MCQ 50 marks

1. B. 200 J

Explanation: $Q_{acb} = \Delta U_{acb} + W_{acb}$

$250 = \Delta U + 90 \Rightarrow \Delta U = 160$ J

$Q_{adb} = \Delta U + W_{adb} = 160 + 40$

$= 200$ J

2. D. 50.0%

Explanation: $\eta = \left(1 - \frac{T_2}{T_1}\right) \times 100\%$

$= \left(1 - \frac{450}{900}\right) \times 100\%$

$= 50.0\%$

3. A. 60 J

Explanation: $K = \frac{Q_2}{W}$

$W = \frac{Q_2}{K} = \frac{300}{5}$

$= 60$ J

4. D. $4.04\ \text{calK}^{-1}$

Explanation: $\Delta S = \frac{ml_f}{T} = \frac{5.86 \times 2 \times 207}{273+327}$

$= 4.04\ \text{calK}^{-1}$

5. B. 628.3 J

Explanation: Area of ellipse $= \pi ab$

$a = \frac{V_2 - V_1}{2} = 2 \times 10^{-3}\ m^3$, $b = \frac{P_2 - P_1}{2} = 1 \times 10^5$ Pa

$W = \pi \times 2 \times 10^{-3} \times 1 \times 10^5$

$= 628.3$ J

6. A. 5000 J

Explanation: $\eta = 1 - \frac{Q_2}{Q_1}$

$0.35 = 1 - \frac{3250}{Q_1}$

$Q_1 = \frac{3250}{0.65} = 5000$ J

7. D. 17 min 30 s

Explanation: $Q_2 = ml_f = 5 \times 336000 = 1.68 \times 10^6$ J

$W = \frac{Q_2}{K} = \frac{1.68 \times 10^6}{4} = 4.2 \times 10^5$ J

Power used by the compressor $P = \frac{80}{100} \times 500 = 400$ W

$t = \frac{W}{P} = 1050\ s = 17$ min 30 s

8. D. $5\ \text{cal mol}^{-1}\text{°C}^{-1}$

Explanation: $C_V = 0.75 \times 4 = 3\ \text{cal mol}^{-1}\text{°C}^{-1}$

$C_P = C_V + R = 3 + 2$

$= 5\ \text{cal mol}^{-1}\text{°C}^{-1}$

9. C. Water freezes into ice

Explanation: When water freezes, heat is rejected: $\Delta S = -\frac{mL_f}{T} < 0$

In the other three, heat is absorbed, so entropy increases.

10. D. $W_1 > W_2 > W_3$

Explanation: Work done = area under the P-V graph

Path 1 is the highest, so its area is the greatest

$W_1 > W_2 > W_3$

11. C. 6.97 min

Explanation: $P = \frac{W}{t} = \frac{ml_v}{t}$

$t = \frac{3 \times 2.09 \times 10^4}{150} = 418$ s

$= 6.97$ min

12. C. 395.6 K

Explanation: $\gamma = \frac{C_P}{C_V} = \frac{29.1}{20.8} = 1.399$

$T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{\gamma - 1} = 300 \times 2^{0.399}$

$= 395.6$ K

13. D. $P^{1-\gamma} T^{\gamma} = K$

Explanation: $PV^{\gamma} = K$ and $V = \frac{nRT}{P}$

$P\left(\frac{nRT}{P}\right)^{\gamma} = K$

$P^{1-\gamma} T^{\gamma} = K$

14. B. 71°C

Explanation: $\frac{\theta - 5}{115 - 5} = \frac{60 - 0}{100 - 0}$

$\theta - 5 = \frac{60}{100} \times 110 = 66$

$\theta = 71$°C

15. B. $\frac{2}{5}$

Explanation: $\frac{W}{Q} = \frac{nR\Delta T}{nC_P \Delta T} = \frac{R}{\frac{5}{2}R}$

