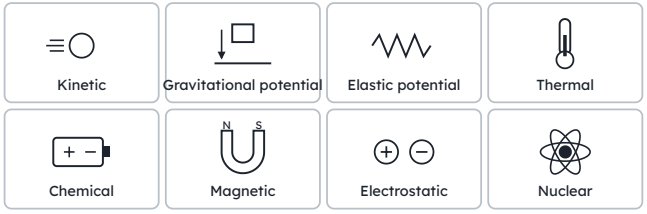
4.1 Energy

ENERGY STORES AND SYSTEMS

- A **system** is an object or group of objects. When a system changes, energy is transferred between stores.
- Energy is transferred by heating, by waves, by an electric current, or by a force doing work.
- **Conservation of energy:** energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed.
- In a **closed system** there is no net change to the total energy.
- Wasted energy is **dissipated**, usually to the thermal store of the surroundings.

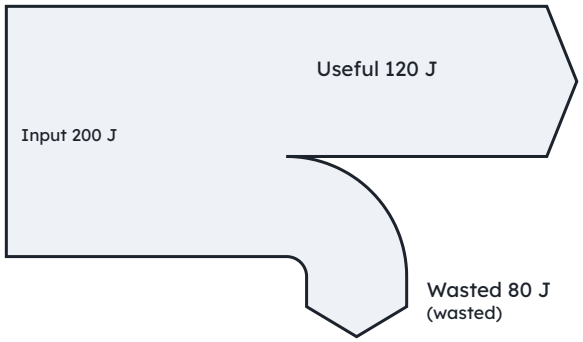
THE EIGHT STORES



POWER AND EFFICIENCY

- **Power** is the rate at which energy is transferred, or the rate at which work is done. 1 W = 1 J/s.
- Two motors lifting the same load: the more powerful one does it faster.
- **Efficiency** = useful output ÷ total input (energy or power). Never more than 1 (100%).
- Reduce waste: **lubrication** (less friction), **thermal insulation**, streamlining.
- Higher **thermal conductivity** → higher rate of energy transfer by conduction. Thick walls with low thermal conductivity slow the rate of cooling of a building.

SANKEY DIAGRAMS



Arrow widths are drawn to scale. Efficiency here = 120 ÷ 200 = 0.6 (60%).

SPECIFIC HEAT CAPACITY

The amount of energy required to raise the temperature of 1 kg of a substance by 1 °C. Water has a high specific heat capacity.

ENERGY RESOURCES

Type	Examples
Renewable	wind, solar, hydro-electricity, tides, water waves, geothermal, bio-fuel (replenished as used)
Non-renewable	coal, oil, gas (fossil fuels), nuclear fuel: reliable but will run out; fossil fuels release CO_2
Reliability	wind and solar depend on weather; tides are predictable; fossil fuels and nuclear meet demand at any time

EXAM TIPS

- Say energy is **dissipated** or **wasted**, never 'lost' or 'used up'.
- Square the speed in Ek before multiplying.
- Convert kW → W and minutes → s first.

MODEL EXPLANATIONS (GRADE 7+ ANSWERS)

Why does a car's brakes get hot when it stops?
The car's kinetic energy store decreases because friction between the brakes and wheels does work, transferring energy to the thermal store of the brakes. The energy is dissipated to the surroundings by heating, so it's less useful, but the total energy stays the same (conservation of energy).

How does loft insulation keep a house warm for longer?
Insulation has a low thermal conductivity, so the rate of energy transfer by conduction is lower. Less energy is transferred out of the house per second. The rate of cooling depends on the thickness and thermal conductivity of the walls and roof: thicker insulation with lower conductivity means slower cooling.

Why is it impossible for any device to be 100% efficient?
Some energy is always dissipated (wasted), usually by heating the surroundings. So the useful output is always less than the total input. e.g. a motor: friction in the bearings and current in the wires heat the motor and surroundings, so energy ends up stored in less useful ways.

RP2: THERMAL INSULATION (PO)

Aim: Investigate the effectiveness of different materials as thermal insulators, and the factors that may affect the thermal insulation properties of a material (such as its thickness).

