V. MODERN PHYSICS

1. The following is a property of a superconductor:

   a) its electrical resistance vanishes at room temperature

   b) it offers no resistance to the flow of an electric current at very low temperatures

   c) it offers no resistance to the flow of heat

   d) it permits direct current to flow through it, but not alternating current.

2. Is the absorption spectrum of atomic hydrogen

   a) a continuous spectrum

   b) a continuous spectrum with superimposed lines

   c) a pure line spectrum

   d) a band spectrum

3. The fine structure constant is equal to

   a) 1.1×10^{-2}

   b) the ratio of the Bohr radius to the classical electron radius, e^2/mc^2.

   c) the ratio of the electron compton wave-length, $\hbar/mc$, to the Bohr radius

   d) 6.3×10^{-27}

4. The nuclei of atoms

   a) may have magnetic dipole moments and in some cases electric quadrupole moments

   b) always are positively charged and always have positive electric dipole moments

   c) contain only protons and electrons

   d) always are positively charged and never have magnetic dipole moments

5. Consider the decay of a π meson at rest into a μ meson plus a neutrino, $\pi \rightarrow \mu + \nu$ (where $m_\pi c^2 \simeq 140$ Mev. $m_\mu c^2 = 106$ Mev. $\mu_\nu c^2 = 0$). The kinetic energy of the meson from this pion decay is approximately

a) 8 Mev

b) 4 Mev

c) 34 Mev

d) 17 Mev

6. When 500 kev electrons impinge on a molybdenum target, as in an x-ray tube, the frequency spectrum of the emitted x-rays consists of

a) a smooth distribution up to some maximum frequency

b) a series of sharp x-ray lines

c) a superposition of a) and b)

d) none of the above possibilities

7. Two nuclear particles of energies E and E' are detected in a Geiger counter. The pulses out of the counter are:

a) the same

b) proportional to the energies

c) proportional to the square root of the energies

d) inversely proportional to the masses of the particles

8. The size of an entire hydrogen atom is closest to

a) 10^{-17} m

b) 10^{-15} m

c) 10^{-13} m

d) 10^{-11} m

9. The ground state of the outer electron in a sodium atom is

a) $^2S\ 1/2$

b) $^1P\ 1/2$

c) $^2D\ 3/2$

d) $^2F\ 3/2$

10. The energy of the ground state of the hydrogen atom is -13.6 electron volts, relative to the energy of widely separated electron and proton. The energy of the first excited state of the atom is about:

a) -27.2 ev

b) - 3.4 ev

c) - 6.8 ev

d) - 9.6 ev

11. A thin straight track is observed to enter a nuclear emulsion, thicken more and more, bend a little and shortly afterwards produce a nuclear disintegration, two of the particles arising from which are later identified as fast π-mesons. Your best bet is that the incoming particle is

a) a π- meson

b) a slow neutron, and that fission occurred

c) a cosmic ray primary

d) an antiproton

12. No α- radioactive nuclides with decay energies below about 4 Mev are found in nature. The reason for this is believed to be:

a) Nuclei contain only high energy particles because the uncertainty principle requires the α particle to be bound by at least 4 Mev to remain in the nuclear volume.

b) The half-lives of low-energy α- emitters are too short to be observed in natural mineral samples with our techniques.

c) α-decay always releases a large amount of energy because of the large binding energy of the particle

d) The half-lives of low-energy α-emitters are too long to be observable with our techniques.

13. According to Einstein's special theory of relativity the mass of a particle moving with a velocity of four fifths of the speed of light is equal to:

a) one half of the particle's rest mass

b) four fifths of the particle's rest mass

c) the particle's mass at rest

d) five thirds of the particle's rest mass

14. In describing the photo-electric effect, which of the following statements is correct?

a) The energy of the ejected electrons depends on the light intensity.

b) The number of ejected electrons depends on the light intensity.

c) A certain amount of light must be absorbed before the first electron is ejected.

d) The number of electrons depends on the light's frequency.

