SHEET 1 - HEAT & TEMPERATURE

The foundation: know what heat is, what temperature is, and how they differ.

1. Core definitions

• Heat: energy transferred from a hotter body to a colder body because of a temperature difference.

• Temperature: a measure of how hot or cold a body is; microscopically it relates to the average kinetic energy of particles.

• Thermal equilibrium: two bodies are in thermal equilibrium when they have the same temperature and there is no net heat transfer between them.

2. The key distinction

Heat	Temperature
Energy transferred between bodies.	A measure of thermal state.
Measured in joules (J).	Measured in degrees Celsius (deg C) or kelvin (K).
Depends on the amount of substance and the temperature change.	Does not directly tell you how much thermal energy the whole body contains.

3. Temperature scales

For temperature differences, a change of 1 deg C is equal in size to a change of 1 K. For absolute temperature: T(K) = T(deg C) + 273 (approximately).

4. Particle model

• Heating a substance generally increases particle motion (average kinetic energy) unless energy is being used in a change of state.

• Cooling removes thermal energy; particles generally move less vigorously.

5. UCE exam traps

Do not say heat is “contained” in a body. In physics, heat is energy transferred because of a temperature difference. A body stores internal energy.

EXAM CHECK: Be ready to define heat, temperature, and thermal equilibrium in one or two precise sentences.

SHEET 2 - HEAT CAPACITY & SPECIFIC HEAT CAPACITY

One equation explains most numerical questions in this section.

1. Specific heat capacity, c

The energy required to raise the temperature of 1 kg of a substance by 1 K (or 1 deg C).

Q = mc delta T

Q = heat energy (J), m = mass (kg), c = specific heat capacity (J kg^-1 K^-1), delta T = temperature change (K or deg C).

2. Heat capacity, C

The energy required to raise the temperature of the whole body by 1 K.

C = Q / delta T and C = mc

Quantity	Meaning	Unit
Q	Heat energy	J
m	Mass	kg
c	Specific heat capacity	J kg^-1 K^-1
C	Heat capacity	J K^-1
delta T	Temperature change	K or deg C

3. Worked example

A 2 kg aluminium block with c = 900 J kg^-1 K^-1 is heated from 20 deg C to 70 deg C. Find Q.

delta T = 70 - 20 = 50 deg C

Q = 2 x 900 x 50 = 90,000 J

4. High-yield meaning

- A substance with a high c needs a lot of energy for a given temperature rise.
- Water has a high specific heat capacity, so it is useful where a large amount of heat must be absorbed with only a modest temperature rise.

EXAM CHECK: When you see mass + specific heat capacity + temperature change, immediately think Q = mc delta T.

SHEET 3 - METHOD OF MIXTURES

The central principle is conservation of energy.

1. Core principle

When a hot object is mixed with a cooler substance in an insulated setup, assume:

Heat lost = Heat gained

This is the basis of calorimetry / method of mixtures questions.

2. Standard setup

- Hot object starts at a higher temperature.
- Cooler object or water starts at a lower temperature.
- They exchange energy until they reach the same final temperature.
- If heat losses to the surroundings are neglected, energy lost by the hot body equals energy gained by the cool body.

3. General equation

m1 c1 (T1 - Tf) = m2 c2 (Tf - T2)

Use the temperature differences as positive amounts of heat lost and heat gained.

4. Worked example

A hot metal of mass 0.20 kg and c = 400 J kg^-1 K^-1 cools from 90 deg C to 30 deg C. How much heat does it lose?

Q = mc delta T = 0.20 x 400 x (90 - 30) = 4,800 J

In a mixture question, those 4,800 J would be the heat gained by the cooler part, subject to the stated assumptions.

5. Common mistakes

- Using grams instead of kilograms when c is in J kg^-1 K^-1.
- Using the initial temperature instead of the temperature change.
- Forgetting that the final temperature is common to both substances.

EXAM CHECK: Write “heat lost = heat gained” before starting any calorimetry calculation. It helps structure the whole question.

SHEET 4 - CHANGE OF STATE

Understand what happens to temperature and particle energy during melting, freezing, boiling, and condensation.

1. The four common changes

Change	From -> To
Melting	Solid -> Liquid
Freezing	Liquid -> Solid
Boiling / vaporisation	Liquid -> Gas
Condensation	Gas -> Liquid

2. Heating curve idea

During a temperature-rise section, added energy increases particle kinetic energy, so temperature rises. During a flat section, the substance is changing state: supplied energy is used to overcome intermolecular attractions, so temperature remains constant.

