MCQ 50 marks

1. C. 14.29°C

Explanation: In winter, $ms(100 - \theta_1) = P\,t_1$

In summer, $ms(100 - \theta_2) = P\,t_2$

$ms(\theta_2 - \theta_1) = P\,(t_1 - t_2)$

$\theta_2 - \theta_1 = \frac{1500 \times 60}{1.5 \times 4200} = 14.29°C$

2. B. 1714.29 m

Explanation: $mgh = \frac{5}{100} \times m \times l_f$

$h = \frac{0.05 \times 3.36 \times 10^5}{9.8}$

$= 1714.29$ m

3. A. 100 J

Explanation: $\gamma = \frac{C_P}{C_V} = \frac{nC_P\,\Delta T}{nC_V\,\Delta T} = \frac{Q_P}{Q_V}$

$Q_V = \frac{Q_P}{\gamma} = \frac{140}{1.4}$

$= 100$ J

4. C. Positive

Explanation: Reversible process: $\Delta S = 0$

Irreversible and spontaneous process: $\Delta S =$ (+)ve

5. D. becomes 11.31 times the initial

Explanation: $P_1^{1-\gamma} T_1^{\gamma} = P_2^{1-\gamma} T_2^{\gamma}$

$P_2 = P_1 \left(\frac{T_1}{T_2}\right)^{\frac{\gamma}{1-\gamma}} = P_1 \left(\frac{300}{600}\right)^{\frac{1.4}{1-1.4}}$

$= 2^{3.5} P_1 = 11.31 P_1$

6. A. 820 J

Explanation: Along ab, $\Delta V = 0$, so $\Delta U_1 = Q - 0 = 200$ J

Along bc, $\Delta U_2 = Q - P\,\Delta V$

$= 800 - 6 \times 10^4 \times (4 \times 10^{-3} - 1 \times 10^{-3})$

$= 800 - 180 = 620$ J

$\Delta U = 200 + 620 = 820$ J

7. B. 416.3°C

Explanation: Energy lost $= \frac{1}{2} m(600^2 - 300^2) = 135000m$ J

Heat produced $= 0.4 \times 135000m = 54000m$ J

$\Delta\theta = \frac{Q}{ms} = \frac{54000m}{m \times 0.031 \times 4184}$

$= 416.3°C$

8. B. 233.33 K

Explanation: $\eta = 1 - \frac{T_2}{T_1} \Rightarrow T_1 = \frac{T_2}{1-\eta}$

$T_1 = \frac{280}{0.6} = 466.67$ K

$T_1' = \frac{280}{0.4} = 700$ K

Increase $= 700 - 466.67 = 233.33$ K

9. A. 25.45°C

Explanation: $m_1 s_1 \Delta\theta = C\Delta\theta'$

$0.4 \times 130 \times (80 - \theta) = 520(\theta - 20)$

$80 - \theta = 10\theta - 200$

$\theta = \frac{280}{11} = 25.45°C$

10. B. 0.215 atm

Explanation: $P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$

$1 \times V_1^{1.4} = P_2 (3V_1)^{1.4}$

$P_2 = 3^{-1.4} = 0.215$ atm

11. A. 2000 J

Explanation: Engine: $\eta = 1 - \frac{300}{500} = 0.4$,

$W = 0.4 \times 1000 = 400$ J

Refrigerator: $K = \frac{T_2}{T_1 - T_2} = \frac{250}{300 - 250} = 5$

$Q_2 = KW = 5 \times 400$

$= 2000$ J

12. A. 26.67°C

Explanation: $\frac{1}{2} m_{car} v^2 = m_{iron} s \Delta\theta$

$\Delta\theta = \frac{0.5 \times 1200 \times 20^2}{20 \times 450}$

$= 26.67°C$

13. B. 4529.62 J

Explanation: $T_2 = T_1 \left(\frac{V_1}{V_2}\right)^{\gamma - 1} = 300 \times \left(\frac{1}{2}\right)^{0.4} = 227.357$ K

