Sample Exam Questions - Module 5

1) Fourier's *Analytical Theory of Heat* is often considered an exemplar of positivism, since it is assumed that Fourier did not have an explanatory model for the nature of heat. However, when one reads this work one does find a qualitative model of heat propagation. a) Explain the main features of this model and discuss its role in Fourier's achievements in this work. b) Would you still agree with the association of Fourier with positivism?

2) In Section V, Chapter 1 of Fourier's *Analytical Theory of Heat* a law of the permanent temperatures in an infinite prism of small thickness is derived in two ways. Explain the basic assumptions of these derivations and show how they lead to the expression $T(x) = Ae^{(-x\sqrt{\frac{2h}{Kl}})}$ representing the temperature T at a distance x from the extremity of a prism kept at constant temperature A. The cross section of the prism is a square of sides $2l$. Moreover, K and h are the internal and external conductibilities, respectively.

3) Sadi Carnot's *Reflections on the Motive Power of Fire* marks the beginning of the science of thermodynamics. One of its main achievements is to show that the reversible engine is the one that gives the maximum efficiency. a) Present the argument given by Carnot (*reductio ad absurdum*) and discuss its validity. b) Describe the stages of the Carnot's cycle (see Figure 1) and justify, using Carnot's terms and reasoning, why no other engine, operating between the same temperatures, can have a greater efficiency.

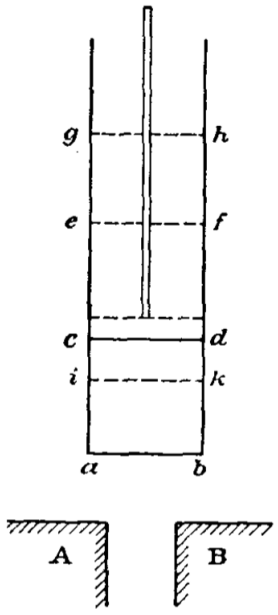

Figure 1: Carnot engine

4) In 1854, Rudolf Clausius publishes a paper that contains the essence of the concept of entropy. a) Explain the main conceptual assumptions that lead to the proposal of his *equivalence-values*. b) In the same paper, Clausius adds two stages (see Figure 2) to the usual Carnot cycle. Why does he do that? c) Show the main physical and mathematical arguments that lead to the proposal of a new state variable $dS = \frac{dQ}{T}$ which was later called entropy.

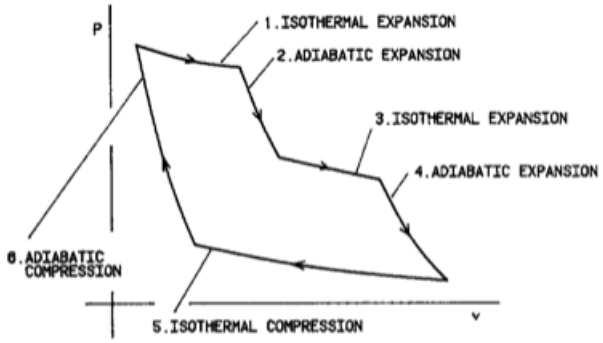

Figure 2: Clausius cycle

5) Carnot's work is usually criticised because of the assumption of the conservation of a fluid called *caloric* in reversible engines. However, as Mendoza (1960) points out, if we associate Carnot's notion of *caloric* with was later conceptualised as entropy, his conservation ideas were not wrong at all. Some authors (e.g. Callendar, 1911) even claim that the origin of entropy is already found in Carnot's work. Present and justify your views on this debate.

6) Compare the original formulation of the concept of entropy in Clausius with the way we learn/teach entropy things today. What was gained and what was lost?