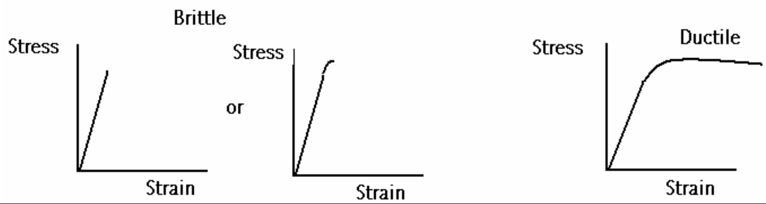
Question Number	Answer	Mark
1	Explain the difference between elastic deformation and plastic deformation QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence Elastic – returns to original shape when deforming force/stress removed /no permanent deformation Plastic – doesn't return to original shape when deforming force/stress removed / permanent deformation Suitable material or object named which undergoes elastic and plastic deformation, e.g. spring/wire/strawberry laces – do not accept rubber / elastic band but accept balloon Illustration comparing both types of deformation under different force / stress / strain / amount of deformation for material / object (independent of material mark)	 **(1)** **(1)** **(1)** **(1)**
	Total for question	**4**

Question Number	Answer	Mark
2(a)	Explain the meaning of the terms: Ductile – can be made/drawn into wires / shows significant/large/lots of plastic deformation / large plastic region Brittle - shatters when subject to impact / sudden force fails/breaks/cracks with little or no plastic deformation / breaks just beyond elastic limit / breaks just beyond limit of proportionality / breaks under stress due to propagation of cracks	 **(1)** **(1)**
2(b)	Calculate the mass that would produce this load. Use of $W = mg$ Correct answer (3600 kg) <u>Example of calculation</u> $W = mg$ m = 35 000 N / 9.81 N kg^{-1} = 3570 kg	 **(1)** **(1)**
	Total for question	**4**

Question Number	Answer	Mark
3(a)	Explain the meanings of the terms brittle and ductile. brittle – undergoes no / little plastic deformation (before breaking) / tends to break when subject to impact [accept breaks just beyond / soon after limit of proportionality / elastic limit] (1) graph (1) ductile – undergoes a lot of plastic deformation (before breaking) / able to undergo permanent deformation under tensile stress / can be drawn into wires (1) graph (1) [Assume axes labels if not given, accept force, extension labels] [1 graph mark max if stress strain labels reversed] [Ductile graph can be curved from start] 	**4**
3(b)	give an example of a ductile material and situation where behaviour desirable material example, e.g. copper (accept metal or any metal) (accept chewing gum, silly putty …) (not rubber)(1) example of desirable application, e.g. making wires (1) [NB Not examples of moulding or malleable behaviour]	**2**
	Total for question	**6**

Question Number	Answer		Mark
4(a)(i)	Stress needed to fracture/break (do not accept a definition of strong)	(1)	**1**
4(a)(ii)	Resistance to indentation/scratching **Or** resistance to plastic deformation of the surface	(1)	**1**
4(b)	**4** (Brass is) strong **Or** high breaking stress (accept high breaking force) **Or** breaking stress is much greater than 10 MPa. so the key will not break (Conditional on MP1) (10MPa/stress) is below the elastic limit **Or** the elastic limit is at about 300(± 50) MPa **Or** the plastic deformation starts at about 300(± 50) MPa The key would keep its shape (when the force is removed) **Or** the key would not plastically deform **Or** any deformation of the key would be elastic (Conditional on MP3) Stiff **Or** high Young's modulus The key would not change shape (as it is being used) (Conditional on MP5) (ignore references to tough and limit of proportionality and accept yield point for elastic limit)	(1) (1) (1) (1) (1) (1)	**4**
	Total for Question		**6**

Question Number	Answer		Mark
5(a)	See stress = $\frac{\text{N}}{\text{m}^2}$ **Or** stress = N m^{-2}	(1)	
	See strain = $\frac{\text{m}}{\text{m}}$	(1)	**2**
5(b)(i)	see $\sigma = \frac{50}{7.0(\times 10^{-2}) \times 7.0(\times 10^{-2})}$ **Or** see $E = \frac{Fx}{A\Delta x}$	(1)	
	see $\varepsilon = \frac{2.0(\times 10^{-2})}{7.0(\times 10^{-2})}$ **Or** substitution into $E = \frac{Fx}{A\Delta x}$ with Δx = 2 (× 10^{-2} m)	(1)	
	E = (3.5 or 3.6) × 10^4 Pa	(1)	**3**
	<u>Example of calculation</u> $\sigma = \frac{50\ \text{N}}{(0.070\ \text{m})^2}$ = 10 204 Pa $\varepsilon = \frac{0.020\ \text{m}}{0.070\ \text{m}}$ = 0.286 $E = \frac{10\ 204\ \text{Pa}}{0.286}$ = 35 678 Pa		
5(b)(ii)	The (cross sectional) area would get bigger (do not allow surface area)	(1)	
	Effect: This would give a smaller value for the Young modulus **Or** the value already calculated is too large.	(1)	**2**
	(If the candidate just states 'YM will get smaller' without any justification, do not award any marks) (MP2 only for (cross sectional) area gets smaller leading to increase in Young modulus)		
	Total for Question		**7**

