Lesson Plan: Introduction to Entropy

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Timeframe: 75 minutes

Materials needed: Scratch paper, pen or pencil, computer.

Objectives:

Basic:

1. Distinguish spontaneous processes from non-spontaneous processes on the micro- and macro-level.

2. Identify examples of spontaneous processes that do (not) require energy input.

3. Contrast processes that are driven by energetic potential differences and those that do not require them.

Advanced:

1. Classify and contrast bulk-scale processes vs. microscale processes

2. Provide proof for the need of a new thermodynamic quantity (entropy) that accounts for non-energetically driven spontaneous processes.

3. Provide understanding of micro- and macrostates

Background: By this point students will have had exposure to the gas laws as well as the 0^{th} and 1^{st} laws of thermodynamics.

Introduction to Lesson: The lesson introduction will be supplied *via* 1) reading 1^{st} five sections in the introductory entropy chapter of the text (15 pages) 2) watch the two 15 min video lectures associated with those three chapter sections 3) actually working out the 2 "example" problems in the chapter. If more insight is necessary for understanding the concept, students will be instructed to look at further web-based content; *i.e.*, further video lectures supplied by IIT, MIT, UM, UCI, ect… If that is still not enough, perhaps a historical review about where the state functions evolved from will provide insight.

Procedure [Time needed, include additional steps if needed]:

Pre-Class Individual Space Activities and Resources:

Steps	**Purpose**	**Estimated Time**	**Learning Objective**
Step 1: Read sections 20-1 through 20-5 in McQuarrie and Simon Physical Chemistry (pages 817-833)	Familiarize the student with the historical context of entropy, the concept of i) spontaneity and energy transfer ii) micro vs macro processes iii) the new state function of entropy.	40 min.	
Step 2: Watch two 15 min video lectures associated with the assigned reading.	Reinforces and expands on the concepts learned in the chapter reading.	30 min	
Step 3: Actually work out the in-chapter exercises.	Forces recall of the recently learned materials.	15-25 min	

In-Class Group Space Activities and Resources:

Steps	**Purpose**	**Estimated Time**	**Learning Objective**
Step 1: We will start the in-class section with a quick review lecture where the students provide consist feedback regarding their understanding. Specifically, the lecture is provided in a series of open ended questions that must be answered by the students for the lecture to progress. If the students haven't prepared, it will be brutally evident *via* the flow and quality of answers.	This refreshes the ideas that were learned in the reading, video lectures, and practice exercise within the students' minds. Also lets students know where their understand sits with respect to others.	15 min	

Step 2: Break up into groups of us to four students and solve numerical and conceptual problems bound to the pre-class lecture and learning outcomes	This is done in an effort to initiate peer learning/teaching. It also forces the students to revisit the ideas learned in the pre-class lecture and exercises.	40-45 min	
Step 3: Presentation of answers to in-class exercises from the groups of students. Not only the numerical solution, but it will be expected that the underlying concepts will be explained as well.	Again, this exercise forces the students to express their understanding in terms that other can understand. This is a difficult task but provides for better answers to test questions	15-20 min	

Closure/Evaluation:

Analysis: Analysis of the class' conceptual understanding will be done on the fly by the instructor during the in-class group activities as well as via analysis of webassign answers after the in-class session. Specifically, during the intro-lecture portion of the in-class group space activities the instructor will see how deep the students' understanding goes and whether or not the majority of students bothered to prepare. Next, during the group problem solving activities the instructor will see how the students' understanding is progressing and what are some sticking points for given individuals as the instructor will constantly walk around the class to aid in students' movement through the material. Then, when the students present their answers to both numerical and conceptual in-class problems to the rest of the class the instructor will be able to evaluate if a deeper understanding was gained. Finally, students will be assigned a series (3-4) of online exercises to provide even further analysis of their progression.

Post-Class Individual Space Activities: Post class activities will involve online exercises aimed at testing conceptual understanding as well and numerical application of the concepts.

Connections to Future Lesson Plan(s): The total lesson (pre-, in-, and post-class) is aimed at laying fundamental understandings which will lead to further applications of the entropy state function.