><td>1
1</td><td></td></tr>
<tr><td>6</td><td>(d)</td><td></td><td>Q = A ⊕ B</td><td>1</td><td></td></tr>
</table>

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td>(e)</td><td></td><td>
<table>
<tr><th>G</th><th>H</th><th>J</th><th>K</th></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>1</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td><td>1</td></tr>
</table>
</td><td>1
1
1
1</td><td>1 mark for each correct column
G
H - allow ecf from G to H (if 0 scored for G)
J
K - allow ecf from H and J to K (if 0 scored for J)</td></tr>
</table>

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