Thermal Physics and Ideal Gases

Thermal physics · 4 questions · step-by-step answers at the end

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USEFUL EQUATIONS

$pV = nRT = NkT \quad pV = \frac{1}{3}Nm\langle c^2\rangle \quad \frac{1}{2}m\langle c^2\rangle = (3/2)kT \quad \Delta E = mc\Delta\theta,\ E = mL$

Questions

Show your working in the space under each question.

1. By what factor does the r.m.s. speed of gas molecules change when the temperature rises from 300 K to 1200 K?

2. A cylinder holds gas at 2.0×10^5 Pa in a volume of 0.050 m³ at 300 K. Find the number of moles and the mean kinetic energy of a molecule.

3. 0.20 kg of water at 80 °C is mixed with 0.30 kg of water at 20 °C. Find the final temperature.

4. How many molecules are in 1.0 m³ of gas at 1.0×10^5 Pa and 300 K?

Step-by-step answers

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1. $c_{rms} \propto \sqrt{T}$, so it **doubles**.

2. 1. $n = pV/(RT) = (2.0 \times 10^5)(0.050)/(8.31 \times 300) =$ **4.0 mol**.
2. Mean KE $= (3/2)kT = 1.5 \times 1.38 \times 10^{-23} \times 300 =$ **6.2×10^{-21} J**.
Answer: 4.0 mol; 6.2×10^{-21} J

3. Energy lost = energy gained: $0.20(80 - \theta) = 0.30(\theta - 20)$, so $\theta =$ **44 °C**.

4. $N = pV/kT = 1.0 \times 10^5/(1.38 \times 10^{-23} \times 300) =$ **2.4×10^{25}**.