Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1	a		**First check the answer on the answer line** **If answer = 15 (m / s) award 3 marks** Evidence for use of area under line / distance = area under (v-t) graph ✓ 30 = ½ × u × 4 **OR** u = 2 × 30 ÷ 4 ✓ (u =) 15 (m / s) ✓	3 (3 x AO 2.2)	**ALLOW** e.g. 5u ÷ 2 **OR** 0.5xbxh **ALLOW** evidence seen on graph **ALLOW** use of higher level answers using SUVAT equations of motion e.g. s = (u + v)t ÷ 2 **Examiner's Comments** This question required candidates to equate the distance travelled to the area under the graph (for the 4 seconds of braking). The majority of candisupdates did not realise this and did not gain any credit. Some candidates attempted to use an equation of motion or speed = distance ÷ time. A few candidates used the area under the entire graph rather than just the braking distance, but did gain some credit as they had shown their working.
	b	i	**First check the answer on the answer line** **If answer = 27 (m) award 3 marks** Select and rearrange: (distance =) final velocity^2 − initial velocity^2 ÷ 2 × acceleration **OR** (s =) $v^2 - u^2 \div 2 \times a$ ✓ Substitution: (s =) $-18^2 \div -12$ **OR** $18^2 \div 12$ **OR** 324 ÷ 12 ✓ (s =) 27 (m) ✓	3 (AO 1.2) (2 x AO 2.1)	**ALLOW** correct substitution into unrearranged equation for 1 mark e.g. $0 - 18^2 = 2 \times -6 \div s$ **OR** $18^2 - 0 = 2 \times 6 \times s$ **ALLOW** d for s **ALLOW** −27 (m) **ALLOW** other correct use of SUVAT equations of motion **Examiner's Comments** It was good to see that the majority of candidates could select the correct equation from the Equation Sheet and most gained 1 mark from substituting

					the values into the unrearranged equation. However, rearranging was again an issue, so something candidates need to practise.
		ii	**First check the answer on the answer line** **If answer = 2400 − 21 000 (N) award 3 marks** Estimation of mass of car = 1500 (kg) ✓ (F =) 1500 × 6 ✓ (F =) 9000 (N) ✓	3 (AO 1.1) (2 x AO 2.1)	**ALLOW** 2 marks for force correctly calculated if mass is outside of range **ALLOW** 400 − 3500 (kg) **ALLOW** candidate's mass estimate x 6 for 1 mark **ALLOW** candidate's mass estimate x 6 correctly calculated for 2 marks **Examiner's Comments** The vast majority of candidates scored at least 2 marks for substituting values into the equation and estimating the force acting on car B. However, estimates of the mass of the car varied a lot, with values of 6 kg to 600 000 kg seen. **Assessment for learning** Candidates could benefit from short activities where they estimate values of quantities such as the masses and speeds of objects.
		iii	**Any two from:** Skid mark may not have clear start or end ✓ Skid mark may be curved / difficult to measure ✓ (Idea that) car may not have produced a skid for whole of braking (distance) / **AW** ✓ (Idea that) skid mark only occurs when the wheels stop turning ✓	2 (2 × AO 3.2a)	**ALLOW** skid marks don't appear as soon as braking starts / deceleration is not always large enough to produce skids marks
			Total	**11**	

