

Exercise 3 (Taking It Together)

1. If $\Delta H = \Delta G - T\Delta S$ and $\Delta G = \Delta H + T \left[\frac{d(\Delta G)}{dT} \right]_p$ the variation of emf of a cell E, with temperature, T, is given by

- (a) $\frac{\Delta H}{nF}$ (b) $\frac{\Delta G}{nF}$ (c) $\frac{\Delta S}{nF}$ (d) $\frac{\Delta S}{nF}$

2. Which is not intensive property?

- (a) Boiling point (b) Refractive index
(c) Molarity (d) **Volume**

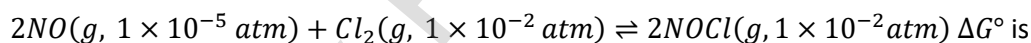
3. 1 g H_2 gas at STP is expanded so that volume is doubled Hence, work done is

- (a) 22.4 L atm (b) 5.6 L atm
(c) **11.2 L atm** (d) 44.8 L atm

4. All the natural process in the universe produce

- (a) a decrease in entropy of the universe
(b) **an increase in entropy of the universe**
(c) no change in entropy
(d) sometimes increase or sometimes decrease in entropy

5. Following reaction occurs at 25°C



- (a) **-45.65 kJ** (b) -28.53 kJ
(c) -22.82 kJ (d) -57.06 kJ

6. 1 mole of NH_3 ($\gamma = 1.33$) gas at 27°C is expanded under adiabatic condition to make volume 8 times. Final temperature and work done respectively are

- (a) **150 K, 900 cal** (b) 150 K, 900 cal
(c) 250 K, 1000 cal (d) 200 K, 800 cal

7. Temperature of 1 mole of a gas is increased by 1° at constant pressure. Work done is

- (a) **R** (b) 2 R

(c) $\frac{R}{2}$ (d) $3R$

8. $C_p - C_v = R$. This R is

- (a) Change in KE
 (b) Change in rotational energy
(c) work done which system can do on expanding the gas per mole degree increase in temperature
 (d) All of the above

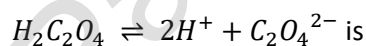
9. Carnot cycle is said to have 25% efficiency when it operates between T (source) and 300 K (sink). T is

- (a) 300 K (b) 350 K
 (c) 375 K **(d) 400 K**

10. Which is equal to the total work done?

- (a) Decrease in G **(b) Decrease in A**
 (c) Decrease in H (d) Decrease in E

11. Heat of neutralization of oxalic acid is $-25.4 \text{ kcal mol}^{-1}$ using strong base, NaOH. Hence enthalpy change of the process is



- (a) 2.0 kcal** (b) -11.8 kcal
 (c) 1.0 kcal (d) -1.0 kcal

12. Heat capacity at constant temperature and constant pressure for H_2 is

- (a) $5 \text{ cal mol}^{-1} \text{ K}^{-1}$ (b) $7 \text{ cal mol}^{-1} \text{ K}^{-1}$
 (c) $8 \text{ cal mol}^{-1} \text{ K}^{-1}$ **(d) ∞**

13. Molar heat capacity of water (liquid) in equilibrium with water vapour at constant pressure is

- (a) zero (b) $40.45 \text{ kJ mol}^{-1} \text{ K}^{-1}$
 (c) $75.48 \text{ J mol}^{-1} \text{ K}^{-1}$ **(d) ∞**

14. If a gas absorbs 200 J of heat and expands by 500 cm^3 against a constant pressure of $2 \times 10^{-5} \text{ N m}^{-2}$, then change in internal energy is

- (a) – 300 J
 (b) – 100 J
(c) + 100 J
 (d) + 300 J

15. For an ideal gas

- (a) $\left(\frac{\Delta E}{\Delta T}\right)_p = 0$
 (b) $\left(\frac{\Delta E}{\Delta T}\right)_V = 0$
(c) $\left(\frac{\Delta E}{\Delta T}\right)_T = 0$
 (d) All of these

16. Inversion temperature is

- (a) $\frac{Rb}{2a}$
(b) $\frac{2a}{Rb}$
 (c) $\frac{Rb}{a}$
 (d) $\frac{a}{Rb}$

17. For an ideal gas Joule-Thomson coefficient is

- (a) Positive
 (b) negative
(c) zero
 (d) dependent on molecular weight

18. For $A \rightarrow B$, $\Delta H = 4 \text{ kcal mol}^{-1}$, $\Delta S = 10 \text{ cal mol}^{-1} \text{ K}^{-1}$

Reaction is spontaneous when temperature can be

- (a) 400 K
 (b) 300 K
(c) 500 K
 (d) None of these

19. If a process is both endothermic and spontaneous, then

- (a) $\Delta S > 0$**
 (b) $\Delta S < 0$
 (c) $\Delta H < 0$
 (d) $\Delta G > 0$

20. For the gas-phase decomposition.



- (a) $\Delta H < 0$, $\Delta S < 0$
(b) $\Delta H > 0$, $\Delta S > 0$

(c) $\Delta H > 0, \Delta S < 0$

(d) $\Delta H < 0, \Delta S > 0$

21. When the reaction mixture is mostly reactants then

(a) $Q \ll 1$

(b) $RT \log_{10} Q \ll 0$

(c) $\Delta > 0$

(d) All of these

22. Under what conditions $\Delta G = \Delta G^\circ$?

(a) $Q = 1$

(b) $Q > 1$

(c) $Q < 1$

(d) $Q = 0$

23. When equilibrium is attained

(a) $Q = 1$

(b) $\Delta G = 0$

(c) $\Delta G^\circ = 0$

(d) $\Delta G = -2.303 RT \log K$

24. $A \rightarrow B$, $\Delta H = +ve$. Graph between $\log_{10} p$ and $\frac{1}{T}$ is a straight line of slope $\frac{1}{4.606}$. Hence, ΔH is

(a) 1 cal

(b) 2 cal

(c) 4 cal

(d) -1 cal

25. Internal energy for one mole of a monoatomic ideal gas is

(a) $\frac{3}{2} RT$

(b) $\frac{5}{2} RT$

(c) $\frac{7}{2} RT$

(d) $4 RT$

26. $T\Delta S$ represents

(a) change in free energy

(b) change in internal energy

(c) quantitative measure of the randomness of a system

(d) work done on the system

27. In a process, a system does 140 J of work on the surroundings and only 40 J of heat is added to the system, hence, change internal energy is

