

WJEC A-LEVEL PHYSICS • UNIT 1

PHYSICS



EXAM QUESTION PACK

1.5 SOLIDS UNDER STRESS

SCORE

/

PERCENTAGE

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STEMUP

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1.

1. (a) (i) Define the Young modulus of a material. [1]

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- (ii) Express the unit of the Young modulus in terms of S.I. base units. [3]

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- (b) (i) When a rubber band is gradually loaded and then unloaded it shows *hysteresis* and *permanent set*. Sketch, and clearly label a force-extension graph for rubber to illustrate these two effects. [3]



- (ii) Considering the molecular structure of rubber explain why it has a much lower value of Young modulus than that of a metal. [2]

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- (iii) What is the effect on the Young modulus of rubber when its temperature rises? Explain your answer. [2]

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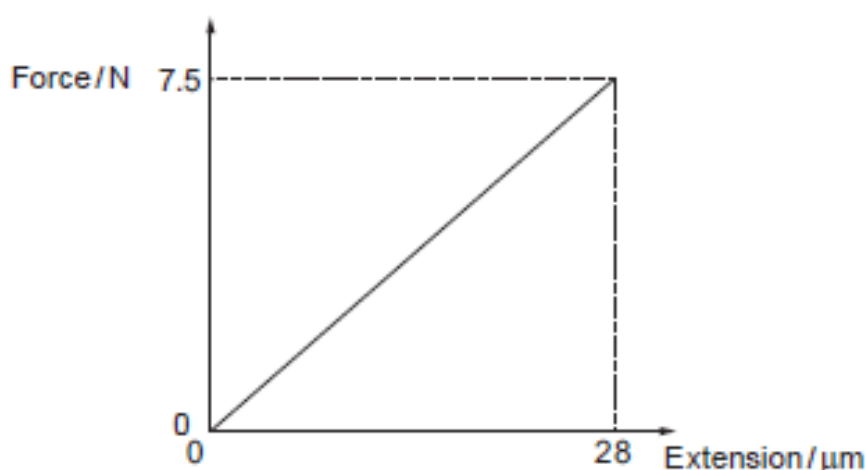
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2.

1. Emily carries out an experiment to obtain a force-extension graph for a thin glass fibre. She loads the thin glass fibre until it breaks. The force-extension graph obtained is shown below.



- (a) (i) Emily measures the length and diameter of the glass fibre and finds them to be 19.8 cm and 1.01 mm respectively. Suggest what measuring instruments she uses. [1]

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- (ii) Determine the Young modulus of glass. [3]

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(iii) Write a risk assessment for Emily's experiment.

[2]

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(iv) Determine the energy stored in the glass just before breaking point is reached. [2]

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(b) Glass is a brittle material. Describe the process by which glass fractures.

[3]

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3. 3. A child's jumping toy uses the compression of a spring to fire it up into the air. The spring used requires a force of 0.50 N to compress it by 1.0 cm .



(a) State Hooke's law.

[1]

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(b) The toy has a mass of 20 g and the spring is compressed by 6.0 cm and then released.

(i) Calculate the velocity with which it leaves the ground.

[3]

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(ii) Determine the initial acceleration of the toy as the spring extends. State any assumption you make.

[2]

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- (c) (i) Ignoring air resistance, determine the maximum height gained by the toy. [3]

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- (ii) Determine the total time of flight. [2]

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4. 3. (a) Describe a method to investigate the force-extension properties of rubber in the form of an elastic band as it is loaded. You should describe how the extension of the rubber is accurately measured. [3]

