

## MSE-483 ADVANCED PHASE TRANSFORMATIONS

FALL 2025

### EXAMINATION PROTOCOL

The oral examination consists of a 30-minute preparation period followed by a 20-minute examination. Exam slots are pre-assigned and listed separately in this document. Students should arrive at least 30 minutes before their scheduled exam time to select their topic and complete their preparation.

The student will select a topic at random from a basket and may then use the area outside MXG 230 to prepare. Students are permitted to bring any materials they require for use during the preparation period.

Each examination is conducted individually in MXG 230. The examination will focus on the topic selected at the start of the preparation period. The student will be asked a series of questions and should provide answers that are concise yet complete. A whiteboard is available in the examination room, and students are encouraged to use it to present mathematical derivations, sketch diagrams, or otherwise support their verbal responses.

Students may bring water or food into the examination room if needed. No notes, textbooks, electronic devices, or other materials are permitted during the examination.

### TOPICS AND QUESTIONS

- Equilibrium criteria in single-phase systems: Derive the equilibrium conditions for a closed single-component system that can exchange heat and volume with an environment at fixed pressure  $p$  and temperature  $T$ .
- Equilibrium in multi-phase systems: Derive an expression for the chemical potential of element A in a binary A-B substitutional solid solution.
- Clausius-Clapeyron relations: Derive an expression for the slope of the solid-liquid coexistence curve in a  $p - T$  phase diagram for a unary system.
- Phase equilibria and phase diagrams: Sketch the free energy and chemical potential curves below the critical temperature for a system exhibiting a miscibility gap.
- Diffusion: Starting from the fundamental equation of thermodynamics, derive an expression for the rate of entropy generation when MgO containing equal concentrations of positively and negatively charged vacancies is placed in a uniform electric field.
- Nucleation: Propose and justify a functional form for the total free energy associated with the formation of a cuboidal solid nucleus from a metastable liquid.
- Spinodal decomposition: Propose and justify a free energy model to describe spinodal decomposition.
- Order-disorder phase transitions: Define and describe appropriate order parameters for the order-disorder transition between a B2 (CsCl-type) intermetallic compound and a disordered bcc phase.
- The effects of strain on phase transitions: Derive a rotation-invariant strain metric for measuring the deformation of a lattice relative to a reference.

**EXAMINATION SCHEDULE**

Name	Exam Time
Breugnot Tom Didier Yves	09:30
Joncquel Hugo Etienne	10:00
Andres Ingrid	10:30
Baiada Elias Julien	11:00
Curti Aurélien Eddie Walter Auguste	11:30
Serée Erwann Louis Valentin	13:00
Abdulmaqsoud Noor Abdulmaqsoud Ibrahim	13:30
Modrzewska Emilia Katarzyna	14:00
Lee Jeanne Cherng Yi	14:30
Paratte Noé	15:10
Kim Tae Hwan	16:00