Emission and absorption of infrared radiation

4.6.3.1 · Waves · revision notes

All objects emit and absorb infrared radiation, and hotter objects emit more of it. You need to know what a perfect black body is and why it would be the best possible emitter. GCSE Physics only, not in Combined Science. This links closely to the required practical on infrared radiation from different surfaces.

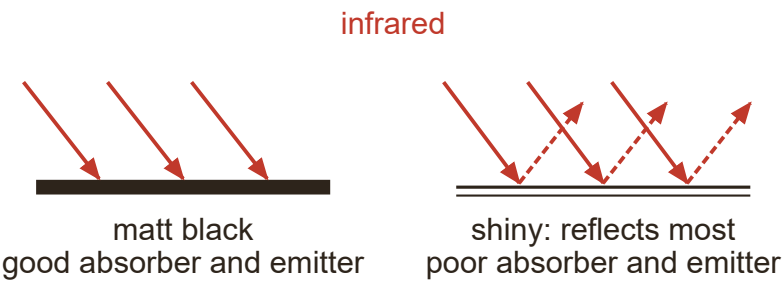
Key facts

- All bodies emit and absorb infrared, at any temperature
- Perfect black body: absorbs all of the radiation incident on it
- Good absorber = good emitter
- Matt black: best emitter and absorber; shiny silver: worst (good reflector)
- Hotter body → more infrared radiated in a given time
- A perfect black body does not reflect or transmit any radiation
- So a perfect black body would be the best possible emitter

Notes

Everything emits and absorbs infrared

- All bodies (objects) emit and absorb **infrared radiation**, whatever their temperature. Even an ice cube emits infrared.
- The **hotter** a body is, the **more** infrared radiation it radiates in a given time.
- The surface also matters. **Dark, matt** surfaces are good emitters and good absorbers of infrared. **Shiny** surfaces, such as polished metal, are poor emitters and poor absorbers, because they reflect most of the radiation that hits them.



A perfect black body would absorb all of it and reflect none.

Perfect black bodies

- A **perfect black body** is an object that **absorbs all** of the radiation incident on it (all the radiation that hits it).
- A black body does **not reflect or transmit** any radiation.
- A good absorber is also a good emitter. So a perfect black body, the best possible absorber, would also be the **best possible emitter**.
- A perfect black body is an ideal: some real objects come close, but none is perfect.

Everyday examples

- Solar water-heating panels are matt black so that they absorb as much of the Sun's radiation as possible.
- Buildings in hot countries are often painted white so they reflect more of the Sun's radiation and stay cooler.
- A shiny foil blanket helps to keep a person warm: its shiny surface emits little infrared and reflects the infrared emitted by the body back towards it.
- In the required practical, the matt black face of a Leslie cube emits the most infrared and the shiny silver face the least, even though they are at the same temperature.

How to answer each type of question

Compare the infrared emitted by two objects 2 marks **Grade 4**

1. Identify which object is hotter, or which has the better emitting surface.
2. Give the rule that explains it.

Example. Two identical metal cans contain water. One is at 80 °C and the other is at 40 °C. Which can emits more infrared radiation each second? Give a reason for your answer.

Model answer. The can at 80 °C (1). The hotter a body is, the more infrared radiation it emits in a given time (1).

Explain an everyday design choice 2 marks **Grade 5**

1. Name the surface and say whether it is a good absorber, emitter or reflector.
2. Link this to the effect (more energy absorbed, less emitted, stays cooler).

Example. Explain why a solar panel used to heat water is painted matt black.

Model answer. Matt black surfaces are the best absorbers of radiation (1). So the panel absorbs more of the Sun's radiation, transferring more energy to heat the water (1).

Define a perfect black body and explain why it is the best emitter 3 marks **Grade 5**

1. Definition: absorbs all of the radiation incident on it (reflects and transmits none).
2. Rule: a good absorber is also a good emitter.
3. Conclusion: so it is the best possible emitter.

Example. (a) What is meant by a perfect black body?
(b) Explain why a perfect black body would also be the best possible emitter of radiation.

Model answer.

(a) An object that absorbs all of the radiation incident on it (1)

(b) A good absorber is also a good emitter (1), so the best possible absorber is also the best possible emitter (1).

Don't lose marks

- Saying cold objects do not emit infrared. All objects do.
- Saying a black body is simply 'an object that is black'. It absorbs all of the radiation incident on it.
- Saying shiny surfaces are good emitters because they 'shine'. They are poor emitters and good reflectors.
- Saying a perfect black body reflects some radiation. It reflects none and transmits none.

More tips

Memory tricks

- 'Good at taking in, good at giving out': good absorbers are good emitters.
- A black body is like a perfect sponge for radiation: it soaks up all of it and bounces none back.
- Hotter means more infrared, every time, and even cold objects emit some.

Exam technique

- Use 'in a given time' or 'each second' when comparing how much infrared is emitted.
- When explaining a design, name the surface property, say whether it is a good absorber, emitter or reflector, and link it to the effect.
- Learn the definition of a perfect black body exactly: absorbs all of the radiation incident on it.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 **State that all objects emit and absorb infrared**
All bodies, whatever their temperature, emit and absorb infrared radiation.

Grade 4 **Link temperature to infrared emitted**
The hotter a body is, the more infrared radiation it radiates in a given time.

Grade 4 **Define a perfect black body**
An object that absorbs all of the radiation incident on it, and does not reflect or transmit any.

Grade 5

Identify good and poor emitters and absorbers

Dark, matt surfaces are good emitters and absorbers; shiny surfaces are poor emitters and absorbers because they reflect radiation.

Grade 6

Explain everyday designs using emission and absorption

E.g. solar water-heating panels are matt black so they absorb as much of the Sun's radiation as possible.

Grade 7

Explain why a black body emits best

A good absorber is also a good emitter, so a perfect absorber would be the best possible emitter.

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