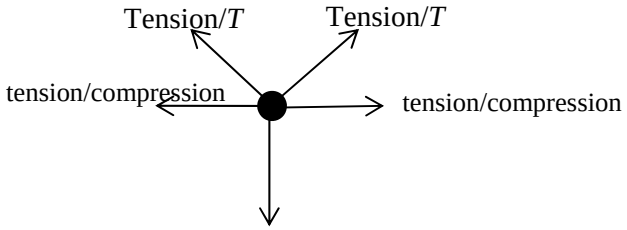
Question Number	Answer		Mark
1(a)*	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) Electrons/atoms move to higher energy levels / get excited They then move to lower energy levels (accept ground state) The energy from the move is given out in the form of a <u>photon</u> The energy levels are discrete **Or** only certain energy levels are possible The energy of the photon must be equal to the difference in energy levels **Or** $hf = E_2 - E_1$ There are only a limited number of energy differences and only a corresponding number of frequencies (looking for differences /changes **not** levels) (The marks above may be obtained from a suitably labelled diagram – but the order of excitation and de-excitation cannot be assumed for two marks just from the presence of both)	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**6**
1(b)	Doppler (accept blue shift) The wavelength of the radiation is decreased / frequencies increases Star moving towards Earth or vice versa	**(1)** **(1)** **(1)**	**3**
1(c)	Light behaves as both particle and wave **Or** wave-particle duality	**(1)**	**1**
	Total for question		**10**

Question Number	Answer		Mark
2(a)	**When illuminated:** Use of the word <u>photon</u> photons/light cause emission of (photo)electrons Idea that (photo) electrons form a current photon energy greater than or equal to work function. **In darkness:** No photons so no photoelectrons released	**(1)** **(1)** **(1)** **(1)** **(1)**	**5**
2(b)	Use of $E = hf$ Conversion of eV to J One of the 4 values below correct $f = 5.2 \times 10^{14}$ Hz or $\lambda = 5.8 \times 10^{-7}$ m for caesium $f = 8.8 \times 10^{14}$ Hz or $\lambda = 3.4 \times 10^{-7}$ m for zinc Comment that Cs is in the visible range or Zn is ultraviolet – allow even without supporting calculation **Alternative method** Allow assumed max freq/min wavelength for visible light then, calculation of work function, quoted in eV, comparison with given work functions, conclusion: Use of (1); work fn (1), in eV (1), comparison (1) <u>Example of calculation</u> $f = \varphi \div h = (2.14 \times 1.6 \times 10^{-19})$ J $\div$ 6.63×10^{-34} J s $= 5.2 \times 10^{14}$ Hz for caesium $f = \varphi \div h = (3.63 \times 1.6 \times 10^{-19})$ J $\div$ 6.63×10^{-34} J s $= 8.8 \times 10^{14}$ Hz for zinc	**(1)** **(1)** **(1)** **(1)**	**4**
19(ci)	Maximum displacement of the wave **Or** maximum displacement from the mean **Or** maximum displacement from equilibrium	**(1)**	**1**
19(cii)	**Max 3** Size of the gap (in the soundtrack) determines the amount of light Amount of light determines number of photons Number of photons determines number of (photo) electrons (released by phototube) Number of electrons determines size of current (in the circuit) (Combining MP 1 and 2 by writing "size of the gap determines number of photons" scores 1 mark. Combining MP 2 and 3 by writing "the amount of light determines number of (photo) electrons" also scores 1 mark)	**(1)** **(1)** **(1)** **(1)**	**3**
	Total for question		**13**

Question Number	Answer		Mark
3(a)	Both upward tensions labelled	**(1)**	
	Weight labelled (allow 2 separate arrows for the weight of the bridge and the lorry)	**(1)**	
	Tension **and/or** compression labels for the horizontal force	**(1)**	
	(-1 for any additional forces and all lines must touch the dot)  		**3**
3(b)	(Diagonal) beams create a upward/vertical force	**(1)**	
	The idea that the beams support/distribute/share the weight **Or** to prevent the bridge from sagging **Or** to reduce the tension/compression in the horizontal section of the bridge	**(1)**	**2**
	Total for Question		**5**

Question Number	Answer	Mark
4(a)	Use of spring constant = gradient **Or** use of $F = k\Delta x$ using a pair of values from the graph **(1)** Spring constant = (3.5 to 3.6) × 10^4 N m^{-1} **(1)** Example of calculation Gradient = $\frac{3.6 \times 10^3 \text{ N}}{10.2 \times 10^{-2} \text{ m}}$ Spring constant = 3 5300 N m^{-1}	**2**
4(b)(i)	Use of $E = ½ F\Delta x$ **Or** use of work done = area under graph **(1)** Using the correct region of the graph (trapezium under graph from 3 to 9 cm) **(1)** Work done by the child on the spring = 126 -128 (J) **(1)** Example of calculation Work done in compressing spring = (½ × (3.2× 10^3 N) × (9 × 10^{-2} m)) - (½ × (1.05 × 10^3 N) × (3 × 10^{-2} m)) Work done by the child on the spring = 128 J	**3**
4(b)(ii)	Elastic potential energy to kinetic energy **(1)** and gravitational potential energy **(1)** (accept EPE, E_{el}, GPE, E_{grav}, KE, E_k) (only penalise once the omission of potential from gravitational or elastic potential energy)	**2**
4(b)(iii)	Use of $E_{grav} = mgh$ **(1)** Use of work done by child on spring = $E_{grav} + E_k$ **(1)** Use of $E_k = ½ mv^2$ **(1)** v = 2.5 m s^{-1} (ecf from part (b)(i)) **(1)** Example of calculation E_{grav} = 35 kg × 9.81 N kg^{-1} × 0.06 m = 20.60 J E_k = 128 J – 20.60 J = 106.4 J $v = \sqrt{\frac{2 \times 106.4 \text{ J}}{35 \text{ kg}}}$ v = 2.48 m s^{-1}	**4**
***4(c)**	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** (The pogo-stick pushes down on the ground and) by N3 the ground exerts an upwards force on the pogo-stick **(1)** Upwards force on pogo-stick > weight of pogo-stick **Or** there is an unbalanced upwards force on the pogo-stick **(1)** Due to N1/ N2 the pogo-stick accelerates (upwards) **(1)**	**3**
	Total for Question	**14**