Question number	Answer	Additional guidance	Mark
2(a)	• downward arrow labelled 'weight' (1) • upward arrow labelled 'reaction' (1) • both arrows of approximately equal length and drawn in line within ball (1)	ignore 'gravity' allow 'gravitational force', 'force due to gravity' allow 'normal reaction force', 'normal contact force'	**3**

Question number	Answer	Additional guidance	Mark
2(b)	Process should include: • substitution • rearrangement • evaluation to at least 2 significant figures (s.f.) e.g. $v^2 = 0 + (2 \times 10 \times 1.3)$ (1) $v = \sqrt{2 \times 10 \times 1.3}$ (1) $v = 5.1$ (m/s) (1)	allow 5.10, 5.099, 5.09	**3**

Question number	Answer	Additional guidance	Mark
2(c)(i)	0.51 (seconds)	allow value in range 0.50–0.52 (seconds)	**1**

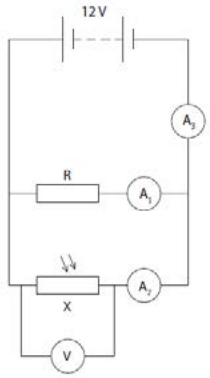
Question number	Answer	Additional guidance	Mark
2(c)(ii)	Average speed = distance moved/time taken	allow in accepted symbols or rearranged.	**1**

Question number	Answer	Additional guidance	Mark
2(c)(iii)	(Speed =) 2.0 (m/s)	accept 2	**1**

Question number	Answer	Mark
2(c)(iv)	An explanation that makes reference to the following points: • gradient is equal to the {speed/velocity} of the ball (1) • gradient is increasing over time (1) • (therefore) the {speed/velocity} is increasing with time (1)	**3**

Total for Question 2 = 12 marks

Question number	Answer	Mark
3(a)(i)	An LDR (light-dependent resistor)	1

Question number	Answer	Mark
3(a)(ii)	• correct symbol (1) • correct position in parallel with X (1)  	2

Question number	Answer	Additional guidance	Mark
3(b)	rearrangement • $I = V/R$ (1) substitution • I = 12/840 (= 0.014 (A)) (1)	0.01429 (A) some evidence of working required for two marks	2

Question number	Answer	Additional guidance	Mark
3(c)(i)	correct addition of current in A_1 with current in A_2 = 0.021 (A) (1)	ecf from 3(b) 0.025 (A) award full marks for correct numerical answer without working	1

Question number	Answer	Mark
3(c)(ii)	An explanation that makes reference to the following points: • resistance of LDR increases (1) • hence current in A_2/A_3 decreases (1)	2

Total for Question 3 = 8 marks

Question number	Answer	Mark
4(a)(i)	A	1

Question number	Answer	Mark
4(a)(ii)	B	1

Question number	Answer	Mark
4(b)(i)	C	1

Question number	Answer	Additional guidance	Mark
4(b)(ii)	2 marks max. available for each named part of the spectrum for each use: • 1 mark for a simple use • 1 mark for a supporting description e.g. for gamma rays: • used to sterilise medical tools (1) • (because) gamma kill bacteria (1) for x-rays: • used to photograph bones (1) • (because) x-rays can penetrate soft tissues but not bone (1) for ultraviolet: • used for detecting security ink (1) • (because) it fluoresces with ultraviolet lighting (1) for infrared: • used for optical fibre communications (1) • (because) they can undergo total internal reflection (1) for micro waves: • used for satellite communications (1) • (because) microwaves can penetrate Earth's atmosphere (1) for radio waves: • used for long-range communications (1) • (because) they can be reflected from the Earth's atmosphere (1)	no mark for simply naming a part of the spectrum	6

Total for Question 4 = 9 marks

Question number	Answer	Mark
5(a)(i)	Process should include: • substitution • rearrangement • evaluation e.g. 100 × 7.5 = p_2 × 5.0 (1) p_2 = (100 × 7.5)/5.0 (1) (p_2 =) 150 (kPa) (1)	**3**

Question number	Answer	Additional guidance	Mark
5(a)(ii)	An explanation that makes reference to the following points: • particles collide with walls (of container) (1) And any two from: • more frequently/time between collisions is less (1) • (resulting in) larger force (1) • (over a) smaller surface area (1)	 allow 'more often'	**3**

