CHAPTER

4

Thermodynamics

EXERCISE I (JEE MAIN)

Basics

1. A thermodynamic property is that physical quantity

(a) which is used in thermochemistry.
(b) which obeys all the laws of thermodynamics.
(c) which is used to define a state of the system.
(d) which is used in measuring thermal change.

2. Which of the following is not a thermodynamic property of a system?

(a) H (b) P
(c) E (d) w

3. Which of the following is the best container for gas during isothermal process?

(a) Glass vessel (b) Wood vessel
(c) Copper vessel (d) Thermos flask

4. The internal energy of an ideal gas increases during an isothermal process when the gas is

(a) expanded by adding more molecules to it.
(b) expanded by adding more heat to it.
(c) expanded against zero pressure.
(d) compressed by doing work on it

5. Maximum work can a gas do, if it is allow to expand isothermally against

(a) vacuum
(b) high pressure of surrounding
(c) low pressure of surrounding
(d) atmospheric pressure

6. The internal energy change when a system goes from state A to B is 40 kJ/ mol. If the system goes from A to B by a reversible path and returns to state A by an irreversible path, what would be the net change in internal energy?

(a) 40 kJ (b) >40 kJ
(c) <40 kJ (d) Zero

7. A system is said to be in thermodynamic equilibrium with surrounding if

(a) it is only in thermal equilibrium with surrounding.
(b) it is in both thermal and chemical equilibrium with surrounding.
(c) it is in thermal, chemical as well as mechanical equilibrium with the surrounding.
(d) it is in thermal and mechanical equilibrium, but not in chemical equilibrium with surrounding.

8. If a closed system has adiabatic boundaries, then at least one boundary must be

(a) permeable (b) imaginary
(c) movable (d) fixed

9. Which of the following pair does show the extensive properties?

(a) temperature and pressure
(b) viscosity and surface tension
(c) refractive index and specific heat
(d) volume and heat capacity

10. Which of the following statement is correct?

(a) Heat is thermodynamic property of system.
(b) Work is thermodynamic property of system.
(c) Work done by a conservative force is path function.
(d) Heat involved in chemical reaction is path independent physical quantity.

11. Which of the following statement is incorrect?

(a) Only a state function may be expressed as difference in its value at two states in any process.
(b) A process cannot be defined on the basis of initial and final states of the system.
(c) In a cyclic process, the internal energy of the system remains throughout constant.
(d) During irreversible process, the equation $PV = nRT$ is not applicable to ideal gas.

12. For an isothermal process, the essential condition is

(a) $\Delta T = 0$ (b) $\Delta H = 0$
(c) $\Delta U = 0$ (d) $dT = 0$

13. Which of the following is correct?

(a) An ideal gas always obeys the equation: PV^{γ} = constant in adiabatic process.
(b) An ideal gas always obeys the equation: PV^{x} = constant in polytropic process.
(c) In a polytropic process, the heat capacity of the system remains same throughout.
(d) In all the cyclic process, w_{net} by the system is non-zero.

14. Which of following is incorrect about reversible process?

(a) System remains always in thermodynamic equilibrium.
(b) The process is extremely slow.
(c) The process may be reversed at any stage only by making infinitesimally small change in opposite direction.
(d) Reversible processes may be performed in finite time.

15. The law of equipartition of energy is applicable to the system whose constituents are

(a) in random motion
(b) in orderly motion
(c) moving with constant speed
(d) in rest

First Law of Thermodynamics

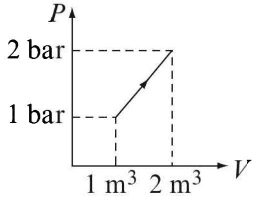
16. A system absorbs 20 kJ heat and does 10 kJ of work. The internal energy of the system

(a) increases by 10 kJ
(b) decreases by 10 kJ
(c) increases by 30 kJ
(d) decreases by 30 kJ

17. The volume of a system becomes twice its original volume on the absorption of 300 cal of heat. The work done on the surrounding was found to be 200 cal. What is ΔU for the system?

(a) 500 cal (b) 300 cal
(c) 100 cal (d) −500 cal

18. A system absorbs 100 kJ heat in the process shown in the figure. What is ΔU for the system?



(a) −50 kJ
(b) +50 kJ
(c) +150 kJ
(d) −150 kJ

19. In a given process on an ideal gas, $dw = 0$ and $dq < 0$. Then for the gas,

(a) the temperature will decrease
(b) the volume will increase
(c) the pressure will remain constant
(d) the temperature will increase

20. Five moles of an ideal gas is expanded isothermally from 5 dm^3 to 5 m^3 at 300 K. Which of the following is incorrect about the gas?

