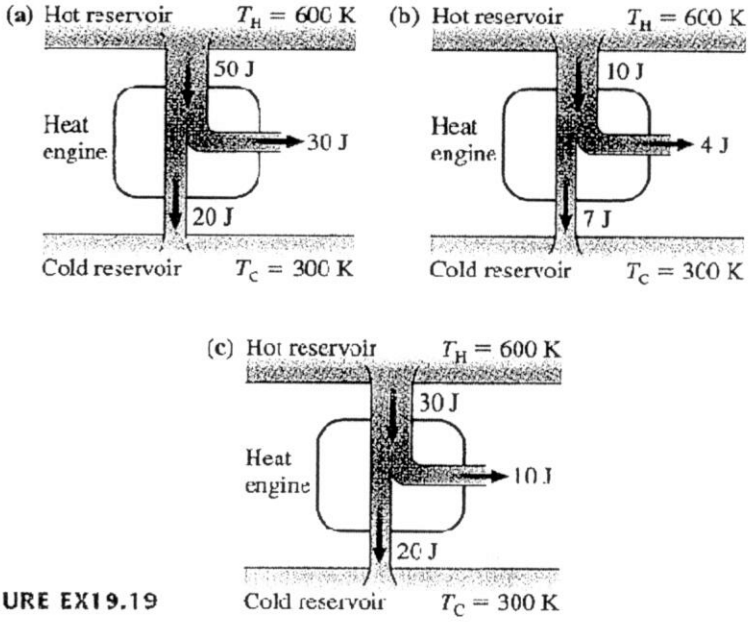
Fysiikka 3 FYSP103 **Exam** **19. 11. 2010** Michael Cochez

There are six equally valued problems to be solved

1) (Knight Problem 17.44) Your 300 mL cup of coffee is too hot to drink when served at 90°C. What is the mass of an ice cube, taken from a −20°C freezer, that will cool your coffee to a pleasant 60°C?
c_{water} = 4190 J/(kg·K) c_{ice} = 2090 J/(kg·K) L_{water} = 333000 J/kg

2) (Knight Problem 19.19) Which, if any, of the heat engines in the figure below violate **a)** the first law of thermodynamics **b)** the second law of thermodynamics? Explain.

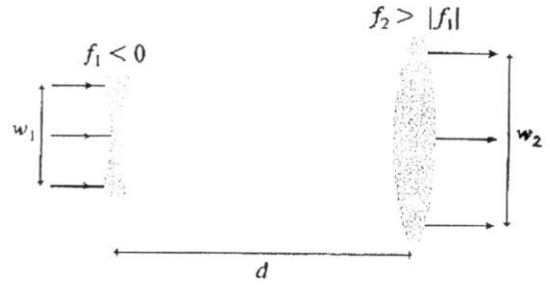


GURE EX19.19

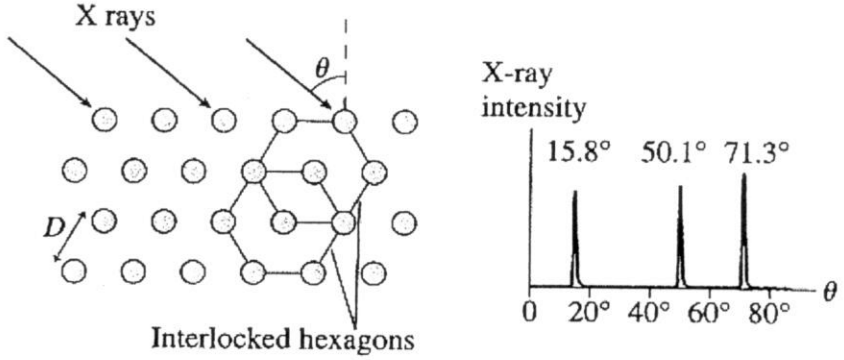
3) Answer briefly, with explanations, the following questions:
a) What causes the pressure of gas against the container walls?
b) Why is C_P greater than C_V?
c) In what way is the phase diagram for water exceptional? Which everyday phenomenon is connected with this fact?
d) Two identical boxes each contain 1,000,000 molecules. In box A, 750,000 molecules happen to be in the left half of the box while 250,000 are in the right half. In box B, 500,100 molecules happen to be in the right half of the box while 499,900 are in the left half. At this instant of time, what can you say about the relative values of the entropies of Box A and box B?

4) a) Explain *very briefly* what is meant by the Doppler effect. **b)** Deduce the formulae for the frequency of the sound heard by a stationary observer in the situation where the source of the sound is emitting sound waves at a frequency of f_0 and moves with respect to the observer at a constant speed of v_s along a straight line passing through the observer. The speed of sound = v.

5) (Knight Problem 24.31) A common optical instrument in a laser laboratory is a *beam expander*. One type of beam expander is shown in the figure below. The parallel rays of a laser beam of width w_1 enter from the left.
a) For what lens spacing d does a parallel laser beam exit from the right?
b) What is the width w_2 of the exiting laser beam?



6) (Knight Challenge Problem 25.40) X rays with wavelength 0.10 nm are incident on a crystal with a hexagonal crystal structure. The x-ray diffraction spectrum is shown in the figure below together with the experimental setup. What is the atomic spacing D of this crystal?



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Possibly useful formulae:

$y(x,t) = A \cdot \sin(k \cdot x - \omega \cdot t + \Phi_0)$
$\Delta r = 2d\cos\theta = m\lambda; \quad k = 2\pi/\lambda; \quad v = f \cdot \lambda$
$\Delta E_{th} = nC_V\Delta T; \quad \Delta E_{th} = W + Q; \quad W = -\int p\mathrm{d}V$
$Q = mc\Delta T; \quad Q = nC\Delta T; \quad Q = mL$