A- General questions: You are expected to answer to most of these questions. You should provide the correct answer to at least 4 out of the 8 questions to get the maximal mark of 12.

1) Indicate two observations that the Standard Model of particle physics can not account for ?
2) Cosmological and astrophysical observations have provided evidences of the existence of dark matter. Briefly describe two of them.
3) Expansion and Redshift — Explain how the observation of galaxy redshifts provides evidence for the expansion of the Universe. What does it mean when we say that "space itself is expanding" rather than galaxies simply moving through space?
4) For a given beam energy, why colliders have larger potential than fixed targets experiments. What limits the LHC to a beam energy of 7 TeV ?
5) Question on statistic with counting experiment:
   Expected background: 100 events (perfectly known)
   Simulation of signal: 50 events for 10 fb cross section
   Observation 130 events
   a) What is the measured cross section and the integrated luminosity used?
   b) What is the statistical error of his measured cross section?
   c) What is the statistical significance ? Would you call it a discovery ?
6) If you would need to design an analysis to search for di-Higgs production, which are the two main channels you would choose and why?
7) Describe the different sources of neutrinos (natural and artificial) and discuss the advantages and disadvantages of artificial sources with respect to natural ones
8) Why we need to look at upgoing muons to identify astrophysical neutrinos? We can use this strategy for whatevever neutrino energy?

B- Topical questions: You should provide the correct answer to at least 2 out of the 4 questions to get the maximal mark of 8.

1) What are the experimental signatures that allow for the observation of a WIMP signal? Briefly describe them.

2) Cosmic Timeline and Observational Evidence — List three major events in the history of the Universe and describe how we are able to obtain observational evidence for each of them.

3) Can you summarize how experiments are searching for CP violation and mass ordering in neutrino oscillations and how to solve the degeneracies between these two parameters?

4) What do we gain using multi-messenger approach, can you cite three of them? What is the difference between leptonic and hadronic processes in gamma-ray production, and why are neutrinos important to distinguish them? How is this related to cosmic rays?