$W = \frac{nR}{\gamma - 1}(T_1 - T_2)$

$= \frac{3 \times 8.314}{0.4}(300 - 227.357)$

$= 4529.62$ J

14. D. 2347.3 JK^{-1}

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

$= 3 \times 4200 \times \ln\left(\frac{353}{293}\right)$

$= 2347.3\ JK^{-1}$

15. C. 17.29 kJ

Explanation: $W = nRT \ln\left(\frac{V_2}{V_1}\right)$

$= 5 \times 8.314 \times 300 \times \ln\left(\frac{40}{10}\right)$

$= 17288.5$ J ≈ 17.29 kJ

16. C. −185.25°C

Explanation: $\frac{\theta-0}{100-0} = \frac{P_\theta - P_{ice}}{P_{steam} - P_{ice}}$
$\theta = \frac{24.5-76.0}{103.8-76.0} \times 100°C$
$= -185.25°C$

17. **B. 3000 W**

Explanation: $P = \frac{W}{t} = \frac{5(Q_1-Q_2)}{t}$
$= \frac{5\times(3.0\times10^3 - 2.1\times10^3)}{1.5}$
$= 3000\ W$

18. **D.** $75.06\ JK^{-1}$

Explanation: $1 \times 4200(100-\theta) = (1.5 \times 4200 + 0.3 \times 400)(\theta - 20)$
$420000 - 4200\theta = 6420\theta - 128400$
$\theta = 51.64°C = 324.64\ K$
$\Delta S = 6420 \ln \frac{324.64}{293} + 4200 \ln \frac{324.64}{373}$
$= 658.30 - 583.24$
$= 75.06\ JK^{-1}$

19. **B.** $111.7\ ms^{-1}$

Explanation: The entire kinetic energy of the gas is converted into internal energy.
$\frac{1}{2}mv_0^2 = nC_V\Delta T$; $n = 1$ mol, $m = 4 \times 10^{-3}$ kg, $C_V = \frac{3}{2}R$
$\frac{1}{2} \times 4 \times 10^{-3} \times v_0^2 = 1 \times \frac{3}{2} \times 8.314 \times 2$
$v_0^2 = 12471$
$v_0 = 111.7\ ms^{-1}$

20. **A. 344.6 K, 42.6%**

Explanation: $T_2V_2^{\gamma-1} = T_1V_1^{\gamma-1}$
$T_2 = \left(\frac{1}{4}\right)^{0.4} \times 600 = 344.6\ K$
$\eta = \left(1 - \frac{344.6}{600}\right) \times 100\% = 42.6\%$

21. **C.** 1.05×10^5 J

Explanation: $W = P\Delta V = 10^5 \times 0.3 = 3 \times 10^4$ J
Air is diatomic, $f = 5$
$\Delta U = \frac{5}{2}P\Delta V = 7.5 \times 10^4$ J
$Q = \Delta U + W = 1.05 \times 10^5$ J

22. **C.** 1.013×10^5

Explanation: $W = P\Delta V$
$= 2.026 \times 10^5 \times (50.5 - 50)$
$= 1.013 \times 10^5$ J

23. **A. 8729.7 J**

Explanation: B→A (isochoric): $\frac{T_B}{T_A} = \frac{P_B}{P_A} \Rightarrow$
$T_B = 400 \times \frac{P_0}{4P_0} = 100\ K$
$T_C = T_A = 400\ K$
C→B (isobaric): $Q = nC_P\Delta T = 1 \times \frac{7}{2} \times 8.314 \times (100 - 400)$
$= -8729.7$ J
Heat rejected = 8729.7 J

24. **D. V vs** $\frac{1}{P}$

Explanation: $PV = K \Rightarrow V = K \cdot \frac{1}{P}$
So the graph of V against $\frac{1}{P}$ is a straight line through the origin.
P vs V is a hyperbola; PV vs P is a horizontal line.

