Particle Physics

1. What are quarks? Experimental evidence for their existence.
2. Discovery of *c*, *b* and *t* quarks.
3. What are gluons? Experimental evidence for their existence.
4. What are leptons? Discovery of τ lepton and electron neutrino.
5. What are W and Z bosons? How were they discovered? What development in the accelerator physics was necessary to make the discovery possible?
6. What is the Higgs particle? Why do we need it? How to search for it?
7. What is the Standard Model of particle physics and what is abelian and non-abelian in it? Gauge symmetry.
8. Couplings in the Standard Model and how do we measure them, how do they depend on the scale of the interaction and what is this scale?
9. Why the Standard Model doesn't look like the final theory? Experimental searches for physics beyond the Standard Model.
10. Resonances and the Breit Wigner formula. What is measured?
11. Rutherford experiment and discovery of the nucleus; what is the nucleus?
12. Deep inelastic lepton-nucleon scattering experiments and searches for substructures. What are we learning?
13. CC weak interactions, parity violation and how the electron neutrino helicity was measured. What would be the charged pion lifetime if muons and electrons were massless?
14. NC interactions, flavour changing and the GIM mechanism.
15. Experimental evidence for the CP violation. Why is this interesting?
16. Neutrino oscillations and experimental observations (solar, atmospheric and terrestrial).
17. Dark matter and dark matter candidates.
18. Space-time symmetries and conservation laws.
19. How to identify: electron, positron, photon, muon, pion and kaon.
20. In a collider experiment; how to identify: *c* or *b* or *t* quark, *W*, *z*, ρ, J/ψ, ν, τ. Drawing Feynman diagrams give examples how these particles might be produced.
21. How to measure lifetimes of *c* or *b* quark or τ lepton. How to measure the lifetime of the *Z* and why do we want to do it very precisely.
22. How to measure the *W* mass and why do we want to know it very well.

Accelerator Physics

23. What is emittance? What is normalised emittance? Why are they important?
24. What determines the RF frequency required to accelerate particles (a) in a synchrotron and (b) in a linac?
25. What limits the energy that can be reached in synchrotrons with (a) protons and (b) electrons?
26. Define luminosity for a high-energy collider, and identify the main parameters that govern the luminosity in practice. What is the equivalent for a fixed target accelerator?
27. What is meant by a lattice? Describe a simple lattice for a synchrotron, explaining clearly the function of the various components.