

Marking Scheme

1.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	(a)	(i)	$\frac{\text{stress}}{\text{strain}}$ (1)	1			1		
		(ii)	Strain: no units (1) Stress: $\frac{\text{kg m s}^{-2}}{\text{m}^2}$ (1) Young modulus: $\text{kg m}^{-1} \text{s}^{-2}$ (1)	1	1 1		3	3	
	(b)	(i)	's' shape on graph (1) Loading and unloading labelled (1) Hysteresis shown (1)	3			3		3
		(ii)	Weak (van de Waals) bonds between molecules / unravelling of long chain molecules (1) Easily broken / strong (metallic) bonds in metals (1)		2		2		
		(iii)	Molecules become more entangled / vibrations increase (1) Increase (1)	2			2		
			Question 1 total	7	4	0	11	3	3

2.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	(a)	(i)	Ruler and micrometer or Vernier callipers	1			1		1
		(ii)	Area = $\pi \times (0.505 \times 10^{-3})^2 = 8.01 \times 10^{-7} \text{ [m}^2\text{]}$ (1) $E = \frac{Fl}{\Delta L} = \frac{7.5 \times 0.2}{(28 \times 10^{-6}) \times 8.01 \times 10^{-7}}$ (1) $E = 6.6 \times 10^{10} \text{ Pa / N m}^{-2}$ with units (1) Accept in N mm^{-2}	1	1 1		3	3	3
		(iii)	Hazard and Risk – thin glass could shatter and cut the skin (1) Control measure – handle with care / wear gloves or protective clothing (1) Alternative: Hazard and Risk – [broken glass is sharp] thin glass could shatter and enter the eyes (1) Control measure – handle with care / wear goggles (1)			2	2		2
		(iv)	Work done = energy stored = $\frac{1}{2}F \Delta l$ (1) $0.5 \times 7.5 \times 28 \times 10^{-6} = 1.05 \times 10^{-4} \text{ [J]}$ (1)	1	1		2	2	2
	(b)		Surface cracks (1) All force concentrated on a single / few bonds below the crack (1) When under tension (1)	3			3		
			Question 1 total	6	3	2	11	5	8

3.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
3	(a)		Force (of a spring) is <u>directly</u> proportional to its extension	1			1		
	(b)	(i)	$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$ (1) $k = 50 \text{ [N m}^{-1}\text{]} (1)$ $v = 3.0 \text{ [m s}^{-1}\text{]} (1)$		3		3	2	
		(ii)	$a = \frac{kx}{m}$ (1) $a = 150 \text{ [m s}^{-2}\text{]} \text{ and assumption that } g \text{ is ignored } (1)$		2		2	1	
	(c)	(i)	Use of $v^2 = u^2 + 2as$ and $v = 0$ (1) $h = \frac{v^2}{2g}$ (1) $h = 0.46 \text{ [m]} (1)$ Accept alternatives Equating energies (1) Rearranging (1) $h = 0.46 \text{ m}$ accept $0.46 + 0.06 = 0.52 \text{ m} (1)$	1	1 1		3	2	
		(ii)	Use of $v = u + at$ or $t = \frac{u}{a}$ (1) Total time = $2 \times 0.306 = 0.61 \text{ [s]} (1)$	1	1		2	2	
			Question 3 total	3	8	0	11	6	0

4.