(a) 180 J

(b) -180 J

(c) 100 J

(d) -100 J

28. Which has maximum entropy of vaporization?

- (a) Water (*l*) (b) Toluene (*l*)
(c) Diethyl ether (*l*) (d) Acetone (*l*)

29. For an endothermic process

- (a) $\Delta S_{system} > 0$ (b) $\Delta S_{system} = 0$
(c) $\Delta S_{surroundings} > 0$ (d) $\Delta S_{surroundings} = 0$

30. For an exothermic process

- (a) $\Delta S_{system} > 0$ (b) $\Delta S_{surroundings} > 0$
(c) $\Delta S_{system} = 0$ (d) $\Delta S_{surroundings} = 0$

31. If the inversion temperature of gas is -80°C . then it will produce cooling under Joule-Thomson effect at

- (a) 298 K (b) 273 K
(c) 193 K (d) 173 K

32. Two moles of an ideal gas at 2 bar and 27°C expand isothermally and reversibly to a pressure of 1 bar. The work done by the gas is equal to

- (a) 3.5 kJ (b) 2.5 kJ
(c) 1.5 kJ (d) 4.5 kJ

33. Which of the following does not have zero entropy even at absolute zero?

CO, CO₂, NaCl, NO

- (a) CO, CO₂ (b) CO, NO
(c) CO₂, NaCl (d) NaCl

34. Sign of ΔG for the melting of ice is negative at

- (a) 265 K (b) 270 K
(c) 271 K (d) 274 K

35. Although dissolution of NH₄Cl in water is endothermic yet it dissolves because

- (a) ΔG is positive (b) ΔH is positive

- (c) ΔS is positive (d) ΔA is positive

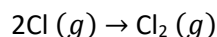
36. Driving force of a reaction is the

- (a) resultant of enthalpy and entropy change
 (b) resultant of enthalpy and internal energy change
 (c) resultant of entropy and internal energy change
 (d) term concerned with driving of a car

37. Sign of ΔG is positive at low temperature when

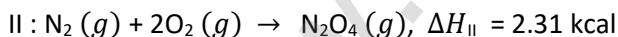
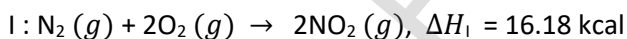
- (a) ΔH is positive and ΔS is positive
 (b) ΔH is negative and ΔS is positive
 (c) ΔH is negative and ΔG is positive
 (d) ΔH is negative and ΔS is zero

38. For the reaction,



- (a) $\Delta H = +ve, \Delta S = +ve$ (b) $\Delta H = +ve, \Delta S = -ve$
 (c) $\Delta H = -ve, \Delta S = +ve$ (d) $\Delta H = -ve, \Delta S = -ve$

39. Given the following reactions



Based on the above facts

- (a) NO_2 is more stable than N_2O_2 at low temperature
(b) N_2O_2 is more stable than NO_2 at low temperature
 (c) Both are equally stable at low temperature
 (d) None of the above

40. In an electrochemical cell $\Delta G = \Delta H$

- (a) $T \rightarrow 0$ (b) $T \rightarrow \infty$

$$(c) \left(\frac{dE_{cell}}{dT} \right)_p = 0$$

(d) Both (a) and (c)

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

(a) $C_v \ln 2$

(b) $C_p \ln 2$

(c) $R \ln 2$

(d) $(C_v - R) \ln 2$

42. The third law of thermodynamics states that in the limit $T \rightarrow 0$

(a) $G = 0$

(b) $H = 0$

(c) $E = 0$

(d) $S = 0$

43. Select the correct statements (S).

(a) Kinetic energy is the energy of motion

(b) Potential energy is stored energy

(c) Fuel gases (as LPG) contain potential energy in their chemical bonds

(d) All of the above

44. Kinetic energy of an article 20 g is 4 J while that of another article of same mass is 16 J. Hence, velocity ratio of their motion is

(a) 1 : 4

(b) 4 : 1

(c) 1 : 2

(d) 2 : 1

45. A substance mass of 10 kg at height of 10 m is allowed to fall A place where kinetic energy is 200 J, potential energy is

(a) 1000 J

(b) 800 J

(c) 200 J

(d) - 800 J

46. 1 J is equal to

(a) $1 \text{ kg m}^2 \text{ s}^{-2}$

(b) $\frac{1}{4.184} \text{ cal}$

(c) Both (a) and (b)

(d) None of these

47. Consider the following statements.

I : Spontaneous processes involving macroscopic objects proceed with a decrease in potential energy.

II : Expansion of an no ideal gas is a spontaneous process in which there is no change of energy at all.

III : For a spontaneous process in an isolated system, the change in entropy is positive

Select the correct statements (S).

(a) I , II

(b) I, III

(c) II, III

(d) I, II, III

48. What are the signs of the entropy change (+ or -) in the following?

I : A liquid crystallizes into a solid.

II : Temperature of a crystalline solid is raised from 0 K to 115 K.

III : $2\text{NaHCO}_3 (S) \rightarrow \text{Na}_2\text{CO}_3 (S) + \text{CO}_2 (g) + \text{H}_2\text{O} (g)$

IV : $\text{H}_2 (g) \rightarrow 2\text{H} (g)$

	I	II	III	IV	I	II	III	IV
(a)	-	+	+	+	(b)	-	-	+
(c)	-	-	-	+	(d)	+	-	-

49. Number of phases present in the following thermodynamic systems are



(a) 2, 3, 1

(b) 3, 2, 1

(c) 1, 2, 3

(d) 3, 1, 2

50. Out of following properties.

(I) entropy S ,

(II) free energy G ,

(III) internal energy E ,

(IV) enthalpy H ,

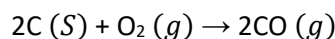
State function are

- (a) all except I (b) all except III
(c) all except I, III (d) All of these

51. A larger positive value of ΔG° corresponds to which of these?

- (a) small positive K (b) small negative K
(c) large positive K (d) small negative K

52. When charcoal burns in air signs of ΔH and ΔS are



- | | ΔH | ΔS | | ΔH | ΔS |
|-----|------------|------------|-----|------------|------------|
| (a) | - | - | (b) | - | + |
| (c) | + | + | (d) | + | - |

53. Consider the following statements.

I : S° values for all elements in their standard states are positive.

