

1.5 Conservation and dissipation of energy

Name: _____ Class: _____ Date: _____

Total: 21 marks

KEY WORDS dissipated • closed system • Lubrication
 • Thermal insulation • thermal conductivity

Objective

Explain conservation and dissipation, reason about closed systems, explain why real results fall short of calculations, and describe RP2 (thermal insulators) with its controls. Original questions for spec statement 4.1.2.1 and required practical 2 (physics only).

1 Key knowledge and worked examples

Energy can be transferred usefully, stored, or dissipated, but never created or destroyed. Dissipated energy is stored in less useful ways – usually spread into thermal stores of the surroundings. “Wasted” energy still exists.

Closed system : no energy enters or leaves. The total energy of all the stores stays the same – a falling ball in an evacuated tube is close to closed.

The three-step “lower than calculated” answer – learn this shape:

1. **Cause:** air resistance / friction between moving parts / energy transferred to the surroundings by heating.
2. **Mechanism:** some energy from the input store is dissipated into (less useful) thermal stores.
3. **Consequence:** less energy arrives in the intended store, so the real height / speed / temperature is lower.

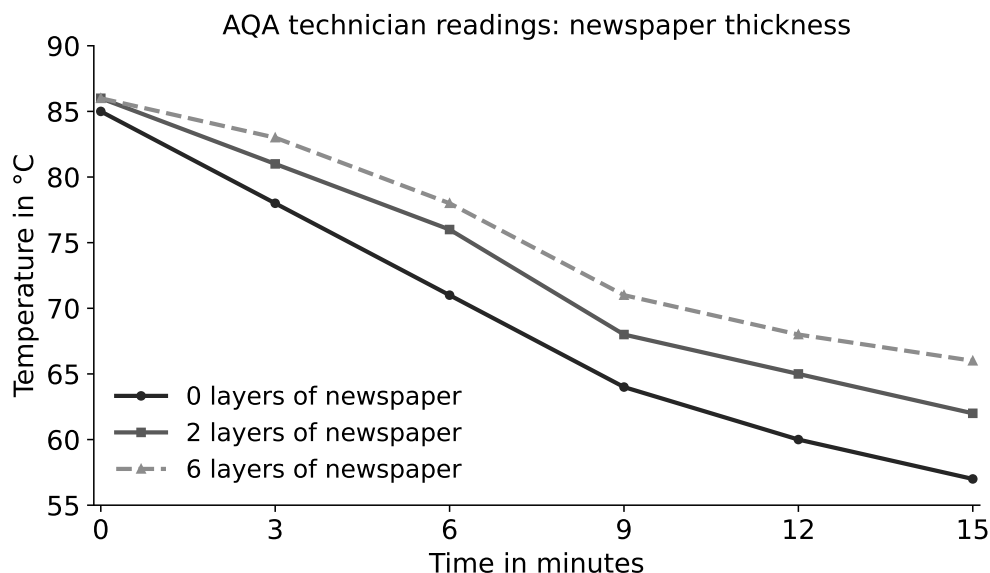
Reducing unwanted transfers:

Method	Works on	How it works
lubrication	friction between moving parts	less energy dissipated by heating
thermal insulation	transfer by heating	slows the transfer away

Thermal conductivity (no definition needed): the higher the thermal conductivity, the higher the rate of energy transfer by conduction across the material. A building cools more slowly with **thick** walls and **low-conductivity** walls. Dou-

bling thickness halves the rate of transfer through the wall (same material, same temperature difference).

RP2: effectiveness of thermal insulators (physics only).



The best insulator keeps the water hottest.

- **Part 1 – different materials, same thickness:** wrap a beaker of hot water in each material; record temperature against time for a fixed period (or time to cool by a fixed amount); smallest temperature fall = most effective.
- **Part 2 – different thicknesses of one material:** repeat with 0, 2, 4, 6 layers; more layers = slower cooling.
- **Controls:** same volume of water, same starting temperature, same beaker, same lid, same time intervals, same thermometer.
- **Independent variable:** the material (or thickness). **Dependent variable:** temperature change in the fixed time (or time for a fixed fall).

Worked example. Two insulating materials, same thickness: material X's water cools by 20 °C in 450 s; material Y's in 745 s. Which material has the higher thermal conductivity?

- Y's water cooled more slowly (745 s for the same fall), so Y transferred energy to the surroundings at a lower rate.
- Same thickness, same area, same temperature difference – the only difference is the material.
- So **X has the higher thermal conductivity:** it conducted energy across it faster.

2 Practice

2.1 A ball bounces on the floor and rises to a lower height each bounce. Explain, in terms of energy stores, where the “missing” energy goes. [2]

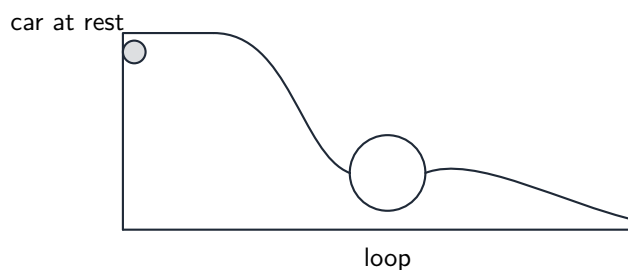
2.2 State what is meant by a closed system. [1]

2.3 A house loses energy through its walls. Give two changes to the walls that would reduce the rate of energy transfer, and name the property each change reduces. [2]

3 Exam-style questions

3.1 A toy car is released from rest at the top of a track and does a loop. A student calculates that the car needs 0.20 J of kinetic energy at the bottom of the loop to complete it. In the real run, the car needs *more* than 0.20 J.

Explain why the real car needs more kinetic energy. Your answer should link the cause to the energy stores involved. [3]



3.2 A student investigates insulating materials. The method: wrap a can of boiling water in one material; measure the time for the temperature to fall by 20 °C; repeat for the same thickness of each material.

(a) Identify the independent variable and the dependent variable. [2]

(b) Give two control variables. [2]

(c) The student uses two thermometers, A and B. Thermometer A has scale divisions of 2 °C; thermometer B has divisions of 0.5 °C. Give one reason why B gives more reliable readings. [1]

(d) Material X: 450 s to fall 20 °C. Material Y: 745 s. Explain what these results show about the thermal conductivity of X compared with Y. [2]

(a) Plot or sketch a results table row for each fill and state which fill is the best insulator. Justify your choice with the numbers. [3]