

Black Body Radiation Notes

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Let's imagine for a moment that it's the height of summer and we're walking through a carpark on a hot sunny day. We touch a white car with our hand, it's warm but that makes sense as it's a warm and sunny day. We touch a different car, a black car, this car is really hot!!

What's going on here? Why is the temperature of the black car so much greater than the white car? We can explain this but it's going to take a moment 😊

The first thing that we need to know is that all objects can **absorb** (take in) and **emit** (give back out) **infrared radiation**. Infrared radiation is part of the electromagnetic spectrum.

The second thing to understand is what makes an object a good absorber or a good emitter of infrared radiation.

If an object is black and matte (dull) in colour it absorbs most of the infrared radiation that hits it. Only a little is reflected. If an object is white and shiny it reflects most of the infrared radiation that hits it. Only a little is absorbed.

So, the best absorbers and emitters of infrared radiation are black matte objects.

A perfect black body: an object that absorbs all radiation incident on it and does not reflect or transmit any. This makes it the best possible emitter of radiation.

Note: perfect black bodies don't actually exist. It's an idealised concept – meaning it's a simplified model used to help us understand something.

Why are there no perfect black bodies? As all materials, regardless of what they are, reflect some of the infrared radiation that hits it. Even if it reflects only the tiniest amount. They all reflect something.

In the example above, we used the black car to get across the idea of a perfect black body as they both have similarities as both absorb and reflect infrared radiation. But the black car in this example is not a perfect black body.

How does temperature affect radiation?

It isn't just the colour of an object that matters, its temperature is really important too!

The intensity and wavelength – as an object gets hotter, two things happen to the radiation it emits:

- It emits more radiation in a given time (the intensity increases).
- It emits radiation with a shorter wavelength. This is why a piece of metal heated in a fire will start by feeling hot (emitting invisible infrared), then glow red, and eventually glow white as it gets hotter and the wavelengths get shorter!

Constant temperature vs changing temperature

The balance of absorbing and emitting radiation changes an object's temperature. It all comes down to rates of absorbing and emitting 😊

Constant temperature: if an object is at a constant temperature, it is absorbing radiation at the exact same rate that it is emitting it.

Heating up: if an object absorbs radiation faster than it emits it, its temperature will increase.

Cooling down: if an object emits radiation faster than it absorbs it, its temperature will decrease.

Exam note: exam questions on this like to use the Earth as an example.

The temperature of the Earth relies on the balance between the radiation absorbed from the Sun and the radiation emitted back into space. If something (like greenhouse gases) slows down the rate of emission, the Earth heats up!