Name: _______________________________________________

CS P1 H Conservation of energy

Date:

Time: 28 minutes

Total marks available: 28

Total marks achieved: ______
Questions

Q1.

Figure 8 shows two ice skaters during a performance.

Figure 8

(i) The two ice skaters are travelling together in a straight line at 3.50 m/s.
    Their total momentum is 371 kgm/s.
    The man has a mass of 64.5 kg.
    Calculate the mass of the woman.

    mass = ........................................................... kg

(ii) Calculate the kinetic energy of the man.

    kinetic energy = ............................................. J

(Total for question = 6 marks)

Q2.

Shot-put is an Olympic event.
The shot is a heavy ball. An athlete throws the shot as far as possible.

A sports scientist analyses an athlete's throw to help improve performance.

(a) The scientist takes pictures of the athlete every 0.1 s during one throw. Figure 3 shows the pictures of one throw.

![Figure 3: Pictures of a shot put throw showing the athlete's hand and shot in different positions.](image)

(i) Estimate the amount of time during the throw when the shot is in the athlete's hand.

\[
\text{time} = \quad \text{s}
\]

(ii) Explain how the scientist could improve this method of analysing the throw.

.................................................................................................................................................
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(iii) The average acceleration of the shot while in the athlete's hand is 20.6 m/s². The mass of the shot is 7.26 kg. Calculate the average force that the athlete applies to the shot during the throw.

\[
\text{force} = \quad \text{N}
\]

(iv) In another throw, the shot is in the athlete’s hand for 0.48 s.
The average acceleration during this time is 23 m/s².
Calculate the velocity of the shot as it leaves the athlete's hand.

velocity = ........................................................... m/s

(b) In one throw, the shot continues to rise by another 1.3 m after it leaves the athlete's hand.
The mass of the shot is 7.26 kg.
Calculate the amount of gravitational potential energy gained by the shot.

gravitational potential energy gained = .......................................................... J

(Total for question = 10 marks)

Q3.
The photograph shows a man dropping an egg inside a padded box from a height.

He is investigating to see if the padding stops the egg from breaking.
(a) State the type of energy which the egg gains as it falls.
.............................................................................................................................

(b) The weight of the egg is 0.6 N.
Calculate the work done on the egg to lift it up by 20 m. State the unit.

(c) The velocity of the container was 18 m/s as it hit the floor.
The mass of the container was 0.5 kg.
Calculate the momentum of the container.

*(d) A student stands on the ground with an egg in his hand.
He throws the egg vertically upwards.
The egg rises to a height of 10 m.
Then the egg falls and lands on the ground.
Describe the energy changes of the egg during this sequence of events.

(Total for Question = 12 marks)

Q1.
No Examiner’s Report available for this question

Q2.
No Examiner’s Report available for this question

Q3.

a

Only a minority of candidates knew that kinetic energy was being gained as the egg fell. Most gave the
answer 'gravitational potential energy'.

\[ 0.6 \times 20 = 12 \]

work done on egg = 12 unit Joules

Results Plus: Examiner Comments
This is a well laid out response with the correct value and an acceptable unit. It should be spelt with a lower case j.

Most candidates carried out the calculation correctly but many then gave an incorrect unit.

\[ 18 \times 0.5 = 4 \]

momentum = 4 kg m/s

Results Plus: Examiner Comments
One mark was given for the substitution (18 \times 0.5).

Most candidates gave the correct answer of 9 (kg m/s). As usual, credit could be given for a correct substitution into the equation even if the evaluation was wrong.

Examiners were looking for a description of energy changes. This could have included kinetic to gravitational potential as the egg rose, or vice-versa as the egg fell. Credit would also have been given for describing other changes such as kinetic to sound when the egg hit the floor. A statement about conservation of energy would also have been accepted. There seems to be much confusion about energy among candidates entered for this paper. Energy was often used as another word for force and/or momentum. A large number of candidates wrote entirely about forces without mentioning energy at all. They could not score any marks for this question. Many candidates could mention kinetic energy and gravitational energy but it was not clear that they appreciated that there was a gradual conversion between the two. There was a widespread view that the change occurred suddenly when the egg was at the top of the trajectory.

Many candidates could give a simple description of energy change from one type into another.

Results Plus: Examiner Comments
The candidate has written that kinetic energy changes into thermal energy. This is a level 1 response. There is some confusion about momentum. It seems to imply that
momentum is a type of energy (which is wrong). There is not sufficient detail to bring it to level 2. This scored 2 marks.

The egg gains upthrust, and air resistance when it is thrown into the air. The egg throughout the sequence uses kinetic energy, when the egg reaches the ground and begins to fall it gains gravitational potential energy. When the egg hits the ground the energy is lost from the egg and only given to the surroundings as energy can only be transferred and not destroyed.

