

國立中央大學97學年度碩士班考試入學試題卷

所別：大氣物理研究所碩士班

科目：大氣動力學 共 / 頁 第 / 頁

\*請在試卷答案卷(卡)內作答

1. (a) For any scalar  $\phi(x, y, z) = \phi(x, y, \sigma)$  where  $\sigma(x, y, z)$  is the new vertical coordinate and is single-valued and monotonic in height  $z$ , please derive the relation between their horizontal derivatives:

$$\left(\frac{\partial \phi}{\partial x}\right)_z = \left(\frac{\partial \phi}{\partial x}\right)_\sigma + \left(\frac{\partial \phi}{\partial \sigma}\right) \frac{\partial \sigma}{\partial x} = \left(\frac{\partial \phi}{\partial x}\right)_\sigma - \left(\frac{\partial \phi}{\partial \sigma}\right) \frac{\partial \sigma}{\partial z} \left(\frac{\partial z}{\partial x}\right)_\sigma \quad (5\%)$$

- (b) Based on (a), show that geostrophic wind  $\mathbf{V}_g$  may be expressed in isothermal coordinates as

$$\mathbf{V}_g = \frac{1}{f} \mathbf{k} \times \nabla_T (RT \ln p + \Phi)$$

where  $f$  is the Coriolis parameter,  $T$  temperature,  $p$  pressure and  $\Phi$  geopotential. (10%)

2. Using the scale analysis of the horizontal momentum equations (neglecting the curvature terms) for midlatitude synoptic motions, discuss the validation of geostrophic approximation in relation to a nondimensional number (Rossby number). (10%)
3. Derive the thermal-wind equation and use this equation to show that it cannot have a cold advection in this layer if geostrophic wind turns clockwise with height in the Northern Hemisphere. (10%)
4. Given a normal high at gradient-wind balance in the Southern Hemisphere, discuss and sketch the flow system (wind and pressure) and the balanced forcings with their directions. (10%)
5. Qualitatively discuss why Ekman pumping will occur due to the presence of the planetary boundary layer, and why these processes may cause geostrophic vorticity to spin down. (15%)
6. (a) The geostrophic wind relations are diagnostic so that the quasi-geostrophic system is addressed in need for the flow to be prognostic. List all meteorological variables and the names of the involved governing equations in this system. Note that you should have the same number of the variables and the equations for a closure of the system. (10%)
- (b) Derive that the ageostrophic wind  $\mathbf{V}_a$  in this system will be directed to the left of the geostrophic wind acceleration following the geostrophic wind  $\mathbf{V}_g$ . (5%)
7. Starting from the linearized barotropic vorticity equation, show that Rossby waves may propagate westward relative to the ground for longer wavelengths. (15%)
8. Briefly discuss the major differences between baroclinic instability and barotropic instability of a zonal mean flow. (10%)

參考用