MCQ 50 marks

1. **B. 934.1°C**
Explanation: Heat absorbed = heat rejected
$20 \times 0.11 \times (\theta - 25) = 200 \times 1 \times (25 - 15)$
$2.2\theta - 55 = 2000$
$\theta = \frac{2055}{2.2} = 934.1°C$

2. **B. $\frac{4}{3}$**
Explanation: $P \propto T^4 \Rightarrow P^{\frac{1}{4}} \propto T \Rightarrow$
$TP^{-\frac{1}{4}} = K$
Comparing with $TP^{\frac{1-\gamma}{\gamma}} = K$,
$\frac{1-\gamma}{\gamma} = -\frac{1}{4} \Rightarrow \gamma = \frac{4}{3}$

3. **C. 77.6 JK^{-1}**
Explanation: Water: $\Delta S_1 = ms \ln \frac{T_2}{T_1} =$
$4200 \ln \frac{293}{353} = -782.4\ JK^{-1}$
Heat received by the lake $Q = ms\Delta\theta =$
$4200 \times 60 = 252000$ J
Lake: $\Delta S_2 = \frac{Q}{T} = \frac{252000}{293} = 860.1\ JK^{-1}$
$\Delta S = -782.4 + 860.1$
$= 77.6\ JK^{-1}$

4. **A. 7.5 m^3**
Explanation: $T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1} \Rightarrow \frac{T_2}{T_1} =$
$\left(\frac{3}{6}\right)^{\gamma-1} = \left(\frac{1}{2}\right)^{\gamma-1}$
$T_2V_3^{\gamma-1} = T_1V_4^{\gamma-1} \Rightarrow \left(\frac{V_4}{V_3}\right)^{\gamma-1} = \frac{T_2}{T_1} = \left(\frac{1}{2}\right)^{\gamma-1}$
$V_4 = \frac{V_3}{2} = \frac{15}{2} = 7.5\ m^3$

5. **D. $1.74 \times 10^4\ JK^{-1}$**
Explanation: $\Delta S = ms_1 \ln \frac{T_2}{T_1} + \frac{ml_f}{T_2} +$
$ms_2 \ln \frac{T_3}{T_2} + \frac{ml_v}{T_3}$
$= 2 \times 2100 \ln \frac{273}{263} + \frac{2\times336000}{273} + 2 \times 4200 \ln \frac{373}{273} +$
$\frac{2\times2268000}{373}$
$= 156.7 + 2461.5 + 2621.6 + 12160.9$
$= 1.74 \times 10^4\ JK^{-1}$

6. **D. 15600 J**
Explanation: $\Delta T = T_A - 0 = 250$ K
$\Delta U = nC_V\Delta T = 3 \times 20.8 \times 250$
$= 15600$ J

7. **B. 4.32×10^{-11} kg**
Explanation: $E = \Delta mc^2$; $E = ms\Delta\theta$
$\Delta m = \frac{ms\Delta\theta}{c^2} = \frac{50\times389\times200}{(3\times10^8)^2}$
$= 4.32 \times 10^{-11}$ kg

8. **B. 2.17R**
Explanation: Let the initial temperature be T. Pressure doubled at constant volume → 2T; volume doubled at constant pressure → 4T
$Q = \frac{3}{2}R(2T - T) + \frac{5}{2}R(4T - 2T) = 6.5RT$
$C = \frac{Q}{n\Delta T} = \frac{6.5RT}{3T}$
$= 2.17R$

9. **D. 3.75R**
Explanation: $W = \frac{Q}{3} \Rightarrow \Delta U = \frac{2Q}{3}$
$nC\Delta T = \frac{3}{2} \times nC_V\Delta T$
$C = \frac{3}{2} \times \frac{5}{2}R$
$= 3.75R$

10. **A. Pyrometer**
Explanation: A pyrometer finds the temperature by measuring the radiation emitted by a very hot body, so no contact is needed.