(a) No heat is absorbed or rejected by the gas.
(b) There is no change in internal energy of the gas.
(c) There is no change in enthalpy of the gas.
(d) Pressure of the gas will decrease by 1000 times.

21. One mole of an ideal gas at 300 K is expanded isothermally from an initial volume of 1 L to 10 L. The change in internal energy, ΔU, for the gas in this process is

(a) 163.7 cal
(b) zero
(c) 1381.1 cal
(d) 9 L-atm

22. Five moles of an ideal gas expand isothermally and reversibly from an initial pressure of 100 atm to a final pressure of 1atm at 27°C. The work done by the gas is ($\ln 100 = 4.6$)

(a) 2760 cal
(b) 6000 cal
(c) 0
(d) 13,800 cal

23. The work done in the isothermal reversible expansion of argon gas at 27°C from 4 l to 16 l was equal to 4200 cal. What is the amount of argon subjected to such an expansion? (Ar = 40, $\ln 4 = 1.4$)

(a) 5.0 g
(b) 20.0 g
(c) 200.0 g
(d) 48.1 g

24. The minimum work which must be done to compress 16 g of oxygen isothermally, at 300 K from a pressure of 1.01325×10^3 N/m² to 1.01325×10^5 N/m² is ($\ln 100 = 4.6$, $R = 8.3$ J/K-mol)

(a) 5727 J
(b) 11.454 kJ
(c) 123.255 kJ
(d) 1232.55 J

25. For a reversible process at $T = 300$ K, volume of the ideal gas is increased from 1 L to 10 L. If the process is isothermal, the ΔH of the process is

(a) 11.47 kJ
(b) 4.98 kJ
(c) 0
(d) −11.47 kJ

26. The magnitude of work done by one mole of a van der Waals gas, during its isothermal reversible expansion from volume V_1 to V_2 at temperature T K, is

(a) $RT\ln\left(\frac{V_2}{V_1}\right)$

(b) $RT\ln\left(\frac{V_2-b}{V_1-b}\right)$

(c) $RT\ln\left(\frac{V_2-b}{V_1-b}\right)+a\left(\frac{1}{V_2}-\frac{1}{V_1}\right)$

(d) $RT\ln\left(\frac{V_2-b}{V_1-b}\right)-a\left(\frac{1}{V_2}-\frac{1}{V_1}\right)$

27. An ideal gas undergoes isothermal expansion from (10 atm, 1 L) to (1 atm, 10 L) either by path–I (infinite stage expansion) or by path–II (first against 5 atm and then against 1 atm). The value of $\left(\frac{q_{\text{path-I}}}{q_{\text{path-II}}}\right)$ is

(a) $\frac{2.303}{1.3}$
(b) $\frac{1.3}{2.303}$
(c) $\frac{1.0}{13\times 2.303}$
(d) 13×2.303

28. An ideal gas is expanded irreversibly from 5 L to 10 L against a constant external pressure of 1 bar. The value of heat involved (q) in this isenthalpic process is

(a) 0
(b) +500 J
(c) +5 J
(d) −500 J

29. The work done in an adiabatic change of fixed amount of an ideal gas depends on change in

(a) volume
(b) pressure
(c) temperature
(d) density

30. In the reversible adiabatic expansion of an ideal monoatomic gas, the final volume is 8 times the initial volume. The ratio of final temperature to initial temperature is

(a) 8:1
(b) 1:4
(c) 1:2
(d) 4:1

31. One mole of monoatomic ideal gas at T K is expanded from 1 L to 2 L adiabatically under a constant external pressure of 1 atm. The final temperature of the gas in Kelvin is

(a) T
(b) $\frac{T}{2^{\left(\frac{5}{3}-1\right)}}$
(c) $T-\frac{2}{3\times 0.0821}$
(d) $T+\frac{3}{2\times 0.0821}$

32. Two moles of an ideal gas $\left(C_{v,m}=\frac{5}{2}R\right)$ was compressed adiabatically against constant pressure of 2 atm, which was initially at 350 K and 1 atm. The work done on the gas in this process is

(a) $250R$
(b) $500R$
(c) $125R$
(d) $300R$

33. Two moles of an ideal gas (γ = 1.4) was allowed to expand reversibly and adiabatically from 1 L, 527°C to 32 L. The molar enthalpy change of the gas is

(a) $-4200R$
(b) $-2100R$
(c) $-1500R$
(d) $-3000R$

34. Equal moles of He, H_2, CO_2 and SO_3 gases are expanded adiabatically and reversibly from the same initial state to the same final volume. The magnitude of work is maximum for (Assume ideal behaviour of gases and all the degree of freedoms are active.)

