Name: _____

Work and Energy

Questions

Date:

Time:

Total marks available:

Total marks achieved: _____

Questions

Q1.

An object of weight 7 N is raised from a height of 2 m to a height of 8 m.

The change in gravitational potential energy is

☒ **A** 42 J

☒ **B** 56 J

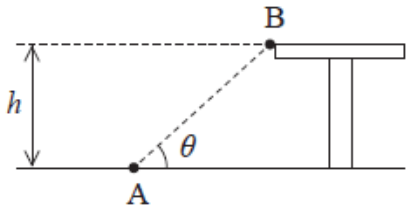
☒ **C** 412 J

☒ **D** 549 J

(Total for question = 1 marks)

Q2.

An object of mass *m* is moved from point A on the ground, to point B on a bench of height *h* as shown in the diagram.



Which of the following is a correct expression for the work done on the object?

(1)

☒ **A** $\frac{mgh}{\sin\theta}$

☒ **B** $\frac{mgh}{\cos\theta}$

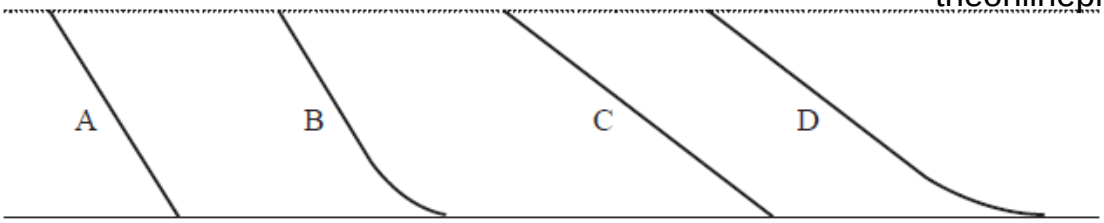
☒ **C** mgh

☒ **D** $mgh\sin\theta$

(Total for question = 1 mark)

Q3.

A child slides down four frictionless slides A, B, C and D.



The speed of the child at the bottom of slides A, B, C and D is given by v_A, v_B, v_C and v_D respectively.

Choose the correct statement.

☒ **A** $v_A = v_B = v_C = v_D$

☒ **B** $v_A > v_B$ and $v_C > v_D$

☒ **C** $v_A > v_B > v_C = v_D$

☒ **D** $v_A > v_C$ and $v_B > v_D$

(Total for question = 1 mark)

Q4.

A car of mass m travelling with a velocity v comes to rest over a distance d in time t.

The constant frictional force acting on the car while it is braking is found using

☒ **A** $\frac{mv}{2t}$

☒ **B** $\frac{2mv}{t}$

☒ **C** $\frac{mv^2}{2d}$

☒ **D** $\frac{2mv^2}{d}$

(Total for question = 1 mark)

Q5.

A car of mass 1400 kg is travelling at 25 m s^{-1}.

The kinetic energy of the car is

☒ **A** 17.5 kJ

☒ **B** 35.0 kJ

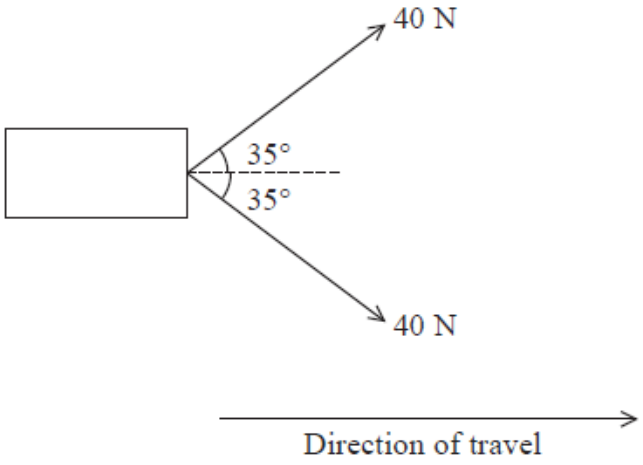
☒ **C** 438 kJ

☒ **D** 875 kJ

(Total for question = 1 marks)

Q6.

Two ropes are attached to a box. Each rope is pulled with a force of 40 N at an angle of 35° to the direction of travel.



