Station Card: Planetary Climate Sandbox

Energy balance and the greenhouse effect (toy model)

Dr. Anna Rosen

Name: _____ **Section:** _____

Date: _____

Station: _____ **Group members:** _____

Goal: Use the demo to make a claim supported by (1) at least one number/readout and (2) at least one sanity check.

Demo: `/demos/planetary-climate-sandbox/`

This station is about **energy in = energy out** and how **greenhouse strength changes infrared escape**.

Use **full redistribution (global average)** unless the prompt says otherwise.

Part A — Solar System comparison (2 minutes)

Load **Venus**, **Earth**, and **Mars** presets and record:

Planet	A (Bond)	T_{eq} (K)	τ_{IR}	T_{surf} (K)	$\Delta T = T_{surf} - T_{eq}$ (K)
Venus	_____	_____	_____	_____	_____
Earth	_____	_____	_____	_____	_____
Mars	_____	_____	_____	_____	_____

One sentence: Why is Venus so hot even though it reflects a lot of sunlight?

Part B — Albedo experiment (2 minutes)

Start from the **Earth** preset.

1. Increase Bond albedo from $A = 0.30$ to $A = 0.60$ (leave everything else unchanged).
2. Record the absorbed flux and the new T_{eq}:

Absorbed flux: _____ W/m^2
T_{eq}: _____ K

Claim: Increasing A makes T_{eq} (circle one): **warmer / cooler / unchanged**

Part C — Greenhouse experiment (2–3 minutes)

Return to the **Earth** preset.

1. Increase greenhouse strength from $\tau_{IR} = 0.49$ to $\tau_{IR} = 1.50$.
2. Record:

ε_{out}: _____
T_{surf}: _____ K
ΔT: _____ K

Claim: Increasing τ_{IR} makes T_{surf} (circle one): **warmer / cooler / unchanged**

> 💡 Word bank + sanity checks
>
> **Word bank:** - **Flux (W/m^2):** power per area. - **Bond albedo A (dimensionless):** fraction of incoming energy reflected. - **Equilibrium temperature T_{eq} (K):** the airless baseline set by absorbed starlight and emission to space. - **Optical depth τ_{IR} (dimensionless):** how hard it is for infrared to escape. - **Escape fraction ε_{out} (dimensionless):** effective to-space emissivity, $\varepsilon_{out} = e^{-\tau_{IR}}$.
> **Key relationships (model):**
>
> $$T_{eq} = \left[\frac{(1-A)L_\star}{16\pi\sigma d^2} \right]^{1/4}$$
>
> $$T_{surf} = T_{eq}\, e^{\tau_{IR}/4}$$
>
> **Sanity checks:** - If A
> $to1$, absorbed energy
> $to0$ so T_{eq}
> $to0$. - If
> $tau_{IR} = 0$, then
> $varepsilon_{out} = 1$ and $T_{surf} = T_{eq}$. - If d increases, flux falls as $1/d^2$, so T_{eq} decreases.