OCR GATEWAY A GCSE PHYSICS J249 | P7

ENERGY

Exam practice notebook

HIGHER TIER

12 diagnostic choices + 24 topic sets
2 extended responses + 7 timed sets
210 marks | Original questions | Detailed answers at the end

P7.1 Work done

P7.2 Power and efficiency

Name: _____

Class: _____ Date: _____

Independent practice resource. Not an official OCR examination paper. Past-paper questions, mark schemes and logos are not reproduced.

© 2026 GCSE Online Tutoring x RS Remote Tutoring. All rights reserved.

Revised edition - 14 November 2026
AI-assisted text and diagrams. Publisher: GCSE Online Tutoring x RS Remote Tutoring.

ROUTE AND TIER COVERAGE

How to use this notebook

Start with the diagnostic choices, then attempt the topic sets after studying each sub-topic. Allow around 8-10 minutes per six-mark set. Complete each extended response in about 10 minutes. The fresh timed check has 42 marks with a suggested 56 minutes.

This is a P7 topic practice collection, not a complete GCSE paper. Its marks and timings are independent guidance. No GCSE grade boundaries are assigned.

Calculator allowed. Use the optional reference page if your teacher permits it. Show equations, substitutions and units. Use a ruler for graphs and clear energy diagrams. Distinguish an energy store, a transfer pathway and a rate of transfer. State the system boundary when discussing conservation.

Both tiers: conservation and dissipation; mechanical, electrical and thermal energy calculations; kinetic, elastic and gravitational stores; appliance power and kWh; efficiency calculations; lubrication, insulation and cooling.

P7.2e explicitly makes describing ways to increase efficiency Higher-only. The Higher book includes improvement design and additional challenging linked applications. Common P7.2f still requires explanations of reducing unwanted transfers, including lubrication and insulation, and P7.2d efficiency calculations remain common.

Higher-demand calculations use common equations in more demanding combinations; they are not all new Higher-only content statements.

Mark, correct and retry

All answers follow the final score record. Each worked answer includes credit points, the reasoning or calculation method, and a common-error note. Use the marking instructions at the start of that section.

Command	Answer approach
Calculate	Show a relationship, substitute, then give a result with units.
Explain	Connect a cause, interaction or observation to its physical consequence.
Draw	Use clear labels, appropriate directions and the stated scale.
Evaluate	Use evidence to judge a claim and recognise limitations.

OPTIONAL SUPPORT | NOT THE OFFICIAL EQUATION SHEET

Practice equation reference

Relationship	Units / conditions
Work = Fs; P = E/t	J; N; distance along force in m; W; s.
Ek = ½mv²	J; mass kg; speed m/s.
Ee = ½kx²; Fspring = kx	J; k in N/m; extension x in m; linear region.
ΔEp = mgΔh	J; kg; g in N/kg; vertical height change m.
ΔE = mcΔT	J; kg; c in J/(kg °C); temperature difference °C; no state change.
E = QV; Q = It; P = VI; E = Pt	Use operating values for the same device/interval.
Efficiency η = useful output / total input	Use energy/energy or matched power/power. Multiply by 100 for a percentage.
Linked-stage efficiency	Overall fraction = product of each successive stage’s fraction.

Conversions: 1 kW = 1000 W; 1 min = 60 s; 1 h = 3600 s; 1 kWh = 3 600 000 J. For kWh use kW and h; for J use W and s. Use the supplied g where stated.

Source alignment: OCR J249 specification, version 5.0 (July 2026), P7 and relevant practical/mathematical skills. Checked 14 November 2026. AI-assisted preparation. Independent resource; not produced, endorsed or approved by OCR.

Official OCR J249 specification

2021-2025 | NEWLY WRITTEN QUESTIONS

Five-series reference review

P7-relevant tasks and marking guidance in J249/02 (Foundation) and J249/04 (Higher) were reviewed for November 2021 and June 2022, 2023, 2024 and 2025. These are the latest five public question-paper series linked in the assessment archive used for this edition.

The papers guide skill coverage, task formats and demand. These notebook questions use original contexts, data and wording; they are not one-to-one paraphrases of official items. No official paper or marking table is reproduced.

2021: Mechanical stores, appliance energy and motor/heater efficiencies, including linked energy calculations.

2022: Work calculations and data; wall thickness/conductivity comparisons; efficiency in energy systems.

2023: Insulation investigations, gravitational/kinetic energy accounts and useful-output efficiency.

2024: Mechanical work, electrical energy and appliance efficiency; consistent energy-store accounts.

2025: Useful and total energy in electronic devices and larger systems; conservation and efficiency calculations.

Official archive: question papers and mark schemes

The companion reference record contains the direct official links. This collection practises P7 skills; it does not predict future questions. Tasks may combine outcomes within P7.

D1-D4 | 4 MARKS

Diagnostic multiple choice

D1. For a closed system with no energy crossing its boundary, what remains unchanged? [1]

A Total energy B Every individual energy store C The temperature of every part D Every object’s speed

Answer: _____

D2. Which store increases when a load is raised near Earth? [1]

A Chemical only B Gravitational potential C Kinetic in every case D Elastic in every case

Answer: _____

D3. At fixed mass, speed doubles. What happens to kinetic energy? [1]

A It halves B It doubles C It quadruples D It stays constant

Answer: _____

D4. A 15 N force acts through 4.0 m along its direction. What work is done? [1]

A 3.75 J B 19 J C 0.27 J D 60 J

Answer: _____

D5-D8 | 4 MARKS

Diagnostic multiple choice

D5. What does a power of 30 W mean? [1]

A 30 J in every complete task B 30 J transferred each second C 30 C of stored charge D 30 N acting in every case

Answer: _____

D6. Which is an energy unit? [1]

A Watt B Volt C Kilowatt-hour D Ampere

Answer: _____

D7. A device takes 400 J and delivers 100 J usefully. What is its efficiency? [1]

A 25% B 75% C 400% D 4%

Answer: _____

D8. What does dissipated energy normally become? [1]

A Destroyed energy B Energy outside every possible system C A new force D Energy spread into less useful stores

Answer: _____

D9-D12 | 4 MARKS

Diagnostic multiple choice

D9. How does suitable lubrication reduce unwanted transfer? [1]

A It makes mass zero B It removes every force C It reduces friction and associated heating D It creates kinetic energy

Answer: _____

D10. Two motor designs perform the same useful task. Which evidence directly establishes a higher energy efficiency? [1]

A A cooler casing alone B A lower input energy with the same useful output C A larger mass alone D A louder sound

Answer: _____

D11. Two successive transfer stages have efficiencies 0.60 and 0.50. What is the overall efficiency? [1]

A 110% B 55% C 30% D 10%

Answer: _____

D12. A task needs 180 J useful output at efficiency 0.75. What input is required? [1]

A 135 J B 240 J C 180.75 J D 75 J

Answer: _____

TOPIC PRACTICE | Q1 | 6 MARKS

Choose the system boundary

A toy vehicle powered by a wound spring moves along a rough track and eventually stops. Consider a system containing the toy, track, surrounding air and Earth, with no energy crossing its outer boundary.

Q1(a) Name the store that decreases as the toy first speeds up and the store that initially increases. [2]

Q1(b) Explain why the toy’s stopping does not mean energy has disappeared. [2]

Q1(c) State what happens to the system’s total energy and explain the boundary condition. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q2 | 6 MARKS

An object projected upwards

A ball is launched with 80 J of kinetic energy. At a later point, its gravitational potential store has increased by 50 J and 5 J has been transferred to internal stores of the ball and surroundings. Take launch height as the reference.

Q2(a) Calculate the ball’s kinetic energy at that point. [2]

Q2(b) Describe the main store changes during the rise. [2]

Q2(c) Explain why its kinetic energy on returning to launch height can be less than 80 J. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q3 | 6 MARKS

Work by a constant force

A constant force of 36 N pulls a container through 5.0 m in the force direction. The motion takes 9.0 s.

Q3(a) Calculate the work done by this force. [2]

Q3(b) Calculate its mean rate of energy transfer. [2]

Q3(c) Explain why work done need not all become kinetic energy if the container moves steadily. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q4 | 6 MARKS

Kinetic energy scales with speed squared

A cart of mass 250 kg travels at 8.0 m/s.

