SOS EXAM III: Detailed solution of #58:

58. One liter of gaseous (diatomic) oxygen combines completely with two liters of gaseous (diatomic) hydrogen to form a gas of water molecules (steam), when all of the gases are contained at the same temperature and pressure. One concludes from this that a water molecule has twice as many hydrogen atoms as it has oxygen atoms. If one also knows the volume of the steam finally produced (at the same temperature and pressure as the original hydrogen and oxygen), one can also choose the correct formula for water from the chemical formulas, H_2O, H_4O_2, and H_6O_3, etc…, all of which have twice as many hydrogen atoms as oxygen atoms in each molecule, as required.

Then suppose that the correct formula for the water molecule were H_6O_3, and compute the volume (at the same temperature and pressure) of steam finally produced. The final volume in that case would be, most nearly:

a. 6.00 liters
b. 3.00 liters
c. 2.00 liters
d. 1.00 liter
e. 0.50 liter
f. 0.33 liter
g. 0.17 liter
(h.) None of the above is within 10% of the correct answer.

Let n be the No. of particles in 1 l.
Then in 2 lt. of H_2 there are $N_H = 2 \cdot 2 \cdot n$ H atoms
and in p lt. of H_6O_3 there are $6 \cdot p n$ H atoms $= N_H$
Therefore $2 \cdot 2 \cdot n = 6pn$ & $p = \frac{2 \cdot 2 \cdot n}{6n} = \frac{4}{6} = 0.667$
& correct answer is (h).

SOS EXAM III Detailed Solution of #59:

59. If 5 g of steam at 100° C are mixed with 45 g of ice at 0° C in a completely insulated container, what is the final equilibrium temperature, most nearly ? (Use 80 cal/gm for the latent heat of fusion, 540 cal/gm for the latent heat of vaporization, and 1 cal/gm -° for the specific heat of water.)

a. 10° C
b. 20° C
c. 30° C
d. 40° C
e. 50° C
f 60° C
g. 70° C
h. 80° C
i 90° C
(j.) None of the above is within 5° C of the correct answer.

Heat Added + Work Done = Increase in internal energy

$0 + 0 = (\Delta U)_{5g} + (\Delta U)_{45g}$

$0 = -5 \cdot 540 + 5 \cdot 1 \cdot (T_f - 100°C) + 45 \cdot 80 + 45 \cdot 1 (T_f - 0°C)$

$+2700 + 500 - 3600 = T_f(5+45) = 50 T_f$.

$-\frac{400}{50} = T_f = -8°C$ IMPOSSIBLE!

Because No combination of $T_i = 0°C$ & $T_i = 100°C$ Material can give a final temperature $> 100°C$ or $< 0°C$. Reconsider the assumption implicit above that ALL of the ice melted: If only a fraction, f, melted, then the final mixture of ice + water has $T_f = 0°C$ and only $+(f \cdot 45 \cdot 80)$ cal is added from the melting.

Then $2700 + 500 - 3600 \cdot f = 50 T_f = 50 \cdot 0°C = 0$.

Then melted fraction is $f = 3200/3600 = 0.889$ & $T_f = 0°C$: (j) is correct