OCR
Oxford Cambridge and RSA

Cambridge Technicals

Engineering

Unit **2:** Science for engineering

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

Mark Scheme for January 2018

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations

Annotation	Meaning
tick	correct response worthy of a mark. **number of ticks = no of marks awarded**
cross	incorrect
omission (carat)	missing something
ecf	error carried forward
bod	benefit of doubt
nbod	not benefit of doubt
pot	power of ten error
con	contradiction
re	rounding error
sf	significant figure error
up	unit penalty

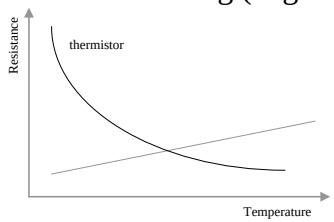
The number of marks awarded for each sub-section should be written on the right hand side of the page adjacent to the marks in square brackets. The total number of marks for each question should be written as a ringed total at the bottom of each question. The ringed totals should be transferred to the boxes on the front cover and the total mark for the paper calculated.

Subject specific marking instructions

- In numerical calculation questions a correct response will gain all marks unless specified otherwise. You do not need to see all the workings if the answer is correct unless it is a 'show that' question.
- Numerical answers should be given to a minimum of 2 significant figures unless specified otherwise. There is usually no penalty for using more than 2 significant figures, but the answer given should equal the stated value when rounded to 2 significant figures.
- Numerical answers given as fractions will not be credited unless specified otherwise.
- Power of ten (POT) errors will lose a max of one mark per calculation.
- In calculation questions where one of the marks is awarded for substitution into the equation, POT errors can be ignored. There will be a penalty in subsequent marks for POT errors.
- Where there is a mark awarded for using a correct equation it can be seen or implied.

<table>
<tr><th colspan="3">Question</th><th>Solution</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td></td><td>
<table>
<tr><td>Base SI unit</td><td>Physical quantity</td></tr>
<tr><td>metre</td><td>length</td></tr>
<tr><td>kilogram</td><td>mass</td></tr>
<tr><td>second</td><td>time</td></tr>
<tr><td>Ampere</td><td>(electrical) current</td></tr>
<tr><td>Kelvin</td><td>temperature</td></tr>
</table>
</td><td>1
1
1
1</td><td>Bold words represent what should be written in the table.
ACCEPT s (lower case) for second.
ACCEPT K (upper case) for Kelvin.</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>Precise and Inaccurate</td><td>1</td><td>Third box down ticked.</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Precise because the values are all close to one another/repeatable/within small range/wtte
Inaccurate because the values are not close to the true value.</td><td>1
1</td><td>NOT they are not accurate to the true value.
If precision and inaccuracy are not mentioned in response, max 1 mark.</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>Relative error = (Absolute error/true value)
= (measured value - true value)/true value
= (4.00 - 4.60)/4.60 = 0.13 or 13 %</td><td>1
1</td><td>Evidence that this combination of equations has been used for first mark.
ACCEPT answer given as fraction (eg 3/23)
Ignore sign of final value.</td></tr>
<tr><td></td><td></td><td></td><td>QUESTION TOTAL</td><td>9</td><td></td></tr>
</table>

Question			Solution	Marks	Guidance
2	(a)	(i)	Vertical component = 30 sin 60 = 26 m s^{-1}	1	Actual value = 25.98
		(ii)	Use of v = u + at a = - acceleration of gravity = - 9.8 m s^{-2} t = (0-26)/-9.8 = 2.65 s or 2.7 s	1 1 1	 Allow ecf of velocity from part (i). If u = 30$ms^{-1;}$; t = 3.1s for max 2 marks If a = -10ms^{-2}; t = 2.6s for max 2 marks. Bald answer of 3s for 1mark.
		(iii)	Use of s = ut + ½at^2. s = (26)(2.65) + ½ (-9.8)$(2.65)^2$ = 34 m OR Use of s = vt - ½at^2 s = 0 – ½(-9.8)$(2.65)^2$ = 34 m OR Use of s = ½(u +v) t s = ½ (26) 2.65 = 34 m OR Use of $v^2 = u^2 + 2as$ to give s = $(v^2 – u^2)/2a$ s = -26^2/(2 x -9.8) = 34 m	1 1	ACCEPT s = 35 m (from early rounding) Allow ecf for u and t used earlier. *[eg, for u = 30 ms^{-1} and t = 3.1 s; answer will be 47 or 46 m]*
	(b)		Torque τ = F r to give F = τ/r F_1 = 90/0.6 = 150 N F_2 = F/2r = 90/(2)(0.5) F_2= 90 N	1 1 1 1	 Substitution of correct values into equation. Use of 2r in the equation for F_2 as there are 2 forces applied. A bald answer of F_2 = 90N will only gain this mark but not the previous calculation mark. Wrong method will not score either mark.
			QUESTION TOTAL	**10**	