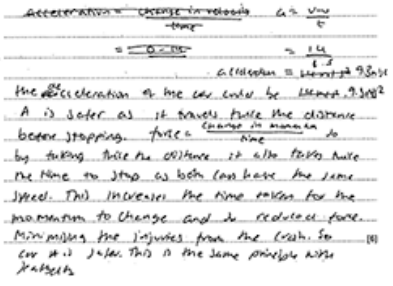
2			B	1 (AO 1.2)	
			Total	**1**	
3			C	1 (AO 1.1)	**Examiner's Comments** Most candidates discarded options A and B as they knew that both of these factors only affected thinking distance. However, a common error was to choose option D.
			Total	**1**	
4			C	1 (AO 1.2)	**Examiner's Comments** This question required students to convert between km / h and m / s. Candidates usually find converting compound units challenging so it was pleasing to see that the majority of candidates were able to do this correctly.
			Total	**1**	
5			B	1 (AO 1.2)	**Examiner's Comments** Although the majority of candidates answered this correctly, a common error was option A as some candidates thought that reaction time can be measured accurately with a stopwatch.
			Total	**1**	
6			**First check the answer on answer line** **If answer = 1.7 × 10^8 (Bq) award 3 marks** (1 μg =) 1 × 10^{-6} g **OR** 0.000001 g ✓ (activity =) 3.57 × 10^{16} ÷ (2.10 × 10^8) **Or** 3.57 × 10^{16} × 10^{-6} ÷ 210 **Or** 170 000 000 (Bq) ✓ (activity =) 1.7 × 10^8 (Bq) ✓	3 (AO 1.2) (AO 2.2) (AO 1.2)	**ALLOW** 1 mark for 2.1 × 10^8 (μg) **ALLOW** 1 mark for 3.57 × 10^{16} ÷ 2.10 × 10^n **OR** 3.57 × 10^{16} × 10^n ÷ 210 **OR** 170…… i.e., in non standard form (where there is no/incorrect unit change) **ALLOW** 2 marks for 1.7 × 10^n (no/incorrect unit change) **ALLOW** this mark for clear evidence of an incorrect answer written in standard form (not a bald incorrect answer written in standard form)

					Examiner's Comments The majority of candidates scored 2 or 3 marks for this question. The main error occurred with the power of 10 in the answer, as many candidates had either incorrectly converted micrograms into grams, or had not attempted to convert the unit at all, so scored 2 marks.
			Total	**3**	
7			**B**	1 (AO 2.2)	**Examiner's Comments** Some candidates believed the car was braking in the first 0.7 seconds of the journey, and therefore calculated the area under that section of the graph (option A) ; this is the thinking distance rather than the braking distance.
			Total	**1**	
8			**B**	1 (AO 2.1)	**ALLOW** 6.0 (m / s^2) **Examiner's Comments** This was a challenging question. Over half of candidates chose an incorrect option. Candidates needed to identify the relevant equation from the equation sheet and rearrange it to determine the deceleration of the vehicle. An alternative approach can be used: use the equation (average) speed = distance ÷ time to determine the deceleration time, and then use acceleration = change in velocity ÷ time. Where this was seen, candidates used the initial speed of 30 m / s instead of the average speed.
			Total	**1**	
9		i	The sound reflects/echoes (from the cliff) ✓ The amplitude of the sound decreases with distance / some of the energy/wave/sound is absorbed (by the cliff/air) ✓	2 (2 × AO1.1)	**IGNORE** bounces **ALLOW** energy lost as travelling through air / energy dissipated into surroundings/cliff **ALLOW** sound/waves/energy spreads out **ALLOW** some sound/waves/energy

					reflect/travel in different directions **IGNORE** just energy lost **Examiner's Comments** The majority of candidates gained both marks. Of those that did not, it was usually from the lack of scientific terminology, e.g. bounce back instead of reflect, or insufficient detail to explain why the second clap is quieter, e.g. energy is lost.
		ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 231 (m) award 4 marks** (distance =) speed × time ✓ (distance travelled by wave =) 330 ×1.40 ✓ (distance travelled by wave =) 462 (m) ✓ (distance to cliff =) ½ × 462 = 231 (m) ✓	4 (AO1.2) (3 × AO2.1)	**ALLOW** symbol equation / equation in any form **ALLOW** 0.7 seen for 1 mark **ALLOW** 330 × 0.7 for 3 marks **ALLOW** 3 marks for answer of 462(m) **Examiner's Comments** Nearly all candidates gained full marks or 3 marks. Several candidates did not gain the last mark because they did not divide either the time or their answer for distance by two.
		iii	**Any two from:** Due to reaction time ✓ Sound may not be heard (clearly) ✓ The student might start the stopwatch too early / stop the stopwatch too late / be distracted ✓ Wind/temperature/humidity/rain affects the speed ✓	2 (2 × AO3.2a)	**IGNORE** human error **ALLOW** cliff surface is not flat so waves take different times to return **ALLOW** starts/stops stopwatch at the wrong time / can't clap and press button at the same time **IGNORE** weather conditions **Examiner's Comments** Most marks were gained for ideas about reaction time, pressing the stopwatch too early/late and the difficulty in clapping and pressing the stopwatch at the same time. Of the candidates who did not score both marks, most answers usually referred to human error.
		iv	**Any one from:** Repeat the measurements and take a mean ✓ (Idea of) recording sound (and playback) to find accurate time ✓	1 (AO3.3b)	**ALLOW** (idea of) clap-echo method / measuring time for multiple claps **ALLOW** (idea of) a method using microphone(s) linked to computer/oscilloscope/electronic

