

Modern Physics – Problem Set # 1

2. The longest wavelength x-ray that can undergo Bragg diffraction in a crystal for a given family of planes of spacing d is

(A) $\frac{d}{4}$

(B) $\frac{d}{2}$

(C) d

(D) $2d$

(E) $4d$

3. The ratio of the energies of the K characteristic x-rays of carbon ($Z = 6$) to those of magnesium ($Z = 12$) is most nearly

(A) $\frac{1}{4}$

(B) $\frac{1}{2}$

(C) 1

(D) 2

(E) 4

14. The total energy of a blackbody radiation source is collected for one minute and used to heat water. The temperature of the water increases from 20.0 °C to 20.5 °C. If the absolute temperature of the blackbody were doubled and the experiment repeated, which of the following statements would be most nearly correct?

- (A) The temperature of the water would increase from 20 °C to a final temperature of 21 °C.
 - (B) The temperature of the water would increase from 20 °C to a final temperature of 24 °C.
 - (C) The temperature of the water would increase from 20 °C to a final temperature of 28 °C.
 - (D) The temperature of the water would increase from 20 °C to a final temperature of 36 °C.
 - (E) The water would boil within the one-minute time period.
-

23. The Fermi temperature of Cu is about 80,000 K. Which of the following is most nearly equal to the average speed of a conduction electron in Cu?

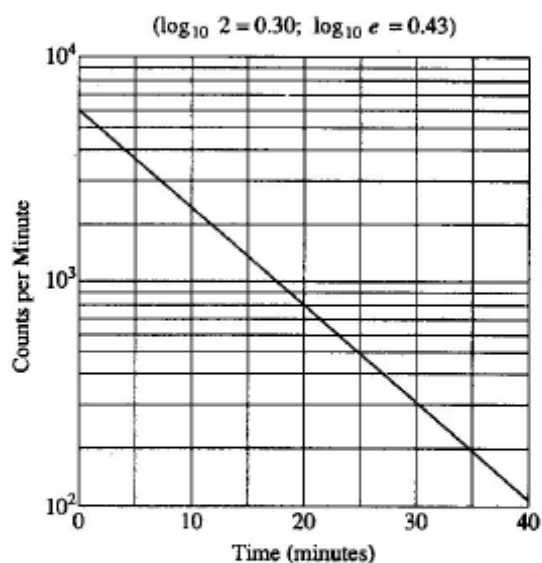
- (A) 2×10^{-2} m/s
 - (B) 2 m/s
 - (C) 2×10^2 m/s
 - (D) 2×10^4 m/s
 - (E) 2×10^6 m/s
-

24. Solid argon is held together by which of the following bonding mechanisms?

- (A) Ionic bond only
 - (B) Covalent bond only
 - (C) Partly covalent and partly ionic bond
 - (D) Metallic bond
 - (E) van der Waals bond
-

25. In experiments located deep underground, the two types of cosmic rays that most commonly reach the experimental apparatus are

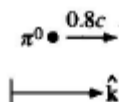
- (A) alpha particles and neutrons
- (B) protons and electrons
- (C) iron nuclei and carbon nuclei
- (D) muons and neutrinos
- (E) positrons and electrons



26. A radioactive nucleus decays, with the activity shown in the graph above. The half-life of the nucleus is

- (A) 2 min
 - (B) 7 min
 - (C) 11 min
 - (D) 18 min
 - (E) 23 min
-

30. Given that the binding energy of the hydrogen atom ground state is $E_0 = 13.6 \text{ eV}$, the binding energy of the $n = 2$ state of positronium (positron-electron system) is
- (A) $8 E_0$
 - (B) $4 E_0$
 - (C) E_0
 - (D) $\frac{E_0}{4}$
 - (E) $\frac{E_0}{8}$
31. In a 3S state of the helium atom, the possible values of the total electronic angular momentum quantum number are
- (A) 0 only
 - (B) 1 only
 - (C) 0 and 1 only
 - (D) $0, \frac{1}{2}$, and 1
 - (E) 0, 1, and 2
-



37. A π^0 meson (rest-mass energy 135 MeV) is moving with velocity $0.8c \hat{k}$ in the laboratory rest frame when it decays into two photons, γ_1 and γ_2 . In the π^0 rest frame, γ_1 is emitted forward and γ_2 is emitted backward relative to the π^0 direction of flight. The velocity of γ_2 in the laboratory rest frame is

- (A) $-1.0c \hat{k}$
 (B) $-0.2c \hat{k}$
 (C) $+0.8c \hat{k}$
 (D) $+1.0c \hat{k}$
 (E) $+1.8c \hat{k}$

38. Tau leptons are observed to have an average half-life of Δt_1 in the frame S_1 in which the leptons are at rest. In an inertial frame S_2 , which is moving at a speed v_{12} relative to S_1 , the leptons are observed to have an average half-life of Δt_2 . In another inertial reference frame S_3 , which is moving at a speed v_{13} relative to S_1 and v_{23} relative to S_2 , the leptons have an observed half-life of Δt_3 . Which of the following is a correct relationship among two of the half-lives, Δt_1 , Δt_2 , and Δt_3 ?

- (A) $\Delta t_2 = \Delta t_1 \sqrt{1 - (v_{12})^2/c^2}$
 (B) $\Delta t_1 = \Delta t_3 \sqrt{1 - (v_{13})^2/c^2}$
 (C) $\Delta t_2 = \Delta t_3 \sqrt{1 - (v_{23})^2/c^2}$
 (D) $\Delta t_3 = \Delta t_2 \sqrt{1 - (v_{23})^2/c^2}$
 (E) $\Delta t_1 = \Delta t_2 \sqrt{1 - (v_{23})^2/c^2}$