Massachusetts Institute of Technology
Thermodynamics of Materials
3.00 Fall 2000

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Exam 1: Friday October 6, 2000 (11:05-11:55AM)

NAME: _____

This exam is composed of three questions. Please read them carefully and thoughtfully before you answer.

Your answers should fit in the space provided in the exam. If you find that the provided space is insufficient, use the back of the previous page and clearly indicate that your answer continues.

You may wish to work your answer out on scratch paper before writing on the exam. Your answers will be graded on their accuracy, physical insight, and clarity. A concise clear answer will get a better score with a longer answer with the same content. You may supplement your answer with a figure, a plot, or equations. Your answers will be graded in their entirety—extraneous or irrelevant equations or remarks may reduce the clarity or accuracy of your answer.

The questions are not necessarily ordered according to their difficulty—it would be prudent to read them all before you start. Finally, each question is not weighted equally in the grading; the weights are given below.

Question 1: 40 points possible _____

Question 2: 30 points possible _____

Question 3: 30 points possible _____

Total: 100 points possible _____

Exam Question 1.1

Consider three isolated systems that are initially composed of an iron spring and a vat of hydrochloric acid. The three systems are identical except for the initial state of the iron spring.

The spring has a mass of 10 grams and has a length of $x_\circ$ if no force is applied to it. The relationship between the applied force, F, and the length, x, of the spring is: $F = -k(x - x_\circ)$ where k is a spring constant that is independent of x and temperature.

The vat of hydrochloric acid is initially at -100°C and can dissolve 1 kilogram of un-stretched iron (also initially at -100°C) and the complete dissolution will cause a temperature rise of 10°.

Demonstrate how or find an expression that you would estimate the final temperature of the system for three different cases:

System A (no force)

The iron spring (mass of 10 grams, initial temperature -100°C) of length $x_\circ$ is dissolved in the vat at constant length.

System B (compression)

The iron spring (mass of 10 grams, initial temperature -100°C) is initially compressed to a length $x_\circ/2$ and then dissolved in the vat at constant length.

System C (tension)

The iron spring (mass of 10 grams, initial temperature -100°C) is initially stretched to a length $3x_\circ/2$ and then dissolved in the vat at constant length.

If possible, rank the three systems, from highest final temperature to lowest final temperature.

Exam Question 1.2

The CRC, Handbook of Chemistry and Physics, 58^{th} edition, defines the *Latent Heat of Vaporization* as follows:

> The quantity of heat necessary to change one gram of liquid to vapor without change in temperature, measured in calories per gram.

As defined, what kind of thermodynamic quantity is the latent heat of vaporization?

Suppose you were to measure the latent heat of vaporization of an unknown material. When you report your results to the rest of the world, would you need to augment the CRC definition in any way? If so, be specific.

Exam Question 1.3

Consider a closed system comprised of 3.00 moles of an ideal monatomic gas with an initial state $P_\circ$ and $V_\circ$.

After some unspecified process, the final state is $P_\circ/3$ and $3V_\circ$.

If possible, compute a result, develop an expression, or clearly describe how you would answer the following two questions:

What is the change in the molar internal energy of the ideal gas system?

How much work was performed *by* the system upon the universe?