			Use another person (next to first student) to measure the time between clap and echo ✓		timers **Examiner's Comments** The improvements suggested often followed on from the candidate's answer to part (a) (iii) and most candidates were given the mark. Incorrect responses often referred to inappropriate technology such as light gates or vaguely described sound-activated timers. **Assessment for learning** It would be beneficial for students to think about which improvements could be made to their method each time they carry out an experiment.
			Total	**9**	
10		i	Smaller radius or closer to the Sun means larger (gravitational/centripetal) force/pull ✓ (smaller radius or closer to Sun or larger gravitational/centripetal force means) larger acceleration/speed ✓ **OR** Closer orbits have a lower GPE ✓ (closer orbits have) higher KE ✓	2 (2 × AO1.1)	**ALLOW ORA** in each case **ALLOW** smaller radius means more gravity **Examiner's Comments** This question assessed candidates' abilities to explain why the speed of a planet must change if the radius changes (P8.3g). The majority of candidates were given at least 1 mark, usually for describing the correct link between the radius and speed. However, the command word for this question was 'Explain' and only some candidates progressed to explain why the speed changes in terms of the gravitational force.
		ii	**Any two from:** (A statement explaining that if proportional, you would expect:) e.g. $T = kr$ **OR** $T \div r = k$ **OR** $T_A \div r_A = T_A \div r_A$ **OR** $r_A \div T_A = r_B \div T_B$ **OR** $T_A \div T_B = r_A \div r_B$ **OR** $T_B \div T_A = r_B \div r_A$ / **ORA** ✓ Correct calculation of k or ratio of	2 (2 × AO3.1b)	**ALLOW** <u>all</u> numbers substituted correctly in any version for 2 marks. e.g. $k = T_A \div r_A = 1.88 \div 2.28 \times 10^{11} = 8.25 \times 10^{-12}$ $k = T_B \div r_B = 0.62 \div 1.08 \times 10^{11} = 5.74 \times 10^{-12}$ e.g. $T_A \div r_A = 8.25 \times 10^{-12} \neq T_B \div r_B = 5.74 \times 10^{-12}$

			variables ✓ (Idea that) planet A is (approximately) double the radius of B but (approximately) triple the time (to orbit the Sun) ✓ **BUT** Statement (comparing two correctly calculated values) showing values are not equal or k is not constant ✓ ✓ Correct calculation of k from planet A (or B) and used to show that this k does not give correct value for the other planet ✓ ✓		$r_A \div T_A = 1.21 \times 10^{11} \neq T_B \div r_B = 1.74 \times 10^{11}$ $T_A \div T_B = 3.03 \neq r_A \div r_B = 2.11$ $T_B \div T_A = 0.330 \neq r_B \div r_A = 0.474$ **Examiner's Comments** This question was well answered and many candidates gained at least 1 mark with some scoring full marks. Candidates with the correct answer calculated one of the many different possible pairs of ratios to show that the time to orbit the Sun was not proportional to the radius of the orbit. Some candidates calculated the value of k for one planet's data and then showed that this value of k did not give the correct value for the radius or time to orbit for the other planet.
			Total	**4**	
11			**Level 3 (5–6 marks)** Detailed explanation of why car **A** is safer than car **B** **AND** good estimation of deceleration of car **A** / quantitative comparison of decelerations *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Detailed explanation of why car **A** is safer than car **B** **AND** an attempt at estimation/comparison of decelerations **OR** Good estimation of deceleration of car **A** / quantitative comparison of decelerations **AND** a basic explanation of why car **A** is safer than car **B** *There is a line of reasoning presented*	6 (3 × AO2.1) (3 × AO1.1)	**AO2.1 Applies knowledge and understanding of scientific ideas to estimate acceleration** Estimation of acceleration using distance or time • car **B** has a higher/double acceleration • Use of $a = (v^2 - u^2)/2s$ • $a = (-)14^2 / 2 \times$ (their value of distance) • Use of $a = (v - u) / t$ • $a = 14/$ (their value of time) **AO1.1 – Demonstrates knowledge and understanding why car A is safer than car B** • (Smaller force) reduces risk of (serious) injury to driver/passengers Explanation • Increased stopping distance/time for car **A** means deceleration of car **A** is half/less than car **B** / **ORA** • Car **A** slows down over a longer distance/time