Change	Type of material (or number of layers)
Measure	Temperature drop over a fixed time
Control	Starting temperature, volume of water, beaker size, time, lid

Must include:

- Investigate a factor such as thickness (number of layers)
- Control the volume and starting temperature of water
- Measure temperature at regular intervals for a fixed time
- Use a lid
- Compare the temperature change for each material

Common mistake: Starting the timer at different temperatures.

4.1 Energy

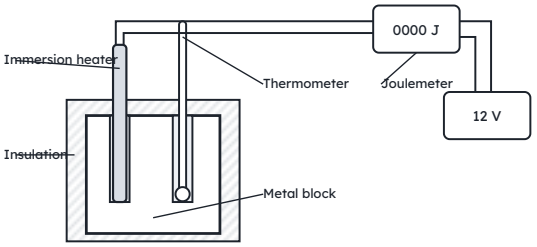
KEY EQUATIONS (ALL ON THE PHYSICS EQUATIONS SHEET)

Equation	Quantities (units)	Watch out
$E_k = \frac{1}{2} m v^2$	kinetic energy (J), mass (kg), speed (m/s)	Square the speed first
$E_p = m g h$	gravitational potential energy (J), mass (kg), g (N/kg), height (m)	g = 9.8 N/kg is given in the question
$E_e = \frac{1}{2} k e^2$	elastic potential energy (J), spring constant (N/m), extension (m)	Extension in metres
$\Delta E = m c \Delta\theta$	change in thermal energy (J), mass (kg), specific heat capacity (J/kg °C), temperature change (°C)	$\Delta\theta$ = final – start temperature
P = E ÷ t	power (W), energy transferred (J), time (s)	kW → W, minutes → s
P = W ÷ t	power (W), work done (J), time (s)	Work done = energy transferred
efficiency = useful output energy transfer ÷ total input energy transfer	no unit (or %); also works with power	Never more than 1 (100%)

KEY WORDS

System: an object or group of objects.
Conservation of energy: energy can be transferred usefully, stored or dissipated, but cannot be created or destroyed.
Dissipated: energy transferred to the surroundings so it is stored in less useful ways; often called 'wasted'.
Specific heat capacity: the amount of energy required to raise the temperature of 1 kg of a substance by 1 °C.
Power: the rate at which energy is transferred, or the rate at which work is done.
Thermal conductivity: the higher it is, the higher the rate of energy transfer by conduction across a material.
Efficiency: useful output energy transfer ÷ total input energy transfer.
Renewable resource: one that is being (or can be) replenished as it is used.

RP1: SPECIFIC HEAT CAPACITY



Aim: Determine the specific heat capacity of one or more materials, such as aluminium and copper blocks, by linking the energy transferred by the heater (work done) to the increase in temperature and thermal energy stored.

Change	Energy transferred (J)
Measure	Temperature (°C)
Control	Mass of block, insulation, power of heater

Must include:

- Measure mass with a balance
- Insulate the block
- Measure energy with a joulemeter or E = VIt
- Record temperature at regular intervals
- Calculate c = ΔE ÷ (mΔθ) or from the gradient

Common mistake: Forgetting to convert mass to kg or time to seconds.

MISCONCEPTIONS

× **Energy gets used up.**	✓ Energy is never used up; it's transferred to other stores, often dissipated.
× **Heat and temperature are the same.**	✓ Temperature is a measure of hotness; energy is transferred by heating.
× **A machine can be 100% efficient.**	✓ Some energy is always dissipated, so efficiency is less than 1.

AIM FOR GRADE 7+

- Combine equations: Ep lost = Ek gained → v = √(2gh).
- Explain why measured specific heat capacity is too high (energy dissipated → smaller Δθ).
- Evaluate energy resources: give both sides and a justified conclusion.

COMMAND WORDS

State	a short answer, no explanation
Describe	say what happens, in order
Explain	say what and why: use "because" and "so"
Calculate	equation, substitution, answer, unit
Evaluate	both sides, then a justified conclusion

QUICK-FIRE QUIZ: COVER THE ANSWERS

Unit of specific heat capacity?	**J/kg °C**
Unit of power?	**Watt (W)**
Store that increases when a spring is stretched?	**Elastic potential**
Value of g on Earth?	**9.8 N/kg**
Way to reduce friction?	**Lubrication**
A reliable renewable resource?	**Tidal, hydroelectric or geothermal**