4.1 Energy transfers and thermal transfer

Name: _____ Class: _____ Date: _____ **Total: 23 marks**

Objective

Build the skills to answer exam questions on **energy transfers and thermal energy** : energy stores and transfers, conservation of energy, efficiency and Sankey diagrams, and conduction, convection and radiation.

You must be able to:

- describe energy stores and how energy is transferred between them
- calculate efficiency and interpret Sankey diagrams
- explain conduction, convection and radiation
- plan a fair test of insulating materials

1 Key knowledge and worked examples

Energy

idea	equation or rule
conservation	energy cannot be made or destroyed, only transferred between stores
stores	kinetic, gravitational, elastic, thermal, chemical, magnetic, electrostatic, nuclear
efficiency	useful energy output ÷ total energy input ×100
Sankey diagram	the width of each arrow shows the amount of energy
thermal transfer	conduction (particles pass on vibrations), convection (warm fluid rises), radiation (infrared waves)

Worked example 1: efficiency. A motor uses 800 J and gives 200 J of useful kinetic energy. Find its efficiency.

1. Known: useful 200 J; input 800 J.
2. Rule: useful ÷ input ×100.
3. Numbers: $200 \div 800 \times 100$.
4. Result: 25%.

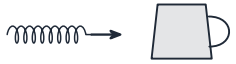
Worked example 2: wasted energy. A lamp is 15% efficient and uses 60 J. Find the wasted energy.

1. Known: input 60 J; efficiency 15%.
2. Rule: useful = efficiency × input; wasted = input − useful.
3. Numbers: useful $0.15 \times 60 = 9$ J; $60 - 9$.
4. Result: 51 **J wasted** (as heat).

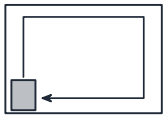
Answer shapes: say which store the energy leaves, which it goes to, and how it is transferred.

2 Practice

2.1 Name the energy store in a stretched spring, and the store that increases when water is heated. [2]



2.2 Explain why warm air rises above a heater. [2]

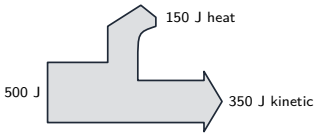


2.3 Which surface is the best emitter of infrared radiation: matt black or shiny silver? Which is the best absorber? [2]



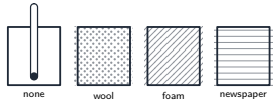
3 Exam-style questions

3.1 The Sankey diagram shows the energy transfers in an electric motor. Calculate the efficiency of the motor, and state what happens to the wasted energy. [3]



3.2 A student fills four beakers with water at 80 °C. Three are wrapped in different materials. She measures the temperature after 10 minutes. The results are shown.

(a) Calculate the mean rate of cooling of the unwrapped beaker in °C per minute. [2]



wrapping	none	wool	foam	newspaper
final temperature / °C	62	72	74	69

(b) Calculate the percentage reduction in the temperature drop when foam is used instead of no wrapping. [3]

(c) Explain why foam is a good insulator. [3]

(d) Describe how the student should make this investigation a fair test, and how she could improve its accuracy. [6]

Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

- elastic (potential) store
- thermal store

2.2

- the warm air expands, so it becomes less dense
- the less dense air rises and cooler, denser air sinks to take its place (convection)

2.3

- best emitter: matt black
- best absorber: matt black

3.1

- $350 \div 500 \times 100 = \mathbf{70}\%$
- the wasted energy heats the motor and its surroundings, and spreads out (is dissipated)

3.2

(a) drop $= 80 - 62 = 18\,^{\circ}\text{C}$; $18 \div 10 = \mathbf{1.8}\,^{\circ}\text{C}$ per minute

(b) foam drop $= 6\,^{\circ}\text{C}$; $(18 - 6) \div 18 \times 100 = \mathbf{67}\%$

(c) foam contains many small pockets of trapped air; air is a poor conductor; the air cannot move, so convection is reduced

(d) points to include:

- use the same volume of water and the same starting temperature in each beaker (App)
- use identical beakers and the same thickness of each material (App)
- put a lid on each beaker, or no lid on any (App)
- measure the temperature at the same times, e.g. every minute, for the same total time (K)
- use a digital thermometer or temperature probe and data logger for accuracy (App)
- repeat the test and find mean temperature drops; plot cooling curves (An)

Levels: **5–6** a full, logical answer with correct physics and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.