15. The terms in the Balmer series for Hydrogen are represented by an expression of the form:

a) $\frac{1}{n_2} - \frac{1}{n_1}$

b) $\frac{1}{(n_2 - n_1)}$

c) $(n_2^2 - n_1^2)$

d) $\frac{1_2}{n_2^2} - \frac{1}{n_1^2}$

16. An element has a half-life of 1000 years. How long does it take for 15/16 of the original atoms to decay?

a) 8000 years.

b) 1000 $(\log \frac{15}{16})$ years

c) $1000^{15/16}$ years.

d) 4000 years.

17. A free electron cannot emit a photon because:

a) energy and momentum cannot be conserved in the process

b) the electron has different spin than the photon.

c) the electron must travel withspeeds comparable to that of light in order to emit the photon.

d) none of the above.

18. A cyclotron accelerates deuterons (heavy hydrogen nuclei). The magnetic field B and oscillator frequency ν are at their maximum values and cannot be increased, but can be decreased. It is desired to use the machine to accelerate protons. Which statement is true?

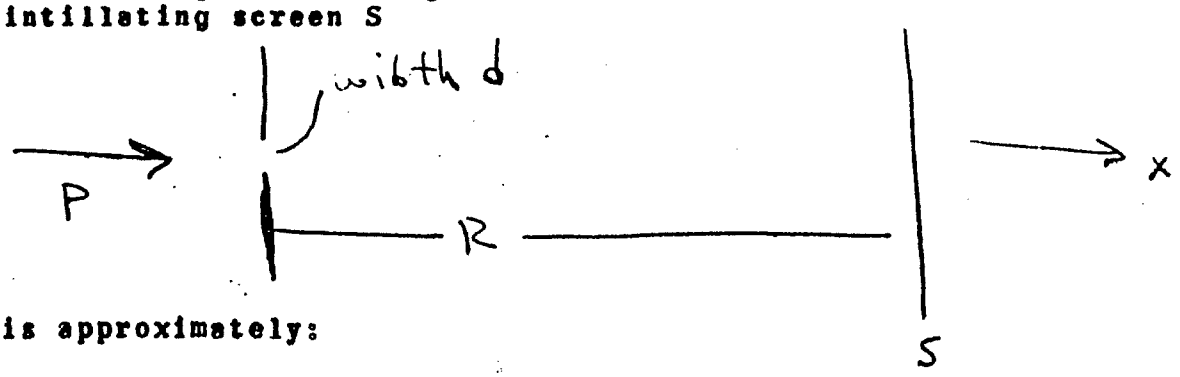
a) It can't be done; a cyclotron must be built specifically for one type of particle.

b) The maximum proton energy possible is greater than the previous deuteron energy.

c) The maximum proton energy is less than the deuteron energy.

d) The maximum proton energy is the same as the deuteron energy.

19. A narrow beam of electrons, travelling in the x - direction with momentum P, is incident on a long narrow slit of width d, as shown in diagram. A bright band of width D is observed on the scintillating screen S



D is approximately:

a) d

b) $\hbar/P$

c) $\frac{\hbar d}{RP}$

d) $\frac{\hbar R}{Pd}$

20. A non-relativistic proton moving through a Pb plate loses more energy per cm

a) by production of electron-positron pairs.

b) by scattering elastically and inelastically off the Pb nuclei.

c) by radiating photons via the bremsstrahlung process.

d) by exciting and ionizing electrons in the Pb atoms.

21. When a particle moves with a speed one-tenth of the speed of light in vacuum its mass appears to be:

a) infinite.

b) greater than its rest mass

c) zero

d) less than its rest mass

22. In a student laboratory the wavelengths of the K_α - line from several metals have been measured. Which of the following ways of plotting would lead to the simplest graph?

a) λ vs. atomic weight.

b) $\sqrt{\lambda}$ vs. atomic number

c) $1/\lambda$ vs. atomic number.

d) $\sqrt{1/\lambda}$ vs. atomic number.