Q4(a) Calculate kinetic energy. [2]

Q4(b) Calculate its kinetic energy at 4.0 m/s. [2]

Q4(c) Explain the energy ratio between these speeds. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q5 | 6 MARKS

Gravitational potential energy

A 12 kg load is raised through a vertical height of 2.5 m. Use g = 10 N/kg. The path may be vertical or along a ramp.

Q5(a) Calculate its gain in gravitational potential energy. [2]

Q5(b) Calculate its weight and the ideal work needed to raise it vertically at steady speed. [2]

Q5(c) Explain why a longer frictionless ramp to the same height does not change the gravitational energy gain. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q6 | 6 MARKS

Energy in a stretched spring

A spring has spring constant 160 N/m. It extends by 0.15 m within its linear region.

Q6(a) Calculate the elastic potential energy stored. [2]

Q6(b) Calculate the spring force at this extension. [2]

Q6(c) Explain why using final force × full extension would overestimate the stretching work. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q7 | 6 MARKS

Heating a material

A 0.40 kg sample has specific heat capacity 900 J/(kg °C). It warms from 18 °C to 43 °C without changing state.

Q7(a) Calculate the temperature change. [1]

Q7(b) Calculate the increase in internal energy associated with this temperature rise. [3]

Q7(c) Explain why an electrical heater might need to supply more than this energy. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q8 | 6 MARKS

Electrical energy by two routes

A 6.0 V supply drives 0.80 A through a component for 50 s. Operating values are constant.

Q8(a) Calculate charge transferred. [2]

Q8(b) Calculate energy transferred using charge and p.d. [2]

Q8(c) Calculate power and check the same energy using time. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q9 | 6 MARKS

Power ratings do not give task energy alone

Device A operates at 600 W for 40 s. Device B operates at 400 W for 90 s. Assume both powers are steady input powers.

Q9(a) Calculate the input energy for A. [2]

Q9(b) Calculate the input energy for B. [2]

Q9(c) Explain why the lower-power device transfers more total energy in this example. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q10 | 6 MARKS

Kilowatt-hours and joules

A heater operates at 1.2 kW for 20 min at steady power.

Q10(a) Calculate energy in kWh. [2]

Q10(b) Calculate energy in joules. [2]

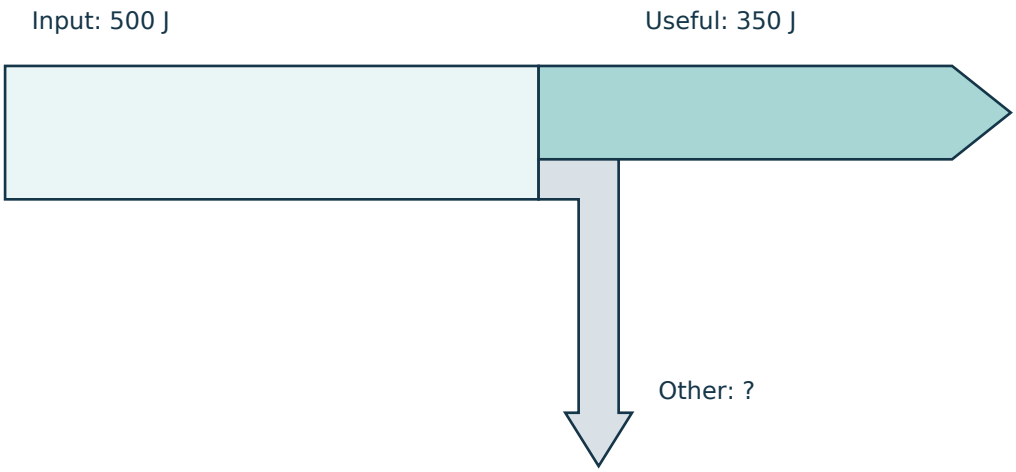
Q10(c) Use your two values to confirm the conversion for 1 kWh. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q11 | 6 MARKS

Read an energy-transfer diagram

The diagram summarises one operating interval of a device. Input is 500 J and useful output is 350 J. Other output energy spreads into the surroundings.



Q11(a) Calculate the unwanted output energy. [2]

Q11(b) Calculate efficiency as a decimal and percentage. [2]

Q11(c) Explain why the unwanted output is not destroyed energy. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q12 | 6 MARKS

Efficiency from power

A motor takes 500 W electrical input and delivers 325 W useful mechanical power under steady conditions.

Q12(a) Calculate efficiency. [2]

Q12(b) Calculate useful mechanical energy delivered in 8.0 s. [2]

Q12(c) Calculate unwanted energy transfer during those same 8.0 s. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q13 | 6 MARKS

Dissipation during stopping

A sliding block begins with 45 J of kinetic energy and stops on a rough horizontal surface. The combined system includes the block, surface and surroundings, with no energy crossing its outer boundary.

Q13(a) State the change in the block’s kinetic energy. [1]

Q13(b) Describe where that energy goes. [3]

Q13(c) Explain why the dissipated energy is less useful for making the block move again. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q14 | 6 MARKS

Lubrication and unwanted heating

Two otherwise identical rotating bearings operate at the same load and speed. One is suitably lubricated and the other is dry.

Q14(a) Explain how lubrication changes the unwanted mechanical interaction. [2]

Q14(b) Explain the expected effect on unwanted heating. [2]

Q14(c) Explain why a lower measured bearing temperature alone is not a complete measurement of energy transfer. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q15 | 6 MARKS

Walls, conductivity and thickness

Compare three wall panels with equal area and the same indoor-outdoor temperature difference. A and B have equal thickness; B and C use the same low-conductivity material.

Panel	Thickness	Conductivity
A	0.10 m	High
B	0.10 m	Low
C	0.20 m	Low

Q15(a) Compare conduction rates through A and B and explain. [2]

Q15(b) Compare conduction rates through B and C and explain. [2]

Q15(c) Name two further conditions that must be controlled when comparing complete model buildings. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q16 | 6 MARKS

Plot and use cooling measurements

Two identical containers each hold 0.25 kg of water at 70 °C initially. Room temperature is 20 °C. They have different insulation arrangements. Plot both temperature-time records on the grid, label axes and curves, and join successive points with straight segments. Use c = 4200 J/(kg °C).

Time / min	0	2	4	6
A temperature / °C	70	60	52	46
B temperature / °C	70	66	62	59



Q16(a) Complete the two curves. [3]

Q16(b) Calculate energy transferred out of the water in A during its first 4 min. [2]

Q16(c) Identify which arrangement has the lower cooling rate over this experiment. [1]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q17 | 6 MARKS

Make a cooling test fair

A student compares insulation P around 100 g of water starting at 80 °C with insulation Q around 300 g of water starting at 60 °C. The containers also have different shapes.

Q17(a) Name two changes needed for a fair comparison. [2]

Q17(b) Explain why different starting temperatures are a problem. [2]

Q17(c) Explain a useful role and one limitation of repeat measurements. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q18 | 6 MARKS

Domestic energy stores and pathways

Consider a battery-powered torch and an electric fan connected to an electrical supply. Follow the energy into the devices and their surroundings.

Q18(a) Name the initial store that decreases in the torch’s battery and the transfer pathway into its circuit. [2]

Q18(b) Describe useful and unwanted transfers from the torch for its lighting task. [2]

Q18(c) Name the fan’s useful energy-store change and one unwanted transfer. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q19 | 6 MARKS

Evaluate a more efficient motor design

Design A takes 600 J to provide 360 J of useful shaft energy. Design B provides the same useful shaft energy from 450 J input.

Q19(a) Calculate both efficiencies. [2]

Q19(b) Describe and explain one mechanical change that could account for reduced unwanted transfer. [2]

Q19(c) A cooler casing is offered as the only evidence that B uses less energy. Evaluate that evidence. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q20 | 6 MARKS

Two linked transfer stages

A first stage transfers 80% of its 1000 J input usefully to a second stage. The second stage transfers 75% of that incoming energy to the final useful output.

Q20(a) Calculate energy entering stage 2 and final useful output. [2]

Q20(b) Calculate overall efficiency. [2]

Q20(c) Compare the unwanted energy amounts at the two stages. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q21 | 6 MARKS

From a spring to a moving cart

A spring of stiffness 400 N/m is compressed by 0.15 m in its linear region. On release, 75% of its stored energy becomes kinetic energy of a 0.30 kg cart, initially at rest.