(a) He
(b) H_2
(c) CO_2
(d) SO_3

35. An ideal monoatomic gas initially at 300 K expands adiabatically into vacuum to double its volume. The final temperature of gas is

(a) 300 K
(b) $300\times(0.5)^{2/3}$ K
(c) $300\times(2)^{2/3}$ K
(d) 600 K

36. Temperature of one mole of an ideal gas is increased by one degree at constant pressure. Work done by the gas is

(a) R
(b) $2R$
(c) $R/2$
(d) $3R$

37. What is the change in internal energy when a gas contracts from 325 ml to 125 ml at a constant pressure of 2 bar, while at the same time being cooled by removing 124 J heat?

(a) −524 J
(b) −84 J
(c) −164 J
(d) +84 J

38. Two moles of an ideal gas [$C_{v,m}$ (/JK^{-1} mol^{-1}) = 20 + 0.01*T*(/K)] is heated at constant pressure from 27°C to 127°C. The amount of heat absorbed by the gas is

(a) 1662.8 J (b) 4700 J
(c) 6362.8 J (d) 3037.2 J

39. A monoatomic gas expands isobarically. The percentage of heat supplied that increases the thermal energy and that involved in doing work for expansion is

(a) 50:50 (b) 60:40
(c) 40:60 (d) 75:25

40. The maximum high temperature molar heat capacity at constant volume to be expected for acetylene which is a linear molecule is

(a) 9 cal/deg-mole
(b) 12 cal/deg-mole
(c) 19 cal/deg-mole
(d) 14 cal/deg-mole

41. Molar heat capacity of water in equilibrium with ice at constant pressure is

(a) zero
(b) infinity
(c) 40.45 kJ/K-mol
(d) 75.48 J/K-mol

42. For which of the following ideal gas, $C_{v,m}$ is independent of temperature?

(a) He (b) H_2
(c) CO (d) SO_2

43. If one mole of a monoatomic gas ($\gamma = 5/3$) is mixed with one mole of a diatomic gas ($\gamma = 7/5$), the value of γ for the mixture is

(a) 1 (b) 1.5
(c) 2 (d) 3.0

44. When an ideal diatomic gas is a heated at a constant pressure, the fraction of heat energy supplied which increase the internal energy of the gas is

(a) $\frac{2}{5}$ (b) $\frac{3}{5}$
(c) $\frac{5}{7}$ (d) $\frac{3}{7}$

45. A gas is heated at constant pressure. The fraction of heat absorbed used in doing work is

(a) $\frac{1}{\gamma}$ (b) $1-\frac{1}{\gamma}$
(c) $\gamma - 1$ (d) γ

46. An ideal gas undergoes a process in which its pressure and volume are related as PV^n = constant, where n is a constant. The molar heat capacity for the gas in this process will be zero if

(a) $n = \gamma$ (b) $n = \gamma - 1$
(c) $n = \gamma + 1$ (d) $n = 1 - \gamma$

47. An ideal gas ($\gamma = 1.5$) undergoes a change in state such that the magnitude of heat absorbed by the gas is equal to the magnitude of work done by the gas. The molar heat capacity of the gas in this process is

(a) $2R$ (b) R
(c) $3R$ (d) $1.5R$

48. A quantity of 70 calories of heat is required to raise the temperature of 2 mole of an ideal gas at constant pressure from 40°C to 50°C. The amount of heat required to raise the temperature of the same gas through the same range at constant volume is

(a) 90 calorie
(b) 70 calorie
(c) 50 calorie
(d) 30 calorie

49. During an adiabatic process, the pressure of a gas is found to be proportional to cube of its absolute temperature. The Poisson's ratio of gas is

(a) 3/2 (b) 7/2
(c) 5/3 (d) 9/7

50. A diatomic ideal gas initially at 273 K is given 100 cal heat due to which system did 210 J work. Molar heat capacity of the gas for the process is (1 cal = 4.2 J)

