Q1 M1-112-17

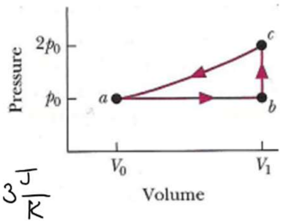
Two moles of a monatomic ideal gas are taken through the cycle shown in figure 5. The change in entropy in going from b to c is:

A) + 17.3 J/K
B) – 17.3 J/K
C) – 2.17 J/K
D) – 34.6 J/K
E) + 34.6 J/K

$$S_c - S_b = nC_v \ln\frac{T_c}{T_b} + nR \ln \overbrace{\frac{V_c}{V_b}}^{=1}$$

$$\left.\begin{array}{l} p_c V_c = nRT_c \\ P_b V_b = nRT_b \end{array}\right\} \frac{P_c \cancel{V_c}}{P_b \cancel{V_b}} = \frac{T_c}{T_b}$$

$$S_c - S_b = nC_v \ln\frac{P_c}{P_b} = 2\left(\frac{3}{2}R\right)\ln 2 = 17.3\,\frac{J}{K}$$



Q2 M1-132-17

A 7.00 g ice cube at −10.0 °C is placed in a lake whose temperature is 10.0 °C. Calculate the change in entropy of the ice cube as the ice cube comes to thermal equilibrium with the lake. The specific heat of ice is 2220 J/kg.K.

A) +10.2 J /K
B) −15.5 J /K
C) +19.2 J /K
D) +2.12 J /K
E) +7.12 J /K

$T_i = -10°C$;
$T_1 = 0$;
$T_f = 10°C$

$$\Delta S = \Delta S_1 + \Delta S_2 + \Delta S_3$$

$$\Delta S = mc_i \ln\frac{T_1}{T_i} + \frac{mL_f}{T_1} + mc_w \ln\frac{T_f}{T_1}$$

$$\Delta S = 7\times10^{-3}\left[2220 \ln\frac{0+273}{-10+273} + \frac{333\times10^3}{0+273} + 4190 \ln\frac{10+273}{0+273}\right]$$

$$\Delta S = 10.2\ J/K$$

Q3 M1-1122-19

A Carnot engine whose cold reservoir is at 15 °C has an efficiency of 34%. Then, the temperature of the hot reservoir is fixed while that of the cold reservoir is decreased. What should the temperature of the cold reservoir be in order to make the efficiency of this engine equal to 36%?

A) 6.3 °C
B) 280 °C
C) 160 °C
D) 7.2 °C
E) 12 °C

$$\varepsilon_c = 1 - \frac{T_L}{T_H}$$

$$\varepsilon_{c1} = 1 - \frac{T_{L1}}{T_H} \Rightarrow T_H = \frac{T_{L1}}{1-\varepsilon_{c1}}$$

$$\varepsilon_{c2} = 1 - \frac{T_{L2}}{T_H} \Rightarrow T_{L2} = (1-\varepsilon_{c2})T_H = (1-\varepsilon_{c2})\frac{T_{L1}}{(1-\varepsilon_{c1})}$$

$$T_{L2} = \frac{(1-0.36)}{(1-0.34)}(273+15) = 279.3\ K = 6.3°C$$

Q4 M1-122-18

Consider an ideal engine that operates between two reservoirs at 300 K and 600 K and absorbs 1.44×10^6 J per cycle. What is the power output of this engine if it completes 10 cycles per minute?

A) 120 kW
B) 100 kW
C) 350 kW
D) 440 kW
E) 500 kW

$$\varepsilon_c = 1 - \frac{T_L}{T_H} = \frac{W}{Q_H} \Rightarrow W = Q_H\left(1 - \frac{T_L}{T_H}\right)$$

$$P = \frac{\text{total work}}{\text{time}} = \frac{10(1.44\times10^6)\left(1 - \frac{300}{600}\right)}{1 \times 60} = 120 \text{ kW}$$

Q5 M1-112-20

A Carnot air conditioner takes heat from a room at 21 °C and transfers it to the outdoors, which is at 35 °C. For each two joules of electric energy required to operate the air conditioner, how many joules are removed from the room in the form of heat?

A) 42 J
B) 21 J
C) 1.7 J
D) 3.3 J
E) 2.0 J

$$K_c = \frac{|Q_c|}{|W|} = \frac{T_L}{T_H - T_L}$$

$$|Q_c| = |W| \frac{T_L}{T_H - T_L} = 2\,\frac{273+21}{35-21} = 42 \text{ J}$$

Q6 M1-142-19

A refrigerator, with a coefficient of performance of 4.0, expels 300 J of heat to the surrounding. How much heat is absorbed from inside the refrigerator?

A) 240 J
B) 430 J
C) 120 J
D) 300 J
E) 400 J

$$K_c = \frac{|Q_L|}{|Q_H| - |Q_L|} \Rightarrow |Q_L| = K_c(|Q_H| - |Q_L|)$$

$$|Q_L| + K_c|Q_L| = K_c|Q_H|$$

$$|Q_L| = \frac{K_c|Q_H|}{(1+K_c)} = \frac{4(300)}{1+4}$$

$$|Q_L| = 240 \text{ J}$$