1. A photon of frequency $6.40 \times 10^{14}$ Hz has what energy?

   A. 1.26 eV  
   B. 1.93 eV  
   C. 2.11 eV  
   D. 2.65 eV  
   E. 3.17 eV

2. A particle with non-zero kinetic energy will

   A. always have the same wavelength as the same energy photon.  
   B. always have a greater wavelength than the same energy photon.  
   C. always have a shorter wavelength than the same energy photon.  
   D. sometimes have a greater wavelength than the same energy photon.  
   E. sometimes have a shorter wavelength than the same energy photon.

3. The uncertainty principle was formulated by

   A. Einstein.  
   B. Bohr.  
   C. Heisenberg.  
   D. Planck.  
   E. Dirac.

4. According to the uncertainty principle, halving the uncertainty in position is accompanied by

   A. halving  
   B. quartering  
   C. doubling  
   D. quadrupling  
   E. no change in

5. An alternate version of the uncertainty principle exchanges the uncertainties in position and momentum with uncertainties in

   A. angular momentum  
   B. charge  
   C. angle  
   D. energy  
   E. wavelength

6. A photon of frequency $6.40 \times 10^{14}$ Hz has what energy?

   A. 1.26 eV  
   B. 1.93 eV  
   C. 2.11 eV  
   D. 2.65 eV  
   E. 3.17 eV
7. How many neutrons are in a $^{35}$Cl nucleus?

A. 17  
B. 18  
C. 16  
D. 19

8. $^{16}$O, $^{17}$O, and $^{18}$O are ________ of oxygen.

A. isotones  
B. isotopes  
C. isobars  
D. isomers  
E. isotherms

9. $^{226}_{88}$Ra decays by alpha decay. What are A and Z for the daughter nuclide?

A. 226, 92  
B. 222, 92  
C. 226, 88  
D. 222, 88  
E. 222, 86

10. In beta-minus decay, which neutrino is emitted?

A. the electron neutrino  
B. the electron antineutrino  
C. the muon neutrino  
D. the muon antineutrino  
E. the tau neutrino

11. $^{26}$Al decays by beta-plus decay. What is the daughter nucleus?

A. $^{27}$Al  
B. $^{25}$Al  
C. $^{26}$Mg  
D. $^{26}$Si  
E. $^{26}$Al

12. A sample contains $1.000 \times 10^{-3}$ g of $^{40}$K. The half-life of $^{40}$K is $1.250 \times 10^{9}$ years. What is the activity of the sample?

A. 3300 Bq  
B. 1250 Bq  
C. 382.0 Bq  
D. 265.0 Bq  
E. 3.000 Bq
13. Compared to the sum of the masses of its constituents, the mass of a nucleus is

A. the same.
B. greater.
C. less.
D. greater, less or the same.

14. What is the kinetic energy of a particle of mass m that has a total energy four times its rest energy?

A. 5 mc²
B. 4 mc²
C. 3 mc²
D. 2 mc²
E. 1 mc²

15. What is the rest energy of a proton? (mₚ = 1.67 x 10⁻²⁷ kg)

A. 1.5 x 10⁻¹⁰ J
B. 5.0 x 10⁻¹³ J
C. 1.6 x 10⁻¹³ J
D. 1.6 x 10⁻¹⁹ J
E. 0.0 J

16. If a spaceship of proper length 40 m is measured to have a length 30 m, how fast is it moving?

A. 0.50 c
B. 0.81 c
C. 0.75 c
D. 0.66 c
E. 0.43 c

17. The expression used for momentum, p = mv,

A. Is a good low-velocity approximation.
B. Is a good high-velocity approximation.
C. Is correct as long as we properly understand v.
D. Always gives too high a value for p.

18. A spaceship is observed from the Earth to be moving toward a star at a speed of 0.80 c. If the distance from the spaceship to the star is 1.6 ly as measured from earth, how long does an observer on Earth find that it takes for the space ship to reach the star?

A. 2.0 years
B. 2.1 years
C. 1.6 years
D. 1.2 years
E. 0.96 years
19. Two observers will always agree on

A. the speed of light.
B. the mass of cosmic ray muons.
C. the charge of cosmic ray muons.
D. the lifetime of cosmic ray muons.

20. What speed is required for a length to contract to 80% of its proper length?

A. 0.80 c
B. 0.60 c
C. 0.40 c
D. 0.20 c
E. 0.50 c

21. Relative to a stationary observer, a moving clock

A. always runs slower than normal.
B. always runs faster than normal.
C. keeps its normal time.
D. Any of these choice could be correct depending on the relative velocity.

22. Protons are sent at 0.900 c down a tube of length 27.0 m. How long does it take for the protons to travel this distance as measured in the lab?

A. 100 ns
B. 44.0 ns
C. 230 ns
D. 150 ns
E. 90.0 ns

23. A spaceship is 25 m wide and 100 m long. When traveling at 0.80 c (in a direction along its length), what is its observed width?

A. 42 m
B. 25 m
C. 16 m
D. 15 m
E. 20 m

24. Which was your favorite unit to study?

A. Electricity
B. Magnetism
C. Optics
D. Modern (Relativity, Quantum and Nuclear)

25. T/F I have completed the online evaluation for this class.