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 2021

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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.

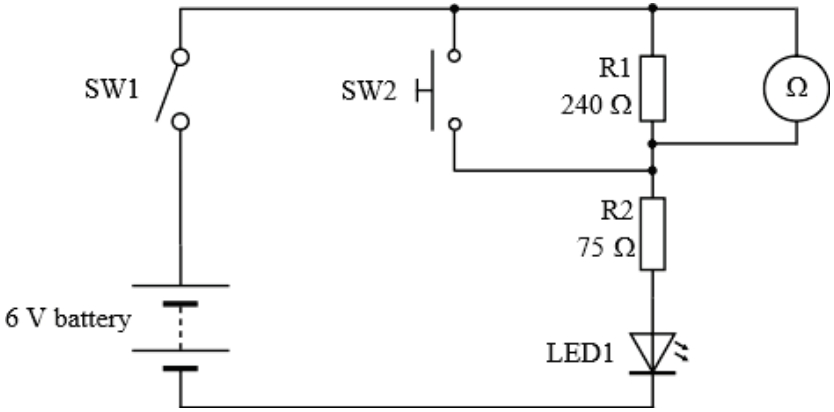
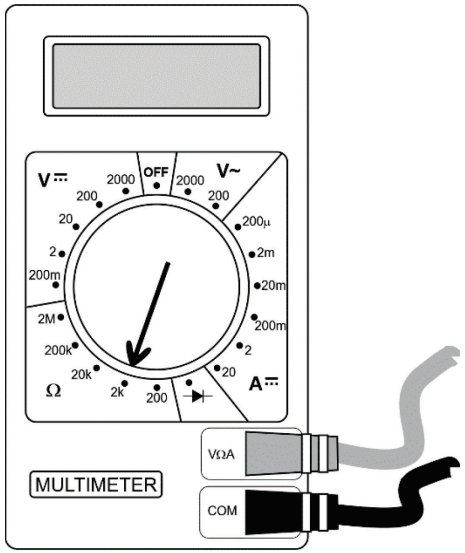
Mark schemes should be read in conjunction with the published question papers and the report on the examination.

Annotations

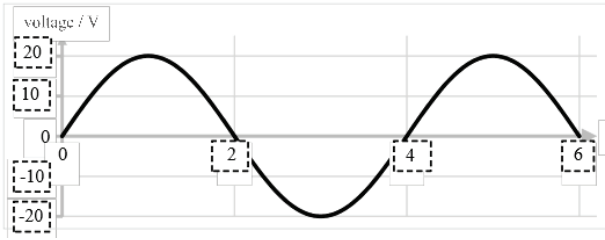
Annotation	***Meaning***
tick	Correct response
cross	Incorrect response
Omission mark (carat)	Incomplete response
ECF	Error carried forward
BOD	Benefit of doubt
NBOD	No benefit of doubt
RE	Rounding error

