**Plasma II** **Spring semester 2025**

# List of questions for the oral exam on June 18-19, 2025

## Group 1

1) Describe the DT fusion reaction. Why is it our first choice to realise a fusion power plant? What are its advantages and disadvantages?
2) Describe the power balance of a fusion reactor. Derive the conditions required for energy production?
3) Discuss the concept and derivation of the MHD equations.
4) Discuss general properties of an ideal MHD equilibrium and explain why field lines need a rotational transform.
5) One-dimensional MHD equilibria: choose one example and discuss it.
6) Two-dimensional MHD equilibria: outline the derivation of the Grad-Sharanov equation.
7) Stability of MHD equilibria: explain the idea of 'linearisation' and outline the derivation of the energy principle.
8) What are the main operational limits of tokamak plasmas? Discuss them using the Hugill diagram.
9) Discuss the need for additional heating to reach the temperatures required for fusion.
10) What are the physical processes when a neutral beam enters a plasma? Discuss criteria to design the ITER neutral beam.

## Group 2

11) Discuss the general principles of diffusive transport (random walks, diffusion coefficient, role of collisions).
12) Discuss the difference between 'classical' and 'neo-classical' transport in toroidal devices and explain why it was necessary to introduce the concept of 'anomalous transport'?
13) Discuss the electron energy transfer in elastic and inelastic collisions. What are the implications for plasma chemistry?
14) Discuss the heating and power balance of a weakly ionised DC plasma and derive the expression for the temperature difference between electrons and the neutral gas.
15) Describe the evolution of gas breakdown and plasma, starting from an initial electron, and derive the Townsend criterion for breakdown.
16) Describe the breakdown voltage curve given by Paschen's law [Reminder: $V_B = B \cdot pd/\ln(C \cdot pd)$].
17) Describe simply the formation of a sheath. What is the ion speed entering a sheath (Bohm criterion) and how do the ions reach this speed?
18) Explain how to calculate the sheath voltage drop to an electrically floating wall, for a DC plasma. Why are sheaths important for the microelectronics industry.

## Group 3

19) Hydrostatic equilibrium of the Sun: explain the basics and discuss one of the important consequences

20) Describe how to compute the luminosity of the Sun from basic principles.

21) How is energy transported from the sun's core to its surface? Discuss the transition from radiative energy transport to convective energy transport.

22) Discuss the emergence of flux ropes/tubes by magnetic buoyancy.

23) Describe the 11-year cycle of the Sun: sunspots and phenomenology.

24) Magnetic reconnection: basic principles and the Sweet-Parker model.

25) Describe the fluid model of the solar wind. What are the assumptions and which parameters can be deduced from the observation of a supersonic solar wind at a sufficient distance from the sun? [Reminder: $\frac{1}{V}\frac{\partial V}{\partial r}\left(\frac{V^2}{V_s^2}-1\right)=\frac{2}{r}\left(1-\frac{GM_\odot}{2V_s^2 r}\right)$]

26) Discuss the electro-magnetic radiation emitted from a plasma – how can it be used for diagnostic purposes?

27) Describe various methods to measure a plasma density.

28) Describe various methods to measure a plasma temperature.