11. **A. Only temperature**
Explanation: $U = \frac{f}{2}nRT$
The internal energy of a fixed amount of ideal gas depends only on temperature, not on the path.

12. **A. γ**
Explanation: Isothermal: $\frac{dP}{dV} = -\frac{P}{V}$
Adiabatic: $\frac{dP}{dV} = -\gamma\frac{P}{V}$
Ratio = γ

13. **D. 0 K**
Explanation: $\eta = 1 - \frac{T_2}{T_1} = 1 \Rightarrow T_2 = 0$ K
Absolute zero cannot be reached, so 100% efficiency is also impossible.

14. **B. 3 m^3, −600 J**
Explanation: $W = P\Delta V \Rightarrow \Delta V = \frac{1500}{500} =$
$3\ m^3$
$\Delta U = Q - W = 900 - 1500$
$= -600$ J

15. **A. 47.81°C**
Explanation: $R_\theta = R_0(1 + \alpha\theta)$
$\frac{196.2}{200} = \frac{1-0.0005\theta}{1-0.0005\times10}$

$1 - 0.0005\theta = 0.981 \times 0.995 = 0.976095$
$\theta = 47.81°C$

16. **C. 82.4°F**
Explanation: $\frac{\theta-0}{100-0} = \frac{L_\theta - L_{ice}}{L_{steam} - L_{ice}} = \frac{9.6-4}{24-4}$
$\theta = 28°C$
$F = \frac{9}{5} \times 28 + 32 = 82.4°F$

17. **D. 4.99 g**
Explanation: Kinetic energy $= \frac{1}{2} \times 0.02 \times 400^2 = 1600$ J
Heat given out by the bullet cooling from 30°C to 0°C $= 0.02 \times 130 \times 30 = 78$ J
$m = \frac{1600+78}{336000} = 4.99 \times 10^{-3}$ kg
$= 4.99$ g

18. **B. 1.76 MJ**
Explanation: $W = \int_{V_1}^{V_2} P\,dV = \int_1^3 \alpha V^2 dV$
$= \frac{\alpha}{3}(3^3 - 1^3) = \frac{2 \times 101325 \times 26}{3}$
$= 1.76 \times 10^6$ J $= 1.76$ MJ

19. **C. Both will decrease**
Explanation: Friction wastes energy, so the net work decreases.
Net work = enclosed area, so the area decreases.
With the same heat absorbed, less work means the efficiency also decreases.

20. **C. 65°C**
Explanation: $m_1 s(80 - \theta) = m_2 s(\theta - 30)$
$700(80 - \theta) = 300(\theta - 30)$
$\theta = \frac{56000+9000}{1000} = 65°C$

21. **B. 2.97 L, 445.8 K**
Explanation: Sudden pressure increase → adiabatic
$V_2 = \left(\frac{P_1}{P_2}\right)^{\frac{1}{\gamma}} V_1 = \left(\frac{1}{4}\right)^{\frac{1}{1.4}} \times 8 = 2.97$ L
$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = 300 \times 4^{\frac{0.4}{1.4}} = 445.8$ K

22. **A.** -1.30×10^7 J
Explanation: Helium is monatomic, $\gamma = \frac{5}{3}$, $\frac{\gamma-1}{\gamma} = 0.4$
$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{0.4} = 300 \times (0.8)^{0.4} = 274.38$ K
$n = \frac{P_1 V_1}{R T_1} = \frac{101325 \times 1000}{8.314 \times 300} = 40624$ mol
$\Delta U = n\frac{3}{2}R(T_2 - T_1) = 40624 \times 1.5 \times 8.314 \times (-25.62)$
$= -1.30 \times 10^7$ J

23. **D. 105 kJ**
Explanation: Step 1: $\Delta U_1 = Q = 120$ kJ
Step 2: $\Delta U_2 = Q - W = -40 - (-25) = -15$ kJ
In the cycle, $\Delta U_1 + \Delta U_2 + \Delta U_3 = 0 \Rightarrow \Delta U_3 = -105$ kJ
Adiabatic: $W_3 = -\Delta U_3 = 105$ kJ