(a) $\frac{3}{2}R$ (b) $\frac{5}{2}R$
(c) $\frac{5}{4}R$ (d) $5R$

51. An ideal monoatomic gas undergoes a reversible process: $\frac{P}{V}$ = constant, from (2 bar, 273 K) to 4 bar. The value of $\frac{\Delta U}{w}$ for this process is

(a) +3.0
(b) −3.0
(c) −1.5
(d) +1.5

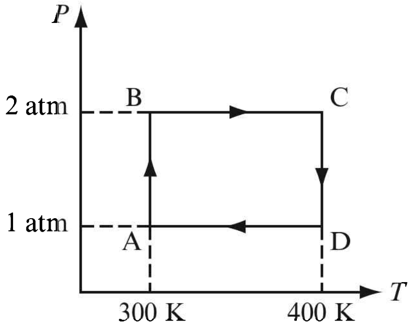
52. The work done by one mole of an ideal gas in the reversible process: PV^3 = constant, from (1 atm, 300 K) to $2\sqrt{2}$ atm is

(a) 150R
(b) 300R
(c) 75R
(d) 600R

53. 2 moles of an ideal monoatomic gas undergoes reversible expansion from (4 L, 400 K) to 8 L such that TV^2 = constant. The change in enthalpy of the gas is

(a) −1500R
(b) −3000R
(c) +1500R
(d) +3000R

54. Two moles of helium gas undergoes a cyclic process as shown in the figure. Assuming ideal behaviour of gas, the net work done by the gas in this cyclic process is



(a) 0
(b) 100R ln2
(c) 100R ln4
(d) 200R ln4

55. One mole of an ideal gas undergoes the following cyclic process:

(i) Isochoric heating from (P_1, V_1, T_1) to double temperature.
(ii) Isobaric expansion to double volume.
(iii) Linear expansion (on P–V curve) to (P_1, 8V_1).
(iv) Isobaric compression to initial state.

If T_1 = 300 K, the magnitude of net work done by the gas in the cyclic process is

(a) 2400 cal
(b) 1200 cal
(c) 4800 cal
(d) 3600 cal

56. One mole of a non-ideal gas undergoes a change of state (2 atm, 3 L, 95 K) → (4 atm, 5 L, 245 K) with a change in internal energy, ΔU = 30.0 L-atm. The change in enthalpy (ΔH) of the process in L-atm is

(a) 40.0
(b) 42.3
(c) 44.0
(d) undefined, because pressure is not constant

57. The normal boiling point of water is 100°C. At 100°C

(a) the average kinetic energy of molecules in vapour is greater than that of liquid water.
(b) the average potential energy of molecules in vapour is greater than that of liquid water.
(c) the molar internal energy is same for vapour and liquid water.
(d) water boils at any pressure.

58. The latent heat of vaporization of a liquid at 500 K and 1 atm pressure is 10 kcal/mol. What will be the change in internal energy if 3 moles of the liquid changes to vapour state at the same temperature and pressure?

(a) 27 kcal
(b) 13 kcal
(c) −27 kcal
(d) −13 kcal

59. A quantity of 1 g of water on evaporation at atmospheric pressure forms 1671 cm^3 of steam. Heat of vaporization is 540 cal/g. The approximate increase in internal energy is

(a) 250 cal
(b) 500 cal
(c) 1000 cal
(d) 1500 cal

60. At 500 kbar and T K, the densities of graphite and diamond are 2.0 and 3.0 g/cm^3, respectively. The value of $(\Delta H - \Delta U)$ for the conversion of 1 mole of graphite into diamond at 500 kbar and T K is

(a) 100 kJ
(b) −100 kJ
(c) 1000 kJ
(d) −1000 kJ

Second and Third Law of Thermodynamics, Entropy

61. The efficiency of the reversible heat engine is η_r and that of irreversible heat engine is η_i. Which of the following relation is correct?

(a) $\eta_r = \eta_1$
(b) $\eta_r > \eta_1$
(c) $\eta_r < \eta_1$
(d) η_1 may be less than, greater than or equal to η_r, depending on the gas.

