

Black body radiation and Earth temperature

AQA GCSE Separate Physics 8463 only | Paper 2 | Foundation and Higher routes

Per chosen route: 23 parts | 44 marks | Estimated/untrialled 35–40 min +15–20 review

Specification points covered

4.6.3.1: infrared emission and absorption; perfect black bodies (both tiers)

4.6.3.2: temperature and emission distributions (both tiers); radiation balance and Earth/atmosphere temperature (Higher only)

An Earth-observation team checks its radiation detector using reference surfaces, then interprets model evidence. Use measurements and radiation ideas to challenge claims in the team's report.

Complete sections 1–3, then ONE route: Foundation sections 4–5 (pages 4–5), OR Higher sections 6–7 (pages 6–8). Do not do both. Detector signals use arbitrary units, not temperature units. Figure 1 is qualitative; no radiation laws are needed.

1 Checking reference surfaces

The team uses a coated metal reference plate. A perfect black body is an ideal model; an ordinary black-looking finish need not behave perfectly.

1(a) Coating P reflects some of the radiation incident on it. Explain why P cannot be a perfect black body. **[1 mark]**

1(b) A trainee writes: "A perfect black body is a poor absorber and cannot emit radiation." Correct the two errors. **[2 marks]**

1(c) The reference plate is at 20°C and does not visibly glow. Explain why that does not mean it emits no radiation. **[2 marks]**

1(d) The same plate is tested at 20°C, 50°C and 80°C. At which temperature does it emit infrared at the greatest rate? Give a reason. **[1 mark]**

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1 Checking reference surfaces continued

1(e) A hot small sample gives a different signal from a cooler large sample. Before attributing the difference to their surface finishes, state two conditions the team must make equal. **[2 marks]**

2 Interpreting emission curves

Figure 1 compares equal emitting areas of two ideal black bodies. A is solid and B is dashed. The same axes are used for both; there are no numerical scales.

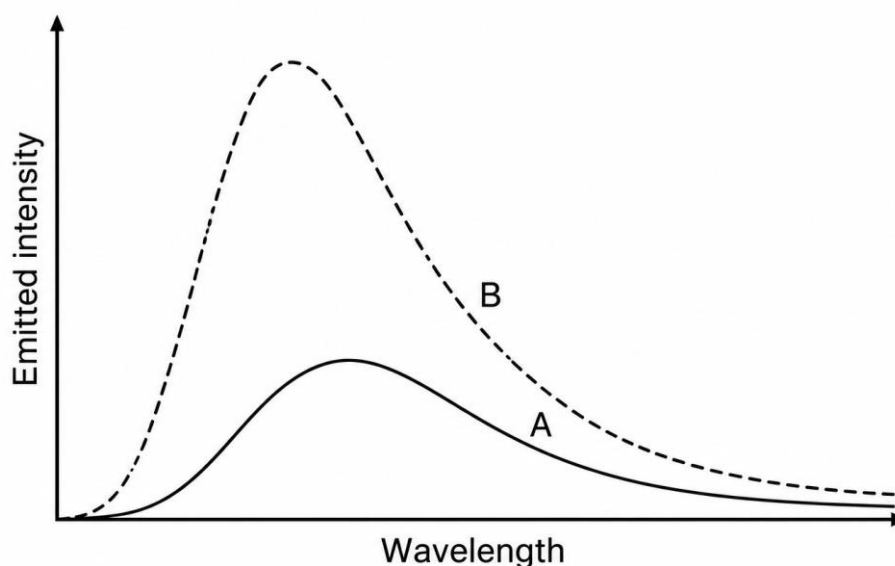


Figure 1

2(a) Which body is hotter, A or B? Give two features of its curve that support your choice. **[2 marks]**

2(b) A colleague says B emits only the wavelength at its peak. Use the shape of the curve to correct this claim. **[2 marks]**



2 Interpreting emission curves continued

2(c) B is cooled until its curve becomes A. State the changes in peak wavelength and peak intensity. [2 marks]

2(d) Can the team calculate a numerical temperature in °C from Figure 1 alone? Explain your answer. [1 mark]

2(e) At the same chosen wavelength where both curves are visible, which equal-area body emits more intensely? Refer to the graph. [1 mark]

3 Checking the detector evidence

Table 1 gives background-corrected detector signals. M and S have different finishes but the same 60°C temperature, emitting area, distance and orientation. Readings are in arbitrary units.

Table 1

Finish	Reading 1 / units	Reading 2 / units	Reading 3 / units
M	44	46	45
S	14	16	15

3(a) Calculate the mean signal for M. [1 mark]

3(b) Calculate the mean signal for S. [1 mark]

3(c) Calculate the ratio of M's mean signal to S's. Explain why it is not the ratio of their temperatures. [2 marks]

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3 Checking the detector evidence continued

3(d) Which finish gives the stronger reference signal under these conditions? Does that prove it is a perfect black body? Explain both answers. **[2 marks]**

3(e) An unknown sample with a different finish gives the same signal as M. A technician assigns it 60°C without further tests. Explain why the assignment is not justified. **[2 marks]**

3(f) A shield is placed between M and the detector. The corrected signal falls to zero. Explain why that does not prove M has stopped emitting. **[2 marks]**

4 Foundation route comparing model surfaces

FOUNDATION REPLACEMENT: complete sections 4–5 only after sections 1–3. Skip Higher sections 6–7. Two model-surface samples P and Q have identical finishes, areas and viewing geometry. Their corrected signals are 12 and 24 units respectively.