Question			Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
3	(a)		Equipment: Award one mark for.....(1) Appropriate diagram [or good description] to include: rubber band supported vertically, ruler [or equivalent], weights (or force-meter attached to band) or appropriate horizontal setup (1) Method. Award 1 mark for 2 of the following: (1) - Add weights [or masses] / increase the force ... in incremental steps - Secure base with G clamp [can be credited from diagram] - Place ruler at appropriate point close to / aligned with band / avoiding parallax or use optical pin (or equivalent) [can be credited from diagram] Measuring extension Award 1 mark for(1) Either: Measure original length, then new length and subtract to find extension. Or: Set ruler to zero at low weight/band taut but not extended and read extension directly [or equiv.]	3			3		3
	(b)	(i)	Strain = $\frac{6}{8} = [0.75]$ [ignore units]		1		1	1	1
		(ii)	Stress = $\frac{7.0}{0.050}$ (1) = 140 N cm^{-2} [Or $1.4 \times 10^6 \text{ N m}^{-2}$] Note: No unit requirement for stress value $E = 140 \div 0.75$ (1) (ecf on strain) $E = 186.7 \text{ N cm}^{-2}$ (1) [UNIT]. Or: $E = 1.87 \times 10^6 \text{ N m}^{-2}$ (or Pa) Alternatives for the first two marks: Use of $E = \frac{Fl}{Ax}$ or $E = \frac{F}{A\epsilon}$ (1) Then 1 mark for substitution (1) Either (in cm): $E = \frac{7 \times 8}{0.050 \times 6}$ or $E = \frac{7}{0.050 \times 0.75}$ Or (in m) $E = \frac{7 \times 8 \times 10^{-2}}{0.050 \times 10^{-4} \times 6 \times 10^{-2}}$ or $E = \frac{7}{0.050 \times 10^{-4} \times 0.75}$			3	3	3	3
	(c)		At (C) molecules unravel / straighten (accept untangle) under the action of a force. [Accept – C-C bond rotates] (1) At (D) molecules fully stretched/ strong forces between atoms within molecule / stretching (covalent) bonds (1) Either: Small force (or stress) produces large extension (or strain) hence shallow gradient initially/ or at C Or: Large force (or stress) produces small extension (or strain) hence steep gradient finally/ or at D (1)	3			3		3
			Question 3 total	6	1	3	10	4	10

5.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	(a)	(i)	$\Delta x_{\text{total}} = \Delta x_A + \Delta x_{3.4}$ (or by implication) [1] $\Delta x_{\text{total}} = \frac{FL_0}{AE} + \frac{FL_0}{3.4E}$ [1] Convincing algebra e.g. $\frac{3FL_0}{3.4E} + \frac{FL_0}{3.4E}$ seen [1]		3		3	2	
		(ii)	Straight line from origin to (400 N, 4.0×10^{-6} m)		1		1		
		(iii)	Using combination: $Y = \frac{4FL_0}{3.4\Delta x_{\text{total}}}$ and $\Delta x_{\text{total}} = 16 \times 10^{-6}$ [m] [1] Substitution - $E = \frac{4 \times 400 \times 1.2}{3 \times 2 \times 10^{-4} \times 16 \times 10^{-6}}$ [1] (gains first and second marks) $E = 2 \times 10^{11}$ Nm ² or Pa unit mark [1] Using bar of CSA.4: $E = \frac{FL_0}{A\Delta x_A}$ and $\Delta x_A = 12 \times 10^{-6}$ [m] [1] Substitution - $E = \frac{400 \times 1.2}{2 \times 10^{-4} \times 12 \times 10^{-6}}$ [1] (gains first and second marks) $E = 2 \times 10^{11}$ Nm ² or Pa unit mark [1] Using bar of CSA 3.4: - ecf $E = \frac{FL_0}{3.4\Delta x_{3.4}}$ and $\Delta x_{3.4} = 4 \times 10^{-6}$ [m] [1] Substitution - $E = \frac{400 \times 1.2}{3 \times 2 \times 10^{-4} \times 4 \times 10^{-6}}$ [1] (gains first and second marks) $E = 2 \times 10^{11}$ Nm ² or Pa unit mark [1]		3		3	3	
		(iv)	$E_{\text{elastic}} = \frac{1}{2} Fx_{\text{total}}$ and substitution: $E = \frac{1}{2} \times 400 \times 16 \times 10^{-6}$ [1] $E = 3.2$ m[J] [1] Alternative: $E_{\text{elastic}} = \frac{2F^2 L_0}{3.4E}$ used with substitution: $E_{\text{elastic}} = \frac{2 \times (400^2) \times 1.2}{3 \times 2 \times 10^{-4} \times 2 \times 10^{11}}$ [1] $E_{\text{elastic}} = 3.2$ m[J] [1] Alternative: Area under graphs - ecf $\frac{1}{2} \times 4 \times 10^{-6} \times 400 + \frac{1}{2} \times 12 \times 10^{-6} \times 400$ [1] $E_{\text{elastic}} = 3.2$ m[J] [1]	1	1		2	2	
	(b)	(i)	From graph, stress = 2.2×10^9 Pa [1] $F = 2.2 \times 10^9 \times \pi \times (0.1 \times 10^{-3})^2 = 69$ [N] [1] ecf for 2.1×10^9 Pa Mass = $\frac{69}{9.81} = 7.0$ k[g] [1]		3		3	2	
		(ii)	Crack propagation [around surface imperfection] - no details in terms of breaking bonds needed [1] Thinner fibre contains fewer surface imperfections [1] (mention of 'surface' required only once)	2			2		
			Question 5 total	3	11	0	14	9	0