3. The two equations to separate in your mind

Temperature changes: Q = mc delta T

State changes: Q = mL

4. Why temperature can stay constant

- Particles are still receiving energy.
- The energy is being used mainly to separate or rearrange particles / overcome intermolecular forces rather than increase average kinetic energy.
- After the state change is complete, further heating can raise the temperature again.

5. Fast identification rule

Look at the question	Use
“temperature rises/falls”	Q = mc delta T
“melts/freezes/boils/condenses”	Q = mL (during the state change)
Both occur in sequence	Calculate each stage separately and add the energies

EXAM CHECK: A flat section on a heating curve means change of state at constant temperature, not “no energy is supplied.”

SHEET 5 - SPECIFIC LATENT HEAT

This is the second major heat calculation area.

1. Definition

Specific latent heat is the energy required to change the state of 1 kg of a substance without changing its temperature.

$$Q = mL$$

Q = heat energy (J), m = mass (kg), L = specific latent heat (J kg^-1).

2. Types

Type	State change	Typical idea
Specific latent heat of fusion	Solid <-> liquid	Melting or freezing
Specific latent heat of vaporisation	Liquid <-> gas	Boiling or condensation

3. Worked example

0.50 kg of a substance requires 110,000 J to melt completely at constant temperature. Find its specific latent heat of fusion.

$$L = Q/m = 110{,}000 / 0.50 = 220{,}000 \text{ J kg}^{-1}$$

4. Common conceptual question

Why does boiling water at 100 deg C have more energy than water at 100 deg C before boiling?

Because boiling requires additional energy to separate particles and change the liquid to gas. That extra energy is associated with latent heat; temperature does not have to rise during the phase change.

5. Exam traps

- Do not use Q = mc delta T during the actual phase-change plateau.
- Keep mass in kilograms when L is in J kg^-1.
- Fusion is solid <-> liquid; vaporisation is liquid <-> gas.

EXAM CHECK: If the wording says “without change in temperature,” think latent heat.

SHEET 6 - EVAPORATION

Evaporation is a surface process and is responsible for many everyday cooling effects.

1. Definition

Evaporation is the escape of molecules from the surface of a liquid into the gas phase. It can occur below the boiling point.

2. Why evaporation causes cooling

- Liquid molecules have a range of kinetic energies.
- The faster-moving molecules are more likely to escape from the surface.
- The molecules left behind have lower average kinetic energy.
- Therefore the liquid cools.

3. Factors that increase the rate of evaporation

Factor	Effect
Higher temperature	More molecules have enough energy to escape.
Larger surface area	More molecules are at the surface.
Moving air / wind	Removes vapour near the surface and speeds evaporation.
Lower humidity	Air can accept more water vapour.

4. Everyday applications

- Sweating cools the body.
- Wet clothes dry faster in moving air and warm conditions.
- Volatile liquids such as ether or alcohol can produce a strong cooling sensation on the skin.

5. Evaporation vs boiling

Evaporation	Boiling
Surface only	Throughout the liquid
Can occur at many temperatures	Occurs at a boiling point for a given pressure
Usually slower	Rapid
No bubbles throughout the liquid	Bubbles form throughout

EXAM CHECK: The best explanation for evaporative cooling must mention high-energy molecules leaving the surface.

SHEET 7 - BOILING & VAPOUR PRESSURE

The key relationship is between a liquid's vapour pressure and the surrounding pressure.

1. Boiling point

A liquid boils when its vapour pressure becomes equal to the pressure acting on its surface (external pressure).

2. Effect of atmospheric pressure

- Higher external pressure -> higher boiling point.
- Lower external pressure -> lower boiling point.

3. Why water boils below 100 deg C on a high mountain

- Atmospheric pressure decreases as altitude increases.
- Water therefore needs a lower temperature for its vapour pressure to equal the surrounding pressure.
- So its boiling point falls below 100 deg C.

4. Pressure cooker application

A pressure cooker keeps pressure above ordinary atmospheric pressure. The boiling point of water increases, so food can cook at a higher temperature and often more quickly.

5. Vapour pressure - essential idea

Even below boiling, some liquid molecules escape and form vapour above the liquid. In a closed container, evaporation and condensation can balance, giving an equilibrium vapour pressure at a given temperature.

6. Exam language

Do not write: "Water boils because it reaches 100 deg C." A better general statement is: "A liquid boils when its vapour pressure equals the surrounding pressure." 100 deg C is the boiling point of water at approximately standard atmospheric pressure.

SHEET 8 - CONDUCTION

Conduction transfers thermal energy through a material without bulk movement of the material.

