

**INDIA METEOROLOGICAL  
DEPARTMENT  
QUESTION BANK  
OF  
ADVANCED METEOROLOGICAL  
TRAINING COURSE (AMTC)  
SEMESTER-I EXAMINATION  
BASED ON 174-181 BATCHES  
(2013-2021)  
PAPER-II: THERMODYNAMICS  
PART B**

**INDIA METEOROLOGICAL DEPARTMENT**  
**METEOROLOGICAL TRAINING INSTITUTE**  
**MET. GR. II TRAINING COURSE**  
**ADVANCED METEOROLOGICAL TRAINING COURSE FINAL EXAMINATION**  
**PAPER II – THERMODYNAMICS**

**SEMESER-I (PART-B)**

**Q.1. Fill in the blanks**

1. An air parcel is conditionally stable if \_\_\_\_\_.
2. Atmosphere is generally transparent to terrestrial radiation in between.....and ..... wavelengths, known as atmospheric window.
3. Auto-convective lapse rate = \_\_\_\_\_.
4. Chemical potential is same as \_\_\_\_\_.
5. Constant pressure process is also known as..... .
6. Dry air is \_\_\_\_\_ than moist air.
7. Expression for scale height is \_\_\_\_\_.
8. Fog formation may happen if overnight temperature dropped by more than \_\_\_\_\_ ( 5Deg C / 3Deg C / 1 Deg C) at a higher relative humidity.
9. Global radiation is the sum of .....and .....
10. GPM is the unit of Specific \_\_\_\_\_.
11. Heat transferred at constant pressure ..... the enthalpy of a system.
12. If the net upward pressure force on the slab is equal to the downward force of gravity on the slab, the atmosphere is said to be in\_\_\_\_\_ (hydrostatic balance/ Instability / None )
13. In a conditional stable condition, environmental curve is steeper than\_\_\_\_\_.
14. In T-Phi Gram the Normand's Point represents \_\_\_\_\_ (Convective Cloud base/ Saturated parcel/ both)
15. Luminous region of sun is called .....
16. Pyrheliometer is an instrument for measurement of .....
17. Quantity of solar radiation reaching a unit area of the earth's surface is known as .....
18. The atmosphere is absolutely stable when ELR is .....than SALR.
19. The constant temperature at which the phase transition from solid to liquid is known as..... .
20. The scale height for an isothermal atmosphere with a temperature of 250 K will be .....K.M.

21. The value of specific heat at constant volume is .....
22. The variation of pressure in (in vertical) in the earth's atmosphere is determined by a balance between .....and .....
23. The wet bulb temperature is the ..... temperature recorded by moistened bulb.
24. Thickness of a layer is proportional to its .....
25. Unit of any portion on T-Phi diagram is .....
26. Unit of Radiant flux is .....
27. Wave length range of visible radiation is .....
28. Work done against the Earth's gravitational field to raise a mass of 1 kg of air from sea level to that height above earth surface is called .....( Geopotential / Lifting level / None)
29. Albedo of the surface is defined by ratio of outgoing to incoming solar radiation. Keeping this view, which of the following surface will have highest albedo?
  - a)Sand
  - b)Snow
  - c)Forest

**Q.2. State with brief reasons whether the following are true or false**

1. Absolute Humidity a good variable for measuring moisture content in the air.
2. Altimeter indicator in the cockpit of Aircraft indicates height of the flight above the Aerodrome when it is set to the pressure at Runway Touch down.
3. Blue colour of sky is due to Mie scattering.
4. CAPE is always negative.
5. Chemical potential is same as Gibb's free energy function.
6. DALR is lesser than SALR
7. Dry adiabatic lapse rate is ALWAYS greater than saturated adiabatic lapse rate.
8. Dry bulb Temperature is never equal to Dew point Temperature.
9. Emittance of earth is more than that of sun.
10. Entropy of a reversible process is greater than that of an irreversible process .
11. For an adiabatic process entropy remains conserved.
12. For an ideal gas internal energy is a function of absolute temperature and pressure.
13. For an ideal gas internal energy is a function of absolute temperature only.
14. For each latitude, the southern hemisphere summer insolation is lesser than that of the corresponding northern hemisphere latitude in its winter

