2B27 Problem Sheet 2

To be handed in by 3 March 2005

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Solar Constant for the Earth = 1373 W m^{-2}
Pressure of the atmosphere = 10^5 Pa
Specific Gas Constant for air = 286.9 J kg^{-1} K^{-1}
Density of the atmosphere = 1.24 kg m^{-3}
Specific heat of air = 1000 J kg^{-1} K^{-1}
Density of water = 1000 kg m^{-3}
Latent Heat of water = 2.5 x 106 J kg^{-1}
$,_0$ = Permittivity of free space = 8.8542 x 10^{-12} F m^{-1}
q, charge on the electron = 1.6022 x 10^{-19} C
Stefan Boltzmann constant = 5.6703 x 10^{-8} W m^{-2} K^{-4}

Not all of these constants might need to be used!!

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1) Calculate the solar constant for the planet Mars given that its mean distance from the Sun, a, is 1.523 AU (i.e. 1.523 times that of Earth). The perihelion and aphelion are the nearest and farthest points from the Sun. The relative distances from the Sun are given by a(1-e) and a(1+e) where e is the orbital eccentricity. Calculate the difference in solar energy influx between perihelion and aphelion given that e for Mars is 0.093. (4 points)
If the albedo of Mars is 0.150, calculate the effective temperature of the planet. (2 marks)
The actual temperature at the surface is a few degrees warmer than this. Given that the predominant gas in the atmosphere is CO_2, suggest why this may be and describe the mechanism that warms it (3 marks).
Given the average surface temperature above, discuss what you would expect to happen to any water released onto the surface. The triple point of water is 273.16K. (3 marks)

2) A cylindrical cloud with diameter 5 km and height 5 km contains about 10^8 raindrops per cubic metre. If the mean radius of a raindrop is 10^{-6} m, calculate the energy released when the cloud is formed from the water vapour, assuming the condensation is adiabatic. (3 marks)
Compare this to the kinetic energy in the cloud if the mean wind velocity is 15m s^{-1}. You may assume the base of the cloud is 1km above the surface, that the scale height is 8.5km, and that the temperature is 288K and constant with height through the cloud. (6 marks)
Also estimate the rise in temperature of the cloud if all the energy released on condensation goes to heating the air in the cloud. (1 mark)
A flash of lightning discharges about 20C when the voltage difference with the ground is about 10^5V. How much energy is released? (1 mark)
If the electric field is uniform from cloud to ground, what approximately is the thickness of the charge layer at the base of the cloud and what is the average charge per water drop in that region? (Assume the Electric field **E** is given by $\mathbf{E} = \Phi/,_0$ where Φ is the surface charge density per square meter.)
(4 marks)

3)Define the term water potential. Using the table below, calculate the gradient in the water potential between a) 10cm and 20cm and b) 50cm and 60 cm. What can be concluded about the direction in which the water is flowing through the soil profile?

Depth (cm)	Suction (cm)
10	300
20	120
30	95
40	88
50	83

(5 marks)

4) Prove that the Coriolis parameter fc is given by

$$f_c = 1.45 \times 10^{-4} \sin N \qquad \text{rad s}^{-1}$$

where N is the latitude (4 marks) .
Explain, giving the balancing equations, what is meant by geostrophic balance and cyclostrophic balance. Why does the wind go in the opposite direction around a high pressure area in the northern hemisphere compared to the southern hemisphere? (5 marks)

A hurricane at 30EN has a velocity within 25 km of the eye of 50m s^{-1}, and a velocity around the outer edge (radius 400km) of 10 m s^{-1}. By calculating the pressure gradient and the controlling forces in each case, discuss whether the hurricane is in cyclostrophic or geostrophic balance. (5 marks)