Scheme of Valuation / Solution

B.Sc. Physics – Thermal Physics and Statistical Mechanics – 11PH /MC /TS 24

Section – A (1 mark each) - Time: 30 minutes

I – Choose the correct Answer (Multiple choice Q's)

1. D
2. C
3. B
4. D
5. B
6. C
7. D
8. B
9. C
10. A
11. A
12. B
13. C
14. D
15. A

II – Fill-in the blanks

16. Nine (9)
17. Increases
18. The Reciprocal of square
19. Decrease
20. $|W|/|Q_H|$

III – True (or) False

21. False
22. True
23. False
24. False
25. True

IV – Answer Briefly

26. $G = H - TS$, H – enthalpy, T – temperature, S – entropy (1/2 mark); during change of phase, G remains constant (1/2 mark)

27. the coefficient of performance of a reversible refrigerator equals to the ratio of heat extracted from cold reservoir to the work done on refrigerant = $|Q_C|/|W|$

28. dQ = dU +dW – first law, dQ = TdS, for a reversible process – second law; therefore, TdS = dU +dW (1/2 mark); explanation of symbols (1/2 mark)

29. Book work – any one of 3 statements

30. A collection of systems with different microstructure (microstate) but representing the same macrostate (1/2 mark); types: microcanonical, canonical and grandcanonical(1/2 mark)

Section – B (Any Five, 5 marks each) (Time: 2 ½ hrs for Secs. B and C)

1. $\eta = (1/3)\, m\, v/\sigma$; mean speed $v = \sqrt{(8kT/\pi m)}$ and $\sigma = \pi d^2$, where d = diameter of molecule, k = Boltzmann constant, m – mass of molecule, T – temperature. Taking T = 300 K and m = (12+32) amu; 1 amu = 1.67×10^{-27} kg, substituting the values, we obtain d = 0.45 nm

2. i) reversible, isothermal expansion: PV = constant, so final volume $V_f = 32$ m^3, temperature remains constant = 400 K, work done = $RT \log(V_f - V_i) = 6.7 \times 10^6$ J, heat absorbed = work done and hence change in internal energy is zero (2 ½ marks);

   ii) reversible, adiabatic process: PV^γ = constant, γ - ratio of specific heats = 5/3, final volume $V_f = 13.9$ m^3, T = 174 K, work done = $(P_iV_i - P_fV_f) / (\gamma - 1) = 2.74 \times 10^6$ J, heat absorbed = zero and change in internal energy = -2.74×10^6 J
   (2 ½ marks)

3. Entropy change for water at 273 (T_1) to 373 K (T_2) $\Delta S_1 = c_P \log(T_2/T_1) = 1310$ J kg^{-1} K^{-1} (2 ½ marks), entropy change for change of state $\Delta S_2 = \ell / T_2 = 6060$, so total change = 7370 J kg^{-1} K^{-1}(2 ½ marks)

4. Direct application of Clausius-Clapeyon equation: d$T = T (V_f - V_i)$ dP/ℓ = 0.03 K

5. N = 3; $g_1 = 3$, $N_1 = 2$; $g_2 = 2$, $N_2 = 1$; W(B-E) $= (g_j+N_j - 1)! / (g_j - 1)!\, N_j! = 12$
   and W(F-D) $= g_j! / (g_j - N_j)!\, N_j! = 6$

6. Standard Book work

7. Standard Book work

Section – C (Any Three, 15 marks each)

1. Text Book Material, a) 3 marks for assumptions and 6 marks for derivation
   b) 3 marks for each deduction

2. Text Book Material, 2 marks for the principle; description of refrigeration cycle with a neat diagram – 10 marks; 3 marks for coefficient of performance

3. Text Book Material, a) 2 marks for each statement; b) 1 mark for definition and 4 marks for derivation using ideal gas in Carnot cycle; c) 3 marks each for the two derivations

4. Standard Text Book Material, 8 marks for theory and 7 marks for experiment

5. Stand Text ook Material, a) 6 marks for the derivation; b) 3 marks each for the three deivations