23. The Rydberg constant R is $\frac{mo^4}{2\hbar^2}$ = 13.6 electron volts. The energy necessary to remove the remaining electron from a singly ionized Helium atomm is approximately:

a) 13 electron volts.

b) 150 electron volts

c) 20 electron volts

d) 50 electron volts.

24. Under certain conditions, ultraviolet light incident on a metal causes electrons to be ejected from the metal (photoelectric effect). The crucial parameter which determines whether or not electrons are ejected is the

a) frequency of the light

b) intensity of the light

c) polarization of the light

d) Wiedemann- Franz ratio of the metal.

25. When a fast positron is stopped in solid material it

a) forms a stable compound which remains indefinitely.

b) decays extremely rapidly into gamma rays.

c) decays extremely rapidly into protons and neutrons.

d) decays after many minutes into gamma rays.

26. The attenuation of 50-MeV gamma rays passing through lead is primarily due to:

a) photoelectric effect.

b) pair production.

c) nuclear excitation.

d) Compton effect.

27. A spaceship heads toward a star, which is 4 light years away, at a velocity of 0.6 c, where c is the speed of light ($c = 3 \times 10^8$ m/sec). A man on the ship is 20.0 years old when the ship leaves the earth. When he reaches the star his age, according to his clocks, is:

a) 28.3 years.

b) 24.0 years.

c) 26.7 years

d) 25.3 years.

28. The wavelength corresponding to the maximum in the radiation spectrum of a black body varies as:

a) T

b) T^{-2}

c) T^{2}

d) T^{-1}

where T is the temperature.

29. Which of the following correctly lists the particles in order of increasing mass?

a) μ-meson, π-meson, neutron, proton.

b) π-meson, μ-meson, proton, neutron

c) μ-meson, π-meson, proton, neutron

d) π-meson, μ-meson, neutron, proton

30. If ν is the initial photon frequency before collision, ν' its frequency after collision with an electron initially at rest, m_0 the rest mass of the electron, and β the velocity of the electron after the collision in units of the velocity of light, the conservation of energy for the Compton effect?

a) $\frac{1}{2} h\nu^2 = \frac{1}{2} h\nu'^2 + \frac{m_0 c^2}{\sqrt{1 - \beta^2}}$

b) $h\nu = h\nu' + m_0 c^2 \sqrt{1 - \beta^2} - m_0 c^2$

c) $h\nu = h\nu' + \frac{m_0 c^2}{\sqrt{1 - \beta^2}} - m_0 c^2$

d) $h\nu = h\nu' + \frac{m_0 c^2}{\sqrt{1 - \beta^2}}$

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31. The radius of the first Bohr orbit of Hydrogen is .529 Å. What is the radius of the corresponding orbit in positronium. (the atom formed from a positron and an electron)?

a) $.529/\sqrt{2}$ Å

b) 1.058 Å

c) .265 Å

d. .529 ($\sqrt{2}$) Å

32. Which of the following best describes the cause of the so-called fine structure of atomic energy levels?

a) interaction of the magnetic moment due to spin of the nucleus and the magnetic moment due to the orbital motion of the electron

b) interaction of the magnetic moment of the electron with an applied magnetic field.

c) interaction of the quadrupole moment of the nucleus with the electric field due to the electrons

d) interaction of the magnetic moment associated with the spin of the electron with the magnetic field the electron experiences as a result of its motion through the Coulomb field of the nucleus.