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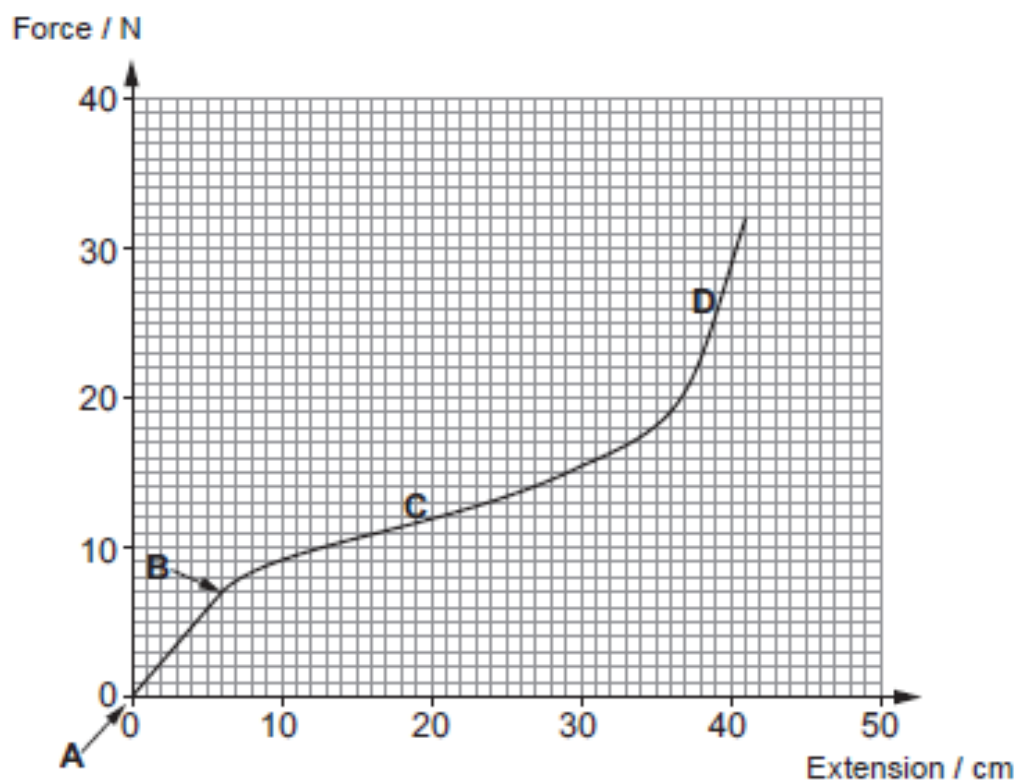
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- (b) The results from such an experiment for a rubber band of unstretched length 8.0 cm are plotted in a graph.



(i) Calculate the strain in the rubber at point B. [1]

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(ii) Determine the Young modulus of the rubber in the region AB. Assume the band has a total cross-sectional area of 0.050 cm^2 . [3]

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(c) By referring to the molecular structure of rubber, explain why the gradient at C is less than the gradient at D. [3]

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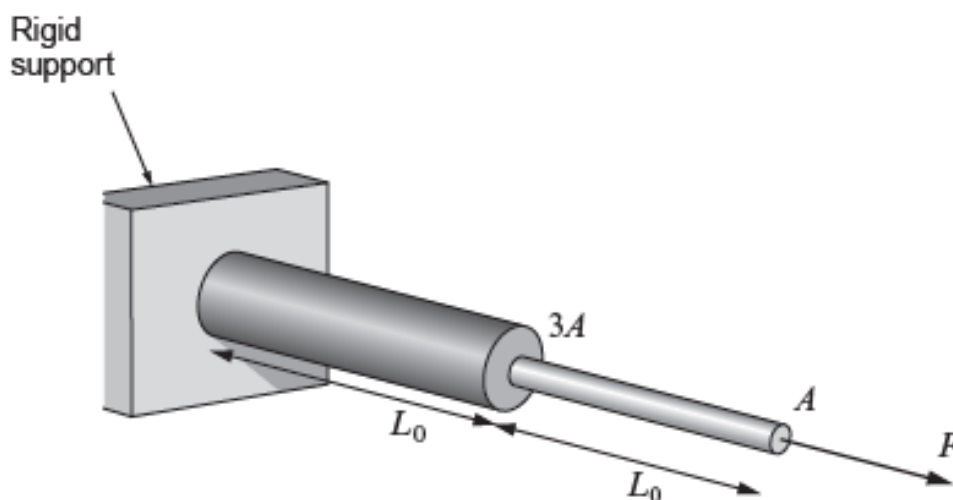
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5.

5. (a) The bar in the figure below is made from a **single piece of metal**. It consists of two parts of equal length L_0 and cross-sectional area A and $3A$. The diagram is not drawn to scale.



- (i) Show that the total extension, Δx_{total} , of the bar under the action of an applied force, F , as shown in the diagram, can be given by:

$$\Delta x_{\text{total}} = \frac{4FL_0}{3AE}$$

where E represents the Young modulus of the metal in the bar.

