

# 5.2 Greenhouse effect and energy balance (full B.2)

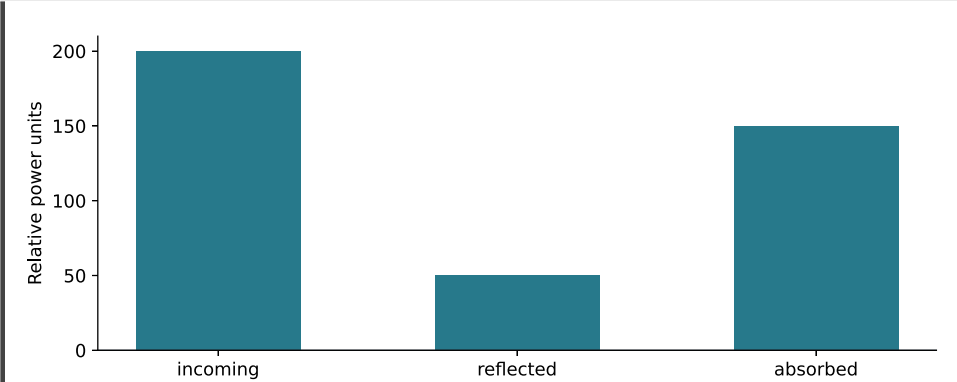
Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_ **Total: 23 marks**

**KEY WORDS** emissivity • albedo • enhanced greenhouse effect

## Objective

Practise the full guide B.2 toolkit: emissivity and albedo definitions, the solar constant with the S/4 disc-to-sphere averaging, equilibrium temperature from energy balance, the four named greenhouse gases with their natural and human origins, molecular-energy-level absorption with re-emission in all directions, the resonance model, and the enhanced greenhouse effect. Original practice; not an official IB paper.

## 1 Key knowledge and worked examples



### ■ The energy-balance toolkit

$$\text{emissivity} = \frac{\text{power radiated per unit area}}{\sigma T^4} \qquad \text{albedo} = \frac{\text{total scattered power}}{\text{total incident power}} \qquad \langle I \rangle = \frac{S}{4}$$

Equilibrium: absorbed incoming = radiated outgoing, so  $(1 - \text{albedo})\frac{S}{4} = e \sigma T^4$ .

**Worked check.** A planet with  $S = 586 \text{ W/m}^2$ , albedo 0.25, emissivity 0.90: absorbed  $= 0.75 \times 586/4 = 110 \text{ W/m}^2$ ;  $T = (110/(0.90 \times 5.7 \times 10^{-8}))^{1/4} = 215 \text{ K}$ .

Greenhouse gases absorb infrared via molecular energy-level transitions and re-emit in all directions; human enhancement is the enhanced greenhouse effect.

## 2 Practice

**2.1** Define emissivity. [1]

**2.2** Define albedo and name two factors that change Earth’s albedo daily. [3]

**2.3** Explain why the mean incoming solar intensity is S/4, not S. [2]

**2.4** Name the four main greenhouse gases. [4]

**2.5** State what the enhanced greenhouse effect is. [1]

## 3 Exam-style questions

**3.1** A planet orbits at a distance where  $S = 2200 \text{ W/m}^2$ , with albedo 0.40 and emissivity 1.0. Calculate its equilibrium temperature, stating the balance equation you used. [4]

**3.2** Explain, in terms of molecular energy levels, how CO<sub>2</sub> absorbs outgoing infrared and why this raises the surface temperature above the equilibrium value in 3.1-style balance. [4]

**3.3** A surface radiates  $300 \text{ W/m}^2$  at  $300 \text{ K}$ . Calculate its emissivity ( $\sigma = 5.7 \times 10^{-8} \text{ W} \cdot \text{m}^{-2} \cdot \text{K}^{-4}$ ), and the power a black body of the same area and temperature would radiate. [4]

---

---

---

---