15. Gibbs free energy function doesn't change during phase change of water substance.
16. Greenhouse effect is good for earth's atmosphere.
17. In a conditionally unstable atmosphere, only moist air parcels will be positively buoyant.
18. In a mixed phase system of a single constituent in equilibrium, the Gibbs Free Energy for the liquid phase is greater than the gaseous phase.
19. In a stable atmosphere potential temperature increases with height.
20. Potential temperature increases with height.
21. Potential temperature remains conserved in a moist adiabatic process.
22. Pseudo-adiabatic process is a reversible thermodynamic process.
23. Saturated adiabatic lapse rate exceeds dry adiabatic lapse rate.
24. Saturated adiabatic lapse rate is lesser than dry adiabatic lapse rate.
25. Saturation vapor pressure decreases with absolute Temp.
26. Saturation Vapour pressure over water is less than over ice.
27. Saturation water vapor pressure varies linearly with absolute temperature.
28. Specific gas content is same for all gases.
29. The Clausius–Clapeyron equation is a way of characterizing a discontinuous phase transition between two phases of a single constituent.
30. The hotter the radiating body, the shorter the wavelength of maximum radiation.
31. The units of geopotential are  $\text{Jkg}^{-1}$  or  $\text{m}^2 \text{S}^{-2}$
32. The virtual temperature is always greater than the actual temperature.
33. Virtual temperature is less than dry bulb temperature.
34. We feel more comfortable when wet-bulb temperature is high.
35. Weight of dry air is greater than moist air.

**Q.3. Answer any two of the following:**

1. Define specific heat of a substance. Why gas has two specific heat? Obtain relation between them.
2. Define Gibb's free energy function. Show that Gibb's free energy function per molecule is same as that of Chemical potential during phase change of a substance.
3. Define lapse rate. Obtain the expression of the same for pseudo adiabatic condition.
4. Derive briefly the Equation of state for dry adiabatic process in terms of "P" and "T".
5. Explain the concept of Potential Temperature and its importance in convection.

6. Derive the ideal gas law for a mixture of dry ideal gases.
7. Explain the concept of Virtual Temperature
8. Derive a relationship of Entropy with Potential temperature. Explain all terms.
9. Derive hydro static equation  $\frac{\partial p}{\partial z} = -\rho g$ . Where  $\partial p$  = Difference in pressure layers,  $\partial z$  = Height difference for pressure change  $\partial p$ ,  $g$  = acceleration due to gravity,  $\rho$  = average density between layers
10. Write short notes on T- Phi Gram.
11. Define Virtual Temperature. Derive the expression for virtual temperature.
12. What is the formula used to calculate the thickness of a layer of the atmosphere given the pressures at the bottom and top of the layer,  $p_1$  and  $p_2$ , and the average virtual temperature of the layer,  $T_v$ .
13. What are the conditions, in terms of the actual lapse rate  $\Gamma_e \equiv -dT/dz$ ,  $\Gamma_d$  (DALR), and  $\Gamma_s$  (SALR), for absolute instability, absolute stability, and conditional instability? Explain Conditional instability with a neat diagram.
14. Derive Poisson's equation.
15. The temperature of an air parcel at 500 hPa is  $-20^\circ\text{C}$ . The air parcel subsides adiabatically to 800 hPa. What is its temperature at 800hPa?
16. Define solar constant. What is its value?
17. Calculate the equivalent blackbody temperature of the solar photosphere based on the following information. The flux density of solar radiation reaching the Earth,  $F_s$ , is  $1368 \text{ W m}^{-2}$ . The Earth-sun distance is  $1.50 \times 10^{11} \text{ m}$  and the radius of the solar photosphere is  $7.00 \times 10^8 \text{ m}$ .
18. Explain the mean heat balance of earth's atmosphere with neat diagram.
19. Describe different types of atmospheric scattering. What is the role of scattering in atmospheric heat budget?
20. State the 2nd law of thermodynamics. Discuss the concept of entropy. Derive the mathematical relation between entropy and potential temperature.
21. Define Gibb's free energy function. Using Gibb's free energy function, derive Clausius – Clapeyron equation.
22. Define CAPE & CINE. Derive expressions for them. Discuss their use in stability analysis.
23. Define virtual temperature. Derive an expression for virtual temperature.

24. Show that equivalent potential temperature remains conserved both in a dry and moist adiabatic process.
25. Write down an expression for Gibb's free energy function. Using Gibb's free energy function derive Clausius Clapeyron equation.
26. Why gas have two specific heats? Derive expressions for two specific heats of gas using 1<sup>st</sup> law of thermodynamics.
27. Define lapse rate. Show that lapse rate for dry adiabatic condition is  $\frac{g}{\theta} \frac{d\theta}{dz}$ .
28. Calculate the changes in specific internal energy (in Joules), specific enthalpy (in Joules) and specific entropy (Joules/Kelvin) of a sample of dry air (consider as ideal gas) at a pressure of 100000 Pa during an isothermal expansion from 1.0m<sup>3</sup> to 1.002m<sup>3</sup> at temperature of 27 deg.C.
  - A) an adiabatic compression from 1.0m<sup>3</sup> to 1.002m<sup>3</sup>.

**Q.4. Write short note on any of the following:**

1. Clausius-Clapeyron equation
2. Parcel method of stability analysis.
3. Equation of state for a mixture of gasses
4. Geopotential height
5. T-phi gram