Physics 2A
Fall 2024

ave. = 5.1
σ = 2.4

Name Answer Key

Lab: early late (please circle one)

Quiz #7: Using Energy and Thermal Properties of Matter

Problem 1 (2 points)
Helium gas at 20 °C is confined within a rigid vessel. The gas is then heated until its pressure is doubled. What is the final temperature of the gas?

a) 10 °C
b) 20 °C
c) 40 °C
(d) 313 °C
e) 586 °C

D

$pV = nRT \rightarrow T = \frac{pV}{nR}$

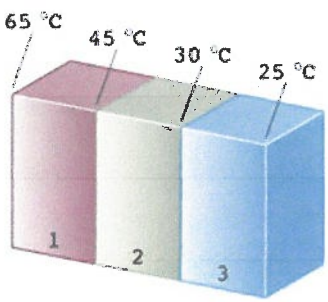
$T_i = 293\,K$

$T_f = 2(293K) = 586K = 313°C$

for constant n & V, doubling p doubles T, but T must be in Kelvin

Problem 2 (2 points)
The drawing shows a composite slab consisting of three materials through which heat is conducted from left to right at a constant rate. The materials have identical thicknesses and cross-sectional areas.

$\frac{Q}{\Delta t} = \frac{KA\Delta T}{L} \rightarrow K = \frac{(Q/\Delta t)L}{A\Delta T} \rightarrow K \propto \frac{1}{\Delta T}$



Which material (1, 2, or 3) has the largest thermal conductivity?

material 3 → the better a conductor, the smaller ΔT

Which material (1, 2, or 3) has the smallest thermal conductivity?

material 1 → the worse a conductor, the greater ΔT

Problem 3 (2 points)
Walking at a brisk pace uses energy at a rate of about 380 W. How many Calories would the human body burn while walking for 45 minutes? Take into account the efficiency of the human body.

$P = E/t = 380\,W$

$t = 45\,min = 2700\,s$

$1\,Cal = 4186\,J$

$E = Pt = (380\,W)(2700\,s) = 1.026 \times 10^6\,J$

$E = 1.026 \times 10^6\,J \left(\frac{1\,Cal}{4186\,J}\right) = 245\,Cal$

note: the rate 380W is rate at which we are "burning energy" and takes into account the efficiency of the human body (0.25). For every 4 Calories burned, we only get 1 Cal of useful output energy.

Problem 4 (4 points)
A 125.0-kg block of ice has a temperature of –10.0 °C. The block of ice then absorbs 6.20×10^7 J of heat. What is the final phase (solid, liquid or gas) and temperature?

$c_{water} = 4186$ J/(kg C°)
$c_{ice} = 2.00 \times 10^3$ J/(kg C°)
$L_f = 3.33 \times 10^5$ J/kg
$L_v = 22.6 \times 10^5$ J/kg

Changing temp of ice from -10.0°C → 0°C requires

$Q = m_{ice} C_{ice} \Delta T_{ice}$

$Q = (125.0\,Kg)(2.00\times10^3\, J/Kg\cdot C°)(10.0C°) = 2.50\times10^6\, J$

melting ice requires $Q = m L_f = (125.0\,Kg)(3.33\times10^5\, J/Kg)$
$= 4.16\times10^7\, J$

changing temp. of water from 0°C to 100°C requires

$Q = (125.0\,Kg)(4186\, J/Kg\cdot C°)(100.0C°) = 5.23\times10^7\, J$

⇒ there is not enough energy to change temp of water to 100°C.

Energy left to change temp. of water:

$Q = 6.20\times10^7\,J - 2.50\times10^6\,J - 4.16\times10^7\,J = 1.79\times10^7\,J$

$Q = m_{water} C_{water} \Delta T_{water} \longrightarrow \Delta T_{water} = \frac{Q}{m_{water} C_{water}}$

$\Delta T = \frac{1.79\times10^7\,J}{(125.0\,Kg)(4186\,J/Kg\cdot C°)} = 34.2\,C°$ (T_i of water after melting is 0°C)

⇒ final phase is water at 34.2°C