Multiple choice questions Dynamical Meteorology

(1) The dynamical definition of the tropopause is in terms of
(a) lapse rate
(b) potential vorticity
(c) potential vorticity substance

(2) The energy conservation equation for an air parcel can be written as follows

\[ \dot{J} dt - c_v dT - pd\alpha = 0 \]

The change in the internal energy is given by
(a) the first term
(b) the second term
(c) the third term

(3) If we let a saturated parcel of air ascend, its equivalent potential temperature will
(a) increase
(b) decrease
(c) not change

(4) CAPE is a measure of
(a) the potential final vertical velocity of air parcels
(b) the maximum possible change in the vertical velocity of air parcels in a potentially unstable layer
(c) the layer stability between the ground and the capping inversion

(5) The equation for thermal wind balance is derived from
(a) the equation for geostrophic balance and the equation for hydrostatic balance
(b) the vorticity equation and the equation for hydrostatic balance
(c) the continuity equation and the equation for geostrophic balance

(6) A descending air parcel follows
(a) an isentrope on a thermodynamic diagram
(b) a pseudo-adiabat on a thermodynamic diagram
(c) an isotherm on a thermodynamic diagram

(7) The mixing ratio by volume of water vapour is defined as
(a) the mass density of water vapour as a fraction of the mass density of air
(b) the mass density of water vapour as a fraction of the mass density of dry air
(c) the pressure exerted by water vapour as a fraction of the pressure exerted by the dry air

(8) The Brunt Vaisala frequency is defined in terms of potential temperature as

\[ N = \left( \frac{g}{\theta} \frac{d\theta}{dz} \right)^{1/2} \]

In an isothermal atmosphere \( N \) is
(a) constant
(b) increases with height
(c) decreases with height
(9) The $Q$-vector measures the change in time
(a) of the vector temperature gradient across an air parcel
(b) of the thermal wind
(c) of the absolute value of the temperature gradient across an air parcel

(10) “Baroclinic instability” is another term for
(a) instability of geostrophic balance
(b) instability of hydrostatic balance
(c) instability of thermal wind balance

(11) Buoyancy oscillations occur in an statically
(a) unstable atmosphere
(b) stable atmosphere
(c) neutral atmosphere

(12) The continuity equation with pressure as a vertical coordinate is

\[ \frac{v \tan \phi}{a} + \frac{\partial \omega}{\partial p} + \left( \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \right) + \frac{\partial}{\partial p} \left( \frac{\partial}{\partial \theta} \sigma \frac{d \theta}{dt} \right) = 0 \]

the derivation of this equations assumes
(a) incompressibility
(b) hydrostatic balance
(c) an adiabatic atmosphere

(13) The “Middleworld” is defined as
(a) that part of the atmosphere for which the isentropes intersect the tropopause
(b) that part of the atmosphere for which the isentropes intersect the tropopause and the Earth’s surface
(c) that part of the atmosphere for which the isentropes span the globe

(14) During the positive phase of the Southern Oscillation Index (SOI-index>0) the Walker circulation is
(a) more intense than normal
(b) less intense than normal
(c) shifted towards the east

(15) The subtropical jet is most intense
(a) in the summer hemisphere
(b) in the winter hemisphere
(c) when it is farthest away from the equator

(16) The continuity equation with potential temperature as a vertical coordinate is

\[ \frac{\partial \sigma}{\partial t} + \left( \frac{\partial \sigma u}{\partial x} \right)_\theta + \left( \frac{\partial \sigma v}{\partial y} \right)_\theta + \frac{\partial}{\partial \theta} \left( \sigma \frac{d \theta}{dt} \right) = 0 \]

($\sigma$ is “isentropic density”). The derivation of this equations assumes
(a) incompressibility and hydrostatic balance
(b) hydrostatic balance
(c) an adiabatic atmosphere
(17) “Baroclinic instability” is another term for
(a) instability of geostrophic balance
(b) instability of hydrostatic balance
(c) instability of thermal wind balance

(18) Geostrophic balance expresses the balance between the following forces
(a) pressure gradient force and centrifugal force
(b) pressure gradient force and Coriolis force
(c) Coriolis force, pressure gradient force and gravitational force

(19) Small amplitude baroclinic waves with a relatively short horizontal wavelength are stabilized by
(a) the effect of static stability on the vertical component of the motion
(b) the “beta-effect”
(c) inertial stability

(20) A rule that can be deduced from the solution of the omega equation,
\[
\frac{\partial^2 \omega}{\partial x^2} + \frac{\partial^2 \omega}{\partial y^2} + \frac{f_0^2}{\sigma} \frac{\partial^2 \omega}{\partial p^2} = -\frac{2R}{\rho \sigma} \nabla \cdot \mathbf{Q}_g,
\]
with the static stability parameter,
\[\sigma > 0,\]
is the following:
(a) upward motion is found in regions where the \( \mathbf{Q}_g \)-vector diverges
(b) downward motion is found in regions where the \( \mathbf{Q}_g \)-vector diverges
(c) downward motion is found in regions where the \( \mathbf{Q}_g \)-vector converges

(21) The aspect ratio of quasi-geostrophic circulation systems is in the order of,
(a) \( NF \)
(b) \( F/N \)
(c) \( N/F \)
where \( N \) is the Brunt-Väisälä, and \( F \) is the inertial frequency

(22) In a stationary, steady state anticyclone, which is not intensifying or weakening in the northern hemisphere the isolabaric wind,
(a) blows in southward direction
(b) is non-existent
(c) blows in northward direction

(23) If there is warm advection in the northern hemisphere,
(a) the geostrophic wind turns clockwise with increasing height
(b) the geostrophic wind decreases in absolute value with increasing height
(c) the geostrophic wind turns anti-clockwise with increasing height
The dispersion relation for baroclinic Rossby waves in the two-level model is

\[ c_x = U_M - \frac{\beta \left( k^2 + \lambda^2 \right)}{k^2 \left( k^2 + 2\lambda^2 \right)} \pm \frac{\beta^2 \lambda^4}{k^4 \left( k^2 + 2\lambda^2 \right)^2} - \frac{U_T^2 \left( 2\lambda^2 - k^2 \right)}{k^2 \left( k^2 + 2\lambda^2 \right)}. \]

These waves are unstable if

(a) \[ U_T^2 > \frac{\beta^2 \lambda^4}{k^4 \left( 4\lambda^4 - k^4 \right)}. \]

(b) \[ U_T^2 > \frac{\beta^2 \lambda^4}{k^4 \left( 2\lambda^2 + k^2 \right) \left( k^2 + 2\lambda^2 \right)}. \]

(c) \[ U_M > \frac{\beta \left( k^2 + \lambda^2 \right)}{k^2 \left( k^2 + 2\lambda^2 \right)}. \]

The Rossby height is a measure of the

(a) vertical distance of penetration of the wind response to frontogenesis
(b) vertical scale of an unstable baroclinic wave
(c) height of the tropopause

The equation,

\[ \frac{d}{dt} \left( \frac{\partial \Phi}{\partial p} \right) = -\sigma \omega, \]

where \( \sigma \) is the static stability, represents the

(a) Quasi-geostrophic adiabatic thermodynamic equation
(b) Quasi-geostrophic vorticity equation
(c) Quasi-geostrophic diabatic thermodynamic equation

Very little or no eddy- and/or wave-activity is observed in the southern hemisphere stratosphere in January because

(a) the zonal mean zonal wind in the southern hemisphere stratosphere is eastward in January
(b) the stratosphere is very stable in the summer because of absorption of solar radiation by ozone
(c) the zonal mean zonal wind in the summer stratosphere is westward