Question			Solution	Marks	Guidance
3	(a)		Current through a conductor is proportional to the potential difference/voltage across it; (when) temperature remains constant.	1 1	ACCEPT Voltage = current x resistance (any subject). If symbols are used they must be defined.
	(b)		Line drawn on axes Decreasing resistance with increase in temperature; With a decreasing (negative) gradient as temp increases.  	 1 1	A straight line with negative gradient would score 1 mark. A line with increasing negative gradient would score 1 mark.
	(c)		Sample X is Iron Iron is a conductor/metal so allows large(r) current/charge to flow	1 1	NOT just iron is a (good) conductor; there must be some reference to increased current or charge flow. eg; 'conducts <u>current</u> better' is good enough for the mark. [Not conducts better]
	(d)	(i)	$C = Q/V = 0.1/10$ $C = 0.01$ mF or 0.01×10^{-3} F or 1×10^{-5} F	1 1	Use of correct equation Final answer with correct POT **and consistent unit**.
		(ii)	$E = ½QV = ½ (0.1)(10)$ $E = 0.5$ mJ $= 0.5 \times 10^{-3}$ J (or 5×10^{-4} J) OR $E = ½CV^2 = ½(0.01)(10)^2$ $E = 0.5$ mJ $= 0.5 \times 10^{-3}$ J (or 5×10^{-4} J)	1 1	Use of correct equation Final answer to correct POT consistent with unit. Allow ecf of incorrect C from part (i). Omission of $x10^{-3}$ for milli is only penalised once in part (d).
			QUESTION TOTAL	**10**	

<table>
<tr><th colspan="3">Question</th><th>Solution</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>4</td><td>(a)</td><td></td><td>Mark each column independently.
<table><tr><th>Curve number</th><th>Type of Material</th><th>Material</th></tr><tr><td>1</td><td>Brittle</td><td>(Cast) Iron</td></tr><tr><td>2</td><td>Ductile</td><td>Copper</td></tr><tr><td>3</td><td>Polymeric</td><td>Rubber</td></tr></table></td><td>2

2</td><td>Curve number: – one correct number for 1 mark, all correct for 2 marks.

Material - one correct material for 1 mark, all correct for 2 marks. Only materials stated are correct – these are given in the question.
Answers to relate to middle column. No ecf from 1st to 3rd columns.</td></tr>
<tr><td></td><td>(b)</td><td></td><td>This is a show that question so the working must be shown.
(U = area under graph =) ½Fx
$F = \sigma A$ and $x = L\varepsilon$
Substitution: $U = ½ (\sigma A)(L\varepsilon) = ½ (AL) \sigma\varepsilon$ ($= ½ V \sigma\varepsilon$)
Use of $E = \sigma/\varepsilon$ so substitute $\sigma = E\varepsilon$ to give $U = ½VE\varepsilon^2$

OR reverse argument:
$\sigma = F/A$ and $\varepsilon = x/L$
$E = \sigma/\varepsilon = (F/A)/(x/L) = FL/Ax$
Substitute into $U = ½VE\varepsilon^2 = ½ (AL) (FL / Ax) (x^2/L^2)$

Simplify to $U = ½ Fx^2$ which is area under graph.</td><td>
1
1
1
1

(1)
(1)
(1)

