Chap27.51 exam Q1

51. What is the required resistance of an immersion heater that will increase the temperature of 1.5 kg of water from 10 °C to 50 °C in 10 min while operating at 110 V?

Solution Assume $E_{(\text{thermal})} = E_{(\text{electrical})}$

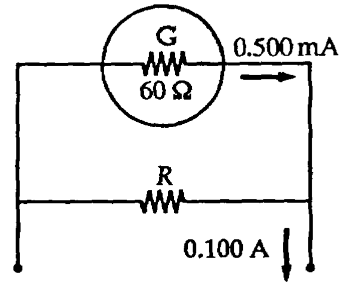
$$E_{(\text{thermal})} = mc\,\Delta T \quad \text{and} \quad E_{(\text{electrical})} = \left(\frac{V^2}{R}\right)t$$

Therefore, since $c = 4186\ \text{J/kg}\cdot{}^\circ\text{C}$

$$R = \frac{V^2 t}{cm\,\Delta T} = \frac{(110\ \text{V})^2(600\ \text{s})}{(4186\ \text{J/kg}\cdot{}^\circ\text{C})(1.50\ \text{kg})(40\ {}^\circ\text{C})} = 29\ \Omega \quad \Diamond$$

55. Assume that a galvanometer has an internal resistance of 60.0 Ω and requires a current of 0.500 mA to produce full-scale deflection. What resistance must be connected in parallel with the galvanometer if the combination is to serve as an ammeter that has a full-scale deflection for a current of 0.100 A?

Solution Consider making the constructed ammeter read full scale. Then the current through the shunt (parallel) resistor must be 0.1 A – 0.5 mA = 99.5 mA.



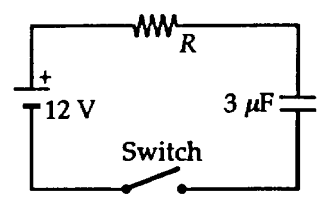
The voltage rule applied around the loop says

$$(-0.5\text{ mA})(60\ \Omega) + (99.5\text{ mA})R = 0$$

$$R = \frac{30\text{ mV}}{99.5\text{ mA}} = 0.302\ \Omega$$

45. A 4.00-MΩ resistor and a 3.00-μF capacitor are connected in series with a 12.0-V power supply. (a) What is the time constant for the circuit? (b) Express the current in the circuit and the charge on the capacitor as functions of time.

Solution We suppose the switch is closed at $t = 0$.



(a) $\tau = RC$

$$\tau = (4.00\times10^{6}\ \Omega)(3.00\times10^{-6}\text{ F})\left(\frac{1\text{ V}}{\text{A}\cdot\Omega}\right)\left(\frac{1\text{ C}}{\text{F}\cdot\text{V}}\right)\left(\frac{1\text{ A}\cdot\text{s}}{\text{C}}\right)$$

$\tau = 12.0\text{ s}$ ◊

(b) $q = \mathcal{E}C\left(1 - e^{-t/RC}\right)$

$$q = (12.0\text{ V})(3.00\ \mu\text{F})\left[1 - e^{-t/12\text{ s}}\right]$$

$q = 36.0\ \mu\text{C}\left[1 - e^{-t/12\text{ s}}\right]$ ◊

Differentiating,
$$I = \frac{dq}{dt} = (36.0\ \mu\text{C})\left[0 - e^{-t/12\text{ s}}\right]\left(-\frac{1}{12\text{ s}}\right)$$

$I = 3.00e^{-t/12\text{ s}}\ \mu\text{A}$ ◊

Chapter 33 exam Q4

65. A series *RLC* circuit consists of an 8.00-Ω resistor, a 5.00-μF capacitor, and a 50.0-mH inductor. A variable frequency source of amplitude 400 V (rms) is applied across the combination. Determine the power delivered to the circuit when the frequency is equal to one half the resonance frequency.

Solution The resonance frequency is

$$f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{(0.0500\text{ H})(5.00\times10^{-6}\text{ F})}} = 318\text{ Hz}$$

Operating at 159 Hz, we have

$$X_L = 2\pi f L = 2\pi(159\text{ Hz})(0.0500\text{ H}) = 50.0\ \Omega$$

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi(159\text{ Hz})(5.00\times10^{-6}\text{ F})} = 200\ \Omega$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{8^2 + (50 - 200)^2}\ \Omega = 150\ \Omega$$

$$I = \frac{V}{Z} = \frac{400\text{ V}}{150\ \Omega} = 2.66\text{ A}$$

The power put in by the source is equal to the power taken out by the resistor:

$$I^2 R = (2.66\text{ A})^2(8.00\ \Omega) = 56.7\text{ W} \quad \Diamond$$

Chapter 19

exam Q5

47. An automobile tire is inflated using air originally at 10°C and normal atmospheric pressure. During the process, the air is compressed to 28% of its original volume and the temperature is increased to 40°C. (a) What is the tire pressure? (b) After the car is driven at high speed, the tire air temperature rises to 85°C and the interior volume of the tire increases by 2%. What is the new tire pressure in pascals (absolute)?