II : S° values for all aqueous ions are positives.

III : ΔS° values for all spontaneous reactions are positive.

Select the correct statements (S).

- (a) I only (b) I and II only
(c) II and III only (d) I, II and III

54. What is the sign of ΔG° and the value of K for an electrochemical cell for which $E^\circ_{cell} = 0.80$ V?

- | | ΔG° | K | | ΔG° | K |
|-----|------------------|-----|-----|------------------|-----|
| (a) | - | > 1 | (b) | + | > 1 |
| (c) | + | < 1 | (d) | - | < 1 |

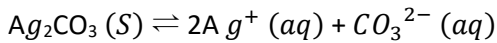
55. When a liquid evaporates, which is true about the signs of the enthalpy and entropy changes?

- | | ΔG | K | | ΔG | K |
|-----|------------|-----|-----|------------|-----|
| (a) | + | + | (b) | - | - |
| (c) | + | - | (d) | - | + |

56. Under which circumstances would the free energy change for a reaction be relatively temperature independent?

- (a) ΔH° is negative
- (b) ΔH° is positive
- (c) ΔS° has a large positive value
- (d) ΔS° has a small value**

57. For the reaction



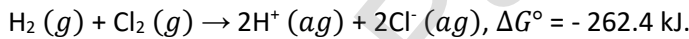
$\Delta G^\circ = +63.3$ kJ. Hence, thermodynamic equilibrium constant at 25°C is

- (a) 3.2×10^{26}
- (b) -63.3×10^3
- (c) 8.06×10^{-12}**
- (d) 1.2×10^{-12}

58. ΔG° and ΔH° for a reaction at 300 K is -66.9 kJ mol⁻¹ and -41.8 kJ mol⁻¹ respectively. ΔG° for the same reaction at 330 K is

- (a) -25.1 kJ mol⁻¹
- (b) $+25.1$ kJ mol⁻¹
- (c) 18.7 kJ mol⁻¹
- (d) -25.1 kJ mol⁻¹**

59. For the given reaction



The value of free energy of formation (ΔG_f°) for ion $Cl^- (aq)$ is

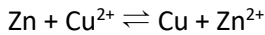
- (a) -131.2 kJ mol⁻¹**
- (b) $+131.2$ kJ mol⁻¹
- (c) -262.4 kJ mol⁻¹
- (d) $+262.4$ kJ mol⁻¹

60. Match list I (thermodynamic properties) with list II (appropriate expression) and select the correct answer.

	List I		List II
A.	Free energy change (ΔG) of a reaction.	1.	$-RT \ln K$
B.	Enthalpy change of a reaction in standard state (ΔH°).	2.	$RT^2 \left(\frac{d \ln K}{dT} \right)_p$
C.	Entropy change (ΔS) of a reaction.	3.	$-nFE$
D.	Free energy change of a reaction in standard state.	4.	$-\left(\frac{d\Delta G}{dT} \right)_p$

	A	B	C	D
(a)	1	2	3	4
(b)	3	2	4	1
(c)	2	3	4	1
(d)	4	1	2	3

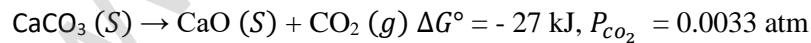
61. If for the cell reaction.



Entropy change ΔS° is $96.5 \text{ J mol}^{-1} \text{ K}^{-1}$ then temperature coefficient of the emf of a cell is

- (a) $5 \times 10^{-4} \text{ VK}^{-1}$ (b) $1 \times 10^{-3} \text{ VK}^{-1}$
 (c) $2 \times 10^{-3} \text{ VK}^{-1}$ (d) $9.65 \times 10^{-4} \text{ kJ K}^{-1}$

62. For the reaction at 1000°C ,



hence, ΔG at this temperature is

- (a) - 60.5 kJ (b) - 87.5 kJ
 (c) - 33.5 kJ (d) + 33.5 kJ

63. One mole of an ideal gas ($C_V = 20 \text{ J K}^{-1} \text{ mol}^{-1}$) initially at STP is heated at constant volume to twice the initial temperature. For the process, W and q will be

(a) $W = 0$; $q = 5.46 \text{ kJ}$

(b) $W = 0$; $q = 0$

(c) $W = - 5.46 \text{ kJ}$; $q = 5.46 \text{ kJ}$

(d) $W = - 5.46 \text{ kJ}$; $q = 5.46 \text{ kJ}$

64. Consider the following statements.

I : Adiabatic demagnetisation of a paramagnetic substances produces low temperature

II : Adiabatic expansion of a gas from a region of high pressure to a region of low pressure produces cooling.

III : A gas can be liquefied by applying high pressure above its critical temperature.

Which of these statements is/are correct?

(a) I only

(b) I and II

(c) I and III

(d) II, and III

65. The adsorption of a vapour on a clean surface is a spontaneous process because

(a) change in the entropy of the process is highly positive

(b) enthalpy change is highly positive

(c) change in entropy is zero

(d) change in enthalpy is highly negative

66. Which one of the following statements is not correct?

(a) The net increase in entropy of the system is zero in any reversible cyclic process

(b) The isothermally available energy present in a system is called its free energy

(c) The change of free energy with pressure for one mole of a perfect gas at constant pressure is

$$\Delta G = RT \log_e \frac{p_2}{p_1}$$

(d) For a spontaneous change $(\Delta G)_{T,P} > 0$

67. For an isomerisation reaction $A \rightleftharpoons B$, the temperature dependence of equilibrium constant is given by

$$\log_e K = 4.0 \frac{2000}{T}$$

The value of ΔS° at 300 K is therefore

- (a) $4 R$ (b) $5 R$
(c) $400 R$ (d) $2000 R$

68. A reaction that is spontaneous can be described as

- (a) proceeding in both the forward and reverse directions
(b) having the same rate in both the forward and reverse directions
(c) releasing heat to the surroundings
(d) proceedings without external influence once it has begun

69. In the process of dissolving sugar in water, the entropy increases. This means that the signs of ΔS ..., and that the randomness of the system

- (a) undetermined, increases (b) positive, decreases
(c) positive, increases (d) negative, decreases