6.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	(a)		2 materials chosen and microscopic structure of each explained [2 × (1)] See below. 1 example given of each material [2 × (1)] See below. Crystalline - long range order / lattice like arrangement/regular arrangement structure e.g. metals Amorphous - short range order / irregular or random arrangement / no order e.g. glass, ceramics, brick Polymeric - long chain molecule arrangement [of hydrocarbons] e.g. rubber, polythene accept plastic	4			4		
	(b)		Indicative content: Measurements: - Extension of wire [with pointer/ruler] - Original length of wire [from clamp to pointer] - Diameter of wire using micrometer or (Vernier) callipers Determination of Young modulus: - Use $E = \frac{Fl}{Ae}$ or plot graph of load/extension or stress/strain and find gradient A determined from $\pi \left(\frac{d}{2}\right)^2$ Precautions: - Repeat readings of e (adding/removing load) - Measure d in various places on wire / mean d - Keep temperature constant / use of Searle's apparatus - Ensure no kinks in wire - Soft wood so as not to damage wire - Ensure wire is securely clamped - Stay within elastic limit - Use of a longer wire / travelling microscope - Avoid parallax	4		2	6		6
			5-6 marks Comprehensive account with reference to how the measurements must be made, how they should be used to determine Young modulus and precautions that should be taken to minimise uncertainties. <i>There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.</i> 3-4 marks Comprehensive account with reference to 2 out of 3 of the following or a limited attempt at all 3 areas - how the measurements must be made, how they should be used to determine Young modulus and precautions that should be taken to minimise uncertainties. <i>There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.</i> 1-2 marks Comprehensive account with reference to 1 out of 3 of the following or a limited attempt at 2 areas - how the measurements must be made, how they should be used to determine Young modulus and precautions that should be taken to minimise uncertainties. <i>There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.</i> 0 marks No attempt made or no response worthy of credit.						
			Question 6 total	8	0	2	10	0	6

7.