The box is moved 20m in the direction shown.

The work done, in joules, is found using

☒ **A** 40 × cos35 × 20

☒ **B** 2 × 40 × cos35 × 20

☒ **C** 40 × sin35 × 20

☒ **D** 2 × 40 × sin35 × 20

(Total for question = 1 mark)

Q7.

An electron gun uses a potential difference *V* to accelerate electrons of mass *m* and charge *e*

from rest to a speed v.
The potential difference V can be expressed as

☒ **A** $\frac{mv^2}{2e}$

☒ **B** $\frac{2ev^2}{m}$

☒ **C** $\sqrt{\frac{2ev}{m}}$

☒ **D** $\sqrt{\frac{mv}{2e}}$

(Total for question = 1 mark)

Q8. Which of these statements about work is **not** correct?

☒ **A** For work to be done a force must always be applied.

☒ **B** When work is done energy is transferred.

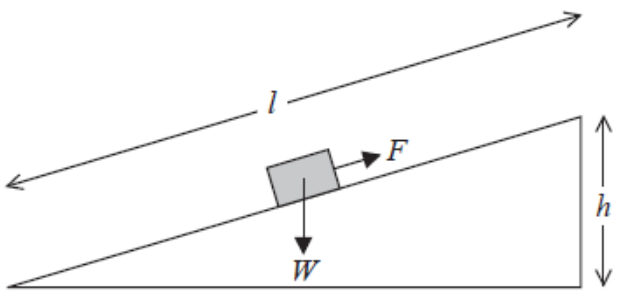
☒ **C** Work done is the product of force and distance moved perpendicular to the force.

☒ **D** Work done is a scalar quantity.

(Total for Question = 1 mark)

Q9.

A student uses a force F to push a block of weight W all the way up a frictionless ramp, at a constant speed.



The work done by the student can be calculated using

☒ **A** Fh

☒ **B** $(F-W)\ l$

☒ **C** Wh

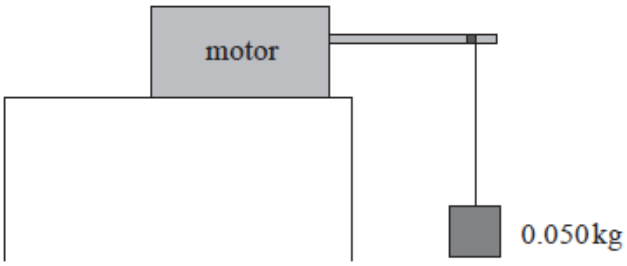
☒ **D** Wl

(Total for question = 1 mark)

Q10.

A motor lifts a block of mass 0.050kg at a constant velocity of 0.40 m s^{-1}.

The current in the motor is 85mA and the potential difference across it is 3.0V.



Calculate the efficiency of the motor.

(3)

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Efficiency of the motor = ...

(Total for question = 3 marks)

Q11.

One region of Australia decided to trial the removal of the speed limit on some roads.

The following statements were made in an online forum discussing this issue.

> Comment
>
> *"If a car was going faster, it would have better fuel economy. A lot of modern cars have engines that are more efficent at 200 km h^{-1} than at 100 km h^{-1}."*
>
> Reply
>
> *"You confuse efficiency with fuel consumption. You cannot get better fuel economy at higher speeds."*

Justify the statement in the reply.

(3)

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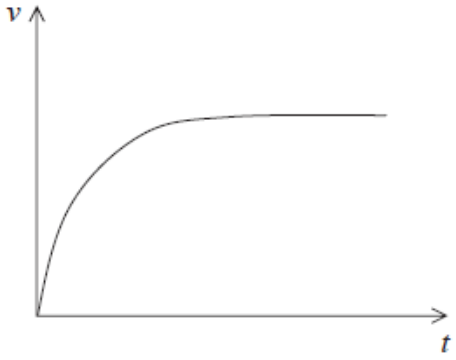
(Total for question = 3 marks)

Q12.

A sports class is studying cycling. They produce a video of a cyclist on a horizontal lawn.
The cyclist starts from rest.
They produce a sketch graph of the velocity *v* of the cyclist against time *t*.