(1)</td><td>

Any subject.
Using V = AL

This mark can be awarded if $E = \sigma/\varepsilon$ and V=AL are substituted to give $U = ½ (AL)(\sigma/\varepsilon) \varepsilon^2$</td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td>To find characteristics/properties/behaviour of materials (or components).</td><td>1</td><td>Accept named (or described) property.
Ignore any reference to safety.</td></tr>
<tr><td></td><td>(c)</td><td>(ii)</td><td>Any 2 valid points eg:
• NDT does not result in failure of material or component/DT results in failure of material.
• DT used on samples of materials/NDT used on component in use.
• NDT can be used for continuous monitoring.
• DT is useful for determining physical properties such as UTS, ductility etc (any named physical property).
• NDT is used to find flaws/voids/discontinuities in components.
• NDT used for quality control in processing environment.</td><td>1

1</td><td>No credit for repeating question stem ie use of ‘destroy’.
ACCEPT material/component can be used after NDT but not DT.
Credit other valid differences.</td></tr>
<tr><td></td><td></td><td></td><td>QUESTION TOTAL</td><td>11</td><td></td></tr>
</table>

Question			Solution	Marks	Guidance
5	(a)		material density of sphere A $\leq$ density of water material density of sphere B $\geq$ density of water material density of sphere C $=$ density of water	2	1 correct for 1 mark All 3 correct for 2 marks. Accept < instead of ≤, and > instead of ≥.
	(b)	(i)	Use of centre of the hatch to find h = 4 + 0.7 = 4.7 m $P = \rho g h = (1000)(9.8)(4.7) = 4.61 \times 10^4$ Pa Hatch area calculation $1.2 \times 1.4 = 1.68$ m^2 Force = P x A = $4.61 \times 10^4 \times 1.68 = 7.7 \times 10^4$ (or $4.6 \times 10^4 \times 1.7 = 7.8 \times 10^4$) N	1 1 1 1 1	ACCEPT all values to 2sf Credit this mark if h = 4m, P = 3.9×10^4 Pa and if h = 5.4 m, P = 5.3×10^4 Pa. Allow ecf of incorrect pressure calculated (F = 6.6×10^4 or 8.9×10^4 from examples above). Correct unit, consistent with POT. (Independent mark)
		(ii)	Breaking the window/porthole. Filling the safe with water reduces pressure difference between the inside and the outside (requiring less force to open the hatch)	1 1	ACCEPT: Apply force on the hatch as far as possible from hinge (1); which gives a greater moment (1). OR: Decrease depth of safe (1); which reduces pressure on safe/hatch (1). Do not accept changing dimensions of safe/window/hatch etc.
			QUESTION TOTAL	**9**	

Question			Solution	Marks	Guidance
6	(a)	(i)	Temperature: 20 °C = 293 K Use of PV = mRT rearranged m = PV/RT m = $(2.3 \times 10^5)(0.055)/(287)(293) = 0.15$ kg	1 1 1	 If T = 20 then m = 2.2 kg for max 2 marks. Final answer must **include a unit** consistent with POT.
		(ii)	Use of P/T is constant or $P_1/T_1 = P_2/T_2$ $P_2 = P_1 T_2 / T_1 = (2.3 \times 10^5)(308)/293 = 2.4 \times 10^5$ Pa OR: Substituting into P = mRT/V = (0.15)(287)(308)/0.055 $P = 2.4 \times 10^5$ Pa	1 1 (1) (1)	Temperature: 35 °C = 308 K If candidate has used temperature in Celcius in both parts (i) and (ii), only penalise in part (i). If not converted in part (ii) only, then max 1 mark here. Allow ecf of incorrect POT pressure used in part (i). Substitution consistent with part (i) Allow ecf of incorrect mass calculated in part (i).
		(iii)	Use of Energy $Q = mc\Delta T = (0.15)(718)(35 - 20)$ $Q = 1.6 \times 10^3$ J	1 1	Need to see a change in temperature. Allow ecf of incorrect mass calculated in part (i). Final answer must **include a unit**
	(b)		Power supplied by people = 10 x 30 = 300W AND Power supplied by bulbs = 10 x 120 = 1200W. Power leaving the system = Power entering the system (Q = W at constant temperature) so 2500 = (10)(30) + (10)(120) + X X = 1000 W supplied	1 1 1 1	 Ignore sign of final answer. Direction of heat flow.
			QUESTION TOTAL	**11**	
			PAPER TOTAL	**60**	

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