1. The energy density of matter and radiation in the universe evolve with the scale factor as:

   (a) a^{-2} and $a^{-1/4}$ respectively
   (b) a^{-2} and a^{-4} respectively
   (c) a^{-3} and a^{-4} respectively

2. If dark matter particles are captured by the Sun, how can we search for dark matter annihilations in the Sun?

   (a) With photons
   (b) With positrons
   (c) With neutrinos

3. The top quark was discovered at TeVatron 17 years earlier than the Higgs boson, even if the mass of the top quark is about 50% bigger than the Higgs boson. Why?

   (a) The Higgs boson cannot be produced in proton-antiproton collisions, because the gluon-gluon fusion production diagram is not possible
   (b) With respect to the top quark, the interaction of the Higgs boson with the constituents of the proton and antiproton is weaker.
   (c) The decay products of the Higgs boson and the top quark are very different and require different dedicated detectors to study them.

4. Which of the following statements resumes the Bayes' theorem?

   (a) posterior = likelihood × prior / evidence
   (b) posterior = likelihood × evidence / prior
   (c) posterior = evidence × prior / likelihood

5. Among the following three neutrino sources, which one provides the most energetic neutrinos?

   (a) Natural radioactivity on Earth
   (b) Sun
   (c) Cosmic-ray interactions in the atmosphere

6. Select which one of these statements is correct, concerning GeV-scale neutrino-nucleon and antineutrino-nucleon cross-sections at different neutrino energies:

   (a) The cross-section increases for increasing neutrino energy and is the same for neutrinos and antineutrinos
   (b) The cross-section increases for increasing neutrino energy and is higher for neutrinos than for antineutrinos
   (c) The cross-section does not depend on neutrino energy and is higher for neutrinos than for antineutrinos

7. In a background-free neutrinoless double beta decay experiment of isotope mass M, the sensitivity to the neutrinoless double beta decay half-life is proportional to:

   (a) $M^{1/2}$
   (b) M
   (c) M^2

8. Name the main challenges for the upgrade of the LHC experiments, in particular their tracking detectors.

   (a) Amount of collected data, radiation dose, allowed type of material.
   (b) Occupancy, radiation dose, data rate.
   (c) Radiation dose, activation, difficult access

9. What is the upgrade strategy of the ATLAS and CMS experience for their calorimeters

   (a) Replace them completely
   (b) Implement mainly new readout electronics
   (c) Implement new readout electronics and replace some components

10. The total kinetic energy, K, of the material emitted by a core-collapse supernova amount to 10^{51} erg. The total energy emitted as electromagnetic radiation amounts to $0.01K$. The total energy emitted as neutrino amounts to:

    (a) a negligible fraction of K
    (b) a value comparable to that of the electromagnetic radiation
    (c) about two orders of magnitude larger than K

11. Galactic Cosmic Rays are accelerated by Supernova remnants up to PeV energies (at most). The model explaining the involved acceleration mechanism

  (a) is not able to reproduce the observed features
  (b) uses iterative scattering processes, with a small amount of gained energy and a large number of iterations.
  (c) uses the Faraday law (induced f.e.m.)

12. Which processes are expected to receive at LHC NLO QCD corrections of order α_s?

  (a) Processes with no jets at LO
  (b) Processes with 1 jet at LO
  (c) Processes with 2 jets at LO

13. The flux of TeV gamma rays is measured for more than 100 sources by IACTs as Magic, HESS and Veritas. The flux of neutrinos for each source is expected

  (a) to be almost equivalent to that of gamma-rays, because both are produced by decays of mesons
  (b) to be present in some of the sources
  (c) there is no connection between neutrinos and TeV gamma-rays

14. In the Standard Model, Flavour Changing Neutral Currents:

  (a) are completely absent from the theory,
  (b) are absent at tree level but appear at one loop,
  (c) are already present at tree level.

15. Which of the following sentences is not correct? "The existence of dark matter is needed to understand. . .

  (a) the observed CMB spectrum"
  (b) the motion of planets in the Solar system"
  (c) the way structure forms in the Universe"

16. If there is physics beyond the Standard Model at energies ~ 10 TeV, flavour transitions like neutral meson mixings:

  (a) are always insensitive to that kind of New Physics, since they occur at a much lower energy scale $\sim$ GeV,
  (b) can be quite sensitive since in the Standard Model they are very suppressed,
  (c) are only relevant if some new particles are discovered at the LHC.

17. How far will a Λ_b baryon be travelling in the LHCb vertex detector before decaying, if we assume a boost $\beta\gamma \sim 100$ in the LHC proton-proton collisions? (the mean lifetime of the Λ_b baryon is $\tau = 1.45 \times 10^{-12}$s)

  (a) 4 mm
  (b) 4 cm
  (c) 0.4 m

18. One of the most relevant decay channels measured by LHCb in 2012, after more than 30 years of searching for it in several experiments was called the "New Physics" killer, since it agreed with the Standard Model prediction. This rare decay is

  (a) $B_s \to \mu\bar{\mu}$
  (b) $B \to K^*\mu\bar{\mu}$
  (c) $B_s \to \phi\gamma$

19. At LHC, some processes receive large NLO QCD corrections of order 100% or more. How we can explain that?

  (a) New kinematic phase space regions appear
  (b) New sub-processes appear
  (c) Both of the previous effects can contribute

20. Neutrino mixing in the three-flavour scenario is described by:

  (a) 3 mixing angles and 1 phase
  (b) 3 mixing angles and 3 phases
  (c) 2 mixing angles and 1 phase

Solutions

1. C
2. C
3. B
4. A
5. C
6. B
7. B
8. B
9. C
10. C
11. B
12. C
13. B
14. B
15. B
16. B
17. B
18. A
19. C
20. A