6.5 Black body radiation

Name: _____ Class: _____ Date: _____ **Total: 23 marks**

KEY WORDS wave

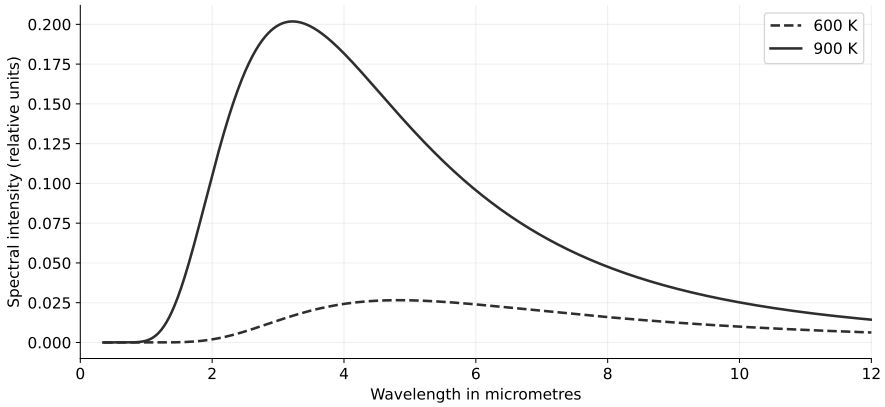
Objective

Explain emission and absorption of infrared, the perfect black body, temperature effects on emitted radiation, and (HT) the Earth's radiation balance. Physics only. Original questions for spec statements 4.6.3.1–4.6.3.2.

1 Key knowledge and worked examples

Core knowledge:

1. Bodies above absolute zero emit thermal radiation and can absorb infrared; everyday-temperature emission is largely infrared.
2. The hotter the body, **the more radiation it emits in a given time**.
3. A **perfect black body** absorbs **all** incident radiation – reflects nothing, transmits nothing.
4. A good absorber is a good emitter, so a perfect black body is the **best possible emitter**.
5. The **intensity and wavelength distribution** of the emitted radiation depend on the body's temperature – hotter shifts the peak to shorter wavelength and raises intensity.



(HT) **Balance**: when radiation is the only net energy transfer, a body at constant temperature absorbs radiation at the same rate it emits it. Absorption faster than emission → temperature rises; the reverse → falls.

(HT) **The Earth's temperature** depends on: the rate of absorption of incoming (mostly visible/UV) radiation, the rate of emission of infrared back to space, and reflection of radiation back into space (clouds, ice). Use these three factors to explain, e.g., melting ice reducing reflection and raising temperature.

Worked example (radiation-only model). A body absorbs 80 J each second and emits 50 J each second; other net transfers are negligible. The net energy gain is $E_{\text{net}} = 80 - 50 = 30$ J each second, so internal energy and temperature rise. At a later steady temperature, emission must be 80 J each second if absorption remains unchanged. Real objects may also exchange energy by conduction and convection.

2 Practice

2.1 State what happens to the amount of infrared a body emits as its temperature rises. [1]

2.2 Define a perfect black body. [2]

2.3 (HT) A body absorbs radiation faster than it emits it. State and explain the temperature change. [2]

3 Exam-style questions

3.1 Two otherwise identical cubes have matt black and shiny metal surfaces. The matt black surface absorbs and emits infrared more strongly. They receive equal infrared illumination and start at the same temperature. Use a radiation-only model.

(a) Explain which cube warms faster at the start. [2]

(b) After a long time both temperatures are steady. Explain what this shows. [2]

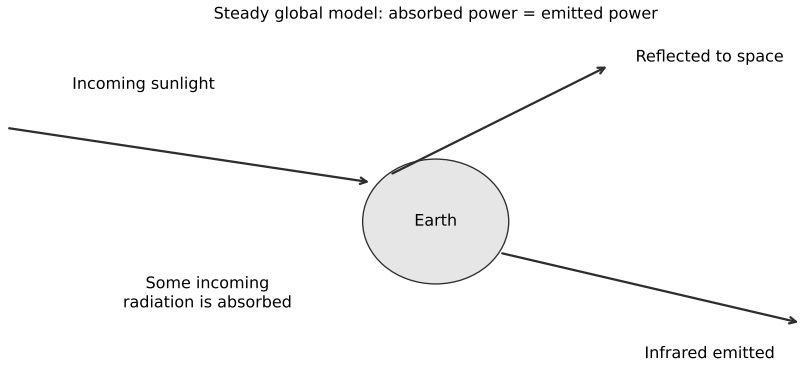
(c) Both cubes are reset to the same temperature above the surroundings and placed in shade, with other losses controlled. Explain why the matt black cube initially cools faster. [2]

3.2 The Earth absorbs radiation from the Sun and emits infrared into space.

(a) For an idealised Earth at steady average temperature, explain the required radiation balance. [2]

(b) Melting sea ice exposes dark ocean. Explain the effect on the Earth's temperature. [3]

(c) Give one factor, other than ice, that changes the reflection of radiation back to space. [1]



3.3 A student measures the radiation from a hot plate at two settings: the emitted intensity increases when the plate's temperature rises, and the peak wavelength moves from 4.0 μm to 2.0 μm.

(a) State two ways the emitted radiation changed. [2]

(b) Explain what the shift in peak wavelength shows about the distribution of emitted wavelengths. [2]

(c) The plate is polished to a mirror finish. Explain the change in its emission, compared with a matt black plate at the same temperature. [2]