Question	Marking details	Marks available				Maths	Prac
		AO1	AO2	AO3	Total		
3 (a)	Test wire and reference wire made from the same material (or identical) (1) Do not accept reference to common support. [Change in] temperature will affect both equally (1)			2	2		2
(b)	$A = \pi (0.08 \times 10^{-3})^2$ and conversion to m^2 $A = 2.01 \times 10^{-8} [m^2]$ (1) % Uncertainty = $\frac{(0.01) \times 100}{0.16}$ (1) (= 6.25%) $\times 2$ [doubling ecf] (= 12.5% / 13%) (1) [accept 3 s.f.] (award 2 marks if 12.5% or 13% seen)		3		3	3	3
(c)	Correct reference to uncertainty taken as ruler resolution i.e. 1 mm (or $1 \times 10^{-3} m$) (1) ecf on same mistake in resolution as (b) Calculation of % uncertainty: 0.059% (or 0.06%) (1) Answer gains both marks	1	1		2	1	2
(d) i	Error bars correctly included for all points ± 2 small divisions on extension axis		1		1	1	1
	II Lines for steepest and least steep gradients drawn appropriately (1) [do not accept lines through the origin] Steepest gradient calculated: $[1.5 \text{ to } 1.6 N mm^{-1}]$ (1) Least steep gradient calculated: $[1.3 \text{ to } 1.4 N mm^{-1}]$ (1)		3		3	3	3
	(d)(ii) max GRADIENT = $\frac{9.7}{6.1} = 1.561 N mm^{-1}$ ✓ min GRADIENT = $\frac{8.3}{6.1} = 1.361 N mm^{-1}$ ✓ d(ii) MEAN GRADIENT = $\frac{1.561 + 1.361}{2} = 1.461$ ✓ % uncertainty = $\left(\frac{1.561 - 1.361}{2} \right) \times 100$ ✓ = 6.8% ✓ d(iv) $E = \text{gradient} \times \frac{l}{A}$ ✓ $E = \frac{1.461 \times 10^3 \times 1.18}{2.01 \times 10^{-8}}$ ✓ $E = 1.22 \times 10^{11} N m^{-2}$ ✓ (or $E = 1.22 \times 10^5 N mm^{-2}$) ✓ % uncertainty = 6.8% + 12.5% ✓ = 19.3% ✓ Absolute uncertainty = $2.35 \times 10^{10} N m^{-2}$ ✓ $E = (1.22 \pm 0.24) \times 10^{11} N m^{-2}$ ✓						
	(ii) Mean gradient calculated correctly using answers to d(i): expect 1.4 to $1.5 N mm^{-1}$ (1) ecf % uncertainty in mean calculated: expect 6%-10% (1) ecf		2		2	2	2
(e)	Understanding shown that $E = \text{gradient} \times \frac{l}{A}$ (1) [or by implication] [not awarded for use of data point rather than line] Substitution and value of E found to any sig fig and using any unit (does not need to be given). e.g. $E = 1.22 \times 10^{11} N m^{-2}$ (1) ecf on A. Total % uncertainty calculated from (b) [+ (c)] + (d)(ii) e.g. 7% + 12.5% = 19.5% (1) ecf Absolute uncertainty calculated: e.g. $2.38 \times 10^{10} N m^{-2}$ (1) Answer and uncertainty to appropriate sig figs with correct unit: e.g. $E = (1.22 \pm 0.24) \times 10^{11} N m^{-2}$ or $(1.2 \pm 0.2) \times 10^{11} N m^{-2}$ (1)			5	5	4	5
(f)	Diameter (1) Use 'thicker' wire or more accurate measuring instrument (or instrument with higher/greater resolution) (1) Apply ecf if candidate's gradient uncertainty greater than candidate's calculation of uncertainty in area: Extension (1); use a micrometer for extension			2	2		2

				Question 3 total	1	10	9	20	13	20
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8.

