Question Number	Answer	Mark
1	The graph for sample A (for small extensions obeys Hooke's law as it) is a straight line **(1)** through the origin **(1)** The graph for B is not a straight line (through the origin) **(1)**	**3**
	Total for question	**3**

Question Number	Answer	Mark
2 (a)	Use of Δx = (1.12 × diameter − diameter) e.g. $\Delta x = 1.27 \times 10^{-11}$ m **(1)** Use of $F = k\Delta x$ **(1)** $F = 1.4 \times 10^{-8}$ N **(1)** <u>Example of calculation</u> $\Delta x = 0.12 \times 1.06 \times 10^{-10}$ m $= 1.27 \times 10^{-11}$ m $F = 1130$ N m^{-1} $\times 1.27 \times 10^{-11}$ N $F = 1.44 \times 10^{-8}$ N	**3**
2 (b)(i)	**Max 3** For positive force/extension the spring is in tension/stretched/extended **(1)** **(**accept after/right of origin) For negative force/extension the spring is in compression/squashed **(1)** **(**accept before/left of origin) From −0.7 (± 0.1) N to 1.5(± 0.1) N the spring obeys Hooke's law **(1)** At 1.5 (± 0.1) N the spring has reached its elastic limit (allow limit of proportionality, yield point) **Or** at –0.9 (± 0.1) N the spring is fully compressed (allow coils touching) **(1)** (answers may be given in terms of extension 1.5 N →7.6 (± 0.4) cm, −0.9 N → −4.0 (± 0.4) cm and − 0.7 N → − 3.6 (± 0.4) cm)	**3**
2 (b)(ii)	Use of gradient **Or** pairs of points from the graph within the linear region **(1)** $k = 20$ N m^{-1} Or 0.20 N cm^{-1} (allow 19 to 21 N m^{-1}) **(1)** <u>Example of calculation</u> gradient = $\frac{7.4 \times 10^{-4}\ \text{m}}{1.5\ \text{N}} = 0.0493$ m N^{-1} $k = \frac{1}{\text{gradient}} = \frac{1}{0.0493} = 20.3$ N m^{-1}	**2**
***2(c)**	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** **MP1 and 2 are for atom separation decreasing** When pushed together the repulsive force is the greater force **(1)** (because) the repulsive graph is steeper (at smaller separations) **Or** repulsive force increases more rapidly **(1)** **MP3 is for atom separation increasing.** When pulled apart the repulsive force is the smaller force **Or** repulsive force is zero but attractive force is still present **(1)**	**3**
	Total for question	**11**

Question Number	Answer		Mark
3 (a)	Line not straight **OR** gradient not constant Force not proportional to extension **OR** to obey Hooke's Law, force should be proportional to extension	**(1)** **(1)**	 **2**
3 (b)	Use of area under graph Work done = 2.5 J <u>Example of calculation</u> 0.5 x 15 x 0.33 = 2.48 J **OR** 1255 squares × 2 ×10^{-3} J = 2.51 J	**(1)** **(1)**	 **2**
3 (c)	Elastic (tries to) return to a smaller/original length (So) will be in <u>tension</u> **OR** applies <u>force /pull</u>	**(1)** **(1)**	 **2**
3 (d)	Work done stretching the elastic greater **OR** area under stretching>area under releasing **OR** the area between the two lines represents the energy (So) energy must be dissipated (in process) **OR** energy transferred as heat **OR** energy transferred to internal energy	 **(1)** **(1)**	 **2**
	Total for question		**8**