			with some structure. The information presented is relevant and supported by some evidence. **Level 1 (1–2 marks)** Basic explanation of why car **A** is safer than car **B** **OR** An attempt at estimation/comparison of decelerations *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit*		• Smaller acceleration / smaller rate of change of momentum for car **A** / **ORA** • So force acting on car **A** is half/less than car **B** / **ORA** • Since F = ma / F= rate of change of momentum • Greater distance/time for (kinetic) energy to be dissipated • Since W = Fd / same KE transferred / same KE dissipated over a longer distance/time **<u>Examiner's Comments</u>** This was the Level of Response question, targeted up to Grade 9, and assessed AO1 and AO2. There was a wide range of marks achieved and the question discriminated very well. Very few candidates were not given any marks. The majority of candidates were able to give a description of why car A was safer in terms of force and/or injuries or attempted to estimate the deceleration, although the values they used for time or distance were often very unrealistic. Many candidates discussed crumple zones. More detailed responses required for Level 2 and 3 included linking deceleration or rate of change of momentum to force with a reference to relevant equations. Exemplar 2  This response achieved Level 3, 6 marks. The explanation is very detailed, using the equation to link

					more time for the momentum to change to less force. There is a good estimation of the deceleration using a correct equation from the Data Sheet and a realistic value for the time taken.
			Total	**6**	
12		i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 7.7 × 10^{17} (J) award 2 marks** 215 (TWh) from graph ✓ (215 × 3.6 × 10^{15} =) 7.7 × 10^{17}(J) ✓	2 (2 × AO1.2)	**ALLOW** 210 – 220 (TWh) from graph **ALLOW** 1 mark for any correct conversion into J e.g. 210 × 3.6 × 10^{15} = 7.6 × 10^{17}(J) 220 × 3.6 × 10^{15} = 7.9 × 10^{17}(J) **IGNORE** answer not in standard form
		ii	**Any two from:** More wind turbines have been built ✓ Modern turbines have a better design / are more efficient ✓ (wind turbines) do not produce air pollution/harmful gases/carbon dioxide/greenhouse gases / do not contribute to global warming/greenhouse effect/climate change ✓ (idea that wind turbines) conserve/reduce use of fossil fuels ✓ (Idea of) renewable energy ✓ (wind turbines) have low fuel/running costs once set up ✓	2 (2 × AO1.1)	**IGNORE** increased demand **ALLOW** better technology **IGNORE** no pollution / better for the environment unless qualified **IGNORE** sustainable **ALLOW** reduce use of finite resources / fossil fuels are running out **ALLOW** high cost of fossil fuels **Examiner's Comments** Most candidates gained at least 1 mark, usually for the idea of renewable energy. Answers such as 'no pollution', 'environmentally friendly', or just 'global warming' were not given any marks.
			Total	**4**	
13			C ✓	1 (AO2.1)	**Examiner's Comments** This question required candidates to take account of the squared relationship between energy stored in the spring and the extension of the spring. A number of candidates chose option B.
			Total	**1**	
14			A ✓	1 (AO2.2)	

			Total	**1**	
15			B ✓	1 (AO1.2)	**Examiner's Comments** This question assessed candidates' knowledge of unit prefixes and the majority of candidates chose the correct option.
			Total	**1**	