1. How it works

- In solids, closely packed particles transfer energy through collisions and vibrations.
- In metals, mobile electrons also help transfer thermal energy rapidly.

2. Good conductors vs insulators

Good conductors	Poor conductors / insulators
Copper	Wood
Aluminium	Plastic
Iron / steel	Air
Many metals	Foam and trapped gases

3. Factors affecting heat flow by conduction

A useful proportional relationship is:

Rate of heat transfer proportional to k A delta T / L

k = thermal conductivity, A = cross-sectional area, delta T = temperature difference, L = length/thickness.

- Higher k -> faster conduction.
- Larger A -> faster heat flow.
- Larger delta T -> faster heat flow.
- Larger L -> slower heat flow.

4. Applications

- Metal saucepan bases conduct heat from a flame/hot plate to food.
- Plastic or wooden handles reduce conduction to the hand.
- Insulating layers reduce heat loss from buildings.

EXAM CHECK: For a conductor-comparison question, state the material and explain in terms of thermal conductivity, not just "it is a metal."

SHEET 9 - CONVECTION

Convection is heat transfer by the actual bulk movement of a fluid.

1. Where convection occurs

Convection occurs in liquids and gases because these fluids can move from one place to another.

2. The convection cycle

- Fluid is heated.
- It expands and becomes less dense.
- The warmer, less-dense fluid rises.
- Cooler, denser fluid sinks to replace it.
- The continuous circulation forms a convection current.

3. Simple example - water in a pan

Water at the bottom is heated -> it expands -> density decreases -> it rises. Cooler water descends -> reaches the heat source -> warms and rises. This repeats.

4. Convection in air

- Warm air above a heater rises.
- Cooler air moves in to replace it.
- The circulation distributes thermal energy through the room.

5. Sea and land breezes

- Land and water heat/cool at different rates.
- The resulting density differences can create convection currents in the air.

6. Key contrast

Method	Main mechanism
Conduction	Energy transfer through a material; no bulk flow.
Convection	Bulk movement of a fluid carries thermal energy.
Radiation	Electromagnetic waves transfer energy; no medium required.

EXAM CHECK: Whenever you explain convection, include density, rising warm fluid, and sinking cool fluid.

SHEET 10 - RADIATION

Radiation is thermal energy transfer by electromagnetic waves and does not require a material medium.

1. Core idea

- Thermal radiation is mainly in the infrared part of the electromagnetic spectrum.
- Radiation can travel through a vacuum.
- That is how energy from the Sun reaches Earth.

2. Surface properties

Surface	Absorber / emitter behaviour
Dull black	Good absorber and good emitter of thermal radiation.
Shiny / polished	Poor absorber and poor emitter; good reflector.

3. Why shiny surfaces are useful

A shiny surface reflects a large fraction of thermal radiation, reducing net radiative heat loss. This principle is used in reflective insulation and thermos flasks.

4. Comparing the three methods

Conduction	Convection	Radiation
Best in solids	In fluids	Can occur through a vacuum
Particle-to-particle transfer	Bulk fluid motion	Electromagnetic waves
No bulk movement required	Requires fluid movement	No medium required

5. Everyday examples

- Feeling heat from a fire without touching it.
- Sunlight warming the ground.
- Dark surfaces warming strongly in sunshine.

EXAM CHECK: If the question asks which heat-transfer method can occur through empty space, the answer is radiation.

SHEET 11 - THERMAL INSULATION

Insulation reduces unwanted heat transfer by reducing conduction, convection, and radiation.

1. Main idea

- Use poor conductors or trapped air to reduce conduction.
- Prevent air movement to reduce convection.
- Use shiny surfaces to reduce radiative transfer.

2. Thermos flask - what each part does

Part / feature	Purpose
Double walls with vacuum between	Greatly reduces conduction and convection.
Silvered / shiny surfaces	Reduce radiation by reflecting thermal radiation.
Cork / plastic stopper	Reduces conduction through the opening.
Narrow neck	Reduces surface area for heat transfer and limits convection.

3. Buildings and clothing

- Foam, wool, and fibrous materials trap air and reduce heat conduction.
- Double glazing reduces heat transfer through windows.
- Thick clothing traps air close to the body, reducing heat loss.

4. Big exam connection

Good insulation does not “stop heat.” It reduces the rate of heat transfer.

5. Quick diagnosis

Problem	Best feature
Heat through a solid wall	Low thermal conductivity / thick insulating layer
Heat moved by air currents	Trap or stop air movement
Radiation from hot surfaces	Shiny reflective surface

EXAM CHECK: A strong thermos-flask answer links each design feature to a specific heat-transfer mechanism.