Question Number	Answer		Mark
4(a)	Use of $F = kx$ $k = 32$ (N m^{-1}) <u>Example of calculation</u> $k = \frac{3.9\ \text{N}}{0.122\ \text{m}} = 32.0$ N m^{-1}	**(1)** **(1)**	**2**
4(b)(i)	Use of $F = kx$ **OR** $F = ma$ $F = 4.1$ (N) (ecf) <u>Example of calculation</u> $F = 31.97$ N m^{-1} × 0.127 m $F = 4.06$ N OR $F = 0.4$ kg x (9.81 m s^{-2} +0.4 m s^{-2}) $F = 4.08$ N	**(1)** **(1)**	**2**
4(b)(ii)	**Max 2** Can be answered using a description: Resultant force = force of spring on mass - weight Substitution of resultant force into $F = ma$ **OR** Could be answered using a calculation e.g. $F = 4.06$ N – 3.9 N $a = \frac{0.16\ \text{N}}{0.4\ \text{m s}^{-2}}$ **OR** clear substitution of any force into this equation.	**(1)** **(1)** **(1)** **(1)**	**2**
4(b)(iii)	Use of $v = u + at$ $v = 0.8$ m s^{-1} (allow ecf) <u>Example of calculation</u> $v = 0 + (0.4 \text{ x } 2) = 0.8$ m s^{-1}	**(1)** **(1)**	**2**
4(b)(iv)	Graph correct shape i.e. 1 region of acceleration, 1 region of deceleration Constant velocity between	**(1)** **(1)**	**2**
4(b)(v)	Use of area under graph to find distance **OR** use of appropriate equations of motion Distance = 4.0 m (correct answer only) <u>Example of calculation</u> Area = (½ × 2 s × 0.8 m s^{-1}) + (3 s × 0.8 m s^{-1}) + (½ × 2 s × 0.8 m s^{-1}) Area = 4.0 m	**(1)** **(1)**	**2**
4(b)(vi)	Spring extended beyond static extension **OR** extension increased at start (So) resultant force upwards	**(1)** **(1)**	**2**
	Total for question		**14**

Question Number	Answer	Mark
5 (a)	Explain whether the spring obeys Hooke's law. States: Straight line shown / constant gradient (So) extension or change in length proportional to force (accept Δx or Δl or e proportional to F) / k constant (Yes, because extension or change in length proportional to force gets 2)	 **(1)** **(1)**
5 (b)	Show that the stiffness of the spring is about 20 N m^{-1} Indication of use of (inverse) gradient, e.g. $k = F/\Delta x$ or with values obtainable from graph (accept extension/force for first mark) Substitution of values as force/extension Correct answer (16 (N m^{-1})) <u>Example of calculation</u> $k = F/\Delta x$ $k = 1.6$ N / (0.51 m – 0.41 m) $k = 1.6$ N / 0.1 m = 16 N m^{-1}	 **(1)** **(1)** **(1)**
5 (c) (i)	Calculate force on spring Use of $F = k\Delta x$ (must be extension, not length) Correct answer (5.1 N) [ecf] <u>Example of calculation</u> $F = k\Delta x$ = 16 N m^{-1} x (0.41 m – 0.09 m) = 5.1 N (Use of 20 N m^{-1} → 6.4 N)	 **(1)** **(1)**
5 (c) (ii)	Calculate energy stored Use of $E = \frac{1}{2} F\Delta x = = \frac{1}{2} k(\Delta x)^2$ Correct answer (0.82 J) <u>Example of calculation</u> $E = 1/2\ F\Delta x$ = 0.5 x 5.1 N x (0.41 m – 0.09 m) = 0.82 J	 **(1)** **(1)**

5 (d)	Explain effect on spring QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence Change in length greater / compression greater **(1)** More force **(1)** More elastic energy / more strain energy / more energy stored / more potential energy / greater ½ $k(\Delta x)^2$ / more work done (on spring) **(1)** Greater acceleration **(1)** (Therefore) more kinetic energy **(1)** (and) greater speed **(1)**	**max 3**
	Total for question	**12**

Question Number	Answer	Mark
6(a)	Use of $W = mg$ (1) Use of $F =(-) kx$ (1) $k = 123$ (N m^{-1}) (1) (use of $g = 10$ N kg^{-1} → 125 (N m^{-1}) scores 2 marks) <u>Example of calculation</u> $W = 0.1$ kg × 9.81 N kg^{-1} = 0.981 N (−) 0.981 N = (−) k × 0.008 m $k = 122.6$ N m^{-1}	**3**
6(b)	(If the load is too high) the <u>elastic limit</u> (of the spring) will be exceeded **Or** the maximum load is at the <u>elastic limit</u> (1) (accept 1.2 kg/12 N for maximum load) The spring will not return to its original length/position **Or** the spring will be permanently deformed (1) The idea that the calibrations of the scale will not be correct e.g. the calibration/scale is now incorrect/inaccurate **Or** the spring constant will change (1) (Accept converse argument for keeping the load below the maximum load)	**3**
	Total for question	**6**