Q1.

Figure 13 shows two ice skaters during a performance.

![Figure 13](image)

(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.

\[ \text{mass} = \text{......................... kg} \]

(ii) Calculate the kinetic energy of the man.

\[ \text{kinetic energy} = \text{................................. J} \]

(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.

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.

\[ \text{gravitational potential energy gained} = \] \[ \text{........................................................... J} \]

(Total for question = 2 marks)

Q3.

(a) Here are some forms of energy:

(i) Use words from the box to complete the table.

<table>
<thead>
<tr>
<th>device</th>
<th>energy transferred from...</th>
<th>energy is mostly transferred into...</th>
</tr>
</thead>
<tbody>
<tr>
<td>electric motor</td>
<td>electrical</td>
<td>kinetic</td>
</tr>
<tr>
<td>bow and arrow</td>
<td>elastic potential</td>
<td></td>
</tr>
<tr>
<td>electric kettle</td>
<td>electrical</td>
<td></td>
</tr>
<tr>
<td>microphone</td>
<td></td>
<td>electrical</td>
</tr>
</tbody>
</table>

(ii) In the electric motor only some of the electrical energy is transferred into kinetic energy.

State what happens to the remaining electrical energy.

...............................................................................................................................................

(b) Many appliances are sold with an energy efficiency rating. A-rated appliances are the most energy efficient.

Here is some information about two types of electric lamp.
(i) Calculate how much energy is wasted in one second by the compact fluorescent lamp (CFL).

(ii) Use the energy transfer diagrams to explain why the CFL lamp has a better efficiency rating than the halogen lamp.

(c) The photograph shows an electric heater used to warm garages.

When the heater is switched on, it quickly warms up and then stays at a constant temperature. Explain why the heater stays at a constant temperature.

(Total for Question is 9 marks)
Q4.

(a) A wind generator is used as the source of energy for a remote farmhouse.

(i) Complete the sentence by putting a cross (X) in the box next to your answer. If the farmhouse is about 7 m high, the height of the axle of the generator is

- A 20 m
- B 50 m
- C 100 m
- D 150 m

(ii) Complete the flow chart to show the energy transfers that take place from the wind to light a lamp.

(b) A student produced a diagram to show energy changes in a lamp.

(i) Calculate the amount of heat energy produced by the lamp.
heat energy =...........................................................J

(ii) Calculate the efficiency of the lamp.

(2)

efficiency =...........................................................

(iii) When the lamp is first switched on, it heats up.
It then reaches a constant temperature.
Explain why the temperature of the lamp remains constant.

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.............................................................................................................................................

(c) A wind power system costs £6000 to install.
It saves £250 each year.
Calculate the payback time.

(2)

payback time =...........................................................

(Total for Question = 10 marks)

Q5.

A student uses a solar powered battery charger to charge some batteries.

(a) The diagram is an energy transfer diagram for a battery being charged.
Use words from the box to complete the energy transfer diagram.
(b) The diagram shows how much energy is usefully transferred by the battery charger.

(i) Calculate the amount of wasted energy.

(ii) Calculate the efficiency of the battery charger.
(c) The following arrangement is used as a solar powered shower.

The bag is left out in the sunlight during the day.

(i) Explain what colour the bag should be to heat the water to the highest temperature.

(ii) On a sunny day the bag is filled with cold water. Explain why the temperature of the water increases and then stays constant.

(Total for Question = 10 marks)
Q6.

The International Space Station (ISS) has several solar panels called wings.

(a) The wings convert energy from the Sun into a form useful in the ISS.

☐ A transverse and electromagnetic
☐ B electromagnetic but not transverse
☐ C transverse but not electromagnetic
☐ D neither transverse nor electromagnetic

(b) In one second, the useful energy available from one wing is 34.3 kJ. The energy incident on the wing from the Sun is five times this amount. What is the percentage efficiency of the wing?

\[
\text{efficiency} = \text{...........................................................} \% 
\]

(c) A wing is in direct sunlight. The ISS is not receiving energy from the wing. The temperature of the wing remains constant. Explain why the temperature of the wing remains constant in these conditions.

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.............................................................................................................................................
.............................................................................................................................................
Q7.

(a) The diagram shows a girl swinging a rubber ball in a horizontal circle above her head.

(i) In which direction does the resultant force act on the ball? 
   Put a cross (☒) in the box next to your answer.
   A away from the centre of the circle  
   B in the direction of the arrow on the diagram  
   C in the opposite direction to the arrow on the diagram  
   D towards the centre of the circle

(ii) State the name of the resultant force acting on the ball.

.............................................................................................................................................

(iii) Suggest what would happen to the ball as the girl gets tired.

.............................................................................................................................................
.............................................................................................................................................
.............................................................................................................................................
.............................................................................................................................................

(iv) The girl lets go of the string and the ball hits a wall. 
    The collision is not elastic. 
    Explain what happens to both momentum and kinetic energy when the ball hits the wall.

