

Energy transfers and conservation

Name: _____ Class: _____ Date: _____

Start here

0-5 minutes

Today: Account for conserved energy, explain dissipation and choose the correct system boundary.

You need: Pen, a different-coloured pen, ruler and calculator. Reading, diagram and all data are supplied.

Work from memory. Write directly in this booklet and show working where needed.

1. A complete device account has 150 J input, 90 J useful transfer and no other source or store decrease. Find the remaining unwanted transfer.

Working and remaining transfer:

2. A moving object slows and its brakes/nearby surroundings warm. Has its kinetic energy been destroyed? Explain.

3. A heater's task is to warm water. Its water and outer casing both warm. Which thermal-store increase is useful for that task?

Stop for check 1. Wait for your teacher before moving on.

Try again A

Only if directed. Use the first 2 reading minutes, then continue on page 2.

Help: Use page 2: balance the complete energy account, name receiving thermal stores and decide usefulness from the intended task.

(a) Input is 240 J; useful transfer is 150 J with no other supply. Find the remaining transfer. (b) A lamp warms its surroundings: has that energy been destroyed? (c) For a water heater, is warming the intended water useful or unwanted?

When your teacher says, turn to page 2.

Read the account and boundary rules

5-15 minutes

Energy can be transferred, stored or dissipated, but it is not created or destroyed. A decrease in one store must be accounted for by increases elsewhere and transfers across the chosen boundary. Dissipation spreads energy into less useful stores, often thermal stores of surroundings; the energy still exists.

Rule / word	Use it precisely
Same event and unit	Compare transfers/store changes over the same stated interval, in joules (J).
Complete account	Total input + store decreases = store increases + energy leaving the boundary. Do not count the same energy twice.
Closed system here	No energy enters or leaves the stated boundary. Internal redistribution can occur while its total stays constant.
Useful / unwanted	Decide from the intended task. Heating water can be useful; warming a casing can be unwanted.
Dissipated	Spread into less useful stores; not destroyed. Name the receiving objects and their thermal stores.

Worked model - the complete revision-note lift account

During one lift a battery's chemical store decreases by 600 J. The load's gravitational potential store increases by 420 J and thermal stores increase by 180 J. There are no other changes. Include battery, motor, load and surroundings in the account. Does it conserve energy? Name the useful increase and the pathway from battery to motor.

$420 + 180 = 600$ J, equal to the battery store decrease, so the full account conserves energy. The useful increase is the raised load's gravitational potential store; 180 J is dissipated to thermal stores. The battery transfers energy electrically to the motor. No new energy is created.

Before using a number

Name the boundary and whether a change stays inside or crosses it. A warm device can retain some thermal energy while other energy leaves by heating. Subtract every distinct internal increase once. To test a claimed complete account, add all gains/outgoing transfers and compare with all supplies/store decreases.

Adapted from PhysicsUK Energy Stores and Changes, section 4, with store/pathway support from sections 1 and 3. Online reading is optional. Optional online reading.

Turn to page 3 for question 4.

Check a closed-system account

15-20 minutes; begin practice at 20 minutes

4. A closed water-and-room system has no energy crossing its boundary. Hot water loses 180 J from its thermal store as the room gains 180 J. Which statement is correct? Choose a letter and justify the complete account.

- A. 180 J has been destroyed
- B. The water-and-room total decreases by 180 J
- C. The water-and-room total is unchanged
- D. The water's thermal store increases by 180 J

Chosen letter and whole-system reason:

Stop for check 2. Wait for your teacher before moving on.

Try again B

Only if directed. Complete this instead of questions 5-6; then answer questions 7-9 on page 4.

Help: Use the boundary and conservation rules on page 2. Count both the decrease and the receiving store's increase inside the stated boundary.

A different combined water-and-room system has no energy crossing its boundary. Water loses 300 J and room thermal energy gains 300 J. Find the change in the combined total and explain where the water's energy went.

Apply conservation to a hoist

For questions 5-6, a hand-cranked hoist receives 1000 J mechanically. The raised load gains 600 J gravitational potential energy (given). It starts and finishes at rest; there are no other changes except warming the hoist and surroundings.

5. Use the supplied hoist account to calculate energy transferred to thermal stores of the hoist and surroundings during the lift.

Working:

Thermal-store increase = J

6. The hoist becomes warm. Explain what happened to the energy you calculated in question 5 and why "destroyed energy" is wrong.

Continue with the dispenser questions on page 4.

Useful heating, cooling and a larger system

20-30 minutes

Questions 7-9 concern cleaning water and its dispenser. For question 7, use the initial heating interval before boiling. For question 8 the dispenser is unplugged; question 9 then specifies a larger closed boundary.

7. A dispenser is intended to warm cleaning water before boiling. Both water and the outer casing warm. Explain why one increase is useful and the other unwanted for this task.

8. The dispenser is unplugged and hot water cools in the room. Describe changes in the water and surroundings energy stores.

9. Now suppose the combined water-and-room system has no energy entering or leaving it. Explain how the water cools while the total energy of this larger system stays constant.

At about 30 minutes turn to page 5 for the independent check.

Pause and check the boundary

30-33 minutes

10. A boundary encloses a wind-up toy, including its spring, wheels and body. During one run the spring's elastic store decreases by 500 J, the kinetic store increases by 200 J and the toy's thermal store increases by 100 J. Heating is the only transfer across the boundary; no other inputs or store changes occur. Calculate energy leaving the boundary. Is this toy-only system closed for that interval? Explain.