Solution

(a) Taking $PV = nRT$ in the initial (i) and final (f) states, and dividing, we have

$$P_iV_i = nRT_i \qquad \text{and} \qquad P_fV_f = nRT_f \qquad \text{yield} \qquad \frac{P_fV_f}{P_iV_i} = \frac{T_f}{T_i}$$

So $$P_f = P_i\frac{V_iT_f}{V_fT_i} = \left(1.013\times10^5 \text{ Pa}\right)\left(\frac{V_i}{0.28V_i}\right)\left(\frac{273 \text{ K} + 40 \text{ K}}{273 \text{ K} + 10 \text{ K}}\right) = 4.00\times10^5 \text{ Pa} \qquad \Diamond$$

(b) Introducing the hot (h) state, $$\frac{P_hV_h}{P_fV_f} = \frac{T_h}{T_f}$$

So $$P_h = P_f\left(\frac{V_f}{V_h}\right)\left(\frac{T_h}{T_f}\right) = \left(4.0\times10^5 \text{ Pa}\right)\left(\frac{V_f(358 \text{ K})}{1.02V_f(313 \text{ K})}\right) = 4.49\times10^5 \text{ Pa} \qquad \Diamond$$

81. A "solar cooker" consists of a curved reflecting mirror that focuses sunlight onto the object to be heated (Fig. P20.81). The solar power per unit area reaching the Earth at some location is 600 W/m^2, and the cooker has a diameter of 0.60 m. Assuming that 40% of the incident energy is converted into thermal energy, how long would it take to completely boil off 0.50 liters of water initially at 20°C? (Neglect the heat capacity of the container.)

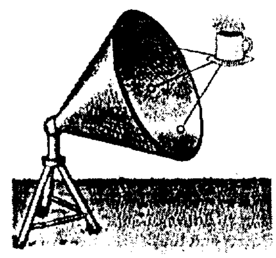


Figure 20.81

Solution The power incident on the solar collector is

$$P_i = IA = (600\ W/m^2)\pi(0.30\ m)^2 = 169.6\ W$$

For a 40% reflector, the collected power is

$$P_c = 67.9\ J/s$$

The total energy required to increase the temperature of the water to the boiling point and to evaporate it is

$$Q = mc\,\Delta T + mL_v = (0.500\ kg)(4186\ J/kg\cdot°C)(80\ °C) + (0.500\ g)(2.26\times10^6\ J/kg) = 1.30\times10^6\ J$$

The time required is

$$\Delta t = \frac{Q}{P_c} = \frac{1.30\times10^6\ J}{67.9\ J/s} = 1.91\times10^4\ s = 5.31\ h \qquad \Diamond$$

exam Q7

45. One mole of an ideal monatomic gas is taken through the cycle shown in Figure P22.45. The process AB is a reversible isothermal expansion. Calculate (a) the net work done by the gas, (b) the thermal energy added to the gas, (c) the thermal energy expelled by the gas, and (d) the efficiency of the cycle.

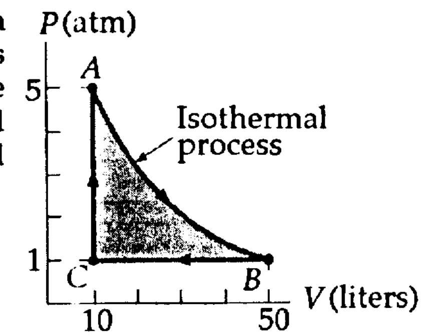


Figure P22.45

Solution

(a) For the isothermal process AB,

$$W_{AB} = P_A V_A \ln\left(\frac{V_B}{V_A}\right)$$

$$W_{AB} = (5\text{ atm})\left(1.013\times10^5\,\frac{\text{Pa}}{\text{atm}}\right)(10\text{ L})\left(10^{-3}\,\frac{\text{m}^3}{\text{L}}\right)\ln\left(\frac{50\text{ L}}{10\text{ L}}\right) = 8.15\text{ kJ}$$

Likewise, $W_{BC} = P_B\,\Delta V = (1.01\times10^5\text{ Pa})\left[(10-50)\times10^{-3}\right]\text{m}^3 = -4.05\text{ kJ}$

$W_{CA} = 0$ because $\Delta V_{CA} = 0$, so

$$W = W_{AB} + W_{BC} = 4.11\text{ kJ} \quad \Diamond$$

(b) AB is an isothermal process; since RT remains constant, the internal energy of the gas also remains constant, and the heat added equals the work done: $Q_{AB} = W_{AB}$.

$$Q_{AB} = W_{AB} = 8.15\text{ kJ}$$

Process CA also adds heat to the gas. If P increases at constant V, RT must also increase. Since no work is done during this process, the additional internal energy of the gas must come from the addition of heat.

