Syllabus for Test 04:

L-11: Carnot cycle, efficiency of Carnot cycle, entropy-definition, entropy as a state variable, entropy change of an ideal gas,

L-12: Examples of entropy change calculations, entropy -ST diagram (and on other diagrams), entropy and disorder, configurational entropy.

1. A Carnot cyclic heat engine does 50 kJ of work per cycle. If efficiency of engine is 75%, the heat rejected per cycle will be:

60.6kJ

16.6kJ

66.6kJ

200kJ

Answer: b Explanation: Carnot efficiency = Work done/Heat supplied(Q1)

0.75 = 50/ Q1

or, Q1 = 200/3

and, Work done = Q1– Q2

or, Q2 = 200/3-50 = 50/3 = 16.6kJ.

2. The efficiency of different reversible heat engines operating between the same two heat reservoirs of temperatures T1 and T2 (where T1>T2) is:

depends on the working substance's molar specific heats

depends on the amount of the working substance

does not depend on the working substance's properties

does not depend on the temperature difference (T1-T2)

only depends on the lower temperature T2, not on T1

Ans: C

3. On an entropy-temperature (ST) graph, a Carnot cycle will be a

rhombus

rectangle

trapezoid

ellipse

a diagram with four sides all having negative slopes

Answer B

4. The processes of a Carnot cycle in which useful work is done are:

isothermal expansion, and adiabatic expansion

isothermal contraction, and adiabatic contraction

adiabatic expansion, and adiabatic contraction

isothermal expansion, and adiabatic contraction

isothermal expansion, and isothermal contraction

Answer: isothermal expansion, and adiabatic expansion

5. Two bodies of masses M1 and M2, respectively having same heat capacity and initially at temperatures T1 and T2 (T1>T2) are brought together in thermal contact, without delivering any work. What will be the final temperature Tf of these two bodies?

Tf = (T1 - T2)/2

Tf = (T1 + T2)/2

Tf = (M1 T1 - M2 T2)/(M1 + M2)

Tf = (M1 T1 + M2 T2)/(M1 + M2)

Tf = sqrt(T1 T2)

Answer: D Tf = (M1 T1 + M2 T2)/(M1 + M2)

6. Suppose that heat is transferred from body A at temperature T1 to body B at temperature T2 without any heat loss to the surrounding and without mixing of the substances. The two bodies form a closed system. The change of entropy of the system will be:

Zero

Positive

Negative

May be positive, zero or negative depending on the temperature difference

Cannot be determined

Answer: Positive

7. An isentropic (constant entropy) process may also be:

a reversible isothermal process

a reversible adiabatic process

a reversible isobaric process

a reversible isochoric process

none of the above

Answer: (b) a reversible adiabatic process

8. A heat engine absorbs heat per cycle 250 kJ at a higher temperature of 226.85 Celsius (500 K) and rejects heat at the temperature 26.85 (300 K) Celsius. The cycle is reversible. The amount of heat rejected per cycle is :

150 kJ

180 kJ

200 kJ

30 kJ

125 kJ

Answer: 150 kJ

Solution:

$Q_h/T_h = Q_l/T_l$ for Carnot cycle; Hence $Q_l = Q_h (T_l/T_h) = 250$ kJ (300 K/500 K) = 150 kJ

9. A Carnot engine operates between the absolute temperatures T1 and T2 (T1>T2) where T1-T2=900K. Another Carnot engine operates between the temperatures T2 and T3 (T2>T3) with T2-T3=400 K. For both heat engines to be equally efficient, T2 would be:

600 K

720 K

500 K

650 K

750 K

Answer: 720 K ; Solution: For equal efficiency : eta = 1 - (T2/T1) = 1 - (T3/T2)

=> T2/T1 = T3/T2 => T2 = sqrt(T1 T3)

T1 = T2+900 ; T3 = T2 -400 ; Hence, T2^2 = (T2+900)(T2-400) = T2^2 +(900-400)T2 -360000

=> 500 T2 = 900*400 => T2 = 900K*400/500 = (900K/5)*4 = 180*4K = 720 K

10. Change of entropy when an ideal gas is heated under constant pressure:

$\Delta S = nR \ln(V_f/V_i)$

$\Delta S = nR \ln(V_f/V_i) + n C_V \ln(T_f/T_i)$

$\Delta S = n C_V \ln(T_f/T_i)$

$\Delta S = nR \ln(T_f/T_i)$

$\Delta S = n C_P \ln(V_f/V_i)$

Answer: $\Delta S = nR \ln(V_f/V_i) + n C_V \ln(T_f/T_i)$

11. A Carnot refrigerator operates between a low temperature reservoir at T_C and a high temperature reservoir at T_H. Its coefficient of performance is given by:

$(T_H-T_C)/T_C$

$(T_H+T_C)/T_C$

$(T_H+T_C)/T_H$

$T_C/(T_H-T_C)$ A

$T_H/(T_H-T_C)$

Solution: COP = Q_c/W , $Q_h=W+Q_c$ => $W=Q_h – Q_c$; Refrigerator is a Carnot engine (heat engine) run in the opposite direction. Hence the relation $Q_h/Q_c=T_h/T_c$ is still valid for a refrigerator. Hence, COP= $Q_c/(Q_h-Q_c)=1/(Q_h/Q_c -1) = 1/(T_h/T_c -1)= T_c/(T_h – T_c)$.