1. According to a postulate of Einstein, which of the following describes the nature of the laws of physics as one observes processes taking place in various inertial frames of reference?
   a. laws are same only in inertial frames with zero velocity
   b. laws are same only in inertial frames moving at low velocities
   c. laws are same only in inertial frames moving at near speed of light.
   d. laws are same in all inertial frames

2. The period of an oscillating weight on a spring in an inertial frame of reference is 0.80 s. What would be its speed if it were to move by an observer who measures its period as 1.2 s?
   a. $1.1 \times 10^8$ m/s
   b. $2.2 \times 10^8$ m/s
   c. $2.5 \times 10^8$ m/s
   d. $2.9 \times 10^8$ m/s

3. A knight on horseback holds a 10-m lance. The horse can run at 0.70 c. (It wins most of its races!) How long will the lance appear to a person that is standing still on the ground as the horse runs past?
   a. 7.1 m
   b. 10 m
   c. 14 m
   d. 15 m

4. A muon formed high in Earth’s atmosphere travels at a speed 0.990 0 c for a distance (as we see it) of 4 600 m before it decays. How far does the muon travel as measured in its frame?
   a. 4 554 m
   b. 2 596 m
   c. 1 298 m
   d. 649 m

5. An electron of mass $9.11 \times 10^{-31}$ kg has a momentum of $3.64 \times 10^{-22}$ kg·m/s. What is its speed?
   a. $0.467 \text{ c}$
   b. $0.632 \text{ c}$
   c. $0.800 \text{ c}$
   d. It cannot have this momentum since it would require a speed greater than c.

6. What is the relativistic kinetic energy of an electron moving at a speed of $1.50 \times 10^8$ m/s?
   a. $1.27 \times 10^{-14}$ J
   b. $7.10 \times 10^{-14}$ J
   c. $9.47 \times 10^{-14}$ J
   d. $11.6 \times 10^{-14}$ J

7. If a monochromatic light beam with quantum energy value of 3.0 eV incident upon a photocell where the work function of the target metal is 1.60 eV, what is the maximum kinetic energy of ejected electrons?
   a. 4.6 eV
   b. 4.8 eV
   c. 1.4 eV
   d. 2.4 eV

8. Of the following photons, which has the highest energy?
   a. infrared
   b. microwave
   c. visible
   d. ultraviolet

9. If an electron (nonrelativistic) has a measured wavelength of $0.850 \times 10^{-10}$ m, what is its kinetic energy?
   a. 55.0 eV
   b. 104 eV
   c. 147 eV
   d. 209 eV

10. A proton (mass = $1.67 \times 10^{-27}$ kg) has a kinetic energy of 1.00 MeV. If its momentum is measured with an uncertainty of 1.00%, what is the minimum uncertainty in its position?
    a. $9.08 \times 10^{-13}$ m
b. $2.28 \times 10^{-13}$ m  
c. $9.08 \times 10^{-14}$ m  
d. $5.64 \times 10^{-14}$ m

11. What is the wavelength of a monochromatic light beam, where the photon energy is $5.00 \times 10^{-19}$ J?
   a. 354 nm  
   b. 398 nm  
   c. 414 nm  
   d. 787 nm

12. The de Broglie wavelength of a 0.060 kg golf ball is $4.28 \times 10^{-34}$ m. What is its speed?
   a. 15 m/s  
   b. 26 m/s  
   c. 31 m/s  
   d. 48 m/s

13. What is the energy of a photon that has the same wavelength as a 12-eV electron? Hint: $KE = \frac{p^2}{2m}$.
   a. $5.6 \times 10^{-16}$ eV  
   b. 12 eV  
   c. 24 eV  
   d. 3.5 keV

14. The Heisenberg uncertainty principle places restriction on the precision of simultaneously measuring both position and momentum. This principle can also be applied to the simultaneous measurement of two other variables, which are:
   a. force and color  
   b. energy and time interval  
   c. mass and charge  
   d. torque and frequency

15. The atomic number of a given element is equivalent to which of the following?
   a. proton number in the nucleus  
   b. neutron number in the nucleus  
   c. sum of the protons and neutrons in the nucleus  
   d. number of electrons in the outer shells

16. The atomic mass number of a nucleus is equivalent to which of the following numbers?
   a. number of neutrons present  
   b. number of protons present  
   c. difference in neutron and proton numbers  
   d. sum of neutron and proton numbers

17. The mass of $^{12}$C is 12 u where 1 u = $1.660 \times 10^{-27}$ kg. This mass is equal to:
   a. the mass of the $^{12}$C nucleus.  
   b. the mass of the $^{12}$C nucleus plus 6 electrons.  
   c. the mass of the $^{12}$C nucleus plus 12 electrons.  
   d. the mass of 6 protons and 6 neutrons.

18. Calculate the binding energy per nucleon of the tritium nucleus, $^{3}_1$H, given that the mass of the tritium nucleus is 3.016 05 u. ($m_p = 1.007 276$ u, $m_n = 1.008 665$, and 1 u = 931.5 MeV/c$^2$)
   a. 2.24 MeV/nucleon  
   b. 2.45 MeV/nucleon  
   c. 2.66 MeV/nucleon  
   d. 2.86 MeV/nucleon

19. An ancient building was known to have been built 3 000 years ago. Approximately what proportion of Carbon-14 atoms are yet in the building’s wooden framing compared to the number which were present at the time of its construction? (half life of $^{14}$C = 5 730 years)
   a. 0.425  
   b. 0.500  
   c. 0.517  
   d. 0.696
20. Approximately how many half-life periods must elapse if the activity of a radioactive isotope sample is to be reduced to 0.004 of the original value?
   a. 3  
b. 6  
c. 8  
d. 60  

21. The half-life of $^{18}$N is 0.62 s. What is the decay constant for this isotope?
   a. $0.43 \text{ s}^{-1}$  
b. $1.1 \text{ s}^{-1}$  
c. $1.7 \times 10^{-11} \text{ Ci}$  
d. The decay constant is not defined for a half-life of less than one second.

22. When radium-224 emits an alpha particle, the remaining daughter nucleus is which of the following?
   a. lead-213  
b. actinium-215  
c. radon-220  
d. bismuth-215

23. The alpha emission process results in the daughter nucleus differing in what manner from the parent?
   a. atomic mass increases by one  
b. atomic number decreases by two  
c. atomic number increases by one  
d. atomic mass decreases by two

24. What particle is emitted when $^{239}$Pu decays to $^{236}$U? (atomic numbers of Pu and U are, respectively, 94 and 92)
   a. alpha

25. The $Q$ of a nuclear reaction is equal to:
   a. the total charge involved.  
b. energy associated with the change in mass.  
c. energy associated with momentum conservation.  
d. the exothermic endothermy.