

Paper 1 multistep calculation practice

AQA GCSE Combined Science Trilogy 8464 and Separate Physics 8463 | Paper 1 | Both tiers

Suggested: 35–40 minutes + 15–20 minutes review | 26 parts | 41 marks

Specification points covered

8463 4.1.1.2 / 8464 6.1.1.2: kinetic, elastic and gravitational energy
 8463 4.1.1.3 / 8464 6.1.1.3: thermal energy changes and specific heat capacity
 8463 4.1.1.4 / 8464 6.1.1.4: power and energy transfer
 8463 4.1.2.2 / 8464 6.1.2.2: efficiency
 8463 4.2.1.2 / 8464 6.2.1.2: current, charge and time
 8463 4.2.1.3 / 8464 6.2.1.3: potential difference, current and resistance
 8463 4.2.4.1 / 8464 6.2.4.1: electrical power
 8463 4.3.1.1 / 8464 6.3.1.1: density, mass and volume

An emergency team must light a field station, warm water and lift supplies. Its 24 V power pack can deliver 0.90 MJ of usable electrical energy and a maximum total power of 600 W. Treat these as separate limits.

Use a calculator and an equations sheet. Show intermediate steps and units; keep unrounded values until the final answer. All questions use shared Foundation/Higher content. Selected Paper 1 topics, not a full practice paper.

1 Reading the power-pack limits

Figure 1 shows electrical energy going to the equipment. It is an energy-flow schematic, not a circuit diagram.

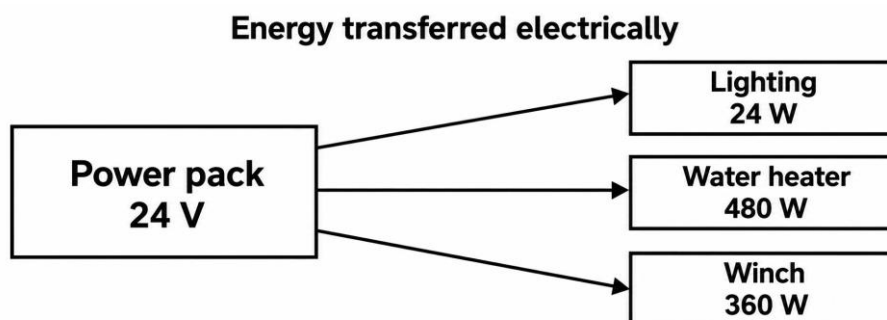


Figure 1

1(a) Write the usable electrical energy capacity of 0.90 MJ in joules. **[1 mark]**

1(b) A volunteer says the 600 W label tells the team how much energy the pack can deliver in total. Explain why this is wrong. **[2 marks]**



2 Keeping the station lit

All equipment receives a steady 24 V. Lighting draws 24 W throughout a six-hour shift. Assume steady ratings and neglect extra lead or control losses. The separate beacon test in 2(b)–2(c) does not use the shift's power pack.

2(a) Use the lighting rating to calculate the current drawn by the lighting. **[1 mark]**

2(b) In a separate bench test, 240 C passes through a beacon in 5.0 minutes. Calculate its mean current. **[2 marks]**

2(c) The beacon has 24 V across it. Use the current from 2(b) to calculate its electrical power. **[1 mark]**

2(d) Calculate the charge flow through the lighting during the full six-hour shift. **[2 marks]**

2(e) Calculate the electrical energy needed for six hours of lighting. Keep the answer in joules for the final budget. **[1 mark]**

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3 Warming the water supply

Use Table 1. The heater draws 480 W and transfers 75% of its electrical input energy to the water. The water remains liquid with no mass loss. The stated efficiency already accounts for energy not transferred to the water.

Table 1

Water-heating data	Value
Water volume	2.0 litres
Water density	1000 kg/m ³
Specific heat capacity of water	4200 J kg ⁻¹ °C ⁻¹
Initial temperature	12 °C
Target temperature	42 °C

3(a) The water volume is 2.0 litres. Calculate its mass using the density in Table 1. Use 1 litre = 0.001 m³. **[2 marks]**

3(b) Calculate the temperature rise needed to reach the target temperature. **[1 mark]**

3(c) Calculate the increase in thermal energy of the water. **[1 mark]**

3(d) Calculate the electrical input energy needed when the heating efficiency is 75%. **[2 marks]**

3(e) The heater draws 480 W at 24 V. Calculate its operating current and then its resistance at this operating point. **[2 marks]**

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3 Warming the water supply continued

3(f) Use the electrical input energy from 3(d) and the 480 W rating to calculate the heating time. **[1 mark]**

3(g) A volunteer predicts 525 s by dividing 252 000 J by 480 W. Explain why this prediction is too short. Use the efficiency in your answer. **[2 marks]**

4 Lifting the supplies

The total raised mass is 50 kg. Each lift raises it vertically by 6.0 m, using an 18 m cable. Take $g = 9.8 \text{ N/kg}$. The load starts and finishes at rest. The winch draws 360 W and has an efficiency of 70% for this lift.

4(a) Calculate the gain in gravitational potential energy during one lift. Select the relevant distance from the information above. **[1 mark]**

4(b) Calculate the electrical input energy for one lift at 70% efficiency. **[2 marks]**

4(c) Calculate the electrical energy needed for six identical lifts. **[1 mark]**

4(d) Calculate the time for one lift using the winch's 360 W electrical input rating. **[1 mark]**

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5 Checking the trolley buffer

A loaded trolley has a total mass of 25 kg and approaches a spring buffer at 1.2 m s^{-1} . The buffer has spring constant 3600 N/m and must not compress by more than 10 cm. It obeys the spring-energy equation over this range. Use an ideal model in which the trolley's lost kinetic energy is stored in the spring. This safety calculation is not an electrical load on the pack.

5(a) Calculate the trolley's kinetic energy as it approaches the buffer. [1 mark]

5(b) Could the buffer store all of this kinetic energy without exceeding 10 cm compression? Calculate the spring energy at 10 cm and compare it with the trolley's kinetic energy. [2 marks]

5(c) The trolley approaches at twice the original speed, with the same mass. Calculate its new kinetic energy and decide whether the same 10 cm buffer limit is sufficient. [2 marks]

6 Can the pack finish the shift

The jobs are six hours of lighting, one heating batch from section 3, and six lifts from section 4. The pack starts with 0.90 MJ of usable electrical energy. No recharging occurs. Include only these three jobs in the budget.

6(a) A volunteer switches on the lighting, heater and winch together. Calculate their total power demand and determine whether it is within the 600 W limit. [2 marks]

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6 Can the pack finish the shift continued

6(b) The lighting must remain on. Describe an operating schedule that allows both heating and lifting without exceeding 600 W. Support your answer with the two relevant power totals. **[2 marks]**

6(c) Calculate the total electrical energy for the six-hour lighting shift, one heating batch and six lifts. Decide whether 0.90 MJ is enough and calculate the energy remaining. **[2 marks]**

6(d) A volunteer claims the pack can support seven hours of lighting as well as the same heating batch and six lifts. Test the claim with a calculation. **[2 marks]**

6(e) After allowing energy for the heating batch and six lifts, calculate the maximum total lighting time in seconds. This includes the original six-hour shift. **[2 marks]**

Review: select one calculation you found difficult. Identify the equation, the conversion and the check that would help you next time.

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