$= \frac{2}{5}$

16. A. η

Explanation: $\eta' = 1 - \frac{2T_C}{2T_H} = 1 - \frac{T_C}{T_H}$

$= \eta$

17. D. $765.2\ \text{JK}^{-1}$

Explanation: ΔS = entropy change of the container + entropy change of the gas

$= ms \ln \frac{T_2}{T_1} + nC_P \ln \frac{T_2}{T_1}$

$= 4 \times 450 \ln 1.5 + 3 \times \frac{7}{2} \times 8.314 \ln 1.5$

$= 729.8 + 35.4 = 765.2\ \text{JK}^{-1}$

18. D. 16697.5 J

Explanation: PV = constant, i.e. an isothermal process; Q = W

$W = PV \ln \frac{V_2}{V_1} = 3 \times 101325 \times 5 \times 10^{-2} \times \ln 3$

$= 16697.5$ J

19. A. $968.6\ JK^{-1}$

Explanation: $\Delta S = \frac{ml_f}{T_1} + ms \ln \frac{T_2}{T_1}$

$= 0.5\left(\frac{336000}{273} + 4200 \ln \frac{323}{273}\right)$

$= 615.4 + 353.2$

$= 968.6\ JK^{-1}$

20. C. 0.87 mm

Explanation: $\Delta L_1 = L_1 \alpha_1 \Delta\theta = 30 \times 1.7 \times 10^{-5} \times 100 = 0.051$ cm

$\Delta L_2 = L_2 \alpha_2 \Delta\theta = 30 \times 1.2 \times 10^{-5} \times 100 = 0.036$ cm

$\Delta L = 0.087$ cm $= 0.87$ mm

21. A. 2.99×10^{-3} K

Explanation: Torque $\tau = Fr = 0.3 \times 0.05 = 0.015$ Nm

Work per second $= \tau\omega = 0.015 \times 2\pi \times 400 = 37.70$ J

$\Delta\theta = \frac{37.70}{ms} = \frac{37.70}{3 \times 4200}$

$= 2.99 \times 10^{-3}$ K

22. A. 35.83°C

Explanation: Heat given out when the steam fully condenses and cools to 0°C:

$0.2(2268000 + 420000) = 537600$ J

Heat needed to turn the ice into water at 0°C:

$1 \times (2100 \times 10 + 336000) = 357000$ J

So all the ice melts and the final temperature $\theta > 0$

$0.2 \times 2268000 + 0.2 \times 4200(100 - \theta) = 357000 + 1 \times 4200\theta$

$537600 - 840\theta = 357000 + 4200\theta$

$\theta = \frac{180600}{5040} = 35.83°C$

23. D. 91350 J

Explanation: $Q_1 = ml_v = 0.03 \times 2268000 = 68040$ J

$Q_2 = m_w s_w \Delta\theta = 0.03 \times 4200 \times 100 = 12600$ J

$Q_3 = ml_f = 0.03 \times 336000 = 10080$ J

$Q_4 = m_i s \Delta\theta = 0.03 \times 2100 \times 10 = 630$ J

$Q = 91350$ J

24. C. 23.85°C

Explanation: $s_A(16 - 10) = s_B(20 - 16) \Rightarrow s_B = 1.5 s_A$

$s_B(26 - 20) = s_C(30 - 26) \Rightarrow s_C = 1.5 s_B = 2.25 s_A$

$s_A(\theta - 10) = 2.25 s_A(30 - \theta)$

$3.25\theta = 77.5$

$\theta = 23.85°C$

25. C. 4.02×10^6 J

Explanation: $K = \frac{T_2}{T_1 - T_2} = \frac{268}{298 - 268} = 8.933$

$K = \frac{Q_2}{Pt} \Rightarrow Q_2 = 8.933 \times 250 \times 30 \times 60$

$= 4.02 \times 10^6$ J

26. B. 6260.4 J

Explanation: $Q = mL = 3 \times 2256 = 6768$ J

$W = P\Delta V = 101325 \times (3 \times 1671 - 3) \times 10^{-6} = 507.6$ J

$\Delta U = Q - W = 6768 - 507.6$

$= 6260.4$ J

27. B. 630 s

Explanation: $P \times t = ms\Delta\theta$

$t = \frac{15 \times 4200 \times 20}{2000}$

$= 630$ s

28. A. −242.1 J

Explanation: $\gamma = \frac{29.2}{20.9} = 1.4$

$P_2 = P_1 \left(\frac{V_1}{V_2}\right)^{\gamma} = 2 \times 10^5 \times \left(\frac{1}{2}\right)^{1.4} = 75785.8$ Pa