A student makes the following statement.

The work done by the cyclist is converted into the kinetic energy of the cyclist and bicycle.

Criticise this statement.

(3)

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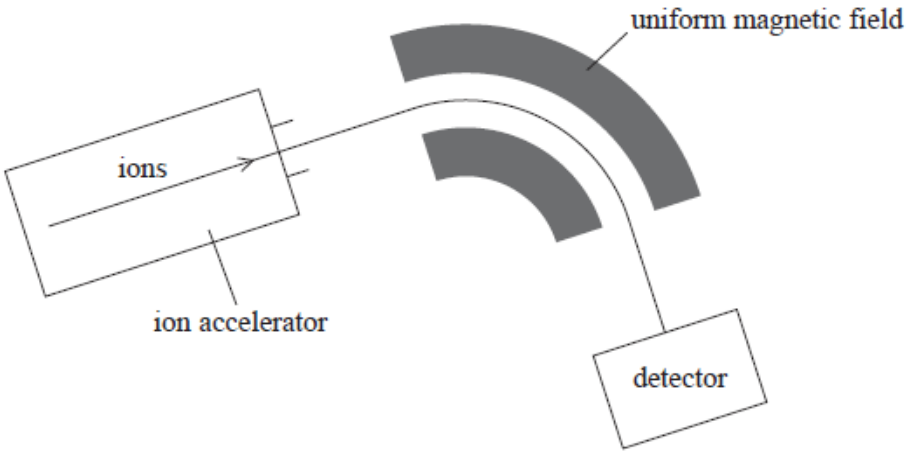
(Total for question = 3 marks)

Q13.

Mass spectrometry is a technique used to separate ions based on their charge to mass ratio.

The atoms in a sample are ionised and then accelerated and formed into a fine beam.
This beam is passed into a region of uniform magnetic field and the ions are deflected by different amounts according to their mass.



Analysis of mass spectrometer data shows that chlorine exists in nature as two isotopes, chlorine-35 and chlorine-37.

In a mass spectrometer, chlorine-35 ions are accelerated through a potential difference of 8.50 kV to produce an ion beam.

Show that the speed of singly ionised chlorine-35 atoms is about 2.2×10^5 m s^{-1}.

mass of an ion of chlorine-35 = 34.97 u

(4)

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(Total for question = 4 marks)

Q14.

(a) State what is meant by work done.

(1)

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(b) A car of mass 1.5×10^3 kg is travelling on a country road towards a village at 55 miles per hour. The speed limit in the village is 30 miles per hour.

When the brakes are applied, there is a constant braking force of 3750 N.

Calculate the minimum distance before reaching the village that the driver should apply the brakes to avoid exceeding the speed limit.

55 miles per hour = 24.6 m s^{-1}

30 miles per hour = 13.4 m s^{-1}

(3)

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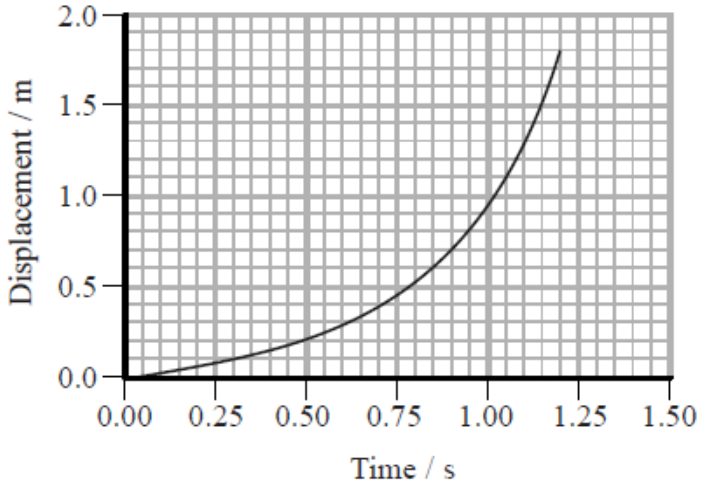
Minimum distance = ...

(Total for question = 4 marks)

Q15.

A small, gas-filled balloon was dropped from a height. The displacement-time graph for the balloon is shown.



