Lecture Ch. 4b

- Hydrostatic equilibrium
  - Special cases
  - Pressure altitude dependence
- More Midterm Review problems
  - Terminology review

Curry and Webster, Ch. 4 (pp. 96-115; skip 4.5 (except 4.5.1), 4.6)
Tuesday, Oct. 20: Homework, Review (bring questions), and Read Ch. 5
Tuesday, Oct. 27: Midterm
Thursday, Oct. 29: meet to work on ROAST!

Water Vapor Metrics

Special Cases of Hydrostatic Equilibrium

- 1. rho=constant (homogeneous)
  - H=8 km =RT/g=scale height eq. 1.39
- 2. constant lapse rate (implied if hydrostatic, homogeneous, and ideal gas)
  - -dT/dz=constant=-g/R=-34/deg/km
- 3. isothermal T=constant (and ideal gas)
  - p=p_0*exp(-z/H)

Special Cases of Hydrostatic Equilibrium

- Hydrostatic: Force balance on gravity and upward pressure

tion of decreasing pressure (upwards). The vertical pressure gradient force is generally in very close balance with the downward force due to gravitational attraction. This is called *hydrostatic balance*, and is written as

$$g = -\frac{1}{\rho}\frac{\partial p}{\partial z} \qquad (1.33)$$

where g is the acceleration due to the Earth's *gravity*. The hydrostatic balance is applicable to most situations in the atmosphere and ocean, exceptions arising in the presence of large vertical accelerations such as are associated with thunderstorms.

Homogeneous Atmosphere

Homogeneous
Constant density
Constant lapse rate

Isothermal Atmosphere

Hydrostatic Equilibrium Example

Consider a planet with an atmosphere in hydrostatic equilibrium. Assume that the atmosphere is an ideal gas. Also assume that the temperature is a maximum at the surface of the planet, and, as height increases, the temperature in the atmosphere decreases linearly (in other words, temperature decreases with height at a constant rate). Derive a formula for atmospheric density as a function of height in this atmosphere.

Quiz

Answer briefly and clearly, with appropriate equations or diagrams.

- If a homogeneous mixture of two substances coexists in liquid and vapor phases at a series of pressures (each of which corresponds to exactly one temperature), how many degrees of freedom are in this system?
- What is thermal equilibrium? Give an equation.
- Give the equation for the Gibbs phase rule.
- What is the change in free energy for a phase change?
- What type of pressure change is described by the Clausius-Clapeyron equation? i.e. what changes as a function of what under what conditions?

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Answers

- If a homogeneous mixture of two substances coexists in liquid and vapor phases at a series of pressures (each of which corresponds to exactly one temperature), how many degrees of freedom are in this system?
  - 1
- What is thermal equilibrium? Give an equation.
  - $T_1=T_2$
- Give the equation for the Gibbs phase rule.
  - f=c+2-p
- What is the change in free energy for a phase change?
  - 0 (at constant T and P)
- What type of pressure change is described by the Clausius-Clapeyron equation? i.e. what changes as a function of what under what conditions?
  - $p_s=f(T)$ for l/v saturation pressure

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Hydrostatic Equilibrium Example

[illegible]

Clausius Clapeyron Example

[illegible]

Degrees of Freedom Example

[illegible]

Quiz

Answer briefly and clearly, with appropriate equations or diagrams.

- If a pure substance coexists in liquid and vapor phases at a series of pressures (each of which corresponds to exactly one temperature), how many degrees of freedom are in this system?
- What is the relationship between two pressures at mechanical equilibrium?
- Give the equation for the Gibbs phase rule.
- What three types of equilibrium are required by the Gibbs phase rule?

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