Diploma in Astronomy—First Term 2005-6

Solar System: Problem Paper 2.

1st November 2005

Solutions should be returned by Tuesday 15 November. After that date they can be accepted, but once model solutions are posted, they cannot receive credit for marks (but can count towards completion of the course). The weighting for each question is given in ().

1. A (fictitious) superior planet, Kreplach, was observed from Earth by the ancient Gladhandians over many centuries. They found an average synodic period of 982.657 days between oppositions. Assuming the sidereal period of Earth is 365.256 days (as given in lectures), calculate the sidereal period of Kreplach. (5)

2. Use the results from (1), plus Kepler's third law, $P^2 = ka^3$, to deduce the semi-major axis a of Kreplach's orbit in astronomical units. Explain your choice of units and state what value of k should be adopted (see lecture notes). How does Kreplach's a compare with Mars' ($a = 1.524$ AU)? (5)

3. In the lectures on Earth we talked about the Greenhouse Effect and the way in which a planet's expected mean temperature can be calculated. Assume that Kreplach is a "terrestrial" planet with a nearly circular orbit. Use the semi-major axis of Kreplach's orbit from (2), assume that its rotation period is 15.5 Earth hours (what does this imply for the temperature calculation?), assume that its Bond Albedo is 0.29, and assume that it has a Greenhouse temperature increase of 27 degrees K due to CO_2 and H_2O in its atmosphere.

Deduce the mean temperature of Kreplach. Comment on whether it is possible for liquid water to exist on the surface. (10)

Hint: Remember that the Solar Constant for Earth, 1367.5 watts/m^2, does not apply to Kreplach; you will need to use the Inverse Square Law to deduce the energy received per square metre at Kreplach's distance from the Sun (see Chapter 19-2). You may scale the value for Earth if you wish, as long as you do this correctly (it's much easier calculation).

Total marks possible for Paper 2: 20