24. **B. 1250 K**
Explanation: $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$; $V \propto r^3$
$T_2 = T_1 \left(\frac{r_1}{r_2}\right)^{3(\gamma-1)} = 8 \times 10^4 \times \left(\frac{50}{400}\right)^2$
$= 1250$ K

25. **A.** 7.14×10^5 cal
Explanation: $u = \frac{30000}{60} = 500$ ms^{-1}, $v = \frac{6000}{60} = 100$ ms^{-1}
$Q = \frac{\frac{1}{2}m(u^2 - v^2)}{J} = \frac{12.5 \times (500^2 - 100^2)}{4.2}$
$= \frac{3 \times 10^6}{4.2} = 7.14 \times 10^5$ cal

26. **C. 0.284 J**
Explanation: $\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{303}{423} = 0.284$
$W = \eta Q = 0.284 \times 1 = 0.284$ J

27. **C. High specific heat**
Explanation: Because water has a high specific heat, it absorbs a lot of heat for a small rise in temperature.

28. **B. 32.60 cm-Hg**
Explanation: $P_2 = P_1 \left(\frac{V_1}{V_2}\right)^\gamma = 76 \times \left(\frac{1}{2}\right)^{1.4} = 28.80$ cm-Hg
$T_2 = 300 \times \left(\frac{1}{2}\right)^{0.4} = 227.36$ K
Isochoric: $P_3 = P_2 \times \frac{T_2+30}{T_2} = 28.80 \times \frac{257.36}{227.36}$
$= 32.60$ cm-Hg

29. **C.** 37.2 kgm^{-3}
Explanation: $P V^\gamma = c \Rightarrow P \left(\frac{m}{\varrho}\right)^\gamma = c \Rightarrow P \varrho^{-\gamma} =$ constant
$\varrho_2 = \varrho_1 \left(\frac{P_2}{P_1}\right)^{\frac{1}{\gamma}} = 1.2 \times 128^{\frac{1}{1.4}} = 1.2 \times 32 = 38.4$ kgm^{-3}
$\Delta\varrho = 38.4 - 1.2 = 37.2$ kgm^{-3}

30. **B. 42.86 m**
Explanation: $W = JQ = 4.2 \times 1000 = 4200$ J
$mgh = 4200$
$h = \frac{4200}{10 \times 9.8} = 42.86$ m

31. **B.** $1000\ cm^3$

Explanation: $W = nRT \ln \frac{V_2}{V_1} \Rightarrow V_2 = V_1 e^{\frac{W}{nRT}}$

$= 500 \times e^{\frac{3458}{2 \times 8.314 \times 300}} = 500 \times e^{0.693}$

$= 1000\ cm^3$

32. **C.** $2167.2\ JK^{-1}$

Explanation: Unmelted ice $= 0.9 \times 255 = 229.5\ g = 0.2295\ kg$

$\Delta S_1 = \frac{0.2295 \times 336000}{273} = 282.5\ JK^{-1}$

$\Delta S_2 = 0.255 \times 4200 \ln \frac{373}{273} = 334.3\ JK^{-1}$

$\Delta S_3 = \frac{0.255 \times 2268000}{373} = 1550.5\ JK^{-1}$

$\Delta S = 282.5 + 334.3 + 1550.5 = 2167.2\ JK^{-1}$

33. **A. 135 kJ**

Explanation: The container is rigid and thermally insulated, so the heat produced in the resistor increases the internal energy of the gas.

$\Delta U = I^2Rt = 3^2 \times 50 \times 5 \times 60$

$= 135000\ J = 135\ kJ$

34. **D. 31.4 kJ**

Explanation: To reach the boiling point, only the temperature has to be raised.

$Q = ms\Delta\theta = 0.1 \times 4.186 \times 75$

$= 31.4\ kJ$

35. **B. Two isothermal and two adiabatic**

Explanation: Carnot cycle: isothermal expansion → adiabatic expansion → isothermal compression → adiabatic compression.

