

List of questions for the oral exam on June 21, 2022

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 get to 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) Solar dynamo: basic concepts, α - and Ω -effect.
- 25) Magnetic reconnection: basic principles and the Sweet-Parker model.
- 26) Discuss the electro-magnetic radiation emitted from a plasma – how can it be used for diagnostic purposes?
- 27) Describe various methods to measure the plasma density.