P1H Energy: Higher Tier Practice

AQA 8463 · Calculator allowed · about 95 minutes

Total Marks

Name: _______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 A skydiver of mass 75 kg jumps from a stationary hot air balloon at a height of 1200 m. Assume g = 9.8 N/kg and ignore air resistance for this question.

Calculate the gravitational potential energy of the skydiver, relative to the ground, at the moment they jump.

(Total for Question 1 is 2 marks)

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2 Ignoring air resistance, the skydiver's gravitational potential energy store transfers completely to their kinetic energy store just before they open their parachute, after falling 800 m.

Using your understanding of energy conservation, calculate the kinetic energy of the skydiver after falling 800 m, then calculate their speed at that point. Use g = 9.8 N/kg and mass = 75 kg.

(Total for Question 2 is 4 marks)

3 In reality, air resistance acts on the skydiver as they fall, so their actual speed after falling 800 m is less than the value calculated in question 2, and is measured as 55 m/s.

Calculate the actual kinetic energy of the skydiver at this point, and hence calculate the energy that has been transferred to the surroundings (dissipated) by air resistance during the 800 m fall.

(Total for Question 3 is 4 marks)

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4 Explain, in terms of energy transfer, why the skydiver in question 3 reaches a constant maximum speed (terminal velocity) if they fall for long enough before opening their parachute.

(Total for Question 4 is 2 marks)

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5 A kettle transfers 480000 J of energy electrically in 160 s to heat water. Calculate the power rating of the kettle.

(Total for Question 5 is 2 marks)

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6 The kettle in question 5 is used to heat 0.80 kg of water from 20 degrees C to 100 degrees C. The specific heat capacity of water is 4200 J/kg degrees C.

Calculate the useful energy transferred to the water, then calculate the efficiency of the kettle. Give your efficiency answer as a percentage to 3 significant figures.

(Total for Question 6 is 4 marks)

7 State two ways the efficiency of the kettle in question 6 could be improved, other than by changing the amount of water heated.

(Total for Question 7 is 2 marks)

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8 Extended response (6 marks).

A national grid must be able to supply electricity efficiently over long distances, from power stations to homes and businesses.

Explain how transformers are used in the National Grid to reduce energy losses, and why this reduces energy dissipated in the transmission cables.

(Total for Question 8 is 6 marks)

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9 A spring is stretched by a force. The extension of the spring is directly proportional to the force applied, up to its limit of proportionality. A student applies a force of 12 N to a spring, producing an extension of 0.060 m. Elastic potential energy stored, Ee = 0.5 x k x e^2, where k is the spring constant.

Calculate the spring constant, k, for this spring, and then calculate the elastic potential energy stored in the spring at this extension.

(Total for Question 9 is 4 marks)

10 A student investigates how the extension of a spring depends on the force applied, as a required practical. State two control variables the student should keep constant to make this a fair test, and explain why the spring should not be stretched beyond its limit of proportionality.

(Total for Question 10 is 2 marks)

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11 A 1200 kg car accelerates from rest to a speed of 18 m/s. Calculate the kinetic energy of the car at 18 m/s, and calculate the minimum work that must have been done by the engine's driving force to reach this speed, assuming no energy is dissipated by resistive forces.

(Total for Question 11 is 3 marks)

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12 The UK is increasing the proportion of its electricity generated from renewable resources, such as wind and solar power, and reducing its use of non-renewable resources, such as coal and natural gas.

Evaluate one advantage and one disadvantage of relying more heavily on wind power for UK electricity generation.

(Total for Question 12 is 2 marks)

Mark scheme · P1H Energy: Higher Tier Practice

Question 1

- **M1** substitutes into Ep = m x g x h: Ep = 75 x 9.8 x 1200
- **A1** 882000 J (8.82×10^5 J) cao
- **Answer: 882000 J**

Question 2

- **M1** calculates the GPE lost as Ek gained: Ek = m x g x h = 75 x 9.8 x 800
- **A1** Ek = 588000 J cao
- **M1** rearranges Ek = 1/2 x m x v^2 to v = $\sqrt{2 \times Ek / m}$ and substitutes: v = $\sqrt{2 \times 588000 / 75}$
- **A1** v = 125 m/s cao
- **Answer: Ek = 588000 J, giving a speed of 125 m/s.**

Question 3

- **M1** substitutes into Ek = 1/2 x m x v^2: Ek = 0.5 x 75 x 55^2
- **A1** Ek = 113437.5 J (accept 113000 J or 1.13×10^5 J to 3 s.f.)
- **M1** uses conservation of energy: energy dissipated = GPE lost - actual Ek = 588000 - 113437.5
- **A1** 475000 J (to 3 s.f.), accept 474562.5 J cao
- **Answer: Actual Ek is approximately 113000 J; approximately 475000 J has been dissipated to the surroundings by air resistance.**