.............................................................................................................................................
.............................................................................................................................................
.............................................................................................................................................
.............................................................................................................................................
*(b) Describe a cyclotron and how charged particles move inside it.
   You may draw a labelled diagram to help with your answer.

(Total for Question = 12 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>(i)</td>
<td>substitution $371 = (64.5 + m) \times 3.5$</td>
<td>full marks will be awarded for correct numerical answer without working</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 ($m = 106-64.5$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$m = 41.5$ (kg)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Q2.

<table>
<thead>
<tr>
<th>Question number</th>
<th>Answer</th>
<th>Additional guidance</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ii)</td>
<td>substitution $KE = \frac{1}{2} \times 64.5 \times 3.5^2$</td>
<td>allow answers which round to 395 e.g. 395.0625</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>evaluation $395$ (J)</td>
<td>full marks will be awarded for correct numerical answer without working</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Q3.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Acceptable answers</th>
<th>Mark</th>
</tr>
</thead>
</table>
| (ai) | (Bow and arrow:) kinetic (1)  
      (Electric kettle:) heat (thermal) (1)  
      (Microphone:) sound (1) | Heat/thermal | (3) |
|------|-----------------------------|-------------|-----|
| (a)(ii) | Any one from  
      (transferred into)  
      thermal/heat/sound/energy (1) (Energy)  
      is dissipated (1) | Do not accept light energy or it disappears goes into surroundings/air (energy) is wasted/lost | (1) |
| (b)(i) | 12 (J)  
      Ignore any unit given by candidate. | 20 - 8 (J) | (1) |
| (b)(ii) | An explanation linking any two of  
      • (For the) same amount of electrical/supplied (energy/power) (1)  
      • (CFL/it) has a greater output (of light energy) (1)  
      • (CFL/it) wastes less (electrical energy) (1) | Same input (energy) gives out/produces more light/useful (energy)  
      Do not accept more energy is used in the (CFL/it) Ignore brightness. (CFL/it) produces less thermal/heat (energy)  
      Accept explanations using data from the energy transfer diagrams as comparisons eg (CFL/it) is four times as efficient gains both marks | (2) |
| (c) | An explanation linking  
      • dissipating heat (1)  
      • at same (rate) as quickly as energy is being supplied (1) | gives out/radiates/conducts /conveys /loses /produces heat/thermal/energy  
      gives out as much energy/power as it takes in(each second) Gains both marks  
      If no other marks scored: There is a constant current/ steady flow of energy into the heater gains one mark Ignore refs to thermostat | (2) |

Total for Question = 9 marks
<table>
<thead>
<tr>
<th>Question Number</th>
<th>Answer</th>
<th>Acceptable answers</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(a)(i)</strong></td>
<td>B (50 m)</td>
<td></td>
<td><strong>(1)</strong></td>
</tr>
<tr>
<td><strong>(a)(ii)</strong></td>
<td>kinetic (1)</td>
<td>movement</td>
<td><strong>(2)</strong></td>
</tr>
<tr>
<td></td>
<td>electrical (1)</td>
<td>electric, electricity poor spellings of electrical electronic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>in this order.</td>
<td>Reject 2 forms of energy in one answer</td>
<td></td>
</tr>
<tr>
<td><strong>(b)(i)</strong></td>
<td>140 (J)</td>
<td>200 – 60</td>
<td><strong>(1)</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>140 in words</td>
<td></td>
</tr>
<tr>
<td><strong>(b)(ii)</strong></td>
<td>• substitution (1)</td>
<td>60 x 100 % 200</td>
<td><strong>(2)</strong></td>
</tr>
<tr>
<td></td>
<td>• evaluation (1)</td>
<td>30 %</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>60 200</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ignore units</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Award full marks for correct answer with no working</td>
<td></td>
</tr>
</tbody>
</table>
### Q5.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Answer</th>
<th>Acceptable answers</th>
<th>Mark</th>
</tr>
</thead>
</table>
| (b)(iii)        | Explanation linking:  
- energy supplied and radiated (1)  
- (at) equal (rate) (1)  
| Allow used for radiated  
heat gained = heat lost 2 marks  
input energy = output energy 2 marks  
input power = output power 2 marks  
input = output 1 mark | (2) |
| (c)             |        | Award full marks for correct answer  
with no working  
| (1) substitution  
6000  
250  
- evaluation (1)  
24 (years) | (2) |

#### (a)
- light → electrical → chemical energy energy energy (1) (1)
- These answers must be in the correct order (2)

#### (b)(i)
- 350 (J)
- 400 – 50 (J) (1)

#### (b)(ii)
- Substitution  
50 ÷ 400 (1)  
or  
$\frac{50 \times 100}{400}$ (%)
- Evaluation  
13(%) (1)
- 12.5(%), 0.125, 0.13 or 1/8  
Give full marks for correct answer, no working (2)