62. For which of the following process, ΔS is negative?

(a) $H_2(g) \rightarrow 2H(g)$
(b) N_2 (g, 1 atm) → N_2 (g, 8 atm)
(c) $2SO_3(g) \rightarrow 2SO_2(g) + O_2(g)$
(d) C (graphite) → C (diamond)

63. ΔS will be highest for the reaction

(a) $Ca(s) + 1/2\ O_2(g) \rightarrow CaO(s)$
(b) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
(c) $C(s) + O_2(g) \rightarrow CO_2(g)$
(d) $N_2(g) + O_2(g) \rightarrow 2NO(g)$

64. Entropy decrease during

(a) crystallization of sucrose from solution
(b) rusting of iron
(c) melting of ice
(d) vaporization of camphor

65. Change in entropy is negative for

(a) Bromine (l) → Bromine (g)
(b) $C(s) + H_2O\ (g) \rightarrow CO(g) + H_2(g)$
(c) N_2 (g, 10 atm) → N_2 (g, 1 atm)
(d) Fe (1 mol, 400 K) → Fe (1 mol, 300 K)

66. When a substance is heated, its entropy increases. The increase will be maximum at

(a) 0°C
(b) the melting point
(c) the boiling point
(d) 100°C

67. An isolated system comprises the liquid in equilibrium with vapours. At this stage, the molar entropy of the vapour is

(a) less than that of liquid
(b) more than that of liquid
(c) equal to zero
(d) equal to that of liquid

68. According to second law of thermodynamics, heat is partly converted into useful work and part of it

(a) becomes electrical energy
(b) is always wasted
(c) increases the weight of the body
(d) becomes K.E.

69. Choose the substance which has higher possible entropy (per mole) at a given temperature.

(a) solid carbon dioxide
(b) nitrogen gas at 1 atm
(c) nitrogen gas at 0.01 atm
(d) nitrogen gas at 0.00001 atm

70. The change that does not increase entropy

(a) evaporation of liquid
(b) condensation
(c) sublimation
(d) melting of solid

71. Ammonium chloride when dissolved in water leads to cooling sensation. The dissolution of NH_4Cl at constant temperature is accompanied by

(a) increase in entropy
(b) decrease in entropy
(c) no change in entropy
(d) no change in enthalpy

72. When the value of entropy is greater, then the ability for work is

(a) maximum
(b) minimum
(c) medium
(d) none of these

73. When one mole of an ideal gas is compressed to half of its initial volume and simultaneously heated to twice its temperature, the change in entropy is

(a) $C_V \ln 2$
(b) $C_P \ln 2$
(c) $R \ln 2$
(d) $(C_V - R) \ln 2$

74. What is the entropy change when 3.6 g of liquid water is completely converted into vapours at 373 K? The molar heat of vaporization is 40.85 kJ/mol.

(a) 218.9 J/K
(b) 2.189 J/K
(c) 21.89 J/K
(d) 0.2189 J/K

75. The entropy change in the fusion of one mole of a solid melting at 300 K (latent heat of fusion, 2930 J/mol) is

(a) 9.77 J/K-mol
(b) 10.73 J/K-mol
(c) 2930 J/K-mol
(d) 108.5 J/K-mol

76. Oxygen gas weighing 64 g is expanded from 1 atm to 0.25 atm at 30°C. What is the entropy change, assuming the gas to be ideal? ($\ln 4 = 1.4$, $R = 8.3$ J/K-mol)

(a) 23.24 J/K (b) 34.86 J/K
(c) 46.48 J/K (d) 11.62 J/K

77. Two moles of an ideal monoatomic gas is heated from 27°C to 627°C, reversibly and isochorically. The entropy of gas

(a) increases by $2R \ln 3$
(b) increases by $3R \ln 3$
(c) decreases by $2R \ln 3$
(d) decreases by $3R \ln 3$

78. One mole of an ideal monoatomic gas undergoes adiabatic free expansion from 2 to 20 dm^3, 300 K. The value of ΔS for the gas is

(a) 0
(b) $+R \ln 10$
(c) $-R \ln 10$
(d) $+1.5\, R \ln 10$

79. The standard molar entropy of an ideal gas $\left(\gamma = \frac{4}{3}\right)$ is 2.5 cal/K-mol at 25°C and 1 bar. The standard molar entropy of the gas at 323°C and 1 bar is

(a) undefined (b) $R \ln 2$
(c) $R \ln 4$ (d) $R \ln 8$

80. Given the following entropy values (in J/K-mol) at 298 K and 1 atm $H_2(g) = 130.6$, $Cl_2(g) = 223.0$ and $HCl(g) = 186.7$. The entropy change (in J/K-mol) for the reaction: $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$, is

(a) +540.3 (b) +727.0
(c) −166.9 (d) +19.8

Gibbs Free Energy Function

81. The ΔG in the process of melting of ice at $-15°C$ is

(a) less than zero
(b) greater than zero
(c) equal to zero
(d) none of these

82. For a system in equilibrium, $\Delta G = 0$ under conditions of constant

(a) temperature and pressure
(b) temperature and volume
(c) pressure and volume
(d) energy and volume