70. The concept of free energy allows prediction of spontaneity of a process by considering the changes in ... and ... during the process

- (a) enthalpy, entropy** (b) enthalpy mass
(c) entropy, mass (d) enthalpy, temperature

71. A process which is unfavourable with respect to enthalpy, but favourable with respect to entropy

- (a) could occur at low temperature, but not at high temperature
(b) could occur at high temperature, but not at low temperature
(c) could not occur regardless of temperature
(d) could occur at any temperature

72. How much energy must be supplied to change 36 g ice at 0°C to water at room temperature, 25°C

$$\Delta H^\circ_{\text{fusion}} = 6.01 \text{ kJ mol}^{-1}$$

$$C_{p\text{liquid}} = JK^{-1} g^{-1}$$

- (a) 12 kJ (b) 16 kJ

- (c) 19 kJ (d) 22 kJ

73. A certain reaction is exothermic by 220 kJ and does 10 kJ of work. What is the change in the internal energy of system at constant temperature?

- (a) + 230 kJ (b) - 230 kJ
(c) - 210 kJ (d) + 210 kJ

74. For a particular reaction, $\Delta H^\circ = -38.3$ kJ and $\Delta S^\circ = -113$ JK⁻¹. This reaction is

- (a) spontaneous at all temperatures
(b) non-spontaneous at all temperatures
(c) **spontaneous at temperature above 338 K**
(d) spontaneous at temperature above 339 K

75. $2\text{Al}_2\text{O}_3 (s) \rightarrow 4\text{Al} (s) + 3\text{O}_2 (g)$, $\Delta G = +138$ kcal

Considering the contribution of entropy to the spontaneity of this reaction, the reaction is ... and entropy of the system ...

- (a) spontaneous, increases
(b) spontaneous, decreases
(c) **non-spontaneous, increases**
(d) non-spontaneous, increases

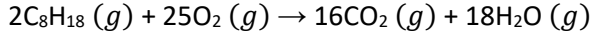
76. All of the statements regarding the symbol ΔG are true except

- (a) it refers to the free energy of the reaction
(b) it allows us to predict the spontaneity of a reaction
(c) **it allows us to identify an exothermic reaction**
(d) it allows us to identify an endergonic reaction

77. When solid melts, there is

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

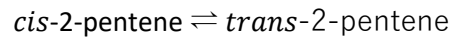
78. Following reaction is occurring in an automobile



The sign of ΔH , ΔS and ΔG would be

- (a) +, -, + (b) -, +, -
 (c) -, +, + (d) +, +, -

79. Standard state Gibbs' free energy change for isomerization reaction,



Is - 3.67 kJ/mol at 400 K. If more *trans*-2-pentene is added to the reaction vessel, then

- (a) more *cis*-2-pentene is formed
 (b) additional *trans*-2-pentene is formed
 (c) equilibrium remains unaffected
 (d) equilibrium is shifted in the forward direction

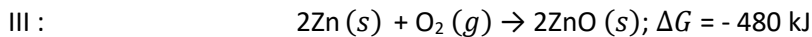
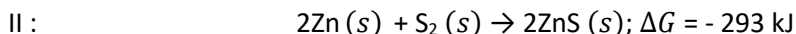
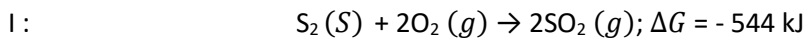
80. For a reaction to occur spontaneously

- (a) ($\Delta H - T\Delta S$) must be negative
 (b) ($\Delta H + T\Delta S$) must be negative
 (c) ΔH must be negative
 (d) ΔS must be negative

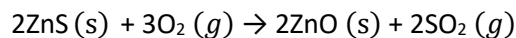
81. 1 mole of an ideal gas at 300 K is expanded isothermally and reversibly from an initial volume of 1 L to 10 L. The work in this process is ($R = 2 \text{ cal mol}^{-1} \text{ K}^{-1}$)

- (a) - 163.7 cal (b) zero
 (c) - 1381.8 cal (d) - 9 L atm

82. The factor of ΔG values is important in metallurgy. The ΔG values for the following reaction at 800 °C are given as



The ΔG for the reaction,



Will be

(a) - 357 kJ (b) - 731 kJ

(c) - 773 kJ (d) - 229 kJ

83. The entropy change in the fusion of 1 mole of a solid melting at 27°C (Latent heat of fusion, 2930 J mol^{-1}) is

(a) $9.77 \text{ JK}^{-1} \text{ mol}^{-1}$ (b) $10.73 \text{ JK}^{-1} \text{ mol}^{-1}$

(c) $2930 \text{ JK}^{-1} \text{ mol}^{-1}$ (d) $108.5 \text{ JK}^{-1} \text{ mol}^{-1}$

84. A system absorbs 600 J of heat and the system works equivalent to -900 J by expanding. The value of ΔE for the system is

(a) - 300 J (b) + 300 J

(c) - 600 J (d) + 600 J

85. 1 mole of gas occupying 3 L volume is expanded against a constant external pressure of 1 atm to a volume of 15 L . The work done by a system is equal to

(a) - $1.215 \times 10^3 \text{ J}$ (b) - $12.15 \times 10^3 \text{ J}$

(c) + $1.215 \times 10^3 \text{ J}$ (d) + $12.15 \times 10^3 \text{ J}$

86. A gas placed in a cylinder fitted with a frictionless piston expands against a constant external pressure of 1 atm from a volume of 5 L to 10 L by absorbing 400 J heat. The change in internal energy is

(a) 88.76 J (b) - 102.00 J

(c) - 106.35 J (d) - 122.22 J

87. $2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(l)$. At 300 K , if the entropies of $\text{H}_2(g)$, O_2 and $\text{H}_2\text{O}(l)$ are 126.6 , 201.20 and $68.0 \text{ JK}^{-1} \text{ mol}^{-1}$ respectively; the entropy change for this reaction is