25. **B.** $1.44\ JK^{-1}$

Explanation: $n = \frac{4}{32} = 0.125$ mol
$\Delta S = \frac{Q}{T} = \frac{nRT\ln\frac{V_2}{V_1}}{T} = nR\ln 4$
$= 0.125 \times 8.314 \times \ln 4$
$= 1.44\ JK^{-1}$

26. **A.** $\frac{1}{2}$

Explanation: $\eta_{heat} = 1 - \frac{420}{600} = \frac{3}{10}$
$\eta_{carnot} = \frac{3}{10} \times \frac{1}{0.6} = \frac{1}{2}$
$\frac{T_2}{T_1} = 1 - \frac{1}{2} = \frac{1}{2}$

27. **D. 1947.75 J**

Explanation: $W_1 = nRT\ln\left(\frac{V_2}{V_1}\right) =$
$P_1V_1\ln 2 = 1500 \times 0.693 = 1039.72$ J
$T_2 = T_1\left(\frac{V_1}{V_2}\right)^{\gamma-1} = 300 \times \left(\frac{1}{2}\right)^{0.4} = 227.357\ K$
$nR = \frac{P_1V_1}{T_1} = \frac{1500}{300} = 5\ JK^{-1}$
$W_2 = \frac{nR}{\gamma-1}(T_1 - T_2) = \frac{5}{0.4} \times 72.643 = 908.03$ J
$W = W_1 + W_2 = 1947.75$ J

28. **C.** 9.11×10^4 J

Explanation: $K = \frac{T_2}{T_1 - T_2} = \frac{273}{310-273} = 7.378$
$K = \frac{Q_2}{W} \Rightarrow W = \frac{mL_f}{K}$
$= \frac{2\times336000}{7.378}$
$= 9.11 \times 10^4$ J

29. **C.** $-3874.3\ JK^{-1}$

Explanation: $\Delta S = ms\ln\frac{273}{323} - \frac{ml_f}{273}$
$= 2 \times 4200 \ln\frac{273}{323} - \frac{2\times336000}{273}$
$= -1412.7 - 2461.5$
$= -3874.3\ JK^{-1}$

30. **B. 2.0**

Explanation: $K = \frac{Q_2}{Q_1 - Q_2}$
$= \frac{600}{900-600} = 2.0$

31. **A. 122°F**

Explanation: $\frac{F-32}{212-32} = \frac{56-4}{108-4}$
$\frac{F-32}{180} = \frac{52}{104} = 0.5$
$F = 122°F$

32. **D.** $2.48\ kms^{-1}$
Explanation: $2 \times \frac{1}{2}mv^2 = 2m(s_i\Delta\theta_1 + l_f + s_w\Delta\theta_2 + l_v)$
$v^2 = 2(2100 \times 20 + 336000 + 4200 \times 100 + 2268000)$
$v^2 = 2 \times 3066000 = 6132000$
$v = 2476.3\ ms^{-1} \approx 2.48\ kms^{-1}$

33. **D. 95.8 g**
Explanation: $Q_{ice} = m_i(2000 \times 10 + 3.34 \times 10^5) = m_i \times 3.54 \times 10^5$
$Q_{juice} = 0.3 \times 4186 \times 27 = 33906.6\ J$
$m_i = \frac{33906.6}{3.54\times10^5} = 0.0958\ kg$
$= 95.8\ g$

34. **C. 0.196°C**
Explanation: $mgh = ms\Delta\theta$
$\Delta\theta = \frac{gh}{s} = \frac{9.8\times84}{4200}$
$= 0.196°C$

35. **A. 6.0 kJ**
Explanation: $\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{127+273}{227+273} = 0.2$
$W = \eta Q_1 = 0.2 \times 3 \times 10^4$
$= 6000\ J = 6.0\ kJ$

36. **B.** $3.40 \times 10^4\ JK^{-1}$
Explanation: $\Delta S = ms\ln\frac{T_2}{T_1} + \frac{ml_v}{T_2}$
$= 5 \times 4200\ln\frac{373}{313} + \frac{5\times2.26\times10^6}{373}$
$= 3682.9 + 30294.9$
$= 3.40 \times 10^4\ JK^{-1}$

37. **C. 47°C**
Explanation: $\frac{1}{5} = 1 - \frac{T_2}{T_1} \Rightarrow \frac{T_2}{T_1} = \frac{4}{5}$
$\frac{2}{5} = 1 - \frac{T_2-80}{T_1} = 1 - \frac{4}{5} + \frac{80}{T_1}$
$T_1 = 400\ K$
$T_2 = \frac{4}{5} \times 400 = 320\ K = 47°C$

