

**Instructions:** You are allowed to consult lecture slides, books and your own notes only. All abbreviations carry usual meaning. Partial marking will be given for calculation mistake, if the concept is correct. [ $\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$ ; Wien's constant = 2897.9 K  $\mu\text{m}$ ; Scale height (H) = 7.31 km; DALR = 9.8°C/km.]

1. A hypothetical spherical planet with radius 10000 km has its axis tilted at an angle 45° towards the star (with radius  $5 \times 10^6$  km) during aphelion and away from the star during perihelion. The planet is orbiting the star in a circular orbit (aphelion = perihelion =  $2 \times 10^9$  km). The temperature of the star is 10000 K. The planet has a homogeneous atmosphere composed only of the greenhouse gases that does not interact with SW radiation, but completely absorbs LW radiation. (Marks 2 + 2 + 2 + 1 + 2 = 9)

- Calculate the solar constant of the star.
- If the surface temperature of the planet is 300 K, estimate the planetary albedo.
- If the planet is forced by  $2 \text{ W m}^{-2}$ , calculate the increase in surface temperature assuming only Stefan-Boltzmann feedback.
- Calculate the SW radiation per unit area reaching the surface at 60° S latitude in this planet during aphelion.
- If GHG properties change in a way that they start absorbing 10% of SW radiation and allow the remaining 90% of SW radiation transmitting through, estimate TOA GHG SW radiative forcing.

2. The following weather parameters are reported at a northern hemisphere site. The sky is completely clear. South-easterly wind is blowing at a speed 9.25 km/hr. Surface pressure has not changed in the last 3 hours. (Marks 2 + 5 = 7)

Altitude (m)	Temperature (K)	RH (%)	Pressure (hPa)
Surface	288	100	Measured, but not reported
100	288	100	988.39
200	287.5	99	974.96

- What is the stability condition in the lowest 100 m of the troposphere?
  - Draw the weather station model for the conditions at the surface [no need to include any special weather event symbol].
3. Write True/False with brief explanation. (Marks 2 × 2 = 4)
- Seasonal contrast will remain same if the Earth's precession changes completely (from present-day), but the eccentricity and tilt remain same as of present-day.
  - Tropopause height is larger in the tropics than in the polar region.