Question number	Answer	Additional guidance	Mark
5(b)(i)	A description that makes reference to the following points: • (average kinetic energy) increases (1) • in (direct) proportion to (1) • Kelvin temperature (1)	 dependent on point 1 dependent on point 1	**3**

Question number	Answer	Additional guidance	Mark
5(b)(ii)	Process should include: • conversion of temperatures to Kelvin scale (1) • rearrangement (1) • substitution (1) • evaluation (1) e.g. 20 °C = 293 K OR 65 °C = 338 K (1) (p_1/T_1)/T_2= p_2 (1) p_2 = (100 x 338)/293 (1) (p_2 =) 115 (kPa) (1)	not converting to Kelvin gains 2 marks max. 100/293 = p_2/338 allow 115.358…	**4**

Total for Question 5 = 13 marks

Question number	Answer	Additional guidance	Mark
6(a)	Any two control variables (2) e.g. • distance between fan and turbine • fan speed • number of turbine blades • turbine angle • fan angle • orientation of fan with respect to turbine	 ignore type of fan/turbine	**2**

Question number	Answer	Additional guidance	Mark
6(b)(i)	Scale (1) Axes (1) Plotting (1)	both axes should occupy at least 50% of the grid both axes should be labelled with quantity and unit orientation unimportant points should be accurate within 1mm. −1 mark for each error	**3**

Question number	Answer	Additional guidance	Mark
6(b)(ii)	• curve starting at (0,0) (1) • smooth curve to a peak at (20, 2.2) (1)	curve should be smooth with roughly equal distribution of points either side	**2**

Question number	Answer	Additional guidance	Mark
6(b)(iii)	A description containing any two from: • voltage increases, then decreases as blade angle is increased (1) • maximum voltage when blade angle is 20° (1) • non-linear relationship (1)	allow range of 15°−25°	**2**

Question number	Answer	Mark
6(c)(i)	Bar chart	**1**

Question number	Answer	Mark
6(c)(ii)	(Number of blades) is a discrete/discontinuous variable	**1**

Total for Question 6 = 11 marks

Question number	Answer	Mark
7(a)	• Axes shown with either voltage or current against time AND more than one wavelength shown (1) • Continuous curve drawn that alternates to + and −, and has approximately equal displacement on either side of x-axis (1)	2

Question number	Answer	Additional guidance	Mark
7(b)	A diode only allows current in one direction	allow answers which describe what would happen to a battery with a.c.	1

Question number	Answer	Additional guidance	Mark
7(c)(i)	• All circuit symbols correct (1) • Bulbs shown in series (1)	allow cell for battery reject power supply symbol	2

Question number	Answer	Additional guidance	Mark
7(c)(ii)	Power = current × voltage	allow rearrangement and correct symbols, e.g. $P = I \times V$	1

Question number	Answer	Additional guidance	Mark
7(c)(iii)	Process includes: • rearrangement • evaluation e.g. $I = P/V$ (1) = 0.33/6.0 = 0.055 (A) (1)	1 mark max if incorrect V is used	2

Total for Question 7 = 8 marks

Question number	Answer	Mark
8(a)	B	1

Question number	Answer	Additional guidance	Mark
8(b)(i)	Transverse	allow any recognisable spelling	1

Question number	Answer	Additional guidance	Mark
8(b)(ii)	Any transverse wave e.g. electromagnetic named part of EM spectrum (surface) water waves waves on a rope seismic S waves	ignore waves on a slinky unless correctly clarified	1

Question number	Answer	Additional guidance	Mark
8(c)(i)	wave speed = frequency × wavelength	equation can be given in words or symbols	1

Question number	Answer	Additional guidance	Mark
8(c)(ii)	• Conversion of kHz to Hz OR cm to m • Substitution • Evaluation e.g 2.9 kHz = 2900 Hz (1) (v =) 2900 x 0.12 (1) (v =) 350 (m/s) (1)	seen anywhere allow 348 (m/s) 0.348, 0.35, 34800, 35000 gains 2 marks 34.8, 35 gains 1 mark	3

Question number	Answer	Additional guidance	Mark
8(d)	An explanation including: • frequency decreases (1) • wavelength increases (1) • (because) wave speed is constant (1)	Ignore references to volume or loudness Allow 'pitch' for frequency	**3**