38. **C. 66.7%**
Explanation: $Q_2 = Q_1\frac{T_2}{T_1} = 1800 \times \frac{600}{900} = 1200\ J$; $W_1 = 600\ J$
$Q_3 = Q_2\frac{T_3}{T_2} = 1200 \times \frac{300}{600} = 600\ J$; $W_2 = 600\ J$
$\eta = \frac{W_1+W_2}{Q_1} = \frac{1200}{1800} = 66.7\%$

39. **C.** $C_P = 4R$
Explanation: $C_P = \frac{\gamma R}{\gamma-1} = \frac{\frac{4}{3}R}{\frac{1}{3}} = 4R$
$C_V = \frac{R}{\gamma-1} = 3R$

40. **A.** $20 \times 10^5\ J$
Explanation: $\frac{T_2}{T_1} = \frac{Q_2}{Q_1}$
$Q_2 = \frac{400}{600} \times 30 \times 10^5$
$= 20 \times 10^5\ J$

41. **B. 6.62 cal K^{-1}**
Explanation: $\Delta S = \Delta S_1 + \Delta S_2 =$
$m_{ice}s_{ice}\ln\frac{273}{253} + \frac{m_{ice}l_f}{273}$
$= 20\left(0.5\ln\frac{273}{253} + \frac{80}{273}\right)$
$= 6.62\ calK^{-1}$

42. **A. 26PV**
Explanation: If the radius is tripled, the volume becomes $3^3 = 27$ times.
$W = P\Delta V = P(27V - V)$
$= 26PV$

43. **A. 1.48**
Explanation: $C_V = \frac{n_1C_{V_1}+n_2C_{V_2}}{n_1+n_2} = \frac{2\times\frac{3}{2}R+3\times\frac{5}{2}R}{5} = 2.1R$
$C_P = C_V + R = 3.1R$
$\gamma = \frac{3.1R}{2.1R} = 1.48$

44. **B.** $1.21 \times 10^6\ J$
Explanation: $Q = ml_f + ms\Delta\theta + ml_v$
$= 0.4 \times (336000 + 4200 \times 100 + 2268000)$
$= 1.21 \times 10^6\ J$

45. **D. 202.14 K**
Explanation: $\frac{T}{273.16} = \frac{P}{P_{tr}}$
$T = \frac{18.5}{25} \times 273.16$
$= 202.14\ K$

46. **B.** 927°C
Explanation: A sudden compression is an adiabatic process, so $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$
Here, $T_1 = 27 + 273 = 300\ K$
and for a diatomic gas, $\gamma = 1.4$
So, $T_2 = 300 \times (32)^{0.4} = 300 \times 4 = 1200\ K$
Therefore, $T_2 = 1200 - 273 \approx 927°C$

47. **D.** $U_C = U_B > U_A$
Explanation: The internal energy of an ideal gas depends only on temperature, not on volume.
Here, B and C are at the same temperature (80°C)

So, $U_B = U_C$
Again, A is at a lower temperature (60°C) than B and C
So, $U_A < U_B$
Therefore, $U_C = U_B > U_A$

48. **B.** $T_C > T_B > T_A$
Explanation: For an ideal gas, $PV = nRT$
Here, n and R are constants
So, $PV \propto T$
That is, on a P-V graph, the farther an isotherm lies from the origin, the greater its PV value
Therefore, $T_C > T_B > T_A$

49. **D.** 54.26°C
Explanation: Let the temperature on the Celsius scale be C
We know, $\frac{C-0}{100-0} = \frac{X-4}{98-4}$
Here, the thermometer reading is $X = 55$
So, $\frac{C}{100} = \frac{55-4}{94} = \frac{51}{94}$
Therefore, $C = \frac{5100}{94} \approx 54.26°C$

50. **C.** 277.7°F
Explanation: Let the Celsius reading be C
Given, $K = 3C$
Again, $K = C + 273$
So, $3C = C + 273$
or, $2C = 273$
Therefore, $C = 136.5°C$
Again, $F = \frac{9}{5}C + 32$
So, $F = \frac{9}{5} \times 136.5 + 32 = 245.7 + 32$
Therefore, $F = 277.7°F$