As the displacement of the balloon from its point of release increased, gravitational potential energy was transferred to kinetic energy and thermal energy.

(a) State why the rate of energy transfer was greatest at 1.20 s.

(1)

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.....

(b) By calculating the change in gravitational potential energy of the balloon between 1.05 s and 1.20 s, show that the average rate at which the gravitational potential energy was transferred during this time interval was about 0.2 W.

mass of balloon and air = 0.004 kg

(3)

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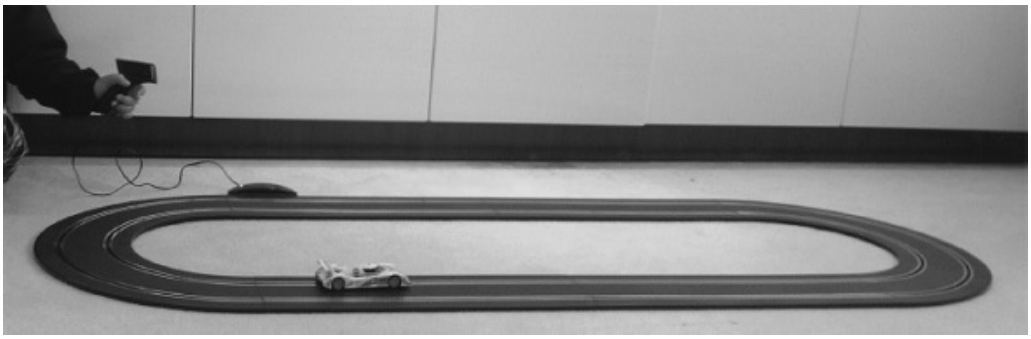
(Total for question = 4 marks)

Q16. The picture shows a track for racing toy electric cars. A guide pin fits in a groove in the track to keep the car on the track. A small electric motor in the car is controlled, with a hand-controller, via contacts in the track.



A child places a car of mass 95 g on the track. She adjusts the controller to a power of 4.2 W so the car accelerates from rest for 0.40 s.

(a) (i) Show that the energy transferred by the motor in 0.40 s is about 2 J.

(2)

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(ii) Calculate the speed of the car at 0.40 s.

(2)

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Speed = ...

(iii) Suggest why the actual speed of the car is less than the calculated speed.

(1)

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(b) At high speed the guide pin may become disengaged from the groove.

Use Newton's first law to explain why the car would then leave the track at a corner.

(2)

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(Total for Question = 7 marks)

Q17. The 'Stealth' roller coaster at the Thorpe Park theme park is advertised as reaching 135 km hour^{-1} from rest in 2.3 seconds.

Most roller coasters are driven slowly up to the top of a slope at the start of the ride. However the carriages on 'Stealth' are initially accelerated horizontally from rest at ground level by a hydraulic launch system, before rising to the top of the first slope.

(a) (i) Calculate the average acceleration of the carriages.

135 km hour^{-1} = 37.5 m s^{-1}

(2)

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Average acceleration = ...

(ii) Calculate the minimum average power which must be developed by the launch system.

mass of carriages and passengers = 10 000 kg

(3)

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Minimum average power = ...

(iii) Suggest why the power in (ii) is a minimum value.

(1)

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*(b) The force required to launch 'Stealth' is not always the same. The ride is monitored and the data from preceding launches is used to calculate the required force.

If the mass of the passengers for a particular ride is significantly more than for preceding launches, this can lead to 'rollback'. This is when the carriages do not quite reach the top of the first slope and return backwards to the start.

Explain why 'rollback' would occur in this situation.

(3)

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(c) Suggest why roller coasters may have a greater acceleration when the lubricating oil between the moving parts has had time to warm up.

(2)

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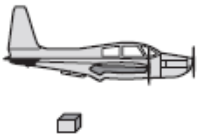
(Total for Question = 11 marks)

Q18.

In areas of the world where a plane is unable to land, free fall aerobatics can be used to deliver

supplies.



Drop zone

A plane travelling at a speed of 75 m s^{-1} and at a height of 63 m releases a package of supplies.

(a) (i) Draw the path of the falling package on the diagram above.