83. One mole of ice is converted into water at 273 K and 1 atm. The entropies of H_2O (s) and H_2O (l) are 38.0 and 58.0 J/K-mol, respectively. The enthalpy change for the conversion is

(a) 5460 kJ/mol
(b) 5460 J/mol
(c) −5460 J/mol
(d) 20 J/mol

84. The solubility of NaCl(s) in water at 298 K is about 6 moles per litre. Suppose you add 1 mole of NaCl(s) to a litre of water. For the reaction: $NaCl(s) + H_2O \rightarrow NaCl(aq)$

(a) $\Delta G > 0, \Delta S > 0$
(b) $\Delta G < 0, \Delta S > 0$
(c) $\Delta G > 0, \Delta S < 0$
(d) $\Delta G < 0, \Delta S < 0$

85. The values of ΔG are very important in metallurgy. The ΔG values for the following reactions at 1000 K are given as:

$$S_2(s) + 2O_2(g) \rightarrow 2SO_2(g);\ \Delta G = -544 \text{ kJ}$$

$$2Zn(s) + S_2(s) \rightarrow 2ZnS(s);\ \Delta G = -293 \text{ kJ}$$

$$2Zn(s) + O_2(g) \rightarrow 2ZnO(s);\ \Delta G = -480 \text{ kJ}$$

The ΔG for the reaction:

$$2ZnS(s) + 3O_2(g) \rightarrow 2ZnO(s) + 2SO_2(g)$$

will be

(a) −357 kJ
(b) −731 kJ
(c) −773 kJ
(d) −229 kJ

86. The following reaction is at equilibrium at 298 K

$$2NO\ (g, 0.00001\ bar) + Cl_2\ (g, 0.01\ bar) \rightleftharpoons 2NOCl\ (g, 0.01\ bar).$$

$\Delta G°$ for the reaction is

(a) −45.65 kJ
(b) −28.53 kJ
(c) −22.82 kJ
(d) −57.06 kJ

87. What is the free energy change, ΔG, when 1.0 mole of water at 100°C and 1 atm pressure is converted in to steam at 100°C and 1 atm pressure?

(a) 540 cal
(b) −9800 cal
(c) 9800 cal
(d) 0 cal

88. The enthalpy and entropy change for a chemical reaction are −2500 cal and +7.4 cal/K, respectively. The nature of reaction at 298 K is

(a) Spontaneous
(b) Reversible
(c) Irreversible
(d) Non-spontaneous

89. A spontaneous reaction is impossible if

(a) both ΔH and ΔS are negative
(b) ΔH and ΔS are positive
(c) ΔH is negative and ΔS is positive
(d) ΔH is positive and ΔS is negative

90. For a reversible reaction, if $\Delta G° = 0$, the equilibrium constant of the reaction should be equal to

(a) Zero
(b) 1
(c) 2
(d) 10

Answer Keys – Exercise I

Basics

1. (c) 2. (d) 3. (c) 4. (a) 5. (b) 6. (d) 7. (c) 8. (c) 9. (d) 10. (d)
11. (c) 12. (d) 13. (c) 14. (d) 15. (a)

First Law of Thermodynamics

16. (a) 17. (c) 18. (a) 19. (a) 20. (a) 21. (b) 22. (d) 23. (c) 24. (a) 25. (c)
26. (c) 27. (a) 28. (b) 29. (c) 30. (b) 31. (c) 32. (b) 33. (b) 34. (d) 35. (a)
36. (a) 37. (b) 38. (c) 39. (b) 40. (c) 41. (b) 42. (a) 43. (b) 44. (c) 45. (b)
46. (a) 47. (b) 48. (d) 49. (a) 50. (d) 51. (b) 52. (a) 53. (a) 54. (c) 55. (a)
56. (c) 57. (b) 58. (a) 59. (b) 60. (b)

Second and Third Law of Thermodynamics, Entropy

61. (b) 62. (b) 63. (b) 64. (a) 65. (d) 66. (c) 67. (b) 68. (b) 69. (d) 70. (b)
71. (a) 72. (b) 73. (d) 74. (c) 75. (a) 76. (a) 77. (b) 78. (b) 79. (d) 80. (d)

Gibbs Free Energy Function

81. (b) 82. (a) 83. (b) 84. (b) 85. (b) 86. (a) 87. (d) 88. (a) 89. (d) 90. (b)