Q21(a) Calculate initial elastic energy. [2]

Q21(b) Calculate the cart’s final speed. [3]

Q21(c) Calculate the energy transferred to other stores. [1]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q22 | 6 MARKS

Heating with a stated efficiency

A 250 W heater warms 0.60 kg of water by 25 °C. The water’s c is 4200 J/(kg °C). Over this run, 84% of electrical input increases the water’s internal energy.

Q22(a) Calculate the water’s energy gain. [2]

Q22(b) Calculate electrical input energy. [2]

Q22(c) Calculate operating time at the stated steady input power. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q23 | 6 MARKS

An apparent efficiency above one

A heating experiment reports 14 000 J input to 0.20 kg of water and a 20 °C rise. Use c = 4200 J/(kg °C). The student assumes no other energy input.

Q23(a) Calculate the implied useful energy and efficiency. [2]

Q23(b) Explain why these data require investigation rather than a claim of created energy. [2]

Q23(c) Describe one specific measurement improvement and explain its purpose. [2]

Score: ____ / 6 Review: secure / developing / revisit

TOPIC PRACTICE | Q24 | 6 MARKS

Useful output depends on the purpose

A device receives 1000 J. It delivers 600 J as shaft work, releases 300 J directly inside a room and transfers 100 J outside. All the shaft work eventually dissipates inside the room.

Q24(a) Calculate efficiency when the intended useful output is shaft work. [2]

Q24(b) Calculate the useful fraction when the intended task is heating the room. [2]

Q24(c) Explain a change that could increase the room-heating useful fraction and why its purpose matters. [2]

Score: ____ / 6 Review: secure / developing / revisit

P7.2f-g; P7.1d; practical planning | 6 MARKS

E1: Compare model-building walls

Two identical model buildings have replaceable wall panels of the same material but different thickness. Small low-voltage heaters maintain each interior at 40 °C in a 20 °C room. Once temperatures are steady, the input energy rate balances the energy-loss rate. Plan a fair comparison of the wall thicknesses using electrical energy measurements.

Write a coherent response. Use calculations, evidence and cause-and-effect links as appropriate. Suggested time: 10 minutes.

P7.1a; P7.2a,c-d | 6 MARKS

E2: Evaluate energy statements

Evaluate three statements: (1) unwanted heating means energy has been used up and no longer exists; (2) a device with a higher power rating always uses more total energy; (3) if 40% of input is useful, the other 60% violates conservation. Use physical explanations and a suitable relation where helpful.

Write a coherent response. Use calculations, evidence and cause-and-effect links as appropriate. Suggested time: 10 minutes.

FRESH QUESTIONS | 42 MARKS

Timed P7 check

Suggested time: 56 minutes. Attempt all 7 sets without consulting answers. Show method and units. The equation reference may be used only if your teacher chooses.

Start time: _____ Finish time: _____
Equation reference permitted? yes / no

Use this check to identify what to practise next. The score is not an official GCSE grade.

TIMED CHECK | T1 | 6 MARKS

T1: Raise a load

An 8.0 kg load rises vertically by 3.0 m in 6.0 s at steady speed. Use g = 10 N/kg and neglect losses.

T1(a) Calculate the weight. [2]

T1(b) Calculate the gain in gravitational potential energy. [2]

T1(c) Calculate useful mean power. [2]

Score: ____ / 6 Review: secure / developing / revisit

TIMED CHECK | T2 | 6 MARKS

T2: Two energy stores

A 0.20 kg cart moves at 4.0 m/s. Separately, a linear spring has k = 80 N/m and extension 0.20 m.

T2(a) Calculate the cart’s kinetic energy. [2]

T2(b) Calculate the spring energy. [2]

T2(c) Explain why equal energy values do not mean equal physical motion. [2]

Score: ____ / 6 Review: secure / developing / revisit

TIMED CHECK | T3 | 6 MARKS

T3: Account for a device input

A device receives 5000 J and transfers 3500 J to its intended useful output.

T3(a) Calculate the unwanted transfer. [2]

T3(b) Calculate efficiency. [2]

T3(c) Explain what becomes of the unwanted energy. [2]

Score: ____ / 6 Review: secure / developing / revisit

TIMED CHECK | T4 | 6 MARKS

T4: Heating and electrical input

Water of mass 0.30 kg warms by 15 °C. Its c is 4200 J/(kg °C). Electrical input over the run is 21 000 J.

T4(a) Calculate the water’s energy gain. [2]

T4(b) Calculate the fraction of input transferred to the water. [2]

T4(c) Account numerically for the remaining energy. [2]

Score: ____ / 6 Review: secure / developing / revisit

TIMED CHECK | T5 | 6 MARKS

T5: Energy in two unit systems

A steady 80 W device operates for 2.5 h.

T5(a) Calculate energy in kWh. [2]

T5(b) Calculate energy in joules. [2]

T5(c) State and explain the effect of halving operating time at the same power. [2]

Score: ____ / 6 Review: secure / developing / revisit

TIMED CHECK | T6 | 6 MARKS

T6: Two-stage useful transfer

A system has consecutive stage efficiencies 0.75 and 0.80. Each percentage refers to energy arriving at that stage.

T6(a) Calculate overall efficiency. [2]

T6(b) Calculate final useful output for 1200 J initial input. [2]

T6(c) Calculate initial input needed for 1800 J final useful output. [2]

Score: ____ / 6 Review: secure / developing / revisit

TIMED CHECK | T7 | 6 MARKS

T7: Recover energy during slowing

A 500 kg vehicle moving at 20 m/s stops. A recovery system stores 36% of its initial kinetic energy in a battery’s chemical store. Recovery takes 12 s.

T7(a) Calculate initial kinetic energy. [2]

T7(b) Calculate the energy stored in the battery. [2]

T7(c) Calculate mean useful recovery power. [2]

Score: ____ / 6 Review: secure / developing / revisit

COMPLETE AFTER MARKING

Score and improvement record

Set	Specification focus	Score / 6
Q1	P7.1a-b	
Q2	P7.1a-b,e	
Q3	P7.1c-d	
Q4	P7.1e	
Q5	P7.1b,d-e	
Q6	P7.1e	
Q7	P7.1c-d	
Q8	P7.1c-d	
Q9	P7.2b-c	
Q10	P7.1d; P7.2c	

Diagnostic: ____ / 12 Extended responses: ____ / 12

Topic sets: ____ / 144 Timed check: ____ / 42

Whole notebook: ____ / 210

Question to retry: _____ Correct physics and method:

COMPLETE AFTER MARKING

Score and improvement record

Set	Specification focus	Score / 6
Q11	P7.1a; P7.2a,d	
Q12	P7.2c-d	
Q13	P7.1a-b; P7.2a	
Q14	P7.2f	
Q15	P7.2f-g	
Q16	P7.2f-g; P7.1c-d	
Q17	P7.2f-g; practical evaluation	
Q18	P7.1b-c; P7.2b	
Q19	P7.2e; P7.2d,f | Higher improvement	
Q20	P7.1d; P7.2d | Higher demand	

Diagnostic: ____ / 12 Extended responses: ____ / 12

Topic sets: ____ / 144 Timed check: ____ / 42

Whole notebook: ____ / 210

Question to retry: _____ Correct physics and method:

COMPLETE AFTER MARKING

Score and improvement record

Set	Specification focus	Score / 6
Q21	P7.1d-e; P7.2d | Higher demand	
Q22	P7.1c-d; P7.2c-d | Higher demand	
Q23	P7.1a,c-d; P7.2d | Higher demand	
Q24	P7.2e; P7.1a; P7.2d | Higher improvement	
T1	P7.1d-e; P7.2c	
T2	P7.1e	
T3	P7.1a; P7.2a,d	
T4	P7.1c-d; P7.2d	
T5	P7.1d; P7.2c	
T6	P7.1d; P7.2d | Higher demand	

Diagnostic: ____ / 12 Extended responses: ____ / 12

Topic sets: ____ / 144 Timed check: ____ / 42

Whole notebook: ____ / 210

Question to retry: _____ Correct physics and method:

COMPLETE AFTER MARKING

Score and improvement record

Set	Specification focus	Score / 6
T7	P7.1b,d-e; P7.2d | Higher demand	

Diagnostic: ____ / 12 Extended responses: ____ / 12

Topic sets: ____ / 144 Timed check: ____ / 42

Whole notebook: ____ / 210

Question to retry: _____ Correct physics and method:

DETAILED SOLUTIONS AND MARKING GUIDANCE

ANSWERS

Stop here until you have attempted the questions. All answers are grouped from this page to the end.