4(a) Which model sample, P or Q, is hotter? Predict how its peak wavelength compares with the other sample. **[2 marks]**

4(b) Q gives twice P's signal. Evaluate the claim that Q's temperature in °C must therefore be twice P's temperature. **[2 marks]**

4(c) A third sample R has an unknown finish and gives 30 units. Can the team safely conclude that R is hotter than Q? Explain. **[2 marks]**

4(d) The team only has a visible-light photograph of a candidate reference surface. State what measurement would give useful evidence about its infrared emission, and one comparison condition that must be controlled. **[2 marks]**

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6 Higher only radiation balance

HIGHER REPLACEMENT: complete sections 6–7 instead of Foundation sections 4–5. Table 2 gives simplified model-planet rates at the same initial temperature, per square metre of the same reference area. Use the whole planet plus atmosphere as the system. No other energy transfers are included.

Table 2

Model	Incoming sunlight / W/m^2	Reflected sunlight / W/m^2	Outgoing thermal / W/m^2
P	320	80	240
Q	320	100	240
R	320	60	240

6(a) Calculate the rate of sunlight absorption for P. Use the emitted rate to explain its initial temperature behaviour. **[2 marks]**

6(b) Predict whether Q and R initially warm or cool. Support each prediction with the absorbed and emitted rates. **[2 marks]**

6(c) R eventually reaches a new constant temperature with incoming and reflected sunlight unchanged. State its outgoing thermal rate and explain why constant temperature does not mean radiation transfers stop. **[2 marks]**

6(d) A reference plate in shade absorbs 30 W/m^2 and initially emits 50 W/m^2 . Explain its initial temperature change and how its emission changes as it approaches a steady temperature. Assume absorption stays at 30 W/m^2 . **[2 marks]**

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7 Higher only surface and atmosphere

Figure 2 shows selected radiation paths, not a complete energy budget. Some sunlight reaches the surface. The atmosphere absorbs some surface infrared and emits infrared towards space and towards the surface. Other paths, including reflection and direct escape, are omitted. Arrow widths are not proportional to rates.

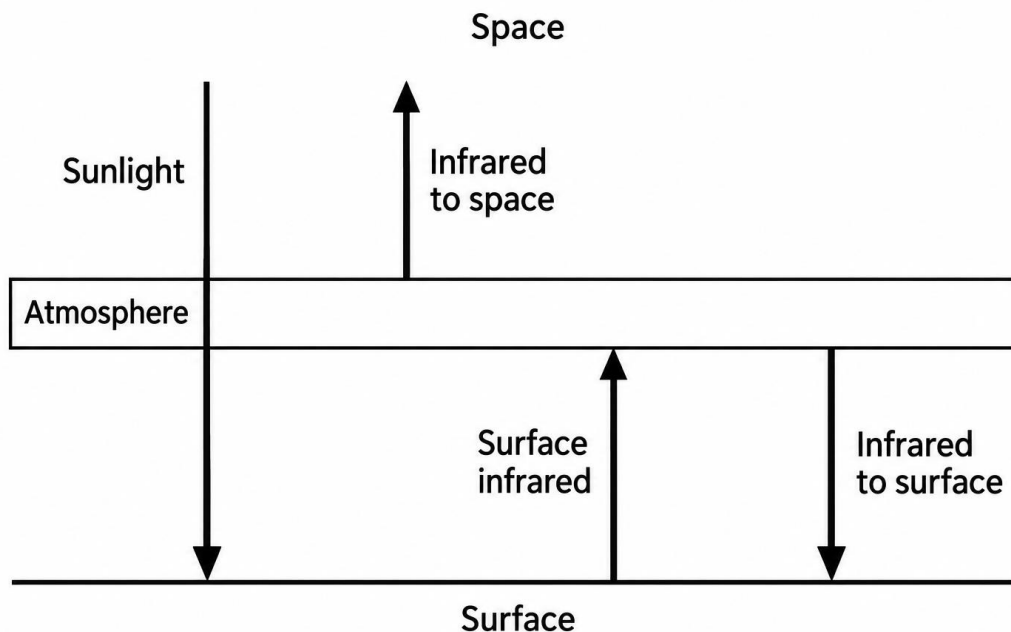


Figure 2

7(a) Does the downward “Infrared to surface” arrow show the atmosphere acting as a mirror? Explain the process represented. **[2 marks]**

7(b) For a 1 m^2 surface patch, absorbed sunlight is 200 W and absorbed atmospheric infrared is 100 W ; the patch emits 300 W . Atmospheric input then rises to 125 W before the surface temperature changes. Calculate the initial net energy gain per second and predict the temperature change. **[2 marks]**