$dU = \frac{P_2V_2 - P_1V_1}{\gamma - 1} = \frac{75785.8 \times 4 \times 10^{-3} - 2 \times 10^5 \times 2 \times 10^{-3}}{0.4}$

$= -242.1$ J

29. C. 2.984 Ω

Explanation: $\frac{\theta - 0}{100 - 0} = \frac{R_\theta - R_0}{R_{100} - R_0}$

$\frac{40}{100} = \frac{R_\theta - 2.60}{3.56 - 2.60}$

$R_\theta = 2.984\ \Omega$

30. C. 1496.5 J

Explanation: Helium is monatomic, $C_V = \frac{3}{2}R$

$Q = nC_V \Delta T = 3 \times \frac{3}{2} \times 8.314 \times 40$

$= 1496.5$ J

31. A. Isochoric

Explanation: In an isochoric process $\Delta V = 0 \Rightarrow W = 0$

$Q = \Delta U + 0 = \Delta U$

32. A. Increases

Explanation: The volume of water is minimum (density maximum) at 4°C.
When cooled from 4°C to 0°C, water expands, i.e. its volume increases.

33. B. 0.99%
Explanation: $P_1V_1^{\gamma} = P_2V_2^{\gamma}$
$V_2 = \left(\frac{P_1}{P_2}\right)^{\frac{1}{\gamma}} V_1 = \left(\frac{1}{1.014}\right)^{\frac{1}{1.4}} V_1 = 0.9901V_1$
$\%\Delta V = (1 - 0.9901) \times 100\% = 0.99\%$

34. D. 90°F
Explanation: $\Delta F = \frac{9}{5}\Delta C$
$= 1.8 \times (90 - 40)$
$= 90°F$

35. B. B; 35.6%
Explanation: $T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{\gamma-1}$
$\eta = 1 - \frac{T_2}{T_1} = 1 - \left(\frac{1}{r}\right)^{0.4}$; it does not depend on the source temperature
$\eta_A = 1 - \left(\frac{1}{2}\right)^{0.4} = 24.2\%$
$\eta_B = 1 - \left(\frac{1}{3}\right)^{0.4} = 35.6\%$
Engine B is more efficient.

36. A. 30%
Explanation: $\eta = \frac{W}{Q_1} = 1 - \frac{Q_2}{Q_1}$
$= 1 - \frac{1120}{1600}$
$= 0.30 = 30\%$

37. B. 3.7×10^5 J
Explanation: $W = P\Delta V = 1.2 \times 10^5 \times (2.0 - 3.0) = -1.2 \times 10^5$ J
$Q = \Delta U + W = -2.5 \times 10^5 - 1.2 \times 10^5$
$= -3.7 \times 10^5$ J
That is, 3.7×10^5 J of heat is removed.

38. C. 70%
Explanation: $T = \frac{PV}{nR}$
$\frac{T_2}{T_1} = \frac{P_2V_2}{n_2} \times \frac{n_1}{P_1V_1} = \frac{2\times300}{200} \times \frac{100}{5\times200} = \frac{3}{10}$
$\eta = \left(1 - \frac{3}{10}\right) \times 100\% = 70\%$

39. A. 14.48 cal K⁻¹
Explanation: $\Delta Q = ml_v = 10 \times 540 = 5400$ cal
$\Delta S = \frac{\Delta Q}{T} = \frac{5400}{373}$
$= 14.48$ calK^{-1}