Question				Marking details	Marks Available
10	(a)	(i)		Strong (covalent) bonds between ions in structure. Accept molecules arranged irregularly or amorphous structure present (1) [No dislocations present] so no slip (accept no movement of dislocations). Accept different sized atoms seize up the structure (1) Do not accept 'untangle'.	2
		(ii)		Scratches (on surface) weaken material or break surface bonds. Scratches have stress concentrations at their tips- can be awarded from diagram. Cracks propagate through material. Correct direction of bending is to open the crack [ANY 2] (credit well annotated diagrams) [Local] stress cannot be relieved by slip / plastic flow/ dislocation movement.	2
		(iii)		Compression (1) [Do not accept 'stress'] More difficult for cracks to develop/ widen/ propagate (1)	2
	(b)	(i)		Gradient shown = 80 GPa e.g. $\frac{800 \times 10^6}{0.01}$ seen.	1
		(ii)		Area under graph = $[\frac{1}{2} \times 0.01 \times 800 \times 10^6 + \frac{1}{2} \times 0.08 \times 100 \times 10^6 + 0.08 \times 800 \times 10^6] = 72 \text{ [MJm}^{-3}]$ (1) Volume = $\pi \times (1.25 \times 10^{-3})^2 \times 2.5 = 12.3 \times 10^{-6} \text{ [m}^3]$ (1) Work done = $72 \times 10^6 \times 12.3 \times 10^{-6} = 884 \text{ [J]}$ (1) (ecf on both area and volume).	3
		(iii)		Initial straight line of same gradient. (1) Yield point at 1 000 MPa. (1) Linear plastic region of small slope (accept zero slope) stopping at 5% strain. (1)	3
		(iv)	(I)	Creep: [Gradual/slow/Over time] AND [extension/stretching/deformity or increase in strain] (1) (under a constant load). Necking: Localised (or reference to 'section' or 'region') thinning (of structure/material before breaking- accept diagram) (1)	2
			(II)	Same shaped curve but steeper gradient (1) Stopped at 15% and $t < 400$ hrs (approx.) (1)	2
		(v)		Repeated bending, stretching or hammering of metal alloy (1) Dislocations become tangled / traffic jam effect or new dislocations created (1) Stopping each other from moving (or inhibiting plastic deformation or collect at grain boundaries) (1)	3
				Question 10 Total	[20]

Examiner's Comments

1. There are no examiner comments available for this question
2. There are no examiner comments available for this question
3. There are no examiner comments available for this question
4. There are no examiner comments available for this question
5. There are no examiner comments available for this question
6. There are no examiner comments available for this question
7. There are no examiner comments available for this question
8. Q.10 (a)(i) The majority of candidates were able to describe the structure of glass in terms of particle arrangement. Nearly all of these candidates used this particle model to explain clearly why glass displays little plastic deformation before fracture. In most cases, candidates referred to the lack of dislocations within glass as being the main factor behind there being very little plastic deformation.
 - (ii) Nearly all candidates were able to clearly explain the fracture mechanism in glass. Many candidates used clearly labelled diagrams to support their answers.
 - (iii) The majority of candidates were able to explain clearly, using ideas of 'crack propagation', how the process of making a car windscreen is designed to make it more difficult to break.
- (b) (i) Nearly all candidates were able to show that the gradient of the graph was 80 GPa. Credit was not awarded however to candidates who did not convert 1% strain to a strain of 0.01.
 - (ii) Few candidates were able to calculate the work done in stretching the alloy to breaking point. Those who attempted the correct approach of calculating the area under the graph often, either forgot to multiply their answer by the volume of the cylinder or miscalculated the volume. The majority of candidates incorrectly attempted to calculate the work done by $\frac{1}{2} \times \text{stress} \times \text{strain}$, using, in most cases, the maximum values of stress and strain given in the graph.
 - (iii) The majority of candidates were able to draw the stress against strain graph for alloy B.
 - (iv)(i) **Creep:** Many candidates were able to give a convincing explanation of creep. The marking emphasis was placed on the key points of '**time**' (gradual/slow/long term) and '**extension**' (deformity/strain/stretch).
- Necking:** Again, well answered by the majority of candidates. The key marking emphasis here was on describing '**thinning**' (reduced CSA/reduced diameter) of a '**section**' (localised/region/point) of a material. A significant minority failed to gain this mark because they did not refer to a small section/region. Conversely, many candidates did pick up this mark through a well-drawn diagram.
- (ii) Nearly all candidates drew the same shaped graph for alloy C with a steeper gradient, thus gaining the first mark. Far fewer candidates realised that the maximum strain remained at 15% and failed to pick up the second mark.
- (v) The majority of candidates were able to describe the process of work hardening in terms of repeated hammering of the metal leading to a 'tangling' of dislocations leading, in turn, to reduced plastic deformation.

This comment originally referred to question 10 on paper 1325/01 (18/06/2015)