Question 4

- **B1** as speed increases, air resistance (drag force) increases, so more of the gravitational potential energy store is transferred (dissipated) to the thermal energy stores of the skydiver and the surrounding air by the work done against air resistance, oe
- **B1** eventually air resistance increases until it balances the (equal and opposite to) weight of the skydiver, so there is no resultant force and no further increase in kinetic energy store, meaning speed becomes constant, oe
- **Answer: As speed rises, air resistance rises and more gravitational potential energy is dissipated as heat to the surroundings by drag. Eventually air resistance equals weight, so there is no resultant force, no more energy is transferred to the kinetic store, and speed stays constant.**

Question 5

- **M1** substitutes into P = E / t: P = 480000 / 160
- **A1** 3000 W cao
- **Answer: 3000 W**

Question 6

- **M1** substitutes into Q = m x c x deltaT: Q = 0.80 x 4200 x (100 - 20)
- **A1** Q = 268800 J cao
- **M1** substitutes into efficiency = (useful output / total input) x 100: (268800 / 480000) x 100
- **A1** 56.0 % cao
- **Answer: 268800 J useful energy transferred; efficiency = 56.0 %.**

Question 7

- **B1** improve thermal insulation of the kettle body (e.g. double-walled or insulated casing) to reduce energy dissipated to the surrounding air, oe
- **B1** reduce friction/resistance losses in the heating element or wiring, or use a lid to reduce energy lost as steam escapes, oe
- **Answer: For example: improve the insulation of the kettle body, and reduce energy lost as escaping steam (e.g. by using a well-fitting lid).**

Question 8

- **Level 3** (5-6): A complete, correctly sequenced explanation using step-up and step-down transformers, correctly linking higher voltage to lower current, and lower current to reduced heating (I^2R) losses in the cables, with accurate scientific terminology throughout.
- **Level 2** (3-4): A mostly correct explanation covering the role of transformers in changing voltage and current, but with an incomplete or partially correct link to why this reduces energy loss.
- **Level 1** (1-2): Basic statements, e.g. 'transformers make transmission more efficient', with little explanation of voltage, current or heating losses.
- **Indicative content:**
  - Step-up transformers at the power station increase the voltage of the electricity supply to a very high value before it is sent along the transmission cables.
  - Because power transferred = current x voltage (P = IV), for a fixed amount of power, increasing the voltage means the current in the cables is correspondingly reduced.
  - The energy dissipated as heat in a cable due to its resistance depends on the current squared (P = I^2 x R), so even a moderate reduction in current causes a much larger reduction in the energy wasted as heat in the cables.
  - This means transmitting electricity at high voltage and low current wastes much less energy (as heat) in the cables than transmitting the same power at a lower voltage and higher current would.
  - Step-down transformers are then used near homes and businesses to reduce the very high transmission voltage back down to a safer, usable voltage (e.g. 230 V in the UK) before it reaches consumers.
  - Overall this system (step-up, high-voltage transmission, step-down) allows the National Grid to transmit electrical power efficiently across the country with minimal energy loss.

Question 9

- **M1** rearranges F = k x e to find k = F / e = 12 / 0.060
- **A1** k = 200 N/m cao
- **M1** substitutes into Ee = 0.5 x k x e^2: Ee = 0.5 x 200 x 0.060^2
- **A1** Ee = 0.36 J cao
- **Answer: Spring constant = 200 N/m; elastic potential energy stored = 0.36 J.**

Question 10

- **B1** control variables: use the same spring throughout (same original length, material and thickness), and keep temperature constant, oe (any two)
- **B1** beyond the limit of proportionality, extension is no longer directly proportional to force, so the straight-line (linear) relationship used to calculate the spring constant no longer applies, and the spring may also be permanently deformed and not return to its original length, oe
- **Answer: Keep the same spring (same length/material) and constant temperature throughout. Beyond the limit of proportionality extension is no longer proportional to force, so the linear relationship (and spring constant) no longer applies, and the spring may be permanently stretched.**

Question 11

- **M1** substitutes into Ek = 0.5 x m x v^2: Ek = 0.5 x 1200 x 18^2
- **A1** Ek = 194400 J cao
- **B1** minimum work done = 194400 J, because with no dissipation all the work done goes into the kinetic energy store, oe
- **Answer: Ek = 194400 J; minimum work done by the driving force = 194400 J.**

Question 12

- **B1** advantage: wind power produces no carbon dioxide (or other greenhouse gas/pollutant) emissions while generating electricity, and the energy resource (wind) will not run out, oe
- **B1** disadvantage: wind power is unreliable/intermittent, as it depends on wind speed and cannot supply electricity on demand (or cannot be easily stored, and requires backup generation), oe
- **Answer: Advantage: wind power produces no emissions during generation and the resource will never run out. Disadvantage: it is unreliable, as output depends on wind speed and cannot be guaranteed on demand.**