

Advanced Thermodynamic Principles

Thermodynamics · Practice Test · 25 Questions

1. In the context of the Maxwell relations, what is the thermodynamic identity for the Gibbs free energy differential dG ?

- A) $dG = -SdT + VdP$
- B) $dG = SdT + VdP$
- C) $dG = -SdT - VdP$
- D) $dG = SdT - VdP$

2. Which thermodynamic potential is minimized at equilibrium for a system kept at constant temperature and volume?

- A) Enthalpy
- B) Gibbs free energy
- C) Helmholtz free energy
- D) Internal energy

3. What is the physical significance of the third law of thermodynamics regarding the heat capacity (C_p) of a pure crystalline substance as T approaches 0 Kelvin?

- A) C_p approaches infinity
- B) C_p approaches a constant value
- C) C_p approaches zero
- D) C_p becomes undefined

4. For an ideal gas undergoing a reversible adiabatic process, which of the following relations holds true (where γ is the adiabatic index)?

- A) $PV^\gamma = \text{constant}$
- B) $TV^\gamma = \text{constant}$
- C) $PT^\gamma = \text{constant}$
- D) $PV = \text{constant}$

5. The Joule-Thomson coefficient (μ) for an ideal gas is exactly:

- A) Positive
- B) Negative
- C) Zero
- D) Infinite

6. What is the statistical definition of entropy according to the Boltzmann formula $S = k \ln(W)$, where W represents:

- A) The work done by the system
- B) The number of microstates
- C) The wave function amplitude
- D) The heat capacity at constant volume

7. Which Maxwell relation is derived directly from the exact differential $dU = TdS - PdV$?

- A) $(dT/dV)_S = -(dP/dS)_V$
- B) $(dT/dP)_S = (dV/dS)_P$
- C) $(dS/dV)_T = (dP/dT)_V$
- D) $(dS/dP)_T = -(dV/dT)_P$

8. What is the value of the fugacity coefficient for a perfect gas?

- A) 0
- B) 1
- C) e
- D) Infinity

9. In an irreversible process involving a closed system, what is the relationship between the change in entropy (dS) and the heat transfer (dQ/T)?

- A) $dS = dQ/T$
- B) $dS > dQ/T$
- C) $dS < dQ/T$
- D) $dS = 0$

10. The chemical potential of a pure substance is equivalent to which molar property?

- A) Molar Enthalpy
- B) Molar Gibbs free energy
- C) Molar Helmholtz free energy
- D) Molar Internal energy

11. Which property is an intensive thermodynamic variable?

- A) Internal energy
- B) Enthalpy
- C) Chemical potential
- D) Volume

12. According to the Clausius-Clapeyron equation, what does the slope (dP/dT) represent for a phase transition boundary?

- A) $(L) / (T * \Delta V)$
- B) $(T * \Delta V) / L$
- C) $(L * \Delta V) / T$
- D) $(\Delta V) / (L * T)$

13. What does the Prigogine principle of minimum entropy production apply to?

- A) Systems far from equilibrium
- B) Systems in steady state near equilibrium
- C) Isolated systems
- D) Adiabatic systems

14. The Debye model for low-temperature heat capacity states that C_p is proportional to:

- A) T
- B) T^2
- C) T^3
- D) T^4

15. What is the condition for mechanical equilibrium between two phases of a pure substance?

- A) Equal temperatures
- B) Equal pressures
- C) Equal chemical potentials
- D) Equal entropies

16. In a Grand Canonical Ensemble, which parameters are kept constant?

- A) T, V, μ
- B) T, P, N
- C) S, V, N
- D) E, V, N

17. What does the compressibility factor $Z = PV/(nRT)$ measure?

- A) Deviation from ideal gas behavior
- B) The rate of heat transfer
- C) The entropy of mixing
- D) The density of a liquid

18. Which of the following is an exact differential?

- A) Heat (dQ)
- B) Work (dW)
- C) Internal Energy (dU)
- D) Entropy in an irreversible process (dS)

19. The Carnot efficiency depends exclusively on:

- A) The working substance
- B) The pressure range
- C) The temperatures of the reservoirs
- D) The volume change

20. What is the enthalpy change of an ideal gas during an isothermal process?

- A) Positive
- B) Negative
- C) Zero
- D) Depends on the pressure change

21. Which law of thermodynamics prohibits the construction of a perpetual motion machine of the second kind?

- A) Zeroth Law
- B) First Law
- C) Second Law
- D) Third Law

22. What is the significance of the critical point in a phase diagram of a pure fluid?

- A) Liquid and gas phases become indistinguishable
- B) Solid and liquid phases reach equilibrium
- C) Sublimation pressure is zero
- D) Entropy reaches maximum

23. The internal energy (U) of an ideal gas is a function solely of:

- A) Pressure
- B) Volume
- C) Temperature
- D) Entropy

24. What is the relation between the heat capacity at constant pressure (C_p) and constant volume (C_v) for an ideal gas?

- A) $C_p - C_v = R$
- B) $C_p - C_v = 0$
- C) $C_p / C_v = R$
- D) $C_p * C_v = R$

25. Which term describes the measure of the 'disorder' or available energy states of a system?

- A) Enthalpy
- B) Entropy
- C) Exergy
- D) Electrochemical potential