Internal increases included in the account:

Energy leaving - working and unit:

Closed or not? Crossing transfer and reason:

Stop for check 3. Wait for your teacher before moving on.

Try again C

Only if directed. Complete this instead of questions 11-12; then continue with questions 13-16.

Help: Use page 2. Subtract all stated increases inside the boundary from the store decrease; the remainder crosses outwards. Do not count an internal increase again as outgoing energy.

Another toy-only boundary contains a spring, wheels and body. Spring energy decreases by 450 J; kinetic energy increases by 150 J and retained toy thermal energy by 50 J. Only heating crosses the boundary; no other changes occur. Find energy leaving and explain whether this system is closed.

After the check, start page 6. If you used C, leave questions 11-12 blank; questions 13-14 still use the supplied diagram/context.

Continue with Figure 2 on page 6.

Read and test the energy account

33-45 minutes - continue practice

Figure 2 is a separate cold-start dispenser test. Its only supply is the stated electrical input; no other store decreases. "Other thermal transfers" warm the casing/surroundings. Equal blocks share one energy scale; thin arrows link the account, not a physical direction or quantitative width.

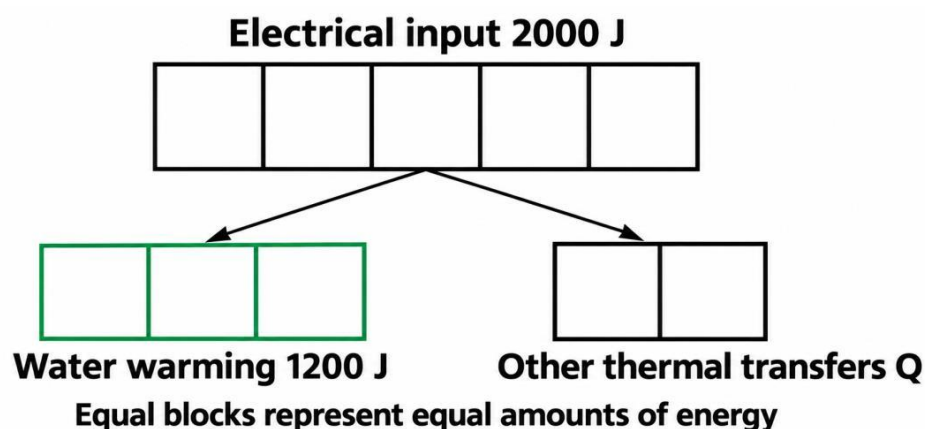


Figure 2: equal blocks represent equal energy amounts. This account is for one complete test interval.

11. Calculate Q, the missing energy in Figure 2.

Working and Q:

12. Explain why the two lower strips together must account for all five input blocks in Figure 2's model.

13. A second record gives 2000 J input, 1200 J to water and 950 J to other thermal stores. Use a calculation to explain why it does not fit the stated model.

Total recorded outputs and difference from input:

Reason the record does not fit:

14. Do the diagonal arrows in Figure 2 mean energy must travel diagonally downwards through the real dispenser? Explain.

Finish practice with the explanations on page 7.

Explain dissipation and a new hoist

Finish practice by 45 minutes

15. For the dispenser's task of warming cleaning water, explain what makes energy dissipated to the room less useful.

16. In a new hoist test a descending counterweight loses 900 J of gravitational potential energy. A second load gains 320 J of gravitational potential energy; the rest increases thermal stores. Explain why the raised load's gain does not create energy, using a calculation. Both loads start/end at rest; there are no other changes.

Store that decreases and amount:

Thermal-store increase - working and unit:

Complete account and conservation explanation:

Check the language

Name the object and store when saying where energy goes. "Less useful" depends on the intended task; it does not mean the energy ceases to exist.

At 45 minutes turn to page 8 for review, then complete the final check.

Review, then show what you can do

45-55 minutes review; 55-60 minutes independent exit

17. Correct practice in a different colour and explain one correction using an energy account, named store or boundary. If all answers were correct, explain how a system can lose energy across its boundary without energy being destroyed.

Independent exit - only when your teacher says

Cover earlier pages and previous answers. Complete question 18 independently.

18. A boundary encloses a lifting device, its load and the room. In one interval 900 J enters electrically; the load's gravitational potential store increases by 500 J and device-and-room thermal stores increase by 300 J. The remaining Q leaves that boundary by sound. No other changes occur. (a) Calculate Q. (b) Is this device-load-room system closed during this interval? Use the crossing transfers. (c) Is the 300 J thermal increase destroyed, and does it help the load-lifting task?

(a) Sound energy Q - working and unit:

(b) Closed or not? Transfers across boundary:

(c) Where the thermal energy remains:

Useful/unwanted for the stated task, with reason:

Stop for check 4. Wait for your teacher before moving on.

Write your name on page 1. Hand in the complete booklet with working and corrections.

Try again D - next lesson

Leave this today. Your usual teacher may direct it next lesson.

Help: Next lesson revisit page 2's account, boundary and usefulness rules. Cover the reading before this new independent attempt.

Next lesson: a different boundary encloses a lifting device, its load and the room. It receives 800 J electrically; raised-load energy increases by 350 J and device-and-room thermal stores by 300 J. Remaining energy leaves that boundary by sound; there are no other changes. Find the sound energy, decide whether this system is closed and explain whether the thermal energy is destroyed or useful for lifting.

Hand your complete booklet to your teacher.