40. D. 31500 J
Explanation: $Q = ms_{ice}\Delta\theta$
$= 1.5 \times 2100 \times 10$
$= 31500$ J

41. D. 1890 J
Explanation: $Q = ms\Delta\theta = 25 \times 1 \times 18 = 450$ cal
$= 450 \times 4.2$
$= 1890$ J

42. B. 3457.7 J
Explanation: $W = \int_{V_1}^{V_2} P\,dV = \int_{V_1}^{V_2} \frac{RT}{V-b} dV$
$= RT \ln \frac{V_2-b}{V_1-b} = 8.314 \times 300 \times \ln \frac{8}{2}$
$= 3457.7$ J

43. A. 89.2 J, 89.2 J
Explanation: For an ideal gas, ΔU depends only on ΔT ; in both cases $dU = mC_V\,dT$
$\Delta U = 8 \times 0.177 \times 15 = 21.24$ cal
$= 21.24 \times 4.2 = 89.2$ J

44. B. 167999.4 J
Explanation: $Q = ms\Delta\theta = 4 \times 4200 \times 10 = 168000$ J
$\Delta V = \frac{4}{998.2} - \frac{4}{999.7} = 6.013 \times 10^{-6}$ m^3
$W = P\Delta V = 10^5 \times 6.013 \times 10^{-6} = 0.6$ J
$\Delta U = Q - W = 167999.4$ J

45. C. 2.53×10^5 Nm^{-2}
Explanation: $P_1V_1 = P_2V_2$
$1.013 \times 10^5 \times V_1 = P_2 \times \frac{2}{5}V_1$
$P_2 = 2.53 \times 10^5$ Nm^{-2}

46. B. 9.0×10^{16} J
Explanation: $E_{generated} = \frac{E_{supplied}}{\eta} = \frac{6.0\times10^{16}}{0.4} = 1.5 \times 10^{17}$ J
$E_{dumped} = 0.6 \times 1.5 \times 10^{17}$
$= 9.0 \times 10^{16}$ J

47. A. 50.61 JK^{-1}
Explanation: $1 \times 4200(\theta - 10) = 2 \times 4200(70 - \theta) \Rightarrow \theta = 50°C$
$\Delta S = m_1 s \ln \frac{323}{283} + m_2 s \ln \frac{323}{343}$
$= 555.2 - 504.6$
$= 50.61$ JK^{-1}

48. C. 28.81 JK^{-1}
Explanation: $dS = \frac{dQ}{T} = \frac{nC_V\,dT}{T}$
$\Delta S = nC_V \ln \frac{T_2}{T_1} = 2 \times \frac{5}{2} \times 8.314 \times \ln 2$
$= 28.81$ JK^{-1}

49. A. 1.72

Explanation: Let the absolute value of the slope be γ
In an adiabatic process, PV^{γ} = constant and $T^{\gamma}P^{1-\gamma}$ = constant
Here, $T_1 = 25 + 273 = 298\,K$
$T_2 = 125 + 273 = 398\,K$
and, $P_2 = 2P_1$
So, $\left(\frac{T_2}{T_1}\right)^{\gamma} = \left(\frac{P_2}{P_1}\right)^{\gamma-1}$
or, $\gamma \ln \frac{398}{298} = (\gamma - 1)\ln 2$
or, $0.2894\gamma = 0.6931\gamma - 0.6931$
or, $0.4037\gamma = 0.6931$
Therefore, $\gamma \approx 1.72$

50. **B.** 0

Explanation: Let the volumes of the two vessels be V_1 and V_2
We know, $PV = nRT$
Here, T and P are the same
So, $\frac{V_1}{2} = \frac{V_2}{3} = \frac{RT}{P}$
After mixing, the total volume is $V_1 + V_2$ and the total amount is 5 mol
Again, $\frac{V_1+V_2}{5} = \frac{RT}{P}$, so the volume per mole is unchanged
So, $\Delta S = 5R \ln \frac{V_1+V_2}{5} - 2R \ln \frac{V_1}{2} - 3R \ln \frac{V_2}{3}$
Therefore, $\Delta S = 0$