[3]

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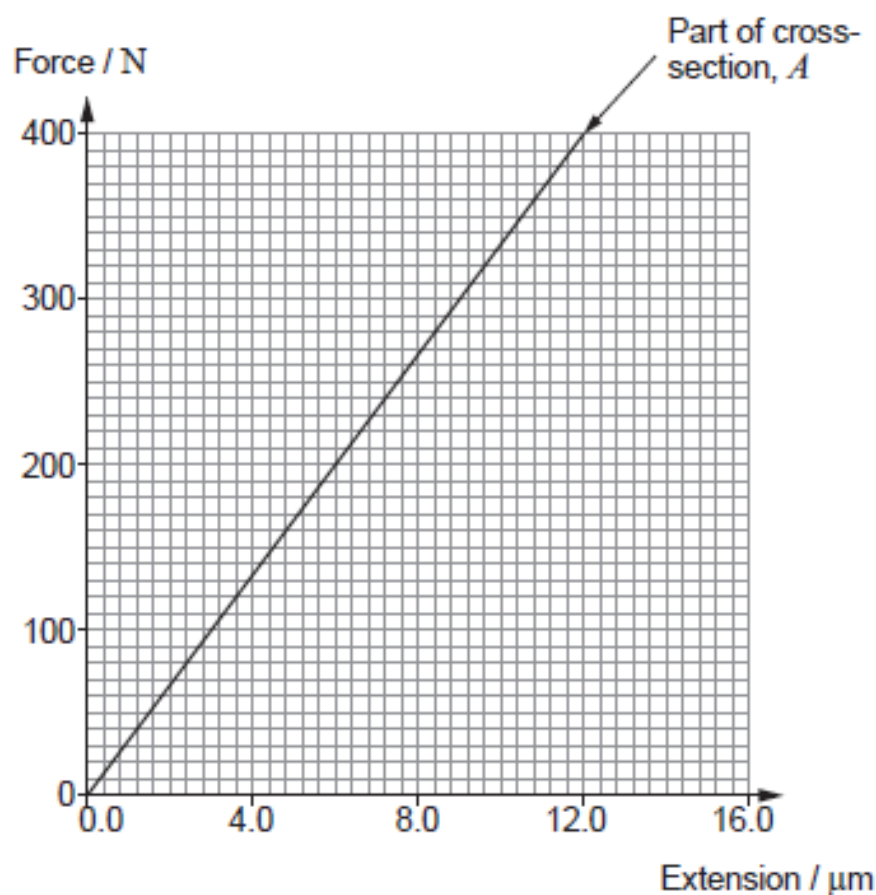
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- (ii) The graph shows the variation of extension with applied force for the part of cross-section, A . Draw (on the same grid) the expected force-extension graph for the segment of cross-section $3A$. [1]



- (iii) Determine the Young modulus of the metal in the bar given that $L_0 = 1.2\text{m}$ and $A = 2.0 \times 10^{-4}\text{m}^2$. [3]

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- (iv) Calculate the elastic potential energy stored in the whole bar when $F = 400\text{N}$. [2]