36. **D. Converting all heat from a single source into work by a cyclic engine**

Explanation: Kelvin-Planck statement: in a cyclic process, it is impossible to convert all the heat taken from a single source into work. Isothermal expansion is a single process (not a cycle), where $Q = W$ is possible.

37. **D. 1662.8 J**

Explanation: $W = P\Delta V = nR\Delta T$

$= 4 \times 8.314 \times 50$

$= 1662.8\ J$

38. **C. −53.8°C**

Explanation: Sudden bursting → adiabatic

$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = 300 \times \left(\frac{1}{3}\right)^{\frac{0.4}{1.4}}$

$= 219.2\ K = -53.8°C$

39. **D. 63.33**

Explanation: $104°F = \frac{5}{9}(104 - 32) = 40°C$

$\frac{X-10}{90-10} = \frac{40-0}{60-0}$

$X = 10 + \frac{2}{3} \times 80 = 63.33$

40. **A. 7307.1 J**

Explanation: In the figure, A to B is isothermal expansion, $T_1 = 127°C = 400\ K$

$W = nRT_1 \ln \frac{V_B}{V_A} = 2 \times 8.314 \times 400 \times \ln \frac{3V_A}{V_A}$

$= 7307.1\ J$

41. **D.** JK^{-1}

Explanation: $dS = \frac{dQ}{T}$

Unit $= \frac{J}{K} = JK^{-1}$

42. **A. 625 g**

Explanation: Final temperature 0°C

$ml_f = m_w s\Delta\theta$

$m = \frac{0.5 \times 4200 \times 100}{336000} = 0.625\ kg$

$= 625\ g$

43. **C. Such an engine is not possible**

Explanation: Maximum (Carnot) efficiency between these two temperatures: $\eta_{max} = 1 - \frac{300}{400} = 25\%$

Claimed efficiency $= \frac{300}{1000} = 30\% > 25\%$

By Carnot's theorem, no engine can be more efficient than a Carnot engine.

So such an engine is not possible.

44. **D. 1.2 : 1**

Explanation: $\eta_1 = 1 - \frac{273+27}{273+227} = \frac{200}{500} = 0.4$

$\eta_2 = 1 - \frac{273-73}{273+27} = \frac{100}{300} = \frac{1}{3}$

$\eta_1 : \eta_2 = 0.4 : \frac{1}{3} = 1.2 : 1$

45. **A. 7.5 J**

Explanation: $\frac{Q_1}{W} = \frac{Q_1}{Q_1 - Q_2} = \frac{T_1}{T_1 - T_2}$

$= \frac{300}{300-260}$

$= 7.5\ J$

46. **B. Adiabatic**

Explanation: For expansion from the same point, the adiabatic curve falls most steeply. So the area under the adiabatic curve is the least: $W_{isobaric} > W_{isothermal} > W_{adiabatic}$

47. **C. Infinite**

Explanation: $C = \frac{Q}{n\Delta T}$; since Q differs from process to process, a gas has infinitely many specific heats.

However, the two special molar specific heats are C_P and C_V.

48. **A.** $919.5\ JK^{-1}$

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

$= 2 \times 900 \times \ln \frac{500}{300}$

$= 919.5\ JK^{-1}$

49. **A. 2036.6 J**

Explanation: $\eta = 1 - \frac{273}{373} = \frac{100}{373}$

$Q_1 = \frac{W}{\eta} = 746 \times \frac{373}{100} = 2782.6\ J$

$Q_2 = Q_1 - W = 2782.6 - 746$

$= 2036.6\ J$

50. **A.** $T_3 > T_2 > T_1$

Explanation: For an ideal gas, $PV = nRT$

Here, for the same amount of gas, n and R are constants

So, $PV \propto T$

That is, the greater the value of PV, the higher the temperature

In the graph, the line for T_3 is the highest and the line for T_1 is the lowest

Therefore, $T_3 > T_2 > T_1$