(a) 22.4 (b) - 22.4

(c) - 318.4 (d) 318.4

88. A gas expands isothermally against a constant extreme pressure of 1 atm from a volume of 10 dm³ to a volume of 20 dm³. It absorbs 800 J of thermal energy from its surroundings. The ΔU is
- (a) – 312 J (b) + 123 J
(c) – 213 J (d) + 231 J
89. 1 mole of an ideal gas for which $C_V = 3/2 R$ is heated reversibly at constant pressure of 1 atm from 25°C to 100°C. The ΔH is
- (a) 3.725 (b) 37.5
(c) 375 (d) 3750
90. During isothermal reversible expansion of 1 mole of an ideal gas from 10 atm to 1 atm at 300 K, the work done is
- (a) – 895.8 cal (b) – 1172.6 cal
(c) – 1381.8 cal (d) – 1499.6 cal
91. For chemical reaction the enthalpy and entropy change are -2.5×10^{-3} cal and 7.5 cal deg^{-1} respectively. At 25°C the reaction is
- (a) spontaneous** (b) non-spontaneous
 (c) reversible (d) irreversible
92. When 1 mole of water at 100°C is converted into steam at 100°C at a constant pressure of 1 atm, the entropy change (in $\text{cal K}^{-1} \text{ mol}^{-1}$) is. (Heat of vaporization of water at 100°C = 540 cal/g)
- (a) 6.66 (b) 12.44
 (c) 20.22 **(d) 26.06**
93. $\text{NH}_3 (g) + \text{HCl} (g) \rightarrow \text{NH}_4\text{Cl} (s)$
- For the above reaction
- (a) ΔH is –ve and ΔS is + ve
 (b) ΔS is –ve and ΔH is + ve
(c) both ΔH and ΔS are – ve
 (d) both ΔS and ΔH are + ve

94. 1 mole of an ideal gas is allowed to expand reversibly and adiabatically from a temperature of 27°C . The work done is 3 kJ. The final temperature of the gas is equal to ($C_V = 20 \text{ J mol}^{-1} \text{ K}^{-1}$)
- (a) 75 K (b) **150 K**
(c) 225 K (d) 300 K
95. If 0.75 mole of ideal gas expands isothermally at 27°C from 15 L to 25 L then the maximum work done is
- (a) - 914 J (b) - f923 J
(c) - **956 J** (d) - 975 J
96. Consider the following statements about thermodynamics.
- I : It is macroscopic science concerning such properties as pressure, temperature and volume
II : Unlike quantum mechanics, it is not based on a specific molecular model.
III : It helps us to predict the direction and extent of chemical reactions, it tells us nothing about the rate of a process.
- Select the correct statements.
- (a) I and II (b) II and III
(c) I and III (d) **I, II and III**
97. For the gas to expand,
- (a) **$p_{in} > p_{ext}$** (b) $p_{in} = p_{ext}$
(c) $p_{in} < p_{ext}$ (d) $p_{ext} = 1 \text{ atm}$
98. A quantity of 0.850 mol of an ideal gas initially at a pressure of 15.0 atm and 300 K is allowed to expand to expand isothermally until its final pressure is 1.00 atm. Work done if the expansion is carried out against a constant external pressure of 1.00 atm is (1 L atm = 101.3 J)
- (a) - 5.74 x 10³ J (b) - **1.98 x 10³ J**
(c) 5.74 x 10³ J (d) 0.00 J
99. For an isothermal reversible process work obtained in the above case is
- (a) - **5.74 x 10³ J** (b) 5.74 x 10³ J
(c) - 1.98 x 10³ J (d) 1.98 x 10³ J

100. A quantity of 0.50 mole of an ideal gas at 20°C expands isothermally against a constant pressure of 2.0 atm from 1.0 L to 5.0 L. Entropy change of the system is

- (a) 6.7 J K⁻¹ (b) - 2.8 J K⁻¹
 (c) 3.9 J K⁻¹ (d) None is correct

101. Entropy change of the surrounding in the above case is

- (a) 6.7 J K⁻¹ (b) - 2.8 J K⁻¹
 (c) 3.9 J K⁻¹ (d) + 6.7 J K⁻¹

102. Entropy change of the system and surrounding taken together is

- (a) 8.7 J K⁻¹ (b) - 2.8 J K⁻¹
 (c) 3.9 J K⁻¹ (d) - 6.7 J K⁻¹

103. Consider the following figure responding the increase in entropy of a substance from absolute zero to its gaseous state at some temperature.



ΔS° (fusion) and ΔS° (vaporization) are respectively indicated by

- (a) AB, BC (b) BC, CD
 (c) BC, DE (d) CD, DE

104. At constant pressure 200 g of water is heated from 10°C to 20°C. Thus, increase in entropy is (molar heat capacity of water at constant pressure is 75.3 J K⁻¹)

- (a) - 227.0 J K⁻¹ (b) 227.0 J K⁻¹
 (c) - 227.0 J K⁻¹ (d) - 29.0 J K⁻¹

105. Supercooled water is liquid water that has been cooled below its normal freezing point. This state is thermodynamically
- (a) stable and tends to freeze into ice spontaneously
 - (b) unstable and tends to freeze into ice spontaneously**
 - (c) stable and tends to fuse into liquid spontaneously
 - (d) unstable and tends to fuse into liquid spontaneously
106. In thermodynamics, a process is called reversible when
- (a) surroundings and system change into each other
 - (b) there is no boundary between system and surroundings
 - (c) the surroundings are always in equilibrium with the system**
 - (d) the system changes into the surroundings spontaneously
107. One mole of a gas undergoes a change of state (2.0 atm, 3.0 L, 95 K) \rightarrow (4.0 atm, 5.0 L, 245 K) with a change in internal energy, $\Delta U = 30.0$ L-atm. The change in enthalpy (ΔH) of the process in L-atm is
- (a) 40.0
 - (b) 42.3**
 - (c) 44.0
 - (d) not defined as P is not constant.
108. Spontaneous adsorption of gas on solid surface is an exothermic process because
- (a) ΔH increases for system
 - (b) ΔS increases for gas
 - (c) ΔS decreases for gas**
 - (d) ΔG increases for gas
109. $\Delta H_{vap} = 30$ kJ mol⁻¹ and $\Delta S_{vap} = 75$ J mol⁻¹ K⁻¹. Thus,
- (a) 400 K**
 - (b) 350 K
 - (c) 298 K
 - (d) 250 K
110. 2 moles of an ideal gas are expanded isothermally and reversibly from 1 L to 10 L at 300 K. What is the enthalpy change?
- (a) 4.98 kJ
 - (b) 11.47 kJ**

- (c) -11.47 kJ (d) 0 kJ

111. When one mole of a monoatomic ideal gas at TK undergoes adiabatic change under a constant external pressure of 1 atm volume changes from 1 L to 2 L. The final temperature in Kelvin would be

- (a) $\frac{T}{2^{10}}$ (b) $T + \frac{1}{3 \times 0.0821}$
 (c) T (d) $T - \frac{1}{3 \times 0.0821}$

112. A monoatomic ideal gas undergoes a process in which the ratio of p to V at any instant is constant and equals to 1. What is the molar heat capacity of the gas?