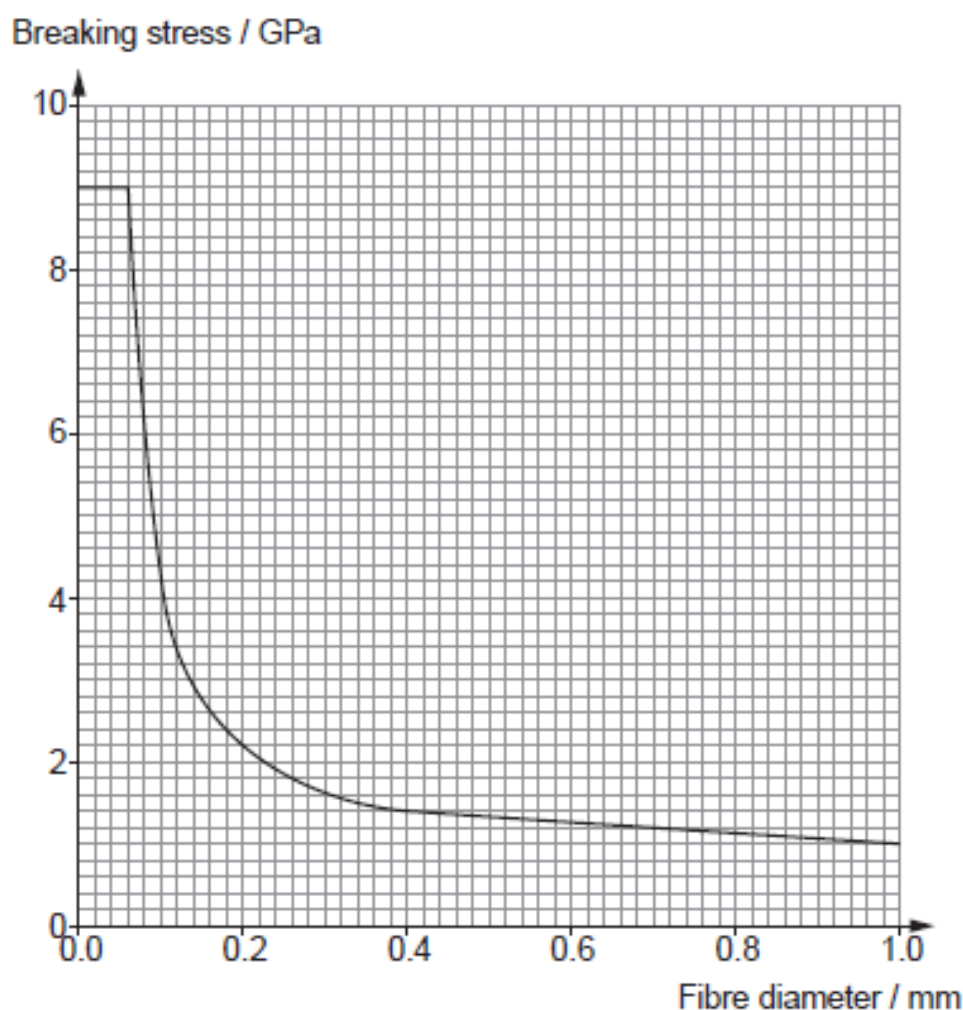
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- (b) Glass is a brittle material. The graph shows how the breaking stress of glass, in the form of thin fibres and rods, varies with the diameter of the fibre.



- (i) Use the graph to estimate the greatest mass which can be hung from a glass fibre of diameter 0.2 mm. [3]

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- (ii) Explain the term *brittle fracture* as it applies to glass and give a reason why very thin fibres have a greater breaking stress than thicker ones. [2]

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6.

6. (a) Materials can be classified as *crystalline*, *amorphous* or *polymeric*. Explain the meaning of two of the terms in italics in terms of microscopic structure. Give one example of each of your chosen materials. [4]