Order: diagnostic answers; topic-practice worked answers; extended-response models; timed-check worked answers; energy-account, spring-work, transfer-diagram and cooling-curve reference answers plus Higher design checks.

Awarding credit

Each part shows its maximum mark. Award independent points once; accept equivalent scientific language and valid alternative methods. A correct calculation with suitable units earns full credit unless a specific drawing, explanation or method is required.

When an arithmetic error is carried into a later part, credit valid later methods that use it consistently. Do not award accuracy marks for incorrect values. Avoid penalising the same arithmetic error repeatedly. Energy accounts must include the stated system and all relevant transfers. In energy diagrams, distinguish the intended useful output from transfers to other stores.

The extended responses use six original independent credit points. Model paragraphs show one coherent full-credit response, not the only acceptable wording. They do not reproduce an official OCR level-of-response scheme.

For each diagnostic item award one mark for the single correct option and zero for another choice or multiple selections. Do not subtract marks. For graph plotting, allow the stated half-small-square tolerance and alternative sensible scales. For efficiency, input and useful output must refer to the same task and interval.

No GCSE grade boundaries are assigned. Use the score record to identify calculation, explanation, graph or evaluation skills to revisit.

D1-D4 | REASONS INCLUDED

Diagnostic answers

D1: A [1]

Stores can redistribute while total energy of the complete closed system stays constant.

D2: B [1]

Raising a load increases the gravitational potential energy of the load-Earth system.

D3: C [1]

Ek = ½mv² makes the speed factor squared: $2^2 = 4$.

D4: D [1]

Work = force × distance = 15 × 4.0 = 60 J.

D5-D8 | REASONS INCLUDED

Diagnostic answers

D5: B [1]

Power is the rate of energy transfer; one watt is one joule per second.

D6: C [1]

A kWh is power multiplied by time and therefore measures energy.

D7: A [1]

Efficiency = 100/400 = 0.25 = 25%.

D8: D [1]

Dissipation spreads energy, commonly into internal stores of surroundings; it does not destroy total energy.

D9-D12 | REASONS INCLUDED

Diagnostic answers

D9: C [1]

Less work against friction means less unwanted transfer to internal stores for the same motion.

D10: B [1]

For a fixed useful output, lower complete input gives a larger useful/input ratio; temperature alone is not sufficient.

D11: C [1]

The fractions multiply: 0.60 × 0.50 = 0.30.

D12: B [1]

Input = useful/efficiency = 180/0.75 = 240 J.

WORKED ANSWER | TOTAL 6 MARKS

Q1: Choose the system boundary

Part (a) / 2

Elastic potential store of the spring decreases (1); kinetic store of the moving toy increases (1).

Part (b) / 2

Friction and other interactions transfer energy to internal stores/sound which is eventually absorbed (1); energy remains in the complete system although less is in the toy’s kinetic store (1).

Part (c) / 2

Total energy stays constant (1); no energy enters or leaves the chosen closed system (1).

Reasoning and worked method

Energy stores change and energy is transferred between parts of the system. A smaller system containing only the toy could lose energy to its surroundings, but the larger specified system accounts for those surroundings. Dissipation means energy becomes spread into less useful stores, not destroyed.

Common error to avoid: Define the system before applying conservation. Avoid inventing a separate store called movement or friction.

WORKED ANSWER | TOTAL 6 MARKS

Q2: An object projected upwards

Part (a) / 2

80 = 50 + 5 + Ek (1); Ek = 25 J (1).

Part (b) / 2

The ball’s kinetic energy decreases (1); gravitational potential energy of the ball-Earth system increases (1).

Part (c) / 2

Further resistive transfers can increase internal stores (1); less energy then returns to the ball’s kinetic store despite conservation for the larger system (1).

Reasoning and worked method

Use a single energy reference and include dissipation. The 25 J remainder is the energy still associated with motion after the two stated transfers. Returning to the same height restores the gravitational reference but does not undo the spread of energy into the surroundings.

Common error to avoid: Do not claim a falling ball must regain all its launch kinetic energy if air resistance acts.

WORKED ANSWER | TOTAL 6 MARKS

Q3: Work by a constant force

Part (a) / 2

W = Fs = 36 × 5.0 (1); 180 J (1).

Part (b) / 2

P = W/t = 180/9.0 (1); 20 W (1).

Part (c) / 2

Constant velocity means no change in kinetic energy (1); energy transferred by the pull can be dissipated into internal stores against friction (1).

Reasoning and worked method

Work done measures energy transfer by a force acting through a displacement. The distance used here is along the force direction. A force can do work even at constant speed if another force dissipates energy. The 20 W is the mean power associated with the stated pull.

Common error to avoid: Work is measured in J, power in W. A zero kinetic-energy change does not mean every force does zero work.

WORKED ANSWER | TOTAL 6 MARKS

Q4: Kinetic energy scales with speed squared

Part (a) / 2

Ek = ½mv² = 0.5 × 250 × 8.0² (1); 8000 J (1).

Part (b) / 2

Ek = 0.5 × 250 × 4.0² (1); 2000 J (1).

Part (c) / 2

The lower-speed energy is one quarter of the higher-speed energy (1); halving speed squares the factor, giving (1/2)² (1).

Reasoning and worked method

The first value is 125 × 64 = 8000 J. The second is 125 × 16 = 2000 J. At a fixed mass, kinetic energy depends on v², so changes in speed have a larger fractional effect on energy than a simple linear rule would suggest.

Common error to avoid: Square speed, not mass. Do not halve kinetic energy simply because the speed halves.

WORKED ANSWER | TOTAL 6 MARKS

Q5: Gravitational potential energy

Part (a) / 2

ΔEp = mgΔh = 12 × 10 × 2.5 (1); 300 J (1).

Part (b) / 2

Weight = mg = 120 N (1); work = 120 × 2.5 = 300 J (1).

Part (c) / 2

The same mass reaches the same vertical height difference (1); gravitational energy depends on mgΔh rather than path length (1).

Reasoning and worked method

The 300 J gain belongs to the load-Earth gravitational system. A frictionless ramp changes the force and distance combination, not the height-based energy change. With friction, the actual input work can be greater because other stores also increase.

Common error to avoid: Use vertical height, not distance along the ramp, in mgΔh.

WORKED ANSWER | TOTAL 6 MARKS

Q6: Energy in a stretched spring

Part (a) / 2

Ee = ½kx² = 0.5 × 160 × 0.15² (1); 1.8 J (1).

Part (b) / 2

F = kx = 160 × 0.15 (1); 24 N (1).

Part (c) / 2

The force increases from zero rather than staying at 24 N throughout (1); the linear force-extension area is a triangle, so work is ½Fx, not Fx (1).

Reasoning and worked method

The squared extension is 0.0225 m² and the energy is 80 × 0.0225 = 1.8 J. The 24 N is the final force, not the average over the stretch. For a linear spring, average force is half the final force, which agrees with the triangular area.

Common error to avoid: Use extension from natural length, not the full stretched length. The linear-spring model matters.

WORKED ANSWER | TOTAL 6 MARKS

Q7: Heating a material

Part (a) / 1

43 - 18 = 25 °C (1).

Part (b) / 3

ΔE = mcΔT (1); 0.40 × 900 × 25 (1); 9000 J (1).

Part (c) / 2

Other objects such as the heater/container and surroundings may also gain energy (1); not all electrical input reaches the measured sample (1).

Reasoning and worked method

The calculation describes energy received by the sample, not necessarily the full electrical energy delivered to the apparatus. Temperature rise is final minus initial. Specific heat capacity connects energy, mass and temperature difference when no state change occurs.

Common error to avoid: Do not put the final temperature 43 °C into ΔT or assume an uninsulated setup transfers all input to the sample.

WORKED ANSWER | TOTAL 6 MARKS

Q8: Electrical energy by two routes

Part (a) / 2

Q = It = 0.80 × 50 (1); 40 C (1).

Part (b) / 2

E = QV = 40 × 6.0 (1); 240 J (1).

Part (c) / 2

P = VI = 6.0 × 0.80 = 4.8 W (1); E = Pt = 4.8 × 50 = 240 J (1).

Reasoning and worked method

The relations agree because Q = It and P = VI, so QV = IVt = Pt. The supply transfers energy electrically; charge circulates rather than being consumed. The intended output might be heating, light or motion depending on the component.

Common error to avoid: Keep charge in C, energy in J and power in W distinct.