(1)

(ii) Show that the time taken for the supplies to reach the ground is about 4 s.

(2)

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(iii) Calculate the horizontal distance of the plane from the drop zone when releasing the package.

(2)

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Horizontal distance = ...

(b) (i) Show that the change in gravitational potential energy of the package during the fall is about 6 kJ.

mass of package = 10 kg

(2)

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(ii) Show that the kinetic energy of the package on release is about 28 kJ.

(2)

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.....

(iii) Determine the kinetic energy of the package on impact.

(1)

.....

Kinetic energy = ...

(iv) State why in practice the actual value for the kinetic energy on impact with the ground is less than the value you calculated in part (b)(iii).

(1)

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.....

(c) Most airdrops are not free fall and use parachutes.

State why using parachutes causes less damage to the package.

(1)

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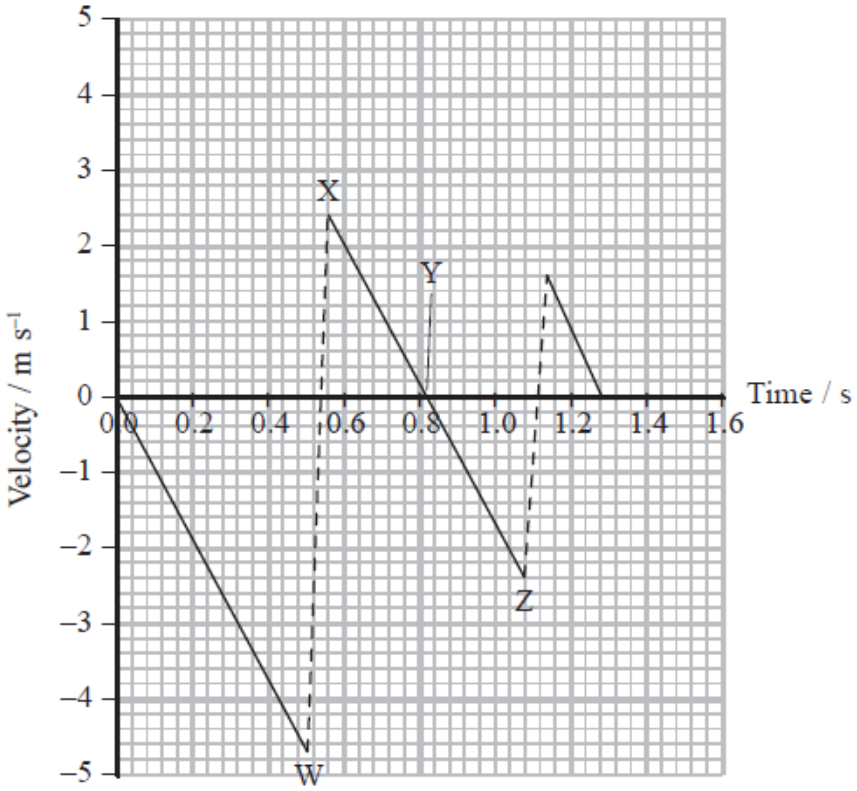
(Total for question = 12 marks)

Q19.

A basketball is dropped vertically onto the horizontal ground and bounces twice before being caught. The graph shows how the velocity of the basketball varies with time.



(a) Suggest why the downward sloping lines are all parallel.

(1)

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.....

(b) (i) State the reason for the upwardly sloping dotted lines.

(1)

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.....

(ii) Describe how the gradient of the dotted lines would change if the basketball was not fully inflated.

(1)

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.....

(c) Calculate the initial height through which the basketball fell.

(2)

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Height = ...

(d) (i) Show that the kinetic energy of the basketball at X is about 1 J.

mass of ball = 0.4 kg

(2)

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(ii) Hence calculate the height of the basketball at Y.

(2)

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Height = ...

(e) The velocity of the basketball on impact at W is greater than the velocity on impact at Z.

State a reason for the difference in velocities at W and Z.