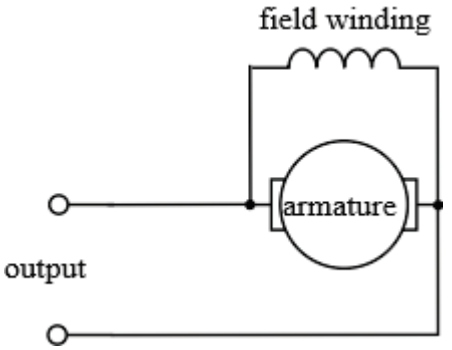
Subject-specific marking instructions

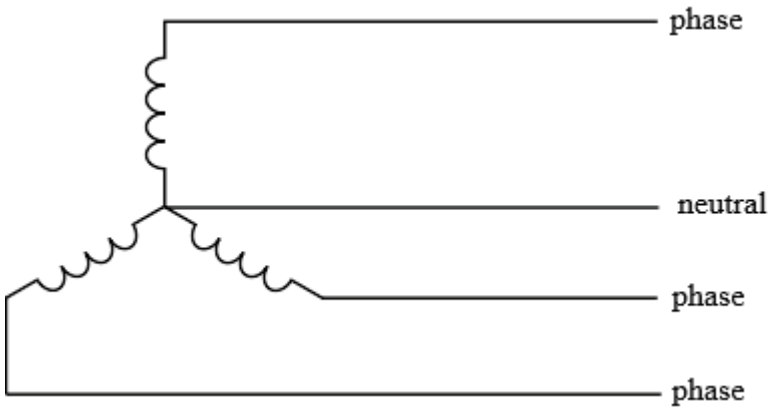
- In all numerical calculation questions a correct response will gain all marks unless specified otherwise.
- Rounding of answers should be to the same number of significant figures as the data in the question, or, otherwise, an answer will be correct provided it rounds to the correct answer.
- Symbols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

Question			Answer	Marks	Guidance
1	(a)	(i)	Ohmmeter connected in parallel with R1 	1	Accept any unambiguous symbol for ohmmeter
1	(a)	(ii)		1	

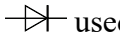
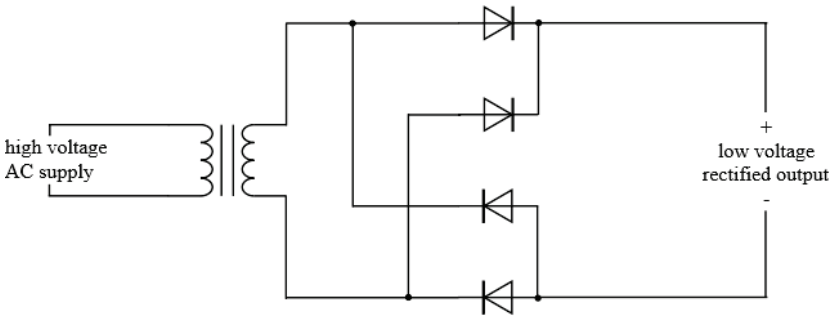
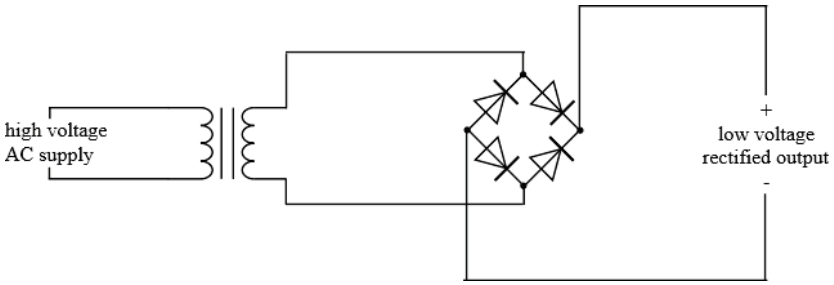
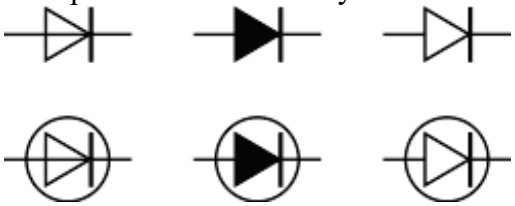
Question			Answer	Marks	Guidance
1	(a)	(iii)	Up to a maximum of 2 marks from the following: Reason SW1 is off • To prevent damage to meter • To stop power supply interfering with reading Reason SW2 is not pressed • To stop the meter reading 0 Ω • To prevent the resistor being shorted out of the circuit • The meter would measure the resistance of the switch if SW2 was pressed Reason both switches are off • The resistance would change • There is greater accuracy in the reading • There is no interference from other components	2	
1	(b)	(i)	6 – 3.6 = <u>2.4</u> V	1	
1	(b)	(ii)	RT = R1 + R2 = 75 + 240 = 315 Ω I = 2.4/315 = <u>0.0076</u> A (ecf from 1bi)	1 1	Evidence of correctly calculating total resistance Voltage from 1bi divided by resistance
1	(b)	(iii)	I = 2.4/75 = <u>0.032</u> A (ecf from 1bi)	1	