#### (c)(i)
- An explanation linking the following points:  
black (1) (because)  
(good) absorber (of thermal radiation) (1)
- absorbs / takes in heat radiation  
ignore references to:  
attract  
good emitter  
light  
dark / darker (2)

#### (c)(ii)
- an explanation linking any three of the following points:  
- (bag / water)
- idea of energy input  
e.g. "sun heats the bag up"  
idea of (3)
absorbs thermal energy / heat / radiation (1)
• (bag / water) radiates / emits thermal energy / heat / radiation (1)
• more heat radiated at higher temperature (1)
• input and output are balanced (at steady temperature) (1)

energy output idea of more heat lost (to surroundings) at higher temperature "a absorbing heat at same rate as radiating heat" (3)
ignore (sun) light / rays

Q6.

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Answer</th>
<th>Acceptable answers</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>A transverse and electromagnetic</td>
<td></td>
<td>(1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Answer</th>
<th>Acceptable answers</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b)</td>
<td>Evaluation 171.5 (1)</td>
<td>award full marks for correct answer with no working</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>Substitution ((34.3/171.5) \times 100) (1)</td>
<td>(34.3 \times 5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluation (20) (%) (1)</td>
<td>([34.3 / (34.3 \times 5)] \times 100) ([34.3 / (34.3 \times 5)]) ([34.3 / 171.5])</td>
<td>Allow 0.2 or 1/5 for 3 marks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Answer</th>
<th>Acceptable answers</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>(c)</td>
<td>rate of {energy/heat} {from the Sun} {absorbed/taken in} (1)</td>
<td>Allow 'energy in = energy out' for 1 mark 'power in = power out' for 2 marks</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>equals rate of {energy/heat} {radiated/emitted/given out} (1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Q7.
<table>
<thead>
<tr>
<th>Question Number</th>
<th>Answer</th>
<th>Acceptable answers</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)(i)</td>
<td>D. towards the centre of the circle</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>(a)(ii)</td>
<td>centripetal (force)</td>
<td>reject centrifugal force accept misspellings where meaning is clear e.g. centripetal</td>
<td>1</td>
</tr>
<tr>
<td>(a)(iii)</td>
<td>Any two of the following :-</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>ball slows down</td>
<td>less kinetic energy / momentum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ball / it drops (down) / circles at a lower height</td>
<td>any lowering / less potential energy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>go in smaller circles</td>
<td>stops going in circles the ball/it would not make complete circles (not just ‘stops’)</td>
<td></td>
</tr>
<tr>
<td>(a)(iv)</td>
<td>An explanation linking:</td>
<td>momentum of the ball decreases / changes (direction) / passed to wall</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>- the idea that momentum (of the closed system) would stay the same</td>
<td>must specify which momentum; do not credit ‘momentum decreases’ by itself</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- the idea that kinetic energy would not be conserved</td>
<td>kinetic energy → heat/sound/wall</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ignore ‘KE decreases / is lost’ without qualification allow ‘KE is lost because it’s not elastic’ (i.e. qualified)</td>
<td>2</td>
</tr>
</tbody>
</table>
**Indicative Content**

A description including some of the following points:
- **Cyclotron**
  - two D-shaped halves
  - gap between the Dees
  - (alternating) voltage across the gap
  - magnetic field (at right angles to the moving particles)
  - vacuum enables free movement of particles

**Particle movement**
- accelerate
- start at the centre
- move in a circular path
- spiral outwards
- exit in a straight line

Examples of labelled diagrams which would give Level 3 by themselves
(not all labels / details needed)

![Diagram 1](image1)

![Diagram 2](image2)

**Level 2** if no labels but Dees AND particle path shown.
**Level 1** if no labels but either Dees OR spiral of particle shown.
Ignore uses of cyclotron.

(6)
<table>
<thead>
<tr>
<th>Level</th>
<th>0</th>
<th>No rewardable content</th>
</tr>
</thead>
</table>
| 1     | 1 - 2        | • a **limited** description of either particle movement OR cyclotron e.g. The particles move in a circle OR Cyclotrons have two Dees OR Cyclotrons are particle accelerators OR there’s a vacuum  
• the answer communicates ideas using simple language and uses limited scientific terminology  
• spelling, punctuation and grammar are used with limited accuracy |
| 2     | 3 - 4        | • a **simple** description of particle movement AND cyclotron OR a more detailed description of one e.g. A cyclotron has two D-shaped halves and the particles inside accelerate OR A cyclotron has a magnetic field and a voltage across the gap OR Charged particles increase in speed as they spiral outwards OR vacuum allows free movement of particles  
• 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 |
| 3     | 5 - 6        | • a description of particle movement AND cyclotron with a **detailed** description of one of them e.g. the charged particles get faster as they accelerate across the gap in the Dees OR the magnetic field (of the cyclotron) causes the particles to move in a circle  
• the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately  
• spelling, punctuation and grammar are used with few errors |

(Total for Question = 12 marks)