

Advanced Thermodynamic Principles

Thermodynamics · Answer Key · 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