WORKED ANSWER | TOTAL 6 MARKS

Q9: Power ratings do not give task energy alone

Part (a) / 2

E = Pt = 600 × 40 (1); 24 000 J (1).

Part (b) / 2

E = Pt = 400 × 90 (1); 36 000 J (1).

Part (c) / 2

It operates for longer (1); total energy depends on both power and time, not the power rating alone (1).

Reasoning and worked method

Power is energy transferred per unit time. A transfers 600 J each second, but for a much shorter interval. B therefore has a smaller rate and a larger accumulated energy input. For devices with thermostats or changing load, use actual operating time/power rather than automatically assuming continuous rated power.

Common error to avoid: A higher rating is not proof of greater energy use for a complete task.

WORKED ANSWER | TOTAL 6 MARKS

Q10: Kilowatt-hours and joules

Part (a) / 2

Time = 20/60 = 1/3 h and E = Pt (1); E = 0.40 kWh (1).

Part (b) / 2

Power = 1200 W and time = 1200 s (1); E = 1 440 000 J (1).

Part (c) / 2

1 440 000/0.40 (1); 3 600 000 J per kWh (1).

Reasoning and worked method

A kWh is an energy unit. The numerical product is valid only with matching units: kW times hours or W times seconds. Converting either result gives the other, offering a useful check. This task does not require an electricity tariff or a cost comparison.

Common error to avoid: Do not label a product of watts and hours as kWh without converting watts to kilowatts.

WORKED ANSWER | TOTAL 6 MARKS

Q11: Read an energy-transfer diagram

Part (a) / 2

Unwanted = input - useful = 500 - 350 (1); 150 J (1).

Part (b) / 2

η = useful/input = 350/500 = 0.70 (1); 70% (1).

Part (c) / 2

It is transferred into less useful stores, such as internal stores of the surroundings (1); including those transfers keeps the energy total conserved (1).

Reasoning and worked method

The widths represent the relative transfers: 350 J continues in the useful branch and 150 J is dissipated. Their sum is 500 J. Efficiency describes the useful fraction for the stated purpose, not the fraction of energy that still exists. The other 30% remains part of the energy account.

Common error to avoid: Do not divide useful energy by unwanted energy. The denominator is total input.

WORKED ANSWER | TOTAL 6 MARKS

Q12: Efficiency from power

Part (a) / 2

η = useful power/input power = 325/500 (1); 0.65 or 65% (1).

Part (b) / 2

Euseful = Puseful × t = 325 × 8.0 (1); 2600 J (1).

Part (c) / 2

Input energy = 500 × 8.0 = 4000 J (1); unwanted = 4000 - 2600 = 1400 J (1).

Reasoning and worked method

The power ratio gives the same efficiency as an energy ratio when the input and output refer to the same interval. In eight seconds the motor receives 4000 J, delivers 2600 J usefully and transfers 1400 J elsewhere. The unwanted power is 175 W.

Common error to avoid: Do not combine input power with output energy in one efficiency fraction; their units would not cancel.

WORKED ANSWER | TOTAL 6 MARKS

Q13: Dissipation during stopping

Part (a) / 1

It decreases by 45 J/to zero (1).

Part (b) / 3

Energy is transferred by work against friction (1); internal stores of the block and/or surface/surroundings increase (1); the full 45 J is accounted for in these stores or optional other transfers (1). A complete all-thermal account earns full credit; sound is not required. Credit sound/vibrations only as a valid alternative route, without double-counting energy.

Part (c) / 2

It is spread among many particles/in the surroundings (1); it is not readily concentrated back into the original organised motion (1).

Reasoning and worked method

The system still contains the energy, but its distribution changes. Dissipation reduces the energy readily available for the intended mechanical task, not total energy. The exactly specified 45 J belongs in the whole closed-system account, including any sound that is eventually absorbed.

Common error to avoid: Energy is not “lost from existence”. State the destination and why its new form is less useful.

WORKED ANSWER | TOTAL 6 MARKS

Q14: Lubrication and unwanted heating

Part (a) / 2

It reduces friction between moving surfaces (1); less work is done against that friction for the same motion (1).

Part (b) / 2

Less energy is transferred to internal stores by friction (1); the heating rate associated with that friction is reduced (1).

Part (c) / 2

Temperature also depends on cooling and thermal properties (1); comparable conditions or an energy/power measurement are needed to infer transfer rate quantitatively (1).

Reasoning and worked method

Lubrication can reduce unwanted transfers under the stated operating conditions. The temperature reading reflects both energy arriving and energy leaving the bearing. Different airflow, mass or conductivity could change temperature without the same change in dissipated power.

Common error to avoid: Do not assume lubrication removes every loss or that temperature is itself an energy quantity.

WORKED ANSWER | TOTAL 6 MARKS

Q15: Walls, conductivity and thickness

Part (a) / 2

B conducts energy more slowly (1); it has lower thermal conductivity at equal thickness and temperature difference (1).

Part (b) / 2

C conducts energy more slowly (1); its greater thickness reduces the transfer rate for the same material and other conditions (1).

Part (c) / 2

Any two (1 each): dimensions/surface area; starting/maintained internal temperature; outside temperature/airflow; roof/floor construction; gaps/air leakage.

Reasoning and worked method

Thermal conductivity is a material property describing how readily it conducts energy. Thickness is a geometrical property. The question changes one at a time, allowing a qualitative comparison without a numerical conduction equation. Complete building cooling also involves other surfaces and air movement.

Common error to avoid: Do not claim the thickest of any two materials must always conduct least; material conductivity matters as well.

WORKED ANSWER | TOTAL 6 MARKS

Q16: Plot and use cooling measurements

Part (a) / 3

Correctly labelled time/temperature axes with consistent scales (1); all eight data points correctly plotted within half a small square (1); two correct joined curves, identified A and B (1).

Part (b) / 2

$\Delta T = 70 - 52 = 18\ °C$ and $E = mc\Delta T$ (1); $0.25 \times 4200 \times 18 = 18\,900\ J$ (1).

Part (c) / 1

B (1).

Reasoning and worked method

At four minutes A has cooled by 18 °C, while B has cooled by 8 °C. The water masses and c values are equal, so B has lost less energy from its water over that same interval. The graph comparison must use matched starting and room conditions. A model graph is in the final reference answers.

Common error to avoid: Use a temperature drop, not the final temperature, to calculate energy lost. Compare equal intervals.

WORKED ANSWER | TOTAL 6 MARKS

Q17: Make a cooling test fair

Part (a) / 2

Any two (1 each): equal water mass; equal starting temperature; identical container geometry/lids; same ambient conditions.

Part (b) / 2

They give different initial temperature differences from the surroundings (1); transfer/cooling rate depends on that difference, so insulation is not the only influence (1).

Part (c) / 2

Repeats reveal random variation and allow a mean (1); they do not remove systematic differences such as unequal masses or starting conditions (1).

Reasoning and worked method

A smaller temperature drop does not automatically establish better insulation when thermal mass and temperature difference differ. Match the conditions before interpreting the cooling curves. Repetition is helpful after the comparison is designed fairly, not as a replacement for controlling variables.

Common error to avoid: Do not assume three repeats can fix a method that changes several variables at once.

WORKED ANSWER | TOTAL 6 MARKS

Q18: Domestic energy stores and pathways

Part (a) / 2

Chemical store (1); energy is transferred electrically/work is done by current (1).

Part (b) / 2

Light carries energy to illuminated surroundings (1); unwanted heating increases internal stores of the torch and surroundings (1).

Part (c) / 2

Kinetic energy of moving air/rotating fan increases or is maintained against resistance (1); unwanted heating or sound transfers energy elsewhere (1).

Reasoning and worked method

Electrical work and radiation are transfer pathways, not separate persistent stores called electrical energy or light energy. A battery supplies energy from its chemical store. A mains-connected device receives energy electrically from the supply rather than storing the mains itself.

Common error to avoid: Distinguish a store from a pathway: kinetic/internal/chemical stores versus mechanical/electrical/heating/radiation transfers.

WORKED ANSWER | TOTAL 6 MARKS

Q19: Evaluate a more efficient motor design

Part (a) / 2

A: 360/600 = 0.60 or 60% (1); B: 360/450 = 0.80 or 80% (1).

Part (b) / 2

For example suitable lubrication or lower-friction bearings (1); less work against friction reduces energy dissipated as heating for the same shaft task (1).