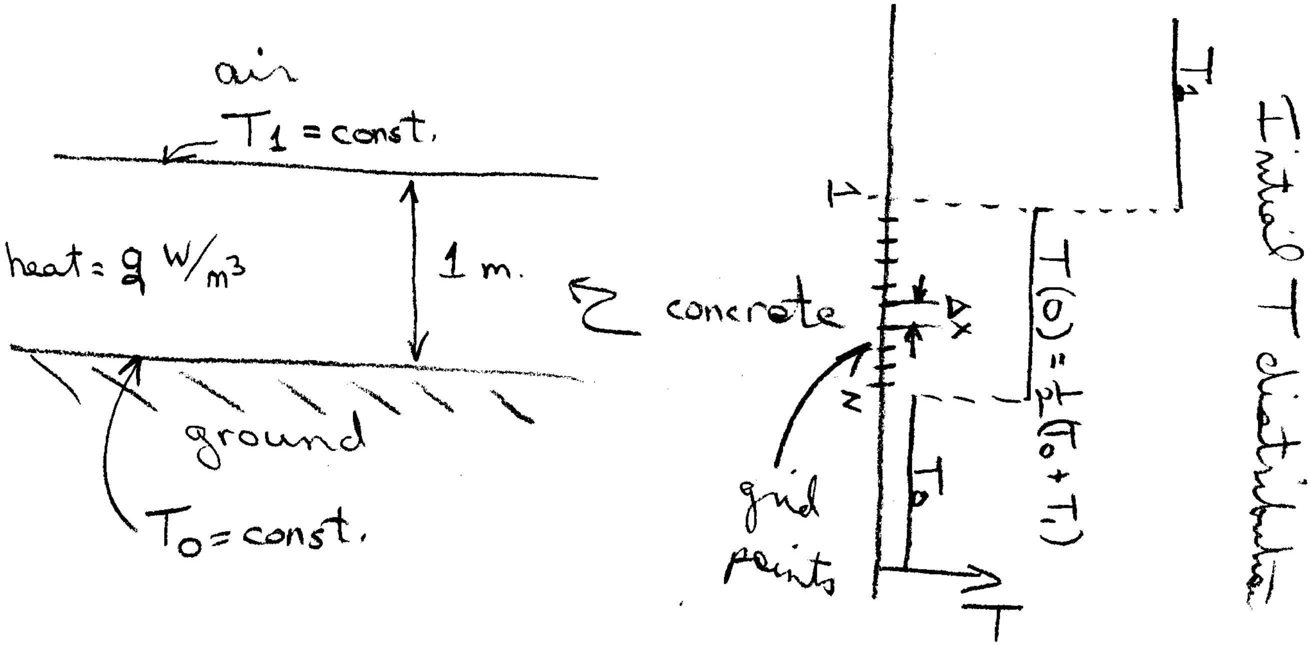
$$Q_{CA} = nC_v\,\Delta T = n\left(\frac{3R}{2}\right)\left(\frac{P_AV_A}{R} - \frac{P_CV_C}{R}\right) = n\frac{3V}{2}\Delta P$$

Solving, $Q_{CA} = (1.00)\dfrac{3\left(10\times10^{-3}\text{ m}^3\right)}{2}(4\text{ atm})\left(1.013\times10^5\text{ Pa/atm}\right) = 6.08\text{ kJ}$

and the thermal energy added is $Q_{in} = Q_{CA} + Q_{AB} = 8.15\text{ kJ} + 6.08\text{ kJ} = 14.2\text{ kJ} \quad \Diamond$

8.

a)



b) $$\rho c \frac{\left(T_i^{t+\Delta t} - T_i^{t}\right)}{\Delta t} = q + k \frac{\left(T_{i+1}^{t} - 2T_i + T_{i-1}^{t}\right)}{\Delta x^2}$$

c) $$T_i^{t+\Delta t} = T_i^{t} + \frac{\Delta t}{\rho c}\left[q + \frac{k}{\Delta x^2}\left(T_{i+1}^{t} - 2T_i + T_{i-1}^{t}\right)\right]$$

Start with $T_i^0 = \frac{1}{2}(T_0 + T_1)$, $1 < i < N$

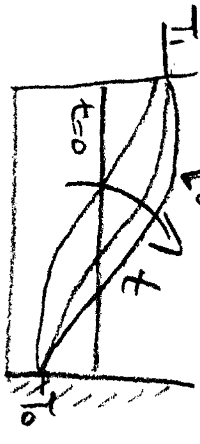
$T_1^0 = T_1$ = air temp = const.

$T_N^0 = T_0$ = ground temp = const.

Loop on i = 2 → N-1 to get $T^{\Delta t}$.

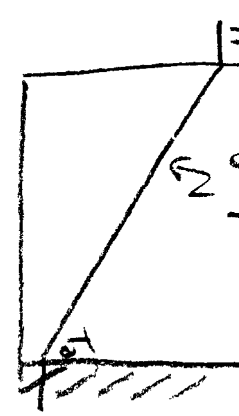
Repeat for next time step + so on.

d)



non-zero q causes a 'hump'

e)



as q → 0 T → linear