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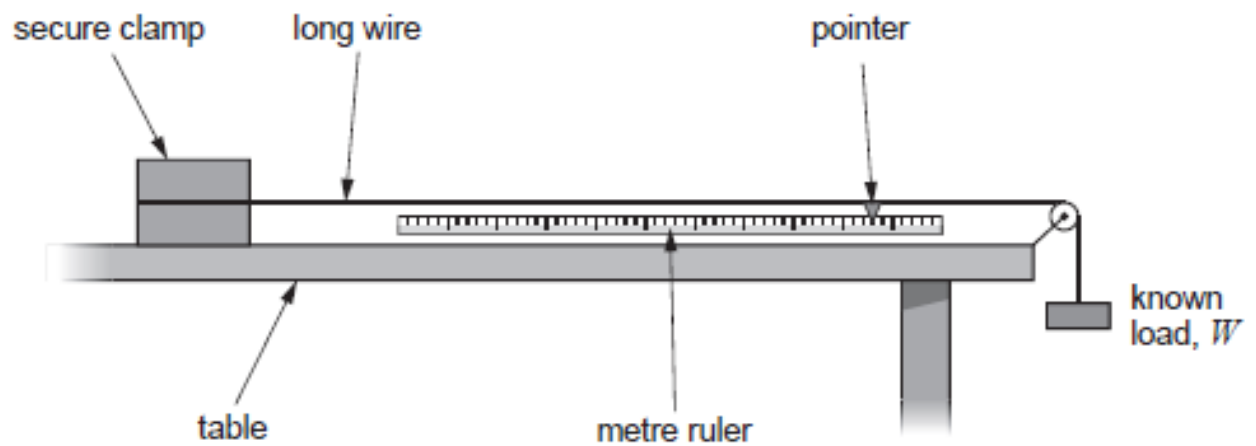
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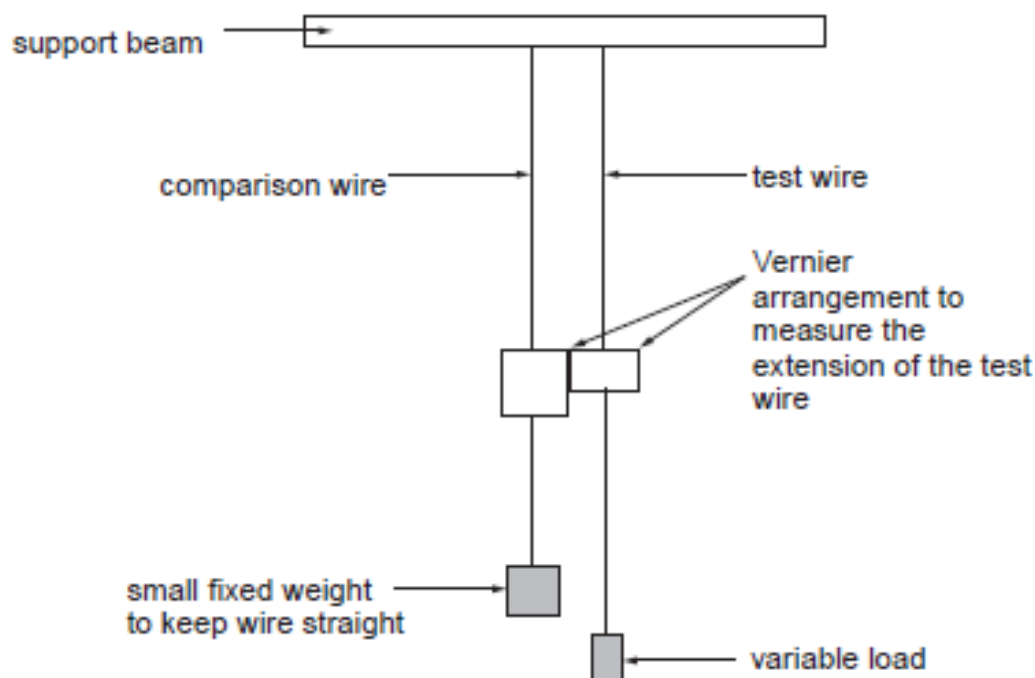
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- (b) The diagram shows apparatus that can be used to determine the Young modulus of a metal in the form of a wire. Describe the measurements which must be made, how they should be used to determine the Young modulus and precautions to minimise uncertainties. [6 QER]



3. Kiera uses the following apparatus to find the Young modulus of a metal alloy in the form of a wire.



- (a) Explain how the choice of a suitable comparison wire minimises the effect of a change in temperature. [2]

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- (b) Kiera uses a micrometer of resolution 0.01 mm to measure the mean diameter of the wire. She determines the mean diameter to be 0.16 mm. Calculate the cross-sectional area of the wire in m^2 , along with its percentage uncertainty. [3]

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- (c) Kiera then uses a metre ruler with a resolution of 1 mm to measure the initial length of the wire. She determines the length to be 1.680 m. Show, with an appropriate calculation, that the percentage uncertainty in this reading can be considered negligible. [2]

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- (d) Kiera adds various masses to the test wire and measures the extension. The table shows the extension of the wire for increasing load

Load (negligible absolute uncertainty) / N	Mean extension / mm	Absolute uncertainty in extension / mm
1.96	1.4	± 0.2
3.92	2.7	± 0.2
5.89	4.1	± 0.2
7.85	5.5	± 0.2
9.81	6.8	± 0.2

Kiera plots a graph (shown opposite) of load against extension from her data, but does not include error bars.