Part (c) / 2

Casing temperature alone is insufficient (1); different cooling/thermal mass could change temperature, so comparable input and useful-output measurements are required (1).

Reasoning and worked method

Both designs perform the same useful task, making the input comparison meaningful. A’s unwanted transfer is 240 J and B’s is 90 J. The efficiency improvement is 20 percentage points, not simply “20% less input”: the input reduction is 150/600 = 25%. The question does not require these extra comparisons but they check the interpretation.

Common error to avoid: Specify the intended useful output and matched conditions before claiming an improvement.

WORKED ANSWER | TOTAL 6 MARKS

Q20: Two linked transfer stages

Part (a) / 2

Stage 2 input = 0.80 × 1000 = 800 J (1); final useful = 0.75 × 800 = 600 J (1).

Part (b) / 2

Overall efficiency = final useful / original input = 600/1000 (1); 0.60 or 60% (1).

Part (c) / 2

Stage 1 unwanted = 1000 - 800 = 200 J (1); stage 2 unwanted = 800 - 600 = 200 J, so they are equal (1).

Reasoning and worked method

Each efficiency applies to that stage’s own input. Multiplying 0.80 by 0.75 gives overall efficiency 0.60. The lower efficiency of stage 2 does not mean it loses more joules here, because it receives a smaller input. Stage losses sum to 400 J, matching 1000 - 600.

Common error to avoid: Do not add stage percentages or apply both percentages directly to the original 1000 J.

WORKED ANSWER | TOTAL 6 MARKS

Q21: From a spring to a moving cart

Part (a) / 2

Ee = 0.5 × 400 × 0.15^2 (1); 4.5 J (1).

Part (b) / 3

Ek = 0.75 × 4.5 = 3.375 J (1); $v^2 = 2Ek/m = 2 \times 3.375/0.30 = 22.5$ (1); $v \approx 4.74$ m/s (1).

Part (c) / 1

4.5 - 3.375 = 1.125 J, or about 1.1 J (1).

Reasoning and worked method

First find the spring store, then apply the useful fraction, then use the kinetic-energy relation. Taking the square root is essential: 22.5 is v^2, not v. The remainder can be transferred to internal stores and sound without violating conservation.

Common error to avoid: Apply efficiency before solving for speed; do not multiply the ideal speed by 0.75.

WORKED ANSWER | TOTAL 6 MARKS

Q22: Heating with a stated efficiency

Part (a) / 2

ΔEwater = 0.60 × 4200 × 25 (1); 63 000 J (1).

Part (b) / 2

η = useful/input, so input = 63 000/0.84 (1); 75 000 J (1).

Part (c) / 2

t = Einput/Pinput = 75 000/250 (1); 300 s or 5.0 min (1).

Reasoning and worked method

The heater rating refers to input power, so the timing calculation must use input energy. The useful heating rate averaged over the run is 0.84 × 250 = 210 W; 63 000/210 also gives 300 s. Either route is valid if the energy and power correspond.

Common error to avoid: Do not divide useful water energy by input power without accounting for the stated efficiency.

WORKED ANSWER | TOTAL 6 MARKS

Q23: An apparent efficiency above one

Part (a) / 2

Water energy = 0.20 × 4200 × 20 = 16 800 J (1); implied η = 16 800/14 000 = 1.20 or 120% (1).

Part (b) / 2

The stated useful energy exceeds the stated complete input, inconsistent with conservation (1); a measurement/model error or an unaccounted energy input must be considered (1).

Part (c) / 2

For example calibrate/check the energy meter, or stir water and measure matched initial/final temperatures (1); this checks under-recorded input or an unrepresentative temperature change respectively (1).

Reasoning and worked method

An efficiency cannot exceed one when all inputs and the useful output are consistently defined. “Heat loss” alone does not explain an efficiency above one; ordinary losses would reduce the useful output for a given input. Check mass, c, energy calibration, temperature change and possible other energy sources.

Common error to avoid: Do not accept 120% as a new physical efficiency or blame every anomalous result vaguely on heat loss.

WORKED ANSWER | TOTAL 6 MARKS

Q24: Useful output depends on the purpose

Part (a) / 2

ηshaft = 600/1000 (1); 0.60 or 60% (1).

Part (b) / 2

Room gain = 600 + 300 = 900 J (1); ηroom = 900/1000 = 0.90 or 90% (1).

Part (c) / 2

Reduce transfer to outside, e.g. appropriate insulation at that boundary (1); useful output is defined by the room-heating task, so internal dissipation can count as useful here unlike unwanted motor heating for a shaft task (1).

Reasoning and worked method

The same energy account supports different useful fractions because the task changes. Nothing has been created in the 90% calculation: 900 J remains inside and 100 J crosses the room boundary. Design judgements must name their purpose and boundary rather than treating every internal temperature rise as waste.

Common error to avoid: Do not compare efficiency figures without checking what each calls useful output.

EXTENDED RESPONSE | 6 MARKS

E1: Compare model-building walls: model answer

Change only panel thickness, keeping wall area, material, building dimensions and other surfaces identical. Keep the maintained interior and outside temperatures the same, and control gaps, lids and airflow so those routes do not change between tests. Wait until the interior temperature is steady before starting the comparison. Measure heater input energy with a suitable joulemeter over the same known interval, then calculate mean power E/t as the steady loss rate. Repeat independent runs and compare mean rates with their spread. Use supervised low-voltage equipment, secure the heaters and protect against hot surfaces.

Credit points: one mark each

1. Vary thickness while controlling panel material and exposed wall area/geometry.
2. Control other loss routes such as lids, gaps and airflow.
3. Match inside/outside temperatures and wait for steady conditions.
4. Measure electrical input energy over a known comparable time and calculate E/t.
5. Repeat independent measurements and compare means/spread.
6. State a specific relevant safety control for the supervised low-voltage heaters or hot surfaces.

Improvement note: The steady-temperature condition makes input power a measure of total heat-loss rate. A fair comparison still needs the other surfaces and leaks controlled.

EXTENDED RESPONSE | 6 MARKS

E2: Evaluate energy statements: model answer

Statement 1 is incorrect: the energy has transferred to internal stores, often spread through the surroundings, and remains in the larger energy account. Statement 2 is incorrect because E = Pt depends on operating duration as well as power; a higher-power device running briefly can transfer less energy than a lower-power device running for longer. Statement 3 is incorrect: efficiency labels the useful fraction for an intended purpose, not the conserved fraction. The other 60% is transferred to other stores, so useful plus other transfers still equals the full input in a complete account.

Credit points: one mark each

1. Reject disappearance and identify a destination such as internal stores.
2. Explain dissipation as spreading into less useful stores while total energy is conserved.
3. Use E = Pt or an equivalent rate-time argument.
4. Explain that duration can reverse a comparison based on power alone.
5. Distinguish useful fraction from total energy conservation.
6. Account for the other 60% as other transfers so the input is fully accounted for.

Improvement note: Always identify the useful purpose and the system boundary. Unwanted for one task does not mean non-existent.

WORKED ANSWER | TOTAL 6 MARKS

T1: Raise a load

Part (a) / 2

W = mg = 8.0 × 10 (1); 80 N (1).

Part (b) / 2

ΔEp = 8.0 × 10 × 3.0 (1); 240 J (1).

Part (c) / 2

P = E/t = 240/6.0 (1); 40 W (1).

Reasoning and worked method

The ideal lifting work equals the gravitational energy gain. A steady speed gives no kinetic-energy change, but the lifting force still does positive work. Power is the useful transfer rate over the six-second lift.

Common error to avoid: Zero acceleration does not imply zero lifting work.

WORKED ANSWER | TOTAL 6 MARKS

T2: Two energy stores

Part (a) / 2

Ek = 0.5 × 0.20 × 4.0^2 (1); 1.6 J (1).

Part (b) / 2

Ee = 0.5 × 80 × 0.20^2 (1); 1.6 J (1).

Part (c) / 2

The stores are different: kinetic versus elastic potential (1); a stretched spring can store energy while stationary, whereas the cart’s kinetic energy is associated with motion (1).

Reasoning and worked method

The same unit joule is used for both stores, allowing energy accounts to compare them. Their equal numerical energies do not say the systems have the same mass, speed or configuration. Each equation describes a different physical state.

Common error to avoid: Do not describe a stationary stretched spring as necessarily having zero energy.

WORKED ANSWER | TOTAL 6 MARKS

T3: Account for a device input

Part (a) / 2

5000 - 3500 (1); 1500 J (1).