Results Plus: Examiner Comments
This response starts with a description of forces which is not relevant here. However, it does go on to describe a change from kinetic energy (KE) to gravitational potential energy (GPE) even though it implies that the GPE increases as it falls. The final sentence is an acceptable description of conservation of energy and was enough to lift this to a level two and score 4 marks.
When the egg is in the student's hand, the egg has gravitational potential energy. When the student raises it up, it will accelerate and will have more kinetic energy and as it gets higher its kinetic energy starts to change to gravitational potential energy because its acceleration and velocity are decreasing and when it reaches its highest point all the energy will be gravitational potential and as it falls its velocity and acceleration will increase and this will be kinetic energy and when it hits the floor all the kinetic energy will turn to sound and heat energy.

Results Plus: Examiner Comments
This is a very clear description of energy changes which scored 6 marks.

Mark Scheme
Q1.

<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
<th>Additional guidance</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>substitution 371 = (64.5 + m) x 3.5</td>
<td></td>
<td>(4)</td>
</tr>
<tr>
<td></td>
<td>rearrangement m+64.5 = 371 / 3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>evaluation of total mass m+64.5 = 106 (kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>evaluation of woman’s mass m = 106-64.5 = 41.5  (kg)</td>
<td>full marks will be awarded for correct numerical answer without working</td>
<td></td>
</tr>
</tbody>
</table>
Q2.

<table>
<thead>
<tr>
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</tr>
</thead>
</table>
| (ii)            | substitution (1)  
KE = \( \frac{1}{2} \times 64.5 \times 3.5^2 \)  
evaluation (1)  
395 (1) | allow answers which round to 395 e.g. 395.0625  
full marks will be awarded for correct numerical answer without working | (2) |

Q2.

<table>
<thead>
<tr>
<th>Question number</th>
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</tr>
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<tbody>
<tr>
<td>(a)(i)</td>
<td>0.45 (s) (1)</td>
<td>Allow any value ( \geq 0.4 ) and ( \leq 0.5 )</td>
<td>(1)</td>
</tr>
</tbody>
</table>

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</table>
| (a)(ii)         | An explanation that combines improvement of the experimental procedure (1 mark) and justification/reasoning which must be linked to the improvement (1 mark)  
- take pictures more frequently (1)  
in order to determine exact time of the release. (1) | other responses may be acceptable | (2) |

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</table>
| (a)(iii)        | Substitution (1)  
\( F = 7.26 \times 20.6 \)  
Evaluation (1)  
150 (N) | Accept 149.6 (N)  
full marks will be awarded for correct numerical answer without working | (2) |
### Q3.

<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
<th>Acceptable answers</th>
<th>Mark</th>
</tr>
</thead>
</table>
| (a)(iv)         | Rearrangement (1)  
                 v = a x t  
                 Substitution (1)  
                 v = 23 x 0.48  
                 Evaluation (1)  
                 11 m/s         | Accept 11.04(m/s)  
                 full marks will be awarded for correct numerical answer without working | (3)  |

<table>
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</table>
| (b)             | Substitution (1)  
                 PE = 7.26 x 10 x 1.3  
                 Evaluation (1)  
                 94.4 (J) |         | (2)  |

### Indicative Content

**QWC** *(d)*  
*a description including some of the following points:  
- chemical to kinetic while in his hand*  

---

Note: The table structure and content have been accurately transcribed. Any additional notes or instructions are also included where possible.
- kinetic (gradually) to potential while rising / from 0-10 m
- eventually all potential at 10 m with a little thermal (heat) energy
- some mention of conservation of energy
- potential (gradually) to kinetic as falls / 10 m-0
- with a little more thermal (heat) energy
- at 0 m sound energy
- at 0 m thermal (heat) energy

<table>
<thead>
<tr>
<th>Level</th>
<th>Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 - 2</td>
<td>a limited description which identifies a change in one relevant type energy or a transfer of energy from one form to another e.g. kinetic energy increases OR kinetic energy changes to sound. The answer communicates ideas using simple language and uses limited scientific terminology. Spelling, punctuation and grammar are used with limited accuracy.</td>
</tr>
<tr>
<td>2</td>
<td>3 - 4</td>
<td>a simple description giving detail of a relevant energy change/transfer e.g. kinetic energy changes into potential energy as it moves upwards OR kinetic energy increases as it falls. The answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately. Spelling, punctuation and grammar are used with some accuracy.</td>
</tr>
<tr>
<td>3</td>
<td>5 - 6</td>
<td>a detailed description of a sequence of relevant energy changes /transfers e.g. kinetic energy is transferred into potential energy as it rises. This then changes back into kinetic energy as it falls back down. The answer communicates ideas clearly and coherently uses a range of scientific terminology accurately. Spelling, punctuation and grammar are used with few errors.</td>
</tr>
</tbody>
</table>