- (i) I. Add error bars for the extension on the plotted points. [1]
- II. Draw lines of maximum gradient and minimum gradient and determine the gradients of both lines. [3]

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- (ii) Hence, calculate the mean gradient and the percentage uncertainty in its value. [2]

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- (e) Determine the Young modulus of the metal alloy, along with its absolute uncertainty. Give your answer to an appropriate number of significant figures. [5]

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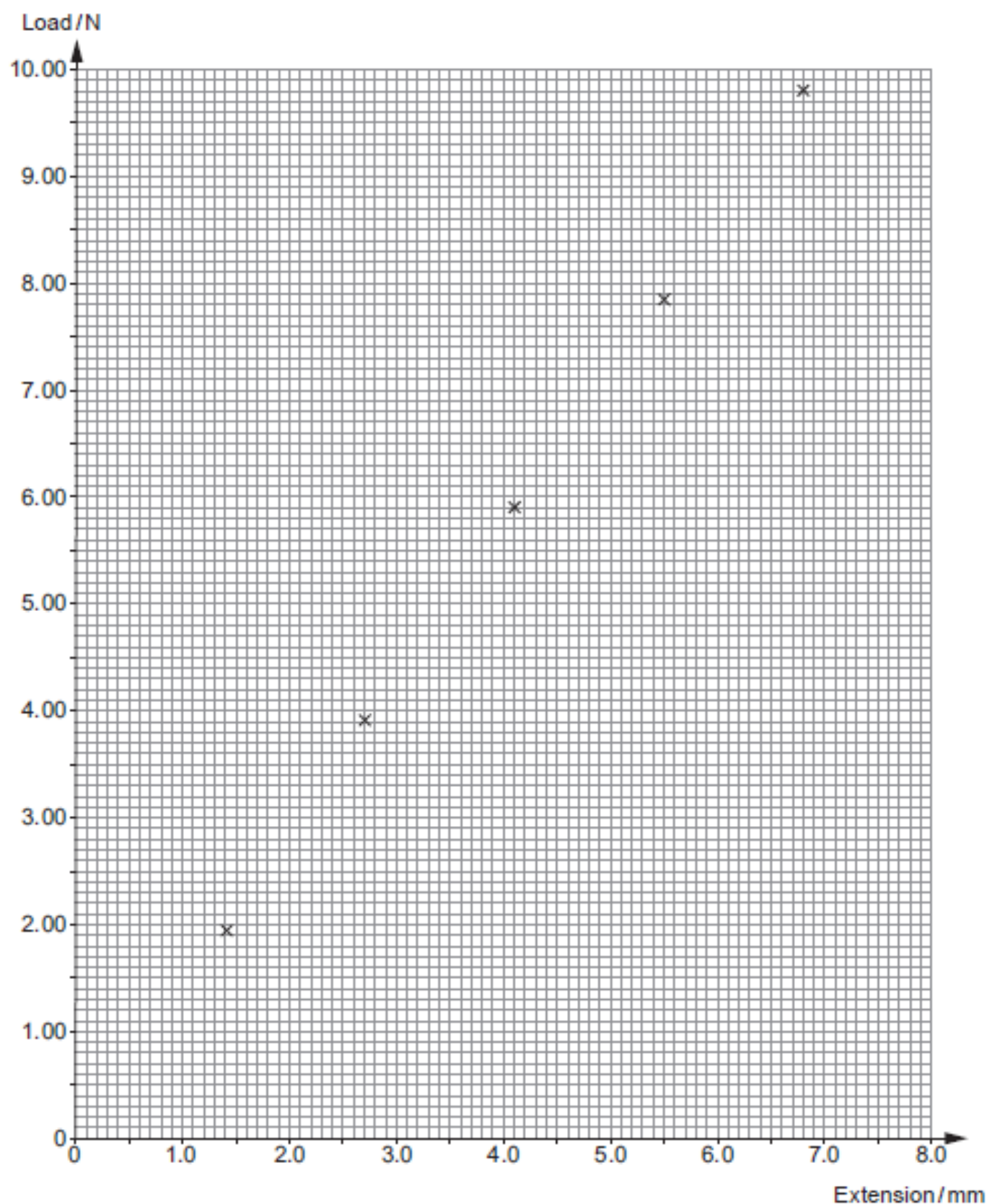
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- (f) State which of the measurements contributes most to the overall uncertainty in your answer and suggest one change Kiera could make to her experiment which would reduce the size of this uncertainty. [2]

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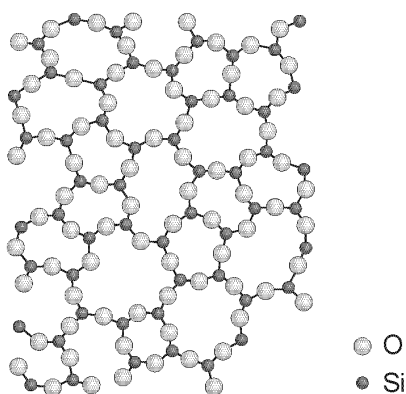
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8.