Part (b) / 2

η = 3500/5000 (1); 0.70 or 70% (1).

Part (c) / 2

It transfers to less useful stores such as internal stores of the surroundings (1); it remains part of a conserved total rather than being destroyed (1).

Reasoning and worked method

The input splits into useful and other transfers. Efficiency is not a conservation fraction: all 5000 J must be accounted for, even though only 3500 J is useful for the stated purpose.

Common error to avoid: Do not divide useful output by the 1500 J unwanted amount.

WORKED ANSWER | TOTAL 6 MARKS

T4: Heating and electrical input

Part (a) / 2

E = mcΔT = 0.30 × 4200 × 15 (1); 18 900 J (1).

Part (b) / 2

η = 18 900/21 000 (1); 0.90 or 90% (1).

Part (c) / 2

21 000 - 18 900 = 2100 J (1); transferred to heater/container/surroundings rather than the measured water store (1).

Reasoning and worked method

The measured temperature rise gives energy in the water. It is smaller than the total input, leaving a 2100 J remainder elsewhere. The arithmetic is consistent with conservation and an efficiency below one.

Common error to avoid: Use the supplied temperature change directly; no absolute final temperature is needed.

WORKED ANSWER | TOTAL 6 MARKS

T5: Energy in two unit systems

Part (a) / 2

80 W = 0.080 kW and E = Pt (1); 0.080 × 2.5 = 0.20 kWh (1).

Part (b) / 2

Time = 2.5 × 3600 = 9000 s (1); E = 80 × 9000 = 720 000 J (1).

Part (c) / 2

Energy halves to 0.10 kWh or 360 000 J (1); E is proportional to time at fixed P (1).

Reasoning and worked method

Both unit routes represent the same transfer. The power rating is a rate; the operating duration determines the accumulated energy. A kilowatt-hour is neither a current nor a power rating.

Common error to avoid: Convert W to kW for kWh, or hours to seconds for joules.

WORKED ANSWER | TOTAL 6 MARKS

T6: Two-stage useful transfer

Part (a) / 2

ηoverall = 0.75 × 0.80 (1); 0.60 or 60% (1).

Part (b) / 2

Useful = 0.60 × 1200 (1); 720 J (1).

Part (c) / 2

Input = useful/η = 1800/0.60 (1); 3000 J (1).

Reasoning and worked method

The first stage delivers three quarters of the initial energy to the second, which passes on four fifths of that. Multiplication therefore gives the overall fraction. To recover required input, divide useful output by that fraction.

Common error to avoid: Do not average or add the efficiencies.

WORKED ANSWER | TOTAL 6 MARKS

T7: Recover energy during slowing

Part (a) / 2

Ek = 0.5 × 500 × 20² (1); 100 000 J (1).

Part (b) / 2

Stored = 0.36 × 100 000 (1); 36 000 J (1).

Part (c) / 2

Puseful = 36 000/12 (1); 3000 W or 3.0 kW (1).

Reasoning and worked method

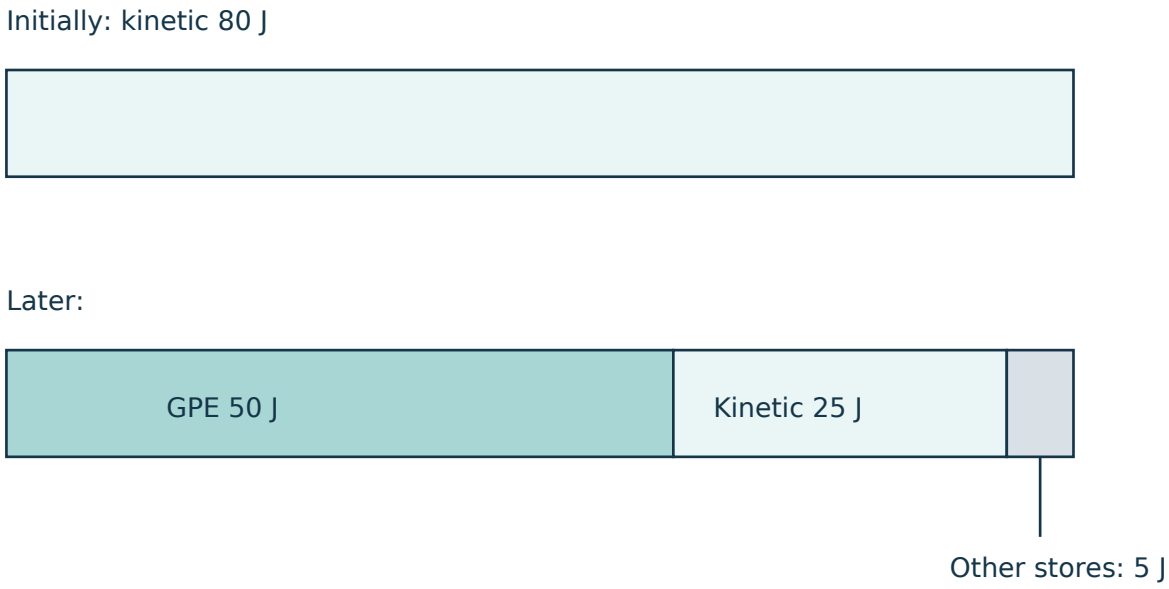
Only the 36% useful share is used for battery recovery power. The remaining 64 000 J is transferred elsewhere in the stopping process. The battery gains chemical energy through an electrical transfer; it is not a permanent store called current.

Common error to avoid: Do not use the full initial kinetic energy as the useful battery output.

Q2 | STORES AND TOTALS

A closed energy account

The diagram compares initial kinetic energy with the later distribution. Both horizontal bars represent a total of 80 J.



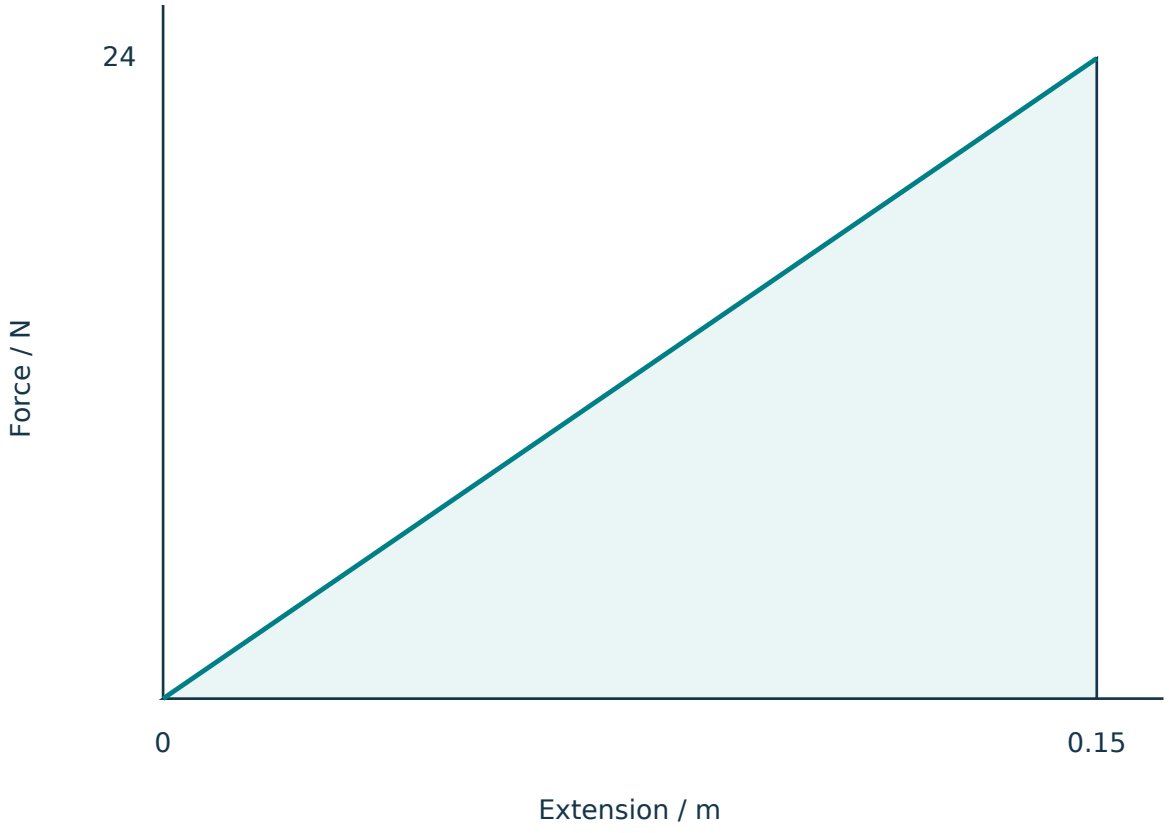
80 J = 50 J + 25 J + 5 J. The larger closed system conserves energy. Dissipation shifts some energy into less useful stores and does not delete it. The gravitational energy reference is the launch height.

