Name: ____

Work and Energy

Mark Scheme

Date:

Time:

Total marks available:

Total marks achieved: ______

Mark Scheme

Q1.

Question Number	Answer	Mark
	A	1

Q2.

Question Number	Acceptable answers	Additional guidance	Mark
	C	*mgh*	**1**
	A uses the distance AB rather than height B uses a component of height D uses a component of height		

Q3.

Question Number	Answer	Mark
	A	1

Q4.

Question Number	Answer	Mark
	C	1

Q5.

Question Number	Answer	Mark
	C	1

Q6.

Question Number	Answer	Mark
	B	1

Q7.

Question Number	Answer	Mark
	A	1

Q8.

Question Number	Acceptable Answers	Reject	Mark
	C		**1**

Q9.

Question Number	Answer	Mark
	C	1

Q10.

Question Number	Acceptable Answer		Additional Guidance	Mark
	• Use of $P = VI$ **Or** use of $\Delta E_{grav} = mg\Delta h$	(1)	Accept use of efficiency $= \frac{\text{useful energy output}}{\text{total energy input}}$ with corresponding times	
	• Use of efficiency = $\frac{\text{useful power output}}{\text{total power input}}$	(1)	<u>Example of calculation</u>	
	• Efficiency = 0.75 to 0.78 (or 75 % to 78%)	(1)	$P_{motor} = (85 \times 10^{-3})$ A × 3.0 V = 0.255 W $P_{block} = 0.05$ kg × 9.81 N kg^{-1} × 0.40 m s^{-1} = 0.196 W Efficiency = $\frac{0.196\text{ W}}{0.255\text{ W}}$ = 0.77 (no unit)	3

Q11.

Question Number	Acceptable Answer	Additional Guidance	Mark
	• As the speed increases, drag increases (1) • There is greater fuel consumption to maintain a higher constant speed **Or** the fuel economy reduces at higher speeds to maintain a constant speed (1) • Statement linking fuel economy to engine efficiency (1)	MP1: accept 'air resistance' for 'drag' MP3 e.g. The efficiency of the engine may increase (with speed) but the fuel economy decreases **Or** you can't compare efficiency which is a ratio with fuel consumption/economy which is a volume	3

Q12.

Question Number	Acceptable answers	Additional guidance	Mark
	• Work done (by cyclist) results in a <u>transfer</u> of energy (1) • initially there is an increase in E_k of (cyclist and bicycle) **Or** work done is transferred/converted to other forms of energy (1) • when the velocity of the cyclist is constant, all the energy is being transferred to other forms (1)		3

Q13.

Question Number	Acceptable Answer		Additional Guidance	Mark
	• Use of $W = QV$ • Use of $KE = \frac{1}{2}mv^2$ • Use of $1u = 1.66 \times 10^{-27}$ kg • $v = 2.16 \times 10^5$ (m s^{-1})	(1) (1) (1) (1)	Example of calculation: $\frac{1}{2}mv^2 = eV$ $\therefore v = \sqrt{\frac{2 \times 1.6 \times 10^{-19}\text{C} \times 8.5 \times 10^3\text{V}}{(34.97 \times 1.66 \times 10^{-27})\text{kg}}} = 2.16 \times 10^5\,\text{m s}^{-1}$	4

Q14.

Question Number	Answer		Mark
(a)	Force × distance moved in the direction of the (applied) force (An equation with defined terms and the direction stated of the distance can score this mark)	(1)	1

Question Number	Answer		Mark
(b)	Use of KE = ½mv^2 (with any velocity in m s^{-1}) Use of Work done = Fd (with any energy) d = 85 m **Or** Use of $F = ma$ to find the acceleration Use of suitable equation(s) of motion to find the braking distance d = 85 m Example of calculation KE_{before} = ½ × 1.5 × 10^3 kg × (24.6 m s^{-1})^2 = 4.54 × 10^5 J KE_{after} = ½ × 1.5 × 10^3 kg × (13.4 m s^{-1})^2 = 1.35 × 10^5 J Transfer of KE = 4.54 × 10^5 J − 1.35 × 10^5 J = 3.19 × 10^5 J 3.19 × 10^5 J = 3750 N × d d = 85.1 m	(1) (1) (1) (1) (1) (1)	3

Q15.