- (a) The picture shows the microscopic structure of glass, an amorphous solid.



Explain the following macroscopic properties of glass.

- (i) Glass fibres are brittle, showing no plastic deformation before fracture. [2]

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- (ii) A sheet of glass can be fractured accurately and cleanly if its surface is scratched and then the glass is bent slightly. [You may wish to draw a labelled diagram to support your answer.] [2]

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- (iii) During production, car windscreens are strengthened by using jets of cold air to cool the outer surfaces of the hot glass. This causes the outside to contract quickly while the inside remains soft. Later, the inside cools and contracts. Explain how this process makes the windscreen difficult to break. [2]

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- (b) Advanced aircraft and spacecraft applications require aluminium based alloys which are able to operate under extremely diverse conditions. The properties of three of these alloys are given in the table.

Aluminium alloy	Young modulus/GPa	Yield strength/MPa	Maximum tensile strain/%
Alloy A	80	800	9
Alloy B	80	1 000	5
Alloy C	60	600	15

The graph opposite shows the stress against strain graph for **alloy A**.

- (i) Use information from the graph to confirm that the Young modulus of alloy A is 80 GPa. [1]

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- (ii) Alloy A is in the form of a cylinder of length 2.5 m and diameter 2.5 mm. Determine the work done to stretch this alloy to breaking point. [3]

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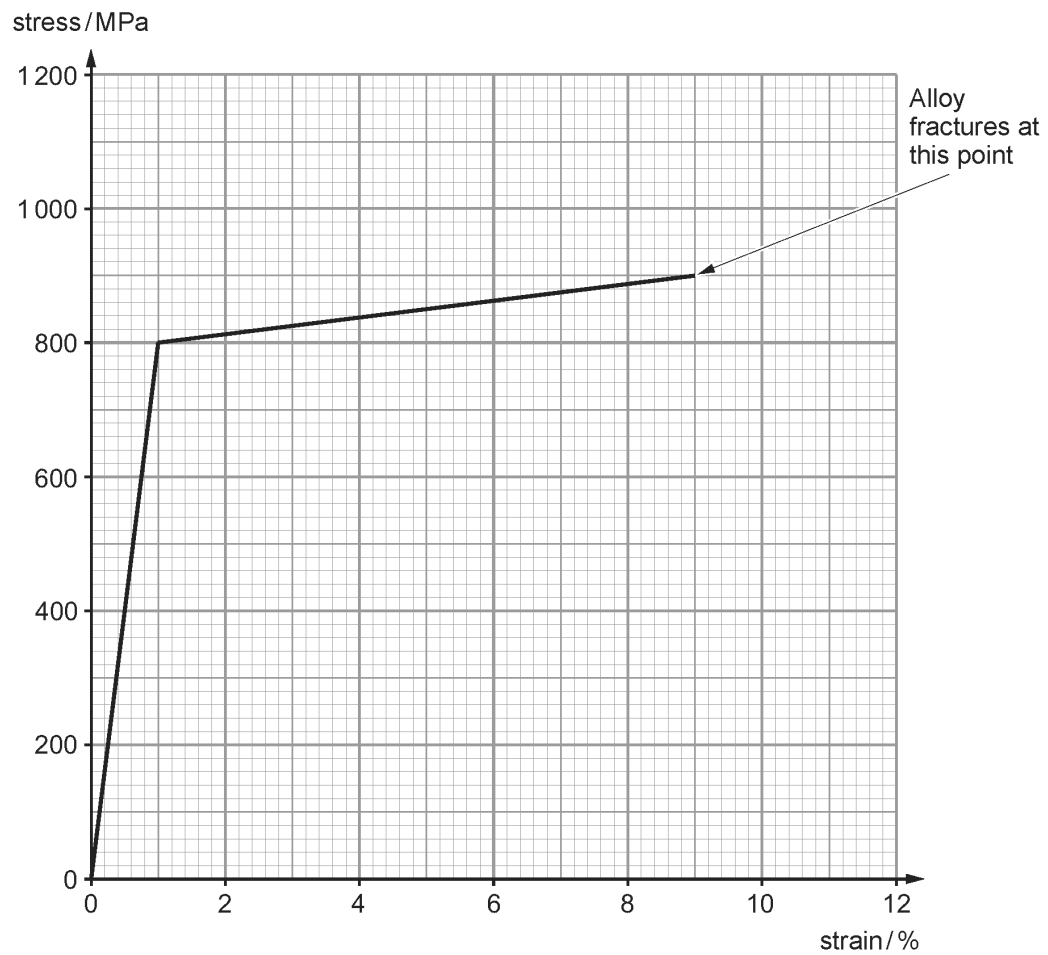
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- (iii) Draw, on the same axes, a simplified stress against strain graph for **alloy B** using data from the table opposite. [3]