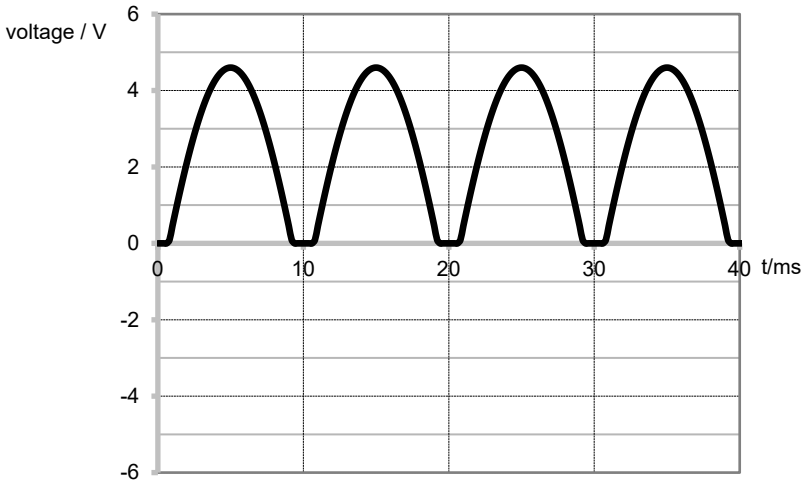
Question			Answer	Marks	Guidance
1	(b)	(iv)	P = IV = 0.032 x 2.4 = 0.0768 W = 0.077 W (2 s.f.) Calculation (ecf from 1biii and/or 1bi) Units	1 1	$P = \frac{V^2}{R} = \frac{2.4^2}{75} = 0.0768$ $P = I^2R = 0.032^2 \times 75 = 0.0768$ Accept answer in mW P = 77 mW Synoptic mark from Unit 2: 1.1
2	(a)		Current changes direction periodically/moves one way then the other/keeps changing direction (owtte)	1	Do not accept 'flows in both directions'. Answer must express the idea that the change in direction of current flow changes with time.
2	(b)	(i)	f = 250 x 1000 =250000 Hz T = 1/250000 = 0.000004 s = 0.000004 x 1000000 = 4 μs	1 1	Evidence of correct conversion to Hz or other route to μs Synoptic mark from Unit 2: 1.1 Evidence of correct use of 1/T
2	(b)	(ii)	20 on voltage axis Voltage axis labelled -20, -10, 10, 20 4 on time axis (ecf from bi) Time axis labelled 2, 4, 6 (ecf)	1 1 1 1	
2	(b)	(iii)	Correct conversion from 250 kHz to 250000 Hz $\omega = 2 \times \pi \times 250000 = 1570000 = 1.6 \times 10^6$ rad s^{-1}	1 1	Synoptic marks from Unit 1: 4.1

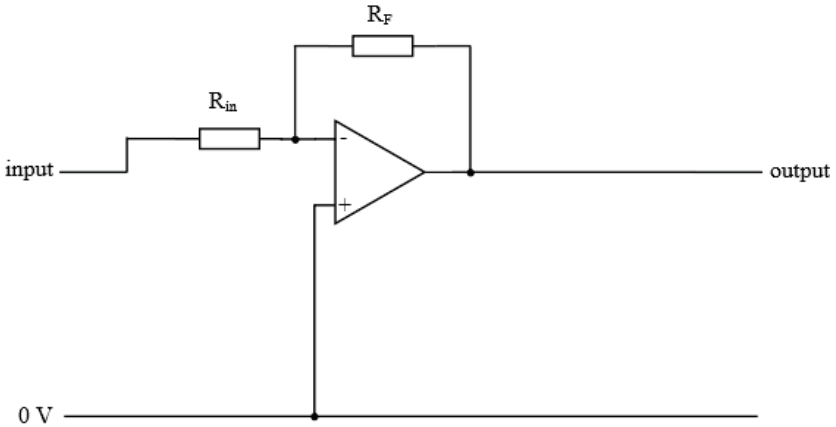
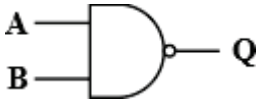
Question			Answer	Marks	Guidance
2	(b)	(iv)	Correct values substituted into equation Correct calculation $v = 20 \sin(1.6\text{x}10^{6} \text{ x } 2.2\text{x}10^{-6}) = -6.1/.15/.147/.18/.2, 7.389$ V	1 1	 Accept: $20 \sin(2 \text{ x } \pi \text{ x } 250000 \text{ x } 2.2\text{x}10^{-6}) = -6.180$ V Beware, incorrect calculation of sin in degrees leads to incorrect answer of 1.2 V
3	(a)		A motor converts electrical energy into mechanical energy A generator converts mechanical energy into electrical energy	1 1	
3	(b)	(i)	Diagram consists of only armature and field winding Field winding and armature labelled (accept labels of 18 Ω and 0.12 Ω) Field winding and armature in parallel Two labelled output terminals from armature (accept if through other components thus losing marks from previous points)	1 1 1 1	Accept any unambiguous symbols for field winding and armature. 
3	(b)	(ii)	$I_f = \frac{V}{R_f} = \frac{16}{18} = 0.889$ A	1	