Question Number	Answer		Mark
(a)	The balloon has the maximum/greatest speed/velocity **Or** the greatest distance is covered in the shortest/same time	(1)	1

Question Number	Answer		Mark
(b)	Use of $\Delta E_{grav} = mg\Delta h$ (with a Δh and not just h)	(1)	
	Use of average rate of energy transfer = $\frac{\text{energy}}{0.15\text{ s}}$ (do not penalise power of ten errors for MP2)	(1)	
	Average rate of energy transfer = 0.18 – 0.19(W)	(1)	3
	<u>Example of calculation</u> $\Delta E_{grav} = 0.004\text{ kg} \times 9.81\text{ N kg}^{-1} \times (1.8\text{ m} - 1.1\text{ m}) = 0.027\text{ J}$ Average rate of energy transfer = $\frac{0.027\text{ J}}{0.15\text{ s}} = 0.18\text{ W}$		

Q16.

Question Number	Acceptable Answers	Mark
(a)(i)	Energy = power × time **Or** power = $\frac{\text{energy}}{\text{time}}$ **Or** see 4.2 × 0.4 **(1)** Energy = 1.7 (J) **(1)** Example of calculation Energy = 4.2 W × 0.4 s Energy = 1.68 (J)	2

Question Number	Acceptable Answers	Mark
(a)(ii)	Use of $E_k = \frac{1}{2} mv^2$ **(1)** v = 5.9 / 6.0 ms^{-1} (ecf) **(1)** Example of calculation $v = \sqrt{\frac{2 \times 1.68\ \text{J}}{0.095\ \text{kg}}}$ $v = 5.9\ \text{m s}^{-1}$	2

Question Number	Acceptable Answers	Mark
(a)(iii)	Energy is dissipated to heat **Or** work is done against friction **Or** not all the energy becomes kinetic energy **Or** air resistance on car **Or** friction between car/wheels/pin and track **Or** resistance in motor **(1)**	1

Question Number	Acceptable Answers	Mark
(b)	No resultant force is acting on the car **(1)** (do not credit use of external force) (Car) continues moving: in a straight line **Or** in same direction **Or** with same velocity. **(1)**	2
	Total for question	7

Q17.

Question Number		Mark
(a) (i)	Use of equation of motion suitable for a, e.g. $v = u + at$ (1) $a = 16.3\ \text{m s}^{-2}$ $(2.1 \times 10^5\ \text{km h}^{-2}$ or $58.7\ \text{km h}^{-1}\ \text{s}^{-1})$ (1) Example of calculation $a = \frac{37.5\ \text{m s}^{-1} - 0}{2.3\ \text{s}}$ $a = 16.3\ \text{m s}^{-2}$	2
(a) (ii)	Use of $E_k = ½ mv^2$ (1) Use of $P = E/t$ (1) Power = 3.1×10^6 W (1) **Or** Use of $F = ma$ (must be a from (i)) **and** Use of equation to find distance **and** use of work done = Fd (1) Use of $P = E/t$ (1) Power = 3.1×10^6 W (1) (distance = 43 m) Examples of calculations $E_k = ½ \times 10\ 000\ \text{kg} \times (37.5\ \text{m s}^{-1})^2 = 7.03 \times 10^6\ \text{J}$ Power = $7.03 \times 10^6\ \text{J} / 2.3\ \text{s} = 3.1 \times 10^6$ W	3
(a) (iii)	Energy transferred by heating **Or** energy transferred due to friction **Or** work done against friction **Or** idea that more energy required (due to energy transfer) due to friction. (1) (do not accept 'lost' but accept air resistance as an alternative to friction)	1
*(b)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) larger force is needed **Or** the (same) force is insufficient (1) need same acceleration/ (max) velocity **OR** acceleration/(max) velocity is too small (1) more energy needed (to reach top) **Or** insufficient energy (to reach top) (1)	3
(c)	Viscosity of oil decreases (with increasing temperature) **Or** the (warm) oil is less viscous (1) (accept a reverse argument e.g. when cold oil is more viscous) Lower frictional/resistive force **Or** less viscous drag (1)	2
	Total for question	**11**

Q18.