- (iv) When these alloys are placed under a constant stress over a long period of time all three undergo *creep* leading to *necking* and eventually fracture.

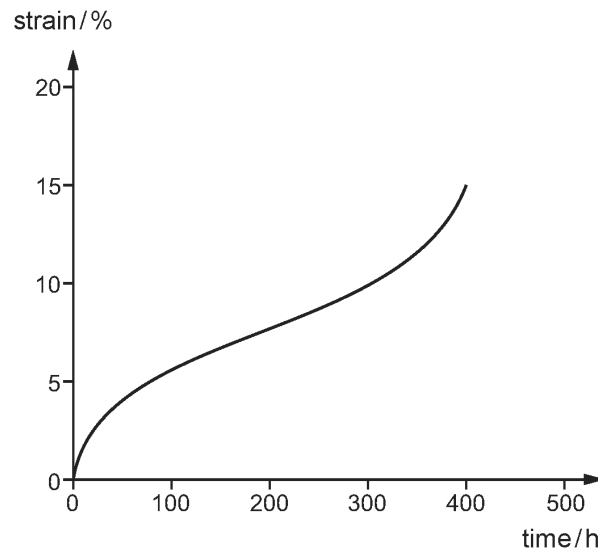
I. Explain the terms in italics.

[2]

Creep:

Necking:

- II. A creep curve for **alloy C** is shown. The alloy was subjected to a constant stress of 100MPa. Using information in the table on page 28, sketch on the same graph (below) a creep curve which could represent alloy C when it is subjected to a constant stress of 120MPa. [2]



- (v) During production the strength of the alloy is controlled by a process called cold working (or work hardening). Describe this process and explain how it increases the strength of the alloy under production. [3]

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

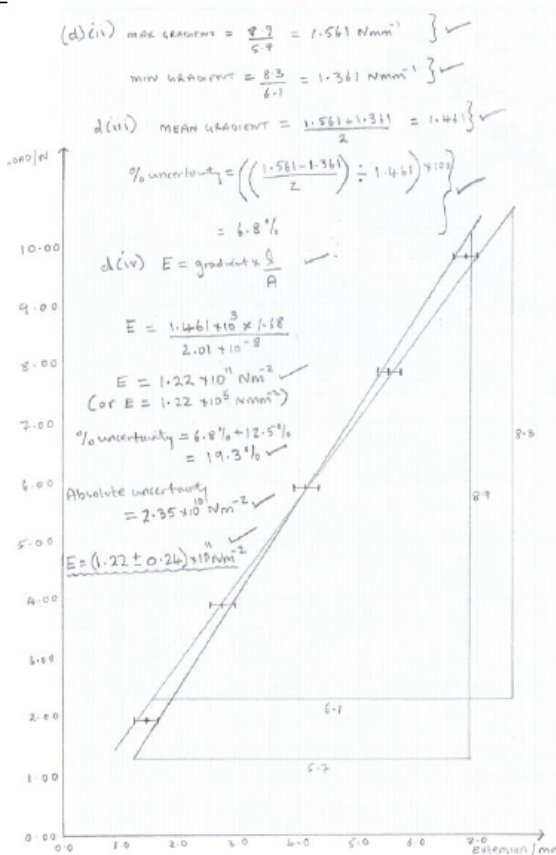
Question			Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
3	(a)		Equipment: Award one mark for.....(1) Appropriate diagram [or good description] to include: rubber band supported vertically, ruler [or equivalent], weights (or force-meter attached to band) or appropriate horizontal 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

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	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 = $\left(\frac{1.561 - 1.361}{2} \div 1.461 \right) \times 100$ ✓ = 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)