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Phy 232

Hw for 11/13/17
T7M.6, T7R.2, T2M.1

Clones, arrison

T7M.6

Suppose we put a 100-g block of Al with $T_i = 100°C$ into a cup containing 250g H_2O @ 25°C. What is the final equilibrium temp of the system?

We can use $T_f = T_B + \frac{\gamma}{1+\gamma}(T_A - T_B)$, where T_A = initial temp of hotter object (A), $T_B = T_i$ colder, $\gamma = \frac{m_A c_A}{m_B c_B}$.

$T_A = 100°C = 373.15\,K$, $T_B = 25°C = 298.15\,K$

$m_A = m_{Al} = 0.100\,kg$, $m_B = m_{H_2O} = 0.250\,kg$

$c_A = c_{Al} = 900\,\frac{J}{kg\,K}$, $c_B = c_{H_2O} = 4200\,\frac{J}{kg\,K}$

So $T_f = 298.15\,K + \left[\left(\frac{0.100\,kg \cdot 900\frac{J}{kg\,K}}{0.250\,kg \cdot 4200\frac{J}{kg\,K}}\right) \Big/ \left(\frac{0.100\,kg \cdot 900\frac{J}{kg\,K}}{0.250\,kg \cdot 4200\frac{J}{kg\,K}} + 1\right)\right](373.15\,K - 298.15\,K)$

$\boxed{T_f = 304\,K}$

T7R.2

Suppose you are given a 4.8 g hunk of an unidentified shiny, silvery metal that you know is from a collection of samples of pure chemical elements. You find it takes almost exactly 2.44 J of energy to increase its temp by 1.00 K. Identify the most likely metal and explain your reasoning.

We know that a change in temp of 1.00 K takes 2.44 J of (thermal) energy. ΔT, ΔU are sufficiently small that we can say $\frac{dU}{dT} \approx \frac{\Delta U}{\Delta T}$. Using equation T1.4, we can define the specific heat of the element is $c = \frac{1}{4.8\cdot10^{-3}\,kg}\frac{2.44\,J}{1.00\,K}$ to three sig figs, this is ≈ 520 $\frac{J}{kg\,K}$. We can express $\frac{dU}{dT}$ from equation T1.5, we get

$\frac{1}{N}\frac{dU}{dT} = n\left(\frac{k_B}{2}\right) \Rightarrow \left(A_V \cdot \frac{m}{\text{molar mass}}\right) \cdot n\,\frac{k_B}{2} = \frac{dU}{dT}$

$\Rightarrow \frac{A_V \cdot m \cdot n \cdot k_B}{2\,\text{molar mass}} = c \cdot m$ (A_V is Avogadro's number)

Solving for molar mass will give us a good idea of what the element is.

molar mass $= \frac{A_V \cdot n \cdot k_B}{2 \cdot c_B}$. Our sample is a solid metal, which is monatomic, so $n = 6$. We calculate the molar mass to be $\frac{6.02\cdot10^{23} \cdot 6 \cdot 1.38\cdot10^{-23}\,\frac{J}{K}}{2 \cdot 518.75\,\frac{J}{kg\,K}}$

$\Rightarrow 0.0481\,\frac{kg}{mol} \approx 48.1\,\frac{g}{mol}$. The closest molar mass is titanium ($47.88\,\frac{g}{mol}$) so

The metal is titanium

T2M.1

Imagine Putting in two solids discussed in Problems T2D.1, T2D.2 into thermal contact. Suppose the resulting combo is isolated from everything else, and that the combined system contains 6 units of energy ($U_A + U_B = 6\varepsilon$)

a) Construct a table showing U_A, U_B, Ω_A, Ω_B, Ω_{AB} for all possible macro partitions of the system, complete the probabilities for each macropartition.

$N_A = 1$, $N_B = 2$, $U_A + U_B = 6\varepsilon \Rightarrow$

U_A	U_B	Ω_A	Ω_B	Ω_{AB}	Probability
0	6ε	1	462	462	$\frac{462}{3003}$
1ε	5ε	3	252	756	$\frac{756}{3003}$
2ε	4ε	6	126	756	$\frac{756}{3003}$
3ε	3ε	10	56	560	$\frac{560}{3003}$
4ε	2ε	15	21	315	$\frac{315}{3003}$
5ε	1ε	21	6	126	$\frac{126}{3003}$
6ε	0	28	1	28	$\frac{28}{3003}$
		total microstates =		3003	

$$\Omega_A(U_A,1) = \frac{(\frac{U_A}{\varepsilon}+2)!}{\frac{U_A}{\varepsilon}!(2)!}$$

$$\Omega_B(U_B,2) = \left(\tfrac{U_B}{\varepsilon}+5\right)! / \left[\tfrac{U_B}{\varepsilon}\right]! \cdot 5!$$

b) Identify the most Probable macro Partitions of this system. Is the energy divided evenly between the solid's atoms in the most probable macro Partitions?

The most probable macro partitions are $(U_A, U_B) = (1\varepsilon, 5\varepsilon)$
$(U_A, U_B) = (2\varepsilon, 4\varepsilon)$.

For $(U_A, U_B) = (2\varepsilon, 4\varepsilon)$ the energy is distributed evenly between oscillators.
For $(U_A, U_B) = (1\varepsilon, 4\varepsilon)$ the energy is more distributed in oscillators of solid B.

Final O classes:

T1M.6: Resolve, fragments. T1R.2: Resolve. T2M.1: Resolve