(1)

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(Total for question = 10 marks)

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 $\triangle E_{grav} = mg\triangle h$ (1) • Use of efficiency = $\frac{\text{useful power output}}{\text{total power input}}$ (1) • Efficiency = 0.75 to 0.78 (or 75 % to 78%) (1)	Accept use of efficiency $= \frac{\text{useful energy output}}{\text{total energy input}}$ with corresponding times Example of calculation $P_{motor} = (85 \times 10^{-3})\ A \times 3.0\ V = 0.255\ W$ $P_{block} = 0.05\ kg \times 9.81\ N\ kg^{-1} \times 0.40\ m\ s^{-1} = 0.196\ W$ Efficiency = $\frac{0.196\ W}{0.255\ W} = 0.77$ (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 transfer 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 $W = QV$	(1)	Example of calculation: $\frac{1}{2}mv^2 = eV$ $\therefore v = \sqrt{\frac{2\times1.6\times10^{-19}\text{C}\times8.5\times10^{3}\text{V}}{(34.97\times1.66\times10^{-27})\text{kg}}} = 2.16\times10^{5}\,\text{ms}^{-1}$	
	• Use of $KE = \frac{1}{2}mv^2$	(1)		
	• Use of $1\text{u} = 1.66\times10^{-27}$ kg	(1)		
	• $v = 2.16\times10^{5}$ (m s^{-1})	(1)		4

Q14.

Question Number	Answer		Mark
(a)	Force × distance moved in the <u>direction</u> 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})	(1)	
	Use of Work done = Fd (with any energy)	(1)	
	d = 85 m	(1)	
	Or		
	Use of $F = ma$ to find the acceleration	(1)	
	Use of suitable equation(s) of motion to find the braking distance	(1)	
	d = 85 m	(1)	3
	<u>Example of calculation</u> $KE_{before} = ½ \times 1.5\times10^{3}\text{ kg} \times (24.6\text{ m s}^{-1})^2 = 4.54\times10^{5}$ J $KE_{after} = ½ \times 1.5\times10^{3}\text{ kg} \times (13.4\text{ m s}^{-1})^2 = 1.35\times10^{5}$ 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		

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 $= \frac{\text{energy}}{0.15\ s}$ (do not penalise power of ten errors for MP2)	(1)	
	Average rate of energy transfer = 0.18 – 0.19(W)	(1)	3
	Example of calculation $\Delta E_{grav} = 0.004\ \text{kg} \times 9.81\ \text{N kg}^{-1} \times (1.8\ \text{m} - 1.1\ \text{m}) = 0.027\ \text{J}$ Average rate of energy transfer $= \frac{0.027\ \text{J}}{0.15\ s} = 0.18\ \text{W}$		

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 $E_k = ½ mv^2$ **(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 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 resistant 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 m s^{-2} (2.1 ×10^5 km h^{-2} or 58.7 km h^{-1} s^{-1})	(1)	**2**
	Example of calculation $a = \frac{37.5 \text{ m s}^{-1} - 0}{2.3 \text{ s}}$ a = 16.3 m s^{-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 (distance = 43 m)	(1)	**3**
	Examples of calculations E_k = ½ × 10 000 kg × (37.5 m s^{-1})^2 = 7.03 ×10^6 J Power = 7.03 × 10^6 J / 2.3 s = 3.1 × 10^6 W		
(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)	**1**
	(do not accept 'lost' but accept air resistance as an alternative to friction)		
***(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 (accept a reverse argument e.g. when cold oil is more viscous)	(1)	
	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 $s = ut + \frac{1}{2} at^2$ t = 3.6 (s) Example of calculation 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] Example of calculation 75 m s^{-1} = $\frac{\text{distance}}{3.6\ s}$ 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) Example of calculation 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) Example of calculation 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) Example of calculation 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 Example of calculation $(4.7\ \text{m s}^{-1})^2 = (0\ \text{m s}^{-1})^2 + (2 \times 9.81\ \text{m s}^{-2} \times s)$ s = 1.13 m	(1) (1)	2
(d)(i)	Use of KE = ½ mv^2 KE = 1.1 – 1.3 (J) (no ue) Example of calculation 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) Example of calculation $h = \frac{1.2\ \text{J}}{0.4\ \text{kg} \times 9.81\ \text{Nkg}^{-1}}$ 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