OLLSCOIL NA hÉIREANN, GAILLIMH

NATIONAL UNIVERSITY OF IRELAND, GALWAY

SPRING EXAMINATIONS 2001

B. Sc. (General) and Third Science
Third and Fourth Environmental Science

Introduction to the Atmosphere (Course MT301)

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Time allowed: THREE hours.
Answer FIVE questions.
The numerical values of some physical quantities are given at the end of the paper.

1 Explain what is meant by the following terms: pressure, hectopascal, scale height.

Derive an expression, which includes the scale height parameter, for the variation of pressure with height in an isothermal atmosphere. At what height is the pressure reduced to half of standard atmospheric pressure, assuming an isothermal atmosphere at temperature 0^0C?.

2. Explain what is meant by each of the following terms: degree Kelvin, triple point of water, planetary short-wave albedo, emissivity.

Give a brief account of solar radiation, to include the distribution with respect to wavelength and maximum emission. Describe briefly emission of radiation from the Earth's surface. Hence determine the equilibrium temperature at which balance occurs between incoming solar radiation and outgoing terrestrial radiation, assuming the absence of trace gases, given that the solar irradiance is 1367 W m^{-2} at the top of the atmosphere and that the planetary shortwave albedo is 0.31.

3. Explain what is meant by the following terms: moist air, sublimation, saturation vapour pressure, relative humidity, dew point temperature.

Derive the expression showing that the density of air (assuming it behaves as an ideal gas) is inversely proportional to temperature.

Given that the saturation water vapour pressure is 12.3 hPa at 10°C, what is the saturation water vapour density at the same temperature?

4. In the context of an air parcel, explain what is meant by the following terms: stable equilibrium, dry adiabatic lapse rate, saturated adiabatic lapse rate, neutral stability.

Determine the conditions under which the atmosphere is

(i) stable

(ii) conditionally unstable

5. Derive the following expression for the speed of the geostrophic wind,

$$V_g = (1/\rho f)(\Delta p/\Delta H)$$
$$(f = 2\Omega \sin\phi)$$

Explain what the various parameters represent and specify assumptions made in the derivation. Show how the expression can be modified for use with contour charts at fixed pressure levels in the atmosphere.

On a surface chart, at a latitude of 53 °N, an isobar for 1004 hPa is shown to be separated from a 1008 hPa isobar by a perpendicular distance of 150 km. Calculate the geostrophic wind speed. The density of the air is given as 1.29 kg m^{-3}.

6. Describe briefly, with the aid of appropriate simple diagrams, the formation and development of a typical frontal mid-latitude depression (cyclone).

Derive the following expression for the equilibrium slope of a frontal surface,

$$\tan\theta = \frac{f\overline{T}}{g}\frac{(V_1 - V_2)}{(T_2 - T_1)}$$

explaining what the various parameters and constants represent. Write a note on the significance of the above expression with regard to frontal mid-latitude depressions in the real atmosphere.

7. Give an account of the depletion of stratospheric ozone, outlining the basic chemistry with regard to the role of chlorofluorocarbons (CFCs) in this process.

Describe in particular the formation of the Antarctic “ozone hole”. Explain the importance of specific meteorological conditions in the Antarctic stratosphere in the winter and early spring. Outline briefly relevant chemical processes which are particular to the polar stratosphere, in winter and early spring.

Comment on significant differences, with regard to ozone depletion, between the Arctic stratosphere and the Antarctic stratosphere in their respective winter and early spring.

8. Write notes on two of the following:
(a) The ionosphere
(b) The subtropical jetstreams
(c) Meteorological charts

Numerical values of some physical quantities

Angular velocity of rotation of Earth	=	7.29×10^{-5} radian s^{-1}
Stefan's constant, σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Gas constant, R	=	8.31×10^{3} J K^{-1} $kmol^{-1}$
Molecular mass of dry air, M	=	28.96 kg $kmol^{-1}$
Molecular mass of water vapour	=	18.0 kg $kmol^{-1}$
Standard atmospheric pressure	=	1.013×10^{5} Pa