Total for Question 8 = 10 marks

Question number	Answer	Mark
9(a)(i)	4 (1) 0 (1)  	2

Question number	Answer	Additional guidance	Mark
9(a)(ii)	(Centre of) stars	allow the Sun	1

Question number	Answer	Mark
9(a)(iii)	An explanation that makes reference to the following points: • hydrogen nuclei repel (1) • need a high speed/kinetic energy (1) • to get close enough to fuse together (1)	3

Question number	Answer	Additional guidance	Mark
9(b)	An explanation that makes reference to the following points: • when fission occurs a large nucleus splits into smaller nuclei (1) • but when fusion occurs small nuclei fuse together to form a larger nucleus (1)	allow 'heavier', 'lighter' allow specific correct named isotopes	2

Total for Question 9 = 8 marks

Question number	Answer	Mark
10(a)(i)	Process includes: • rearrangement (1) • substitution (1) • evaluation of orbital radius (1) • answer to 3 s.f. (1) e.g. $r = v \times T/2\pi$ (1) $r = (7.66 \times 92.7 \times 60)2\pi$ (1) $r = 6781$ (km) (1) $r = 6780$ (km) (1)	**4**

Question number	Answer	Additional guidance	Mark
10(a)(ii)	Earth radius = r − 409 = 6370 (km)	Allow ecf Allow 6 371 (km) Allow 6 372 (km)	**1**

Total for Question 10 = 5 marks

Question number	Answer	Additional guidance	Mark
11	A description that makes reference to six of the following points: • **all** main sequence stars fuse H into He (1) • lower mass stars stay on the MS line for longer (1) • lower mass stars become red giants (1) • higher mass stars become red super giants (1) • red giant becomes a white dwarf (1) • supergiant becomes a supernova (1) • supernova becomes a neutron star (1) • supernova becomes a black hole (1)	accept numerical values allow red giant to planetary nebula	**6**

Total for Question 11 = 6 marks

<table>
<tr><th>Question number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>12(a)(i)</td><td>

answer 3 correct (1)
answers 4 and 5 in either order (1)
answers 6 and 7 in either order (1)

<table>
<tr><th>Statements</th><th>Order</th></tr>
<tr><td>record the data in a table</td><td>8</td></tr>
<tr><td>take the temperature of the two test tubes</td><td>5</td></tr>
<tr><td>tie 7 test tubes together</td><td>1</td></tr>
<tr><td>heat the water to 90 °C</td><td>2</td></tr>
<tr><td>take the temperatures every minute</td><td>6</td></tr>
<tr><td>place equal volumes of water in all test tubes</td><td>3</td></tr>
<tr><td>put thermometers into the middle test tube and single test tube</td><td>4</td></tr>
<tr><td>record data for 15 minutes</td><td>7</td></tr>
</table>
</td><td>3</td></tr>
</table>

Question number	Answer	Mark
12(a)(ii)	• correct units shown (1) • temperature and indication of two different thermometers' readings (1)	**2**

Question number	Answer	Mark
12(a)(iii)	The single test tube will cool faster/RA	**1**

Question number	Answer	Mark
12(a)(iv)	• correct labels on axes (x = time, y = temperature) (1) • both lines start on y-axis at the same temperature (1) • both lines show that temperature decreases with time (1) • line for single tt thermometer is below other line at all points (1)	**4**

Question number	Answer	Additional guidance	Mark
12(a)(v)	An explanation that makes reference to the following three points: • thermal energy loss by convection is reduced because of the air pockets in the 7 tt (1) • causes the single tt to lose more thermal energy/RA (1) • radiation loss is the same for both (1) • conduction losses for 7 tt are not high/layer of tt acts as an insulator (1)	allow heat for thermal energy accept alternative descriptions of 7 tt e.g. huddle	**3**

Question number	Answer	Mark
12(b)	**Fat** Acts as an insulator so keeps penguins warm(1) **Feathers** Feathers trap pockets of air (1) and either reduce thermal energy loss by convection (1) or air is a poor conductor so thermal energy loss is reduced (1)	**3**

Total for Question 12 = 16 marks

TOTAL FOR PAPER = 110 MARKS