- (a) $\frac{4R}{2}$ (b) $\frac{3R}{2}$
 (c) $\frac{5R}{2}$ (d) 0

113. The direct conversion of A to B is difficult, hence it is carried out by the following shown path



Given $\Delta S_{(A \rightarrow C)} = 50$ eu

$$\Delta S_{(C \rightarrow D)} = 30$$
 eu

$$\Delta S_{(E \rightarrow D)} = 20$$
 eu

Where, eu is entropy unit, then $\Delta S_{(A \rightarrow B)}$ is

- (a) + 100 eu (b) + 60 eu
 (c) - 100 eu (d) - 60 eu

114. Which is the correct statement if N_2 is added at equilibrium condition?

- (a) The equilibrium will shift to forward direction because according to second law of thermodynamics the entropy must increase in the direction of spontaneous reaction
(b) The condition for equilibrium is $G_{n_2} + 3G_{H_2} = 2G_{NH_3}$ where, G is Gibbs' free energy per mole of the gaseous species measured at the partial pressure. The condition of equilibrium is unaffected by the use of catalyst, which increases the rate of both the forward and backward reactions to the same extent.

(c) The catalyst will increase the rate of forward reaction by α and that of backward reaction by β

(d) Catalyst will not alter the rate of either of the reactions

115. For the process $\text{H}_2\text{O} (l) (1 \text{ bar}, 373 \text{ K}) \rightarrow \text{H}_2\text{O} (g) (1 \text{ bar}, 373 \text{ K})$, the correct set of thermodynamic parameters is

(a) $\Delta G = 0, \Delta S = +ve$

(b) $\Delta G = 0, \Delta S = -ve$

(c) $\Delta G = +ve, \Delta S = 0$

(d) $\Delta G = -ve, \Delta S = +ve$

116. The value of $\log_{10}K$ for the reaction $A \rightleftharpoons B$ is (Given $\Delta H^\circ_{298 \text{ K}} = -54.07 \text{ k mol}^{-1}$, $\Delta S^\circ_{298 \text{ K}} = 10 \text{ J K}^{-1} \text{ mol}^{-1}$ and $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$; $2.303 \times 8.314 \times 298 = 5705$)

(a) 5

(b) 10

(c) 95

(d) 100

117. 117. For an isothermal process

I : $\Delta E = 0$

II : $\left(\frac{\partial E}{\partial V}\right)_T = 0$

III : $q + W = 0$

Select the correct statements(S).

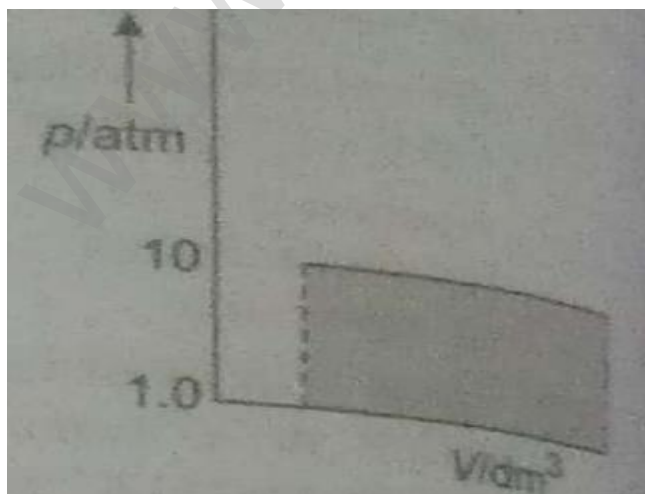
(a) I, II

(b) I, III

(c) II, III

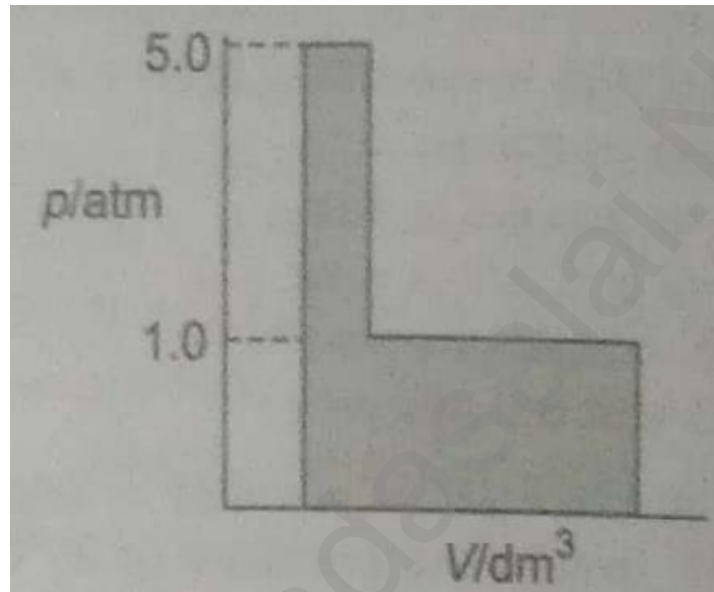
(d) I, II, III

118. A 0.150 mole sample of an ideal gas is allowed expand at 294 K from 10.00 atm to 1.00 atm. If external pressure is kept constant at 1.00 atm work done is



- (a) -330 J
 (b) - 3.26 dm³ atm
(c) Both (a) and (b)
 (d) None of the above

119. If external pressure is held at 5.00 atm in (q-118) above until the expansion stops and then further reduced to 1.00 atm, then work done is



- (a) - 476 J** (b) - 4.70 J
 (c) - 476 kJ (d) - 4.70 kJ

120. One of the earliest uses of steam engine was for lifting weights. Estimate the number of moles of superheated steam at 398 K needed to lift a woman of 60 kg mass by 5.0 m

- (a) 8.9 mol **(b) 0.89 mol**
 (c) 89 mol (d) 0.089 mol

121. A 225 g sample of helium at a temperature of 330 K expands adiabatically. The final temperature is 300 K. Thus, work done is

- (a) - 21.0 kJ** (b) + 21.0 kJ
 (c) - 84.2 kJ (d) + 84.2 kJ

122. For adiabatic change, some relations are:

$$I : W = \int C_v dT$$

$$II : \frac{V_1}{V_2} = \left(\frac{T_2}{T_1}\right)^{C_v/R}$$

$$III : pV^\gamma = \text{constant}$$

$$IV : \frac{p_1}{p_2} = \left(\frac{V_2}{V_1}\right)^{C_p/C_v}$$

Select the correct statements (S).

