Answers to examination-style questions

Answers	Marks	Examiner's tips
1 **(a)** **(i)** Using power = force × speed, top speed = maximum output power/ driving force ✓ = 12000 W/600 N = 20 m s^{-1} ✓	1 1	Tests your ability to use the given data to calculate the top speed of an electric car and its range.
(ii) Distance range = speed × time ✓ = 20 × 90 × 60 m = 108 km ✓	1 1	
(b) The hybrid car is 1.8 times more fuel efficient than the equivalent petrol-only car. Its carbon emission would be therefore be 1.8 times less ie. 100 grams per km. This would cut the annual carbon emission per vehicle by 20 000 × 80 grams = 1600 kg or 16% for the average UK household. If a significant number of UK motorists switched to hybrid vehicles, there would be significant reduction in UK carbon emissions (eg a 20% switch would cut UK carbon emissions by 3.2% (= 20% of 16%)).	1 1 1 1 1	How Science Works features in part **(b)** which requires students to compare data and other facts supplied about a hybrid car's efficiency and carbon emissions in comparison with a 'petrol car'. Any general statements in the answer (e.g. the braking distance is less) needs to be backed up with a relevant numerical comparison.
2 **(a)** **(i)** gravitational potential energy changes to kinetic energy	1 1	You have to read this question carefully. In **(i)** you are only asked about the falling mass, whereas in **(ii)** you are asked about the whole system.
(ii) both trolley and falling mass gain kinetic energy frictional forces cause energy to be converted into thermal energy	1 1	
(b) *Required measurements*: • masses of the trolley and of the falling mass • distance (s) fallen by mass and time (t) taken to fall	2	To investigate conservation of energy, you need to calculate $m\,g\,\Delta h$ and $\frac{1}{2}\,m\,v^2$ for the whole system. In order to find v, you need distance and time measurements.
(c) *Relevant points include*: • calculate $m\,g\,\Delta h$ for the falling mass, where $\Delta h = s$ • calculate speed of the mass as it hits the floor by using $s = \frac{1}{2}(u + v)\,t$, where s and t have been measured and $u = 0$ • calculate $\frac{1}{2}\,m\,v^2$ for the trolley • calculate $\frac{1}{2}\,m\,v^2$ for the mass • compare value of E_P lost with total E_K gained	4	Your answer must give full details of how you would use all your measurements in order to check whether energy has been conserved. For full credit it would not be sufficient to give a vague answer such as 'calculate the E_P lost and the E_K gained'.

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3 **(a)** use of $E_P = m\,g\,\Delta h$ gives $E_P = 1.0 \times 9.81 \times 4.8 = 47$ J	1 1	A very straightforward application of the potential energy equation, as it applies to hydroelectric power.
(b) power $= \dfrac{\text{energy converted}}{\text{time taken}} = \dfrac{mg\Delta h}{t}$ $= \dfrac{6.7 \times 10^7 \times 9.81 \times 4.8}{3600}$ $= 8.8 \times 10^5$ W	1 1 1	Alternatively, you could work this out from your answer in **(a)**. The energy available in 1 h would be (6.7×10^7) times larger than 47 J. Power is energy per second, and dividing by 3600 will give you the answer.
(c) *Relevant points include*: • locations for power stations are limited (e.g. by geographical and meteorological factors) • continuous generation may not be possible (e.g. times of drought) • environmental impact (e.g. population is displaced when reservoir is built, damage to wildlife habitats, visual intrusion)	2	Your response to this kind of question may depend on your social awareness and on your previous knowledge, as well as on your common sense. Even though hydroelectric power is regarded as a classic 'green' energy resource, there can still be a down side.
4 **(a)** the resultant force steadily decreases during the first 4 s it is zero for the all times beyond 4 s	1 1	**(a)** is an exercise in interpreting the velocity-time graph. The gradient decreases over the first 4 s, indicating a decreasing acceleration. Beyond 4 s, the constant velocity shows that there is no acceleration.
(b) maximum kinetic energy $= \frac{1}{2} m\,v^2 = \frac{1}{2} \times 1.4 \times 10^3 \times 16^2$ $= 1.8 \times 10^5$ J	1 1	When the car has its maximum kinetic energy it has reached its constant speed, which you read from the graph. Take care when doing this: it is **not** 15 m s^{-1}.
(c) when at a constant speed, power $P = F\,v$ gives $2.0 \times 10^4 = F \times 30$ $\therefore$ driving force $F = 670$ N	1 1	For this part of the question, the car is travelling at a higher constant speed. Power is equal to the work done per second, which is (force) $\times$ (distance moved per second), or $F \times v$.
5 **(a)** **(i)** use of $\Delta E_P = m\,g\,\Delta h$ gives $\Delta E_P = 70 \times 9.81 \times 150$ $= 1.03 \times 10^5$ J **(ii)** use of $E_K = \frac{1}{2} m\,v^2$ gives $E_K = \frac{1}{2} \times 70 \times 45^2$ $= 7.09 \times 10^4$ J	1 1 1 1	Part **(ii)** requires particular care, because you cannot use (E_K gained) = (E_P lost). You may only become aware of this when you first read through part **(b)**. The skydiver encounters significant air resistance and therefore some of the E_P lost becomes thermal energy.

