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.

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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).

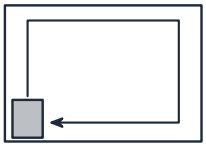
Answer shapes: say which store the energy leaves, which it goes to, and how it is transferred.

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]



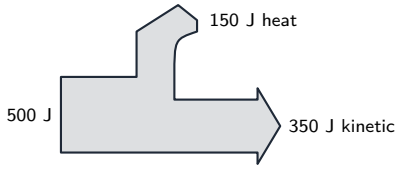
2.3 Which surface is the best emitter of infrared radiation: matt black or shiny silver? Which is the best absorber? [2]



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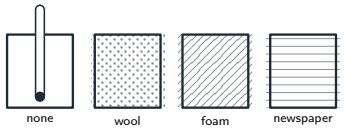
3 Exam-style questions

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]

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(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]

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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.

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