SHEET 12 - UCE HEAT EXAM PRACTICE

Use this page to test whether you actually understand the high-yield ideas.

A. Must-know formulas

Situation	Formula
Temperature change	Q = mc delta T
Heat capacity	C = Q / delta T = mc
Change of state	Q = mL
Mixtures	Heat lost = heat gained
Electrical heating	E = Pt
Conduction (relationship)	Rate proportional to kA delta T / L

B. Mini practice - calculation

1. Calculate the heat needed to raise 2 kg of water from 20 deg C to 70 deg C. Take c = 4200 J kg^-1 K^-1.

2. A 0.50 kg material absorbs 50,000 J while melting. Find its specific latent heat.

3. A 0.20 kg metal with c = 400 J kg^-1 K^-1 cools from 90 deg C to 30 deg C. Find the heat lost.

Answers: 1) 420,000 J 2) 100,000 J kg^-1 3) 4,800 J

C. Mini practice - explanations

- Why does evaporation cool a liquid?
- Why does water boil at a lower temperature on a high mountain?
- Why does temperature remain constant during melting?
- Why is copper used for good heat conduction?
- Why can the Sun heat Earth even though space is nearly a vacuum?

Model answer keywords

Evaporation: high-energy molecules escape from the surface -> lower average kinetic energy -> cooling.
Mountain boiling: lower atmospheric pressure -> vapour pressure equals external pressure at a lower temperature.
Melting: supplied energy is used for the change of state / overcoming intermolecular forces, not raising temperature.
Conduction: copper has high thermal conductivity.
Sun: energy travels by electromagnetic radiation, which does not require a medium.

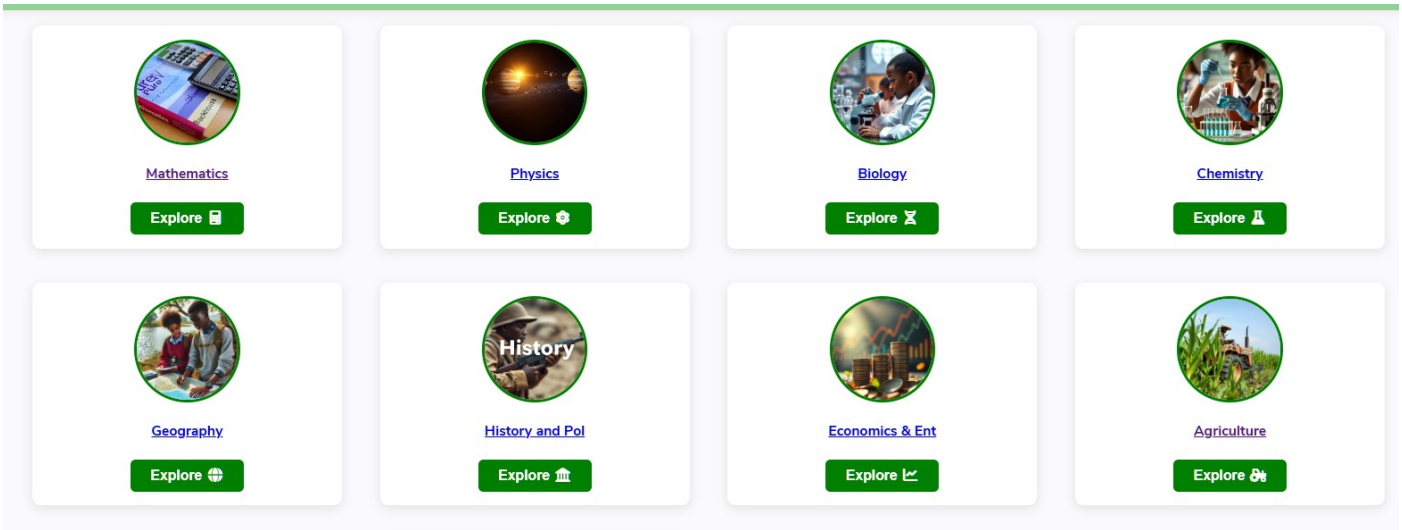
D. 60-second memory map

Temperature changes -> mc delta T | State changes -> mL | Mixtures -> lost = gained

Conduction = through material | Convection = moving fluid | Radiation = EM waves

FINAL EXAM RULE: Read the wording first. Identify whether the question is about temperature change, state change, or a heat-transfer method before choosing a formula.

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