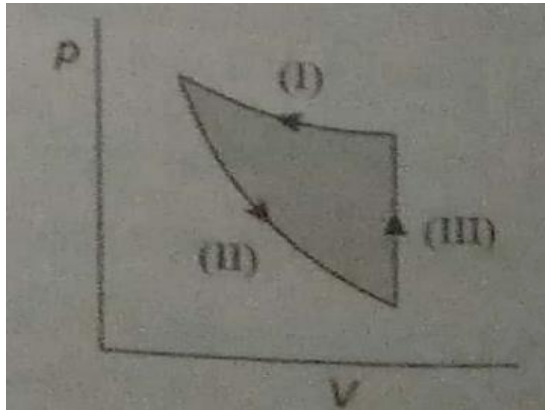
(a) all except II

(b) all except II, IV

(c) all except I

(d) All of these

123. Consider the following cyclic process



I : Isothermal

II : adiabatic

III : Constant-volume process

Sum of the work and heat in the above is

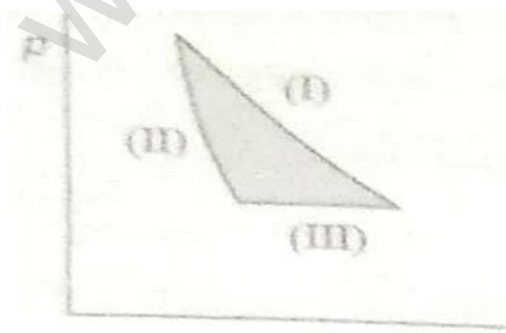
(a) Zero

(b) pV

(c) R

(d) $-pV$

124. Consider the following cyclic process



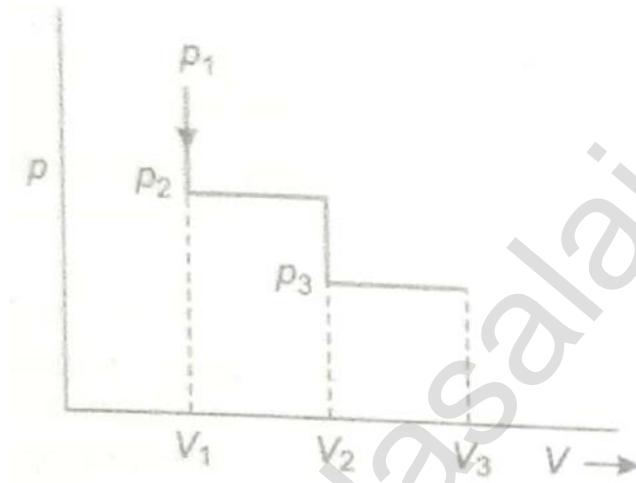
I : Isothermal

II : Adiabatic

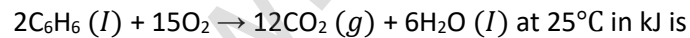
III : Constant-pressure process

Sum of the work and heat in the above is

(a) Zero

(b) pV (c) R (d) $-pV$ 125. The following diagram represents the ($p - V$) changes of a gas. Thus, total work done is(a) $p_2(V_2 - V_1) + p_3(V_3 - V_2)$ (b) $p_1(V_2 - V_1) + p_3(V_3 - V_2)$ (c) $p_2(V_3 - V_1) + p_3(V_2 - V_1)$ (d) $p_2(V_3 - V_1) + p_3(V_2 - V_1)$

126. The difference between heats of reaction at constant pressure and constant volume for the reaction



(a) - 7.43

(b) + 3.72

(c) - 3.72

(d) + 7.43

127. For an endothermic reaction, where ΔH represents the enthalpy of the reaction in kJ/mol, the minimum value for the energy of activation will be(a) less than ΔH

(b) zero

(c) more than ΔH (d) equal to ΔH

128. ($\Delta H - \Delta U$) for the formation of carbon monoxide (CO) from its element at 298 K is ($R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$)

(a) $-1238.78 \text{ J mol}^{-1}$ (b) **$1238.78 \text{ J mol}^{-1}$**

(c) $-2477.57 \text{ J mol}^{-1}$ (d) $2477.56 \text{ J mol}^{-1}$

129. In thermodynamics, a process is called reversible when

(a) surroundings and system change into each other

(b) there is no boundary between system and surroundings

(c) **the surroundings are always in equilibrium with the system**

(d) the system changes into the surroundings spontaneously

130. Which of the following statements is false?

(a) **Work is a state function**

(b) Temperature is a state function

(c) Change in the state is completely defined when the initial and final states are specified

(d) Work appear at the boundary of the system

131. Identify the intensive quantities from the following

(a) enthalpy

(b) **temperature**

(c) volume

(d) entropy

132. Which of the following reactions defines ΔH_f° ?

(a) $C_{(diamond)} + O_2(g) \rightarrow CO_2(g)$

(b) **$\frac{1}{2}H_2(g) + \frac{1}{2}F_2(g) \rightarrow HF(g)$**

(c) $N_2(g) + \frac{1}{2}3H_2(g) \rightarrow 2NH_3(g)$

(d) $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

133. Spontaneous adsorption of a gas on solid surface is an exothermic process because

(a) ΔH increases for system

(b) ΔS increases for gas

(c) **ΔS decreases for gas**

(d) ΔG increases for gas

134. $\Delta H_{\text{vap}} = 30 \text{ kJ/mol}$ and $\Delta S_{\text{vap}} = 75 \text{ J mol}^{-1} \text{ K}^{-1}$, Find temperature of vapour, at one atmosphere

- (a) **400 K** (b) 350 K
(c) 298 K (d) 250 K

135. 2 moles of an ideal gas expanded isothermally and reversibly from 1 L to 10 L at 300 K. What is the enthalpy change?