A store is a way energy is held, such as kinetic, elastic, gravitational, chemical or internal. Mechanical work, electrical work, heating and radiation describe transfer pathways.

Q6 | FORCE-EXTENSION AREA

Spring-work reference

For a linear spring the force increases from zero. Work is the triangular area under the force-extension line.

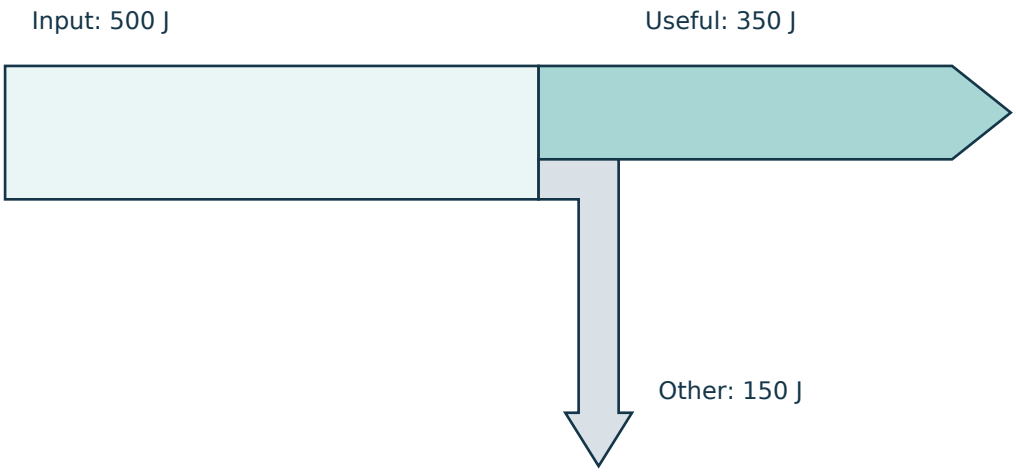


Final force = kx = 160 × 0.15 = 24 N. Energy = ½ × base × height = ½ × 0.15 × 24 = 1.8 J, matching ½kx². Using 24 N throughout would double the true linear-spring work.

Q11 | USEFUL AND OTHER OUTPUTS

Energy-transfer reference

The useful and other branches together account for the full input. Branch stem widths show the 350:150 division, or 70:30.



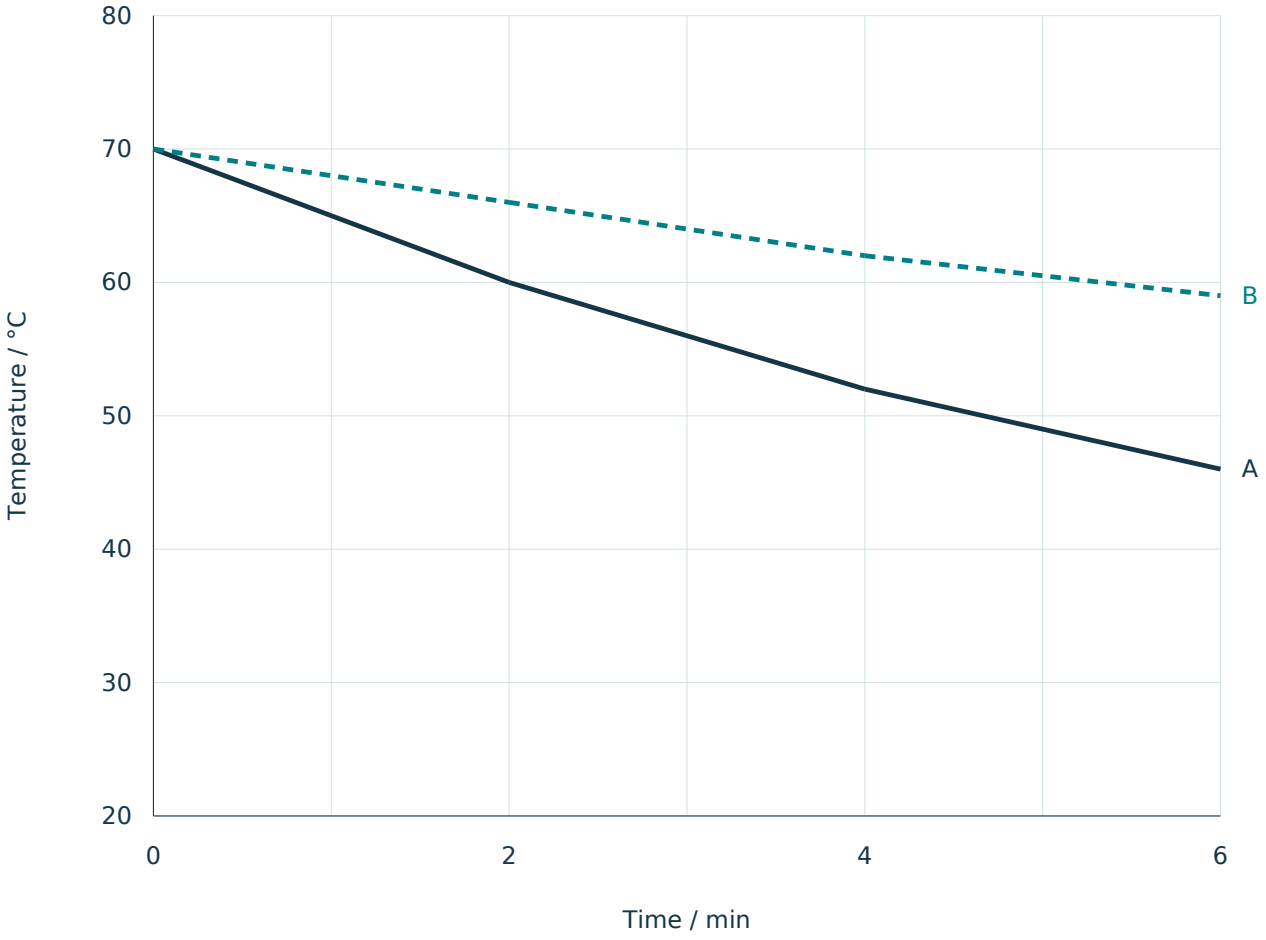
Efficiency = 350/500 = 0.70 = 70%. Other transfer = 150 J. The full 500 J remains accounted for. Whether a transfer is useful depends on the intended task.

The arrowhead shape indicates direction; use stem widths and labels when interpreting the energy quantities. Unwanted energy commonly raises internal stores of the device and surroundings.

Q16 | GRAPH AND ENERGY CHECK

Cooling-curve reference

A is solid; B is dashed. Both begin at 70 °C, with the same water mass and room conditions.



A loses 18 °C over its first 4 min: E = 0.25 × 4200 × 18 = 18 900 J from its water. B cools more slowly in the matched comparison. Temperature drop alone is not an energy comparison if mass or specific heat capacity differs.

HIGHER | PURPOSE, BOUNDARY AND INPUT

Design and multistage checks

Motor comparison: Q19

Design	Useful	Input	Efficiency	Other
A	360 J	600 J	60%	240 J
B	360 J	450 J	80%	90 J

Same useful output makes input comparison meaningful. For a shaft task, reducing frictional heating can increase the useful fraction. A cooler casing alone is not an input-energy measurement.

Two stages: Q20

1000 J input → stage 1 at 80% → 800 J → stage 2 at 75% → 600 J final useful output. Stage 1 other transfer = 200 J; stage 2 other transfer = 200 J.

Overall efficiency = 0.80 × 0.75 = 0.60. Input for a required useful output is E_{useful}/η. Do not add percentages or compare absolute losses without considering each stage's input.

Purpose changes the account: Q24

The shaft-task fraction is 600/1000 = 60%. For the stated room-heating task, shaft work eventually dissipated inside plus direct internal heating gives 900/1000 = 90%. Both are consistent with the same conservation account.