THE UNIVERSITY OF BRITISH COLUMBIA

Physics 122

Old Thermal Physics Examination Questions

1992-2001

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1. "QUICKIES"

   (*a*) [1992 Xmas] For an ideal gas the pressure and temperature are directly related to one of the following velocities of the gas molecules (underline the correct one): (*i*) most probable velocity; (*ii*) average velocity; (*iii*) root-mean-square velocity; (*iv*) maximum velocity.

   (*b*) [1994 Final] A special constant-temperature rocket engine heats up an ideal gas of "fuel" atoms of mass m to a fixed temperature T and allows them to escape through a small hole as "exhaust." Which would impart a *larger impulse* to the rocket payload — a fuel of hydrogen atoms or the same total fuel mass of lead atoms? (Remember, the average kinetic energy of ideal gas atoms depends only on T and not on m.)

   (*c*) [1995 Final] For an ideal gas of N particles in thermal equilibrium, the mean internal energy depends on *[encircle all correct answers]*

   (*i*) temperature (*ii*) pressure (*iii*) volume

   (*d*) [1996 Final] In the same room we have a mixture of helium gas, oxygen gas, *etc.* What is the ratio of the helium average velocity to that of the oxygen molecules?

   (*e*) [1997 Final] For an ideal gas the pressure and temperature are directly related to one of the following velocities of the gas molecules: [**underline one**]

   (*i*) most probable velocity; (*ii*) average velocity; (*iii*) root-mean-square velocity; (*iv*) maximum velocity.

2. [1993 P115 Xmas]

   (*a*) What are the two fixed points on the thermodynamic scale (constant volume ideal gas thermometer scale)?

   (*b*) How much heat is required to warm 6.0 kg of ice ($c = 2220$ J/kg-K) from -10°C to 0°C (staying as ice)?

   (*c*) How much heat is given off if you freeze 0.3 kg of water initially at 30°C ($c = 4190$ J/kg-K and $L = 333,000$ J/kg)?

   (*d*) If 0.3 kg of water is dropped onto a 6 kg block of ice at -10°C, what is the final temperature when equilibrium is reached, and how much ice and/or water is there?

3. States of Mind and the Heat of Thought [1995 Final] Consider the following grossly over-simplified model: A *mind* is a system $\mathcal{S}$ capable of N distinct *thoughts*, of which only $n \le N$ are actually held in memory at any given time. Any given thought is either in memory or not; there is no middle ground. Furthermore, each thought takes the same amount of "mental energy" ε, so that a mind with a total available mental energy U will always have exactly $n = U/\varepsilon$ thoughts in memory. A specific set of n thoughts can be considered one "fully specified state of mind" for $\mathcal{S}$. We shall make the further (rather insulting) assumption that *every possible* fully specified state of mind with n thoughts is *a priori* equally likely.

   (*a*) *How many* different fully specified states with n thoughts could occupy a mind which has "mental room" for N thoughts?

   (*b*) What is the *entropy* σ of a mind which has the capacity for 12 thoughts but currently contains only 4?

(*c*) Explain how to define a *mental temperature* τ for a given mind, assuming only that you know how the number of possible fully specified states of that mind depends on its total mental energy. [The specific form of said dependence need not be the one you gave above.]

(*d*) If $\mathcal{S}_1$, which has very little mental energy U_1 but a large mental temperature τ_1, is free to exchange thoughts with $\mathcal{S}_2$, which has enormous mental energy U_2 but a small mental temperature τ_2, *whose mental energy is most likely to increase?* Explain. (Assume both are isolated mentally from the rest of the world.)

(*e*) Now suppose that one particular mind is in "mental equilibrium" with the UBC intellectual community, which we shall assume has a "mental temperature" of $\tau = 1$ mJ. If it takes that mind an extra mental energy of $\varepsilon = 4$ mJ to have a given thought (in addition to whatever other thoughts it might be having), what is the *probability* of that specific thought being present in that mind at any given time?

4. [1992 P115 Xmas] A 180 g copper pot contains 200 litre of water at an initial temperature of 20°C. A copper rod heated to 900 °C is dropped into the water. This causes the water to boil with 5.0 g of water converted to steam. What is the mass of the copper rod?

$$\text{Specific heat of copper} = 386 \text{ J/kg.K}$$

$$\text{Specific heat of water} = 4190 \text{ J/kg.K}$$

$$\text{Heat of vaporisation of water} = 2256000 \text{ J/kg}$$

5. [1992 P115 Xmas] An igloo, a hemispherical enclosure built of ice, has an inner radius of 2.5 m . The thickness of the ice is 50 cm. On a cold winter day the outside temperature is -40°C. At what rate must thermal energy be generated to maintain the temperature inside the igloo at -5°C?

$$\text{Thermal conductivity of ice} = 0.592 \text{ W/m}\cdot\text{K}$$

A quantity of gas ($\gamma = 1.4$) expands adiabatically and quasi-statically from an initial pressure of 2 atm and volume of 2 ℓ at temperature of 20°C to twice its original volume.

(*a*) What is the final pressure of the gas?

(*b*) What is the final temperature of the gas?

— *FINIS* —