Question			Answer	Marks	Guidance
3	(b)	(iii)	$I_a = \frac{E - V}{R_a}$	1	Correct rearrangement of equation Synoptic marks from Unit 1: 1.4
			$= \frac{18.8 - 16.0}{0.12} = 23.3\,A$	1	Correct values substituted into equation
3	(b)	(iv)	Because the field winding is in parallel with the output and some of the current goes through the field winding.	1	Reference to current in the field winding
4	(a)		Neutral wire correctly identified One wire labelled neutral and three wires labelled phase (ecf) 	1 1	Ignore any additional labelling of phase wire. Accept L1, L2, L3 for phase labels. Other acceptable labels for phase wires e.g. colours (brown, black, grey or Br, Bl, G) or the old colour scheme (red, yellow, blue or R, Y, B). N allowed for neutral

Question			Answer	Marks	Guidance
4	(b)		**star**	1	
			phase	1	
			line	1	

Question			Answer	Marks	Guidance
4	(c)	(i)	Correct diode symbol  used anywhere in diagram Diodes achieve rectification Rectifier produces correct polarity full-wave rectified dc Correct answers for 3 marks:  OR 	1 1 1	Accept alternative diode symbol  Award this mark even if polarity of output is incorrect Must obtain rectification mark for this mark For a correct half-wave rectifier circuit that produces the required polarity award 2 marks.

Question			Answer	Marks	Guidance
4	(c)	(ii)	All voltages on one side of zero volts line (t-axis) Graph shows full wave rectification  	1 1	Ignore polarity (give marks for either positive or negative) Ignore amplitude and any time at zero
5	(a)		Correctly rearrange formula V_{out} = Voltage Gain × V_{in} Correct substitution of values and calculation V_{out} = -12 x 0.3 = -3.6 V	1 1	Synoptic marks from Unit 1: 4.1
5	(b)		Resistors in ratio 12:1 R_F larger than R_{in}	1 1	

Question			Answer	Marks	Guidance
5	(c)		Resistor connected from inverting input to output of op-amp [1] Labelled $\mathbf{R_F}$ (dependent upon previous mark) [1] Resistor connected from input connection to inverting input of op-amp / Input connection labelled "**input**" [1] Resistor Labelled $\mathbf{R_{in}}$ (dependent upon previous mark) [1] Output of op-amp connected output connection [1] Output connection labelled "**output**" [1] Non-inverting input connected to 0 V only [1] 	7	7 x 1 marks
6	(a)			1	

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<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td>(b)</td><td></td><td>
<table>
<tr><th>A</th><th>B</th><th>Q</th></tr>
<tr><td>0</td><td>0</td><td>1</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>
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All combinations of A and B (any order), 1 mark
Q correct, 1 mark.
</td><td>2</td><td></td></tr>
<tr><td>6</td><td>(c)</td><td></td><td>$\mathbf{Q = \overline{A \cdot B}}$</td><td>1</td><td></td></tr>
<tr><td>6</td><td>(d)</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>0</td></tr>
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1
1
1</td><td>1 mark for each correct column
allow ecf from G to J
allow ecf from H and J to K</td></tr>
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