Question Number	Answer		Mark
(a)(i)	Convex curve drawn from the box to the drop zone	(1)	**1**
(a)(ii)	Use of $s = ut + ½ at^2$ t = 3.6 (s) <u>Example of calculation</u> 63 m = 0 + (½ × 9.81 m s^{-2} × t^2) t = 3.6 s	(1) (1)	**2**
(a)(iii)	Use of speed = $\frac{\text{distance}}{\text{time}}$ Distance = 270 m (ecf) [300 m using the show that value] <u>Example of calculation</u> 75 m s^{-1}= $\frac{\text{distance}}{3.6\ \text{s}}$ Distance = 270 m	(1) (1)	**2**
(b)(i)	Use of GPE = mgh GPE = 6.2 (kJ) (A unit is required for an answer in J to score MP2) <u>Example of calculation</u> GPE = 10.0 kg × 9.81 N kg^{-1} × 63 m GPE = 6180 J	(1) (1)	**2**
(b)(ii)	Use of KE = ½ mv^2 KE = 28.1 (kJ) (A unit is required for an answer in J to score MP2) <u>Example of calculation</u> KE = ½ × 10.0 kg × (75 m $s^{-1})^2$ KE = 28 125 J	(1) (1)	**2**
(b)(iii)	KE at bottom = 34.3 kJ (ecf) <u>Example of calculation</u> KE at bottom = 6180 J + 28 125 J = 34 305 J	(1)	**1**
(b)(iv)	Work is done against air resistance **Or** energy transferred due to air resistance	(1)	**1**
(c)	Reduces the acceleration of the package **Or** reduces the speed on impact of the package **Or** has a lower terminal velocity **Or** less (resultant) force on the package	(1)	**1**
	Total for question		**12**

Q19.

Question Number	Answer		Mark
(a)	Same (downwards) acceleration **Or** acceleration = g (accept constant acceleration)	(1)	1
(b)(i)	The ball is in contact with the floor (accept the ball bounces)	(1)	1
(b) (ii)	Lower gradient **Or** the lines would be not be as steep	(1)	1
(c)	Use of equation(s) of motion to find s **Or** use of distance = area under the graph **Or** use of GPE = KE s = 1.1 m – 1.4 m <u>Example of calculation</u> $(4.7 \text{ m s}^{-1})^2 = (0 \text{ m s}^{-1})^2 + (2 \times 9.81 \text{ m s}^{-2} \times s)$ s = 1.13 m	(1) (1)	2
(d)(i)	Use of KE = ½ mv^2 KE = 1.1 – 1.3 (J) (no ue) <u>Example of calculation</u> KE = ½ × 0.40 kg × $(2.4 \text{ m s}^{-1})^2$ = 1.15 J	(1) (1)	2
(d)(ii)	Use of GPE = KE h = 0.27 m – 0.32 m (ecf from 16(d)(i)) (If area under graph or an equation of motion is used e.g. $h = \frac{(u+v)t}{2}$ or $v^2 = u^2 + 2as$ only MP2 can be scored) <u>Example of calculation</u> $h = \frac{1.2 \text{ J}}{0.4 \text{ kg} \times 9.81 \text{ Nkg}^{-1}}$ h= 0.31 m	(1) (1)	2
(e)	(Elastic potential) energy transferred to thermal energy **Or** energy dissipated as heat	(1)	1
	Total for question		**10**