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(b) **(i)** work done against air resistance $= (1.03 \times 10^5) - (7.09 \times 10^4)$ $= 3.21 \times 10^4$ J	1	The 'missing' energy must be equal to the work done.
(ii) use of work done = $F\,s$ gives $3.21 \times 10^4 = F \times 150$ ∴ average resistive force = 210 N (to 2 significant figures)	1 1	The resistive force will increase as the speed of the skydiver increases. This result is an average value.
6 **(a)** use of $P = F\,v$ gives $1.8 \times 10^4 = F \times 10$ and F = 1800 N	1	You are asked to show that this value is 1800 N, and so only one mark is available.
(b) **(i)** $250 + F_R = 1800$ gives $F_R = 1550$ N	1	You know from **a** that the total resistive force is 1800 N when the speed is 10 m s^{-1}.
(ii) new air resistance force $= 4 \times F_R$ $= 6200$ N	1	The force due to air resistance is proportional to (speed)^2, and the speed has doubled.
(iii) total resistive force $= 6200 + 250 = 6450$ N use of $P = F\,v$ gives $P = 6450 \times 20$ $= 1.3 \times 10^5$ W	1 1	You are told that the frictional force of 250 N is constant. Comparing the values of power in **(a)** and **(b)(ii)**, it is clear that this car requires its power to be increased by more than 7 times when the speed is doubled in this way.
7 **(a)** **(i)** *Relevant points include*: • (gravitational) potential energy is lost (ΔE_P) • **some** of this becomes kinetic energy of ball bearing (ΔE_K) • some is converted into thermal energy (Q) • work is done against frictional forces • $\Delta E_P = \Delta E_K + Q$	3	Because frictional forces are present, some energy has to be used to overcome them. Therefore only a part of the potential energy lost is passed to the ball bearing as kinetic energy. Because we are used to objects that fall in circumstances where friction is negligible, we are usually able to write 'ΔE_P lost = ΔE_K gained' – but it does not apply here. Overall, energy must be conserved however.
(ii) *Relevant points include*: • kinetic energy of ball bearing is constant • because its speed is constant • potential energy lost (ΔE_P) is converted into thermal energy (or work done against frictional forces) (Q) • $\Delta E_P = Q$	3	Once the ball bearing reaches terminal velocity its kinetic energy does not change. Yet it still loses potential energy as it falls. In this case **all** of the lost potential energy is converted into thermal energy in overcoming the frictional forces.

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(b) potential energy gained by object $= m\,g\,\Delta h = 470 \times 9.81 \times 0.58 = 2670$ J	**1**	This calculation has not been put into a structured format. Hence your first task is to think through the steps you will need to take to arrive at the efficiency. The final answer would normally be quoted as a percentage. For any system, the efficiency can be found from $\left(\dfrac{\text{useful output energy (or power)}}{\text{input energy (or power)}}\right)$.
work done per stroke of handle $= F\,s = 150 \times 0.42 = 63$ J	**1**	
total work done $= 52 \times 63 = 3280$ J	**1**	
efficiency $= \dfrac{\Delta E_P \text{ gained}}{\text{work done}} = \dfrac{2670}{3280}$	**1**	
$= 0.814$ (or 81.4%)	**1**	