GX 749

OLLSCOIL NA hÉIREANN, GAILLIMH

NATIONAL UNIVERSITY OF IRELAND, GALWAY

SPRING EXAMINATIONS 1999

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. Derive an expression for the variation of pressure with height, in an isothermal layer of the atmosphere, below the turbopause. Calculate what fraction of the atmosphere, by mass, is below a level of 12 km above the surface, if that part of the atmosphere can be regarded as isothermal at 260 K.

2. Give an account of the origin and evolution of the atmosphere, with particular regard to its composition, radiation environment and average near-surface temperature. Name two atmospheric gases that are radiogenic in origin (i. e. have a radioactive source).

3. Describe the interaction of radio waves with the ionosphere, outlining how this interaction may be investigated experimentally. Derive the following expression for the plasma frequency (f_p) for an electron at a particular level in the ionosphere:

$$f_p^2 = Ne^2 / (4\pi^2\varepsilon_0 m_e)$$

Explain what the various parameters and constants represent.

Pulses of frequency 4.0 MHz are transmitted vertically upward by an ionosonde and are received back at the same location after a time interval of 1.8 ms. At what level in the ionosphere are these pulses reflected and what is the electron density (concentration) at that level ?

4. Give a brief account of the radiation balance of the Earth-atmosphere system, explaining how an average brightness temperature can be calculated for the system, on the basis of that balance.

Outline the scientific basis for the enhanced greenhouse effect, i.e. the part of the greenhouse effect arising from the emission of greenhouse gases as a result of the activities of humankind. What are the main climate and sea-level changes suggested by computer models for the next century?

5. Explain the concept of the geostrophic wind. Derive the expression for the geostrophic wind velocity;

$$V_g = (1/\rho f)(\Delta p/\Delta H)$$

stating any assumptions made in the derivation:

Show how this equation can be modified, for use with contour charts drawn for fixed pressure levels in the atmosphere.

6. Give an account of the general circulation of the atmosphere, outlining its role in the re-distribution of heat and momentum. Write a note on the subtropical jetstreams.

A parcel of air, originally at rest at the equator, rises to a level near the tropopause, as a result of convection. The air then starts moving towards the north, eventually reaching a latitude of 30° N. Calculate the velocity of the air parcel, relative to the ground, when it reaches 30° N. Friction can be regarded as negligible.

7. Write a brief note on frontal surfaces and fronts in the atmosphere. Explain how a sloping frontal surface can be stable on a rotating Earth. Derive the following expression for the equilibrium slope (tan θ) of a frontal surface:

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

Explain what the various parameters and constants represent. What are the implications of this expression for the real atmosphere ?

8. Write notes on two of the following:
   (a) Escape velocity and its importance for the composition of planetary atmospheres
   (b) The anatomy and development of a typical mid-latitude cyclone
   (c) The natural creation and destruction of stratospheric ozone