Question Number	Answer		Mark
6(a)(i)	Can withstand large stress/ force / tension **Or** requires a large stress/force to fracture	(1)	**1**
***6(a)(ii)**	(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate) **Max 4 (any two properties and corresponding explanations)** Higher elastic limit so will return to its original length/shape if greater forces are applied (if a fly flies into it for the same thickness of silk) Higher ultimate /breaking <u>stress</u> so stronger **Or** higher strength **Or** so the thread could be thinner (so less visible to the fly) **Or** for same (cross-sectional)area can withstand larger force Larger area under the graph so tougher **Or** can absorb more energy (and will not break if a fly stretches the web) Larger gradient **Or** steeper **Or** greater Young modulus **Or** smaller strain/extension for the same stress/force so stiffer	(1) (1) (1) (1) (1) (1) (1) (1)	**4**
6(b)(i)	Use of the gradient **Or** correct use of pair of values from linear section of the graph (up to 0.05 for strain) Young modulus = 1.5×10^9 Pa (Accept from 1.45×10^9 Pa to 1.65×10^9 Pa) <u>Example of calculation</u> Gradient = [illegible] Young Modulus = 1.49×10^9 Pa	(1) (1)	**2**
6(b)(ii)	Use of $E = \sigma / \varepsilon$ **Or** uses σ = 44 (MPa) read from graph Use of ε = 0.03 (or lengths equal to this) Use of $\sigma = \frac{F}{A}$ $r = 2.0 \times 10^{-6}$ m (ecf from part (b)(i) for YM) (Accept answers in the range 1.9×10^{-6} m to 2.1×10^{-6} m) <u>Example of calculation</u> Stress = 1.49×10^9 Pa × 0.03 = 4.47×10^7 Pa $A = \frac{5.80 \times 10^{-4}\ \text{N}}{4.47 \times 10^7\ \text{Pa}} = 1.30 \times 10^{-11}\ \text{m}^2$ $r = \sqrt{\frac{1.30 \times 10^{-11}\ \text{m}^2}{\pi}} = 2.03 \times 10^{-6}$ m	(1) (1) (1) (1)	**4**
	Total for question		**11**

Question Number	Answer		Mark
7(a)(i)	Brittle = A Ductile = B and /or C Strongest = A Least stiff = C	**(4)**	**4**
7(a)(ii)	A = Glass B =Steel C = Copper 3 correct = 2 marks, 1 or 2 correct = 1 mark	**(2)**	**2**
7(b)	One property stated One behaviour stated The property and behaviour from the same row in the table **and** clearly linked in the candidate's response	**(1)** **(1)** **(1)**	**3**
7(c)	X = yield point Point at which material shows a large (increase in) strain for a small/no increase in stress (Accept the point at which plastic deformation/behaviour/property begins)	**(1)** **(1)**	**2**
	Total for Question		**11**

Property	**Behaviour**
High UTS **Or** strong **Or** not brittle	Will not break when opened/ Will not break when force/stress applied
High Young Modulus or stiff	Grips paper (firmly)
Ductile	Can be drawn into wires
Malleable	Can be bent into shape
Elastic	Will close after being opened

Question Number	Answer		Mark
8	• Reference to strain = $\frac{\text{change in length}}{\text{original length}}$ [just quoting $\Delta x/x$ without defining terms does not get the mark] • Compressive is a decrease in length/squash/squeeze/causes a negative extension **and** tensile is an increase in length/stretch/pull/causes a (positive) extension	**(1)** **(1)**	**2**
	Total for question		**2**

Question Number	Answer	Mark
*9	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max 5** <u>Malleable</u> for shields **(1)** Undergoes (large) <u>plastic</u> deformation **(1)** Under compression **Or** compressive force **Or** compressive stress **(1)** <u>Ductile</u> for wires **(1)** Undergoes large (plastic) deformation **(1)** Under tension Or tensile stress Or tensile force **(1)**	**5**
	Total for question	**5**

Question Number	Answer	Mark
10*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Small extension hard to measure accurately (or converse) (1) Small extension gives large percentage uncertainty (or converse) (1) **Max 4 from** (thin wire has) small area (1) stress = force/area (1) so get a larger stress (for a given force) / don't need such a large force / need too much force needed if not thin (1) greater extension - linked to thinner wire (1) strain = extension/original length / extension ˜ original length (1) greater extension - linked to longer length (1) ____ (Alternative to equation marks: Young modulus = stress / strain or $E = Fx / A\Delta x$ (accept alternative symbols) scores 1 mark, rearranged to make extension the subject scores 2 marks) Accept converse arguments (Ignore references to breaking or surface, as in surface area)	**Max 5**
	Total for question	**5**

Question Number	Answer	Mark
11(a)	(The graph shows) brittle – undergoes no/little plastic deformation/behaviour (before breaking) / breaks/fails just beyond/soon after limit of proportionality/elastic limit (1) (The graph shows) ductile – undergoes lots of/significant/large plastic deformation (before breaking) / able to undergo permanent deformation under tensile stress (1)	**2**
11(b)	Porcelain/vase/it is brittle (1) When broken it doesn't (permanently) deform/change shape/bend (or synonyms – but 'dent' is not sufficient) (No elastic deformation not sufficient) (1)	**2**
	Total for question	**4**