33. For X-rays of frequency ν the energy of a single photon is given by

a) $k\nu$

b) kT

c) $\frac{1}{2} h\nu$

d) $h\nu$

34. The electronic structure of Ca ($Z = 20$) is

a) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$

b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^2$

c) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ 4s3d

d) $1s^2\ 2s^2\ 2p^6\ 3s^2$ 2p^6 4p^2

35. The Larmor frequency for a particle of mass m and charge e in a magnetic field B is proportional to

a) eB^2/mc

b) eB/mc

c) e^2B/mc

d) mc^2/eB

36. If the Zeeman effect is observed along the magnetic field lines, the displaced components are

a) linearly polarized

b) elliptically polarized

c) circularly polarized

d) not at all polarized

37. A reasonable estimate of the number of electrons in you is

a) 10^{23}

b) 10^{26}

c) 10^{28}

d) 10^{30}

38. Electric charges

a) can be created in equal and opposite pairs

b) can be created singly as either positive or negative charges

c) can never be created or destroyed

d) are always associated with spin 1/2 particles

39. The threshold energy for the production of an electron-position pair is

a) 0.5109 MeV

b) 1.02 MeV

c) mc^2

d) it depends upon the mass of a third body in the system

40. What is the loss in mass of the sun per minute if 2 calories of radiated energy per minute fall on a square centimeter at normal incidence just outside of the earth's atmosphere? (The distance from the earth to the sun is about 150×10^6 km)

a) $4\pi \times (150)^2 \times 10^{18} \times 2 \times 10^4 \times 4.19 \times 9 \times 10^{16}$ kgm

b) $\dfrac{(150)^2 \times 10^{18} \times 2 \times 10^4 \times 4.19}{4\pi \times 9 \times 10^{16}}$ kgm

c) $\dfrac{4\pi \times (150)^2 \times 10^{18} \times 2 \times 10^4 \times 4.19}{9 \times 10^{16}}$ kgm

d) $\dfrac{4\pi \times 9 \times 10^{16}}{(150)^2 \times 10^{18} \times 2 \times 10^4 \times 4.19}$ kgm

41. Complete the statement below with the best (most accurate) of the four alternatives.

U^{235} is fissionable with thermal neutrons, but U^{238} is not, because

a) U^{238} is "doubly magic" and U^{235} is not.

b) U^{238} has three more protons than U^{235}

c) U^{238} has an even number of neutrons and U^{235} has an odd number.

d) U^{238} is heavier than U^{235}

42. A meson of mass π which is at rest decays into a meson of mass μ and a neutrino: What is the kinetic energy of the neutrino?

a) $\dfrac{(\pi^2 - \mu^2)\, c^2}{2\pi}$

b) $\dfrac{(\pi - \mu)^2\, c^2}{2\pi}$

c) $\dfrac{(\pi^2 + \mu^2)\, c^2}{2\pi}$

d) $\sqrt{\mu^2 c^4 + \pi^2 c^4}$

43. Find the binding energy of the last α particle in C^{12} from the information in the accompanying table

a) 7.36 Mev.

b) 7.16 Mev.

c) 25.2 Mev.

d) 26.3 Mev.

Nuclide	Mass (amu)
n^1	1.008665
H^1	1.007825
H^2	2.01410
He^3	3.01603
He^4	4.00260
Li^7	7.01601
Be^8	8.00531
Be^9	9.01219
B^{10}	10.01294
B^{11}	11.00931
C^{12}	12.00000
C^{13}	13.00335
N^{14}	14.00307
O^{16}	15.99491
F^{16}	16.01171

44. An X-ray is scattered from a free electron which was at rest. The frequency of the incident ray is denoted by ν, and that of the ray scattered in the direction making angle θ from the incident direction is denoted by $\nu(\theta)$. Then $\nu - \nu(\theta)$ is

a) an increasing function of θ

b) a decreasing function of θ

c) a constant

d) a function of θ which has a maximum at $\theta = 90°$

45. The measurement of the Hall coefficient provides useful information about

a) the number of charge carriers in a semi-conductor
b) the ratio of the number of γ-rays to β-rays in a nuclear de-excitation
c) the noise generated in a resistor
d) the reverberation time of an auditorium