- (a) 4.98 kJ (b) 11.47 kJ
(c) - 11.47 kJ (d) **0 kJ**

136. One mole of monoatomic ideal gas expands adiabatically at initial temperature T against a constant external pressure of 1 atm from 1 L to 2 L. Find out the final temperature ($R = 0.0821 \text{ L atm K}^{-1} \text{ mol}^{-1}$)

- (a) T (b) $\frac{T}{(2)^{\frac{5}{3}-1}}$
(c) $T - \frac{2}{3 \times 0.082}$ (d) $T + \frac{2}{3 \times 0.082}$

137. A monoatomic ideal gas undergoes a process in which the ratio of p to V at any instant is constant and equals to 1. What is the molar heat capacity of the gas?

- (a) $\frac{4R}{2}$ (b) $\frac{3R}{2}$
(c) $\frac{5R}{2}$ (d) 0

138. In which case ΔS is positive?

- (a) $\text{H}_2\text{O} (l) \rightarrow \text{H}_2\text{O} (s)$
(b) $\text{H}_2\text{O} (g) \rightarrow \text{H}_2\text{O} (l)$
(c) **$\text{H}_2\text{O} (g) \rightarrow \text{H}_2\text{O} (g)$**
(d) $\text{N}(g) + 3\text{H}(g) \rightarrow \text{NH}_3 (g)$

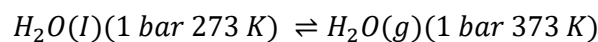
139. Which of the following is not the endothermic reaction?

- (a) **Combustion of methane**
(b) Decomposition of water
(c) Dehydrogenation of ethane to ethylene
(d) Conversion of graphite to diamond

140. The value of $\log_{10} K$ for a reaction, $A \rightleftharpoons B$ is (Given ; $\Delta_r H^\circ_{298k} = -54.07 \text{ kJ mol}^{-1}$, $\Delta_r S^\circ_{298k} = 10 \text{ Jk}^{-1} \text{ mol}^{-1}$ and $R=8.314 \text{ JK}^{-1} \text{ mol}^{-1}$; $2.303 \times 8.314 \times 298 = 5705$)

- (a) 5 (b) **10**
 (c) 95 (d) 100

141. For the process,



the correct set of thermodynamic parameters is

- (a) $\Delta G = 0$, $\Delta S = +ve$
 (b) $\Delta G = 0$, $\Delta S = -ve$
 (c) $\Delta G = +ve$, $\Delta S = 0$
 (d) $\Delta G = -ve$, $\Delta S = 0$

142. Among the following, the state function(S) are except

- (a) internal energy
 (b) **irreversible expansion work**
 (c) reversible expansion work
 (d) molar enthalpy

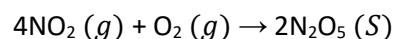
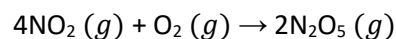
143. Among the following, intensive property is not shown by

- (a) molar conductivity (b) electromotive force
 (c) **free energy** (d) pH

144. The entropy change involved in the isothermal reversible expansion of 2 moles of an ideal gas from a volume of 10 dm^3 at 27°C is

- (a) **$38.3 \text{ J mol}^{-1} \text{ K}^{-1}$** (b) $35.8 \text{ J mol}^{-1} \text{ K}^{-1}$
 (c) $32.3 \text{ J mol}^{-1} \text{ K}^{-1}$ (d) $42.3 \text{ J mol}^{-1} \text{ K}^{-1}$

145. Consider the reactions at 300 K



Thus entropy change for the sublimation of $N_2O_5 (S)$ is

- (a) $180 \text{ J mol}^{-1}\text{K}^{-1}$ (b) $360 \text{ J mol}^{-1}\text{K}^{-1}$
 (c) $-360 \text{ J mol}^{-1}\text{K}^{-1}$ (d) $-180 \text{ J mol}^{-1}\text{K}^{-1}$

146. The direction conversion of A and B is difficult, hence it is carried out by the following shown path.



Given $\Delta S_{(A \rightarrow C)} = 50 \text{ eu}$

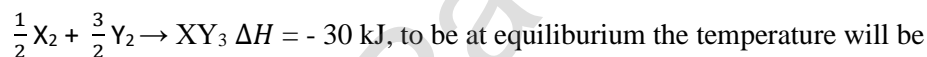
$$\Delta S_{(C \rightarrow D)} = 30 \text{ eu}$$

$$\Delta S_{(E \rightarrow D)} = 20 \text{ eu}$$

Where, eu is entropy unit, then $\Delta S_{(A \rightarrow B)}$ is

- (a) $+100 \text{ eu}$ (b) $+60 \text{ eu}$
 (c) -100 eu (d) -60 eu

147. Standard entropy of X_2 , Y_2 and XY_3 are 60 , 40 and $50 \text{ JK}^{-1} \text{ mol}^{-1}$, respectively. For the reaction



- (a) 1250 K (b) 500 K
 (c) **750 K** (d) 1000 K

148. Identify correct statement regarding a spontaneous process.

- (a) **For a spontaneous process in an isolated system, the change in entropy is positive**
 (b) Endothermic processes are never spontaneous
 (c) Exothermic process are always spontaneous
 (d) Lowering of energy in the reaction process is the only criterion for spontaneity.

149. In conversion of limestone to lime,



The values of ΔH° and ΔS° are $+179.1 \text{ kJ mol}^{-1}$ and 160.2 JK^{-1} respectively at 298 K and 1 bar. Assuming that ΔH° and ΔS° do not change with temperature, temperature above which conversion of limestone to lime will be spontaneous is

- (a) 1008 K (b) 1200 K (c) 845 K **(d) 1118 K**

150. An ideal gas is allowed to expand both reversibly and irreversibly in an isolated system. If T_i is the initial temperature and T_f is the final temperature, which of the following statements is correct?

(a) $(T_f)_{\text{irrev}} > (T_f)_{\text{rev}}$

(b) $T_f > T_i$ for reversible process but $T_f = T_i$ for irreversible process

(c) $(T_f)_{\text{rev}} = (T_f)_{\text{irrev}}$

(d) $T_f = T_i$ for both reversible and irreversible process