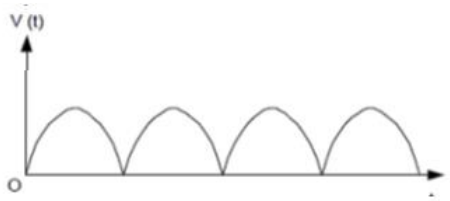
Problem 1:

In the Stern-Gerlach effect, observed when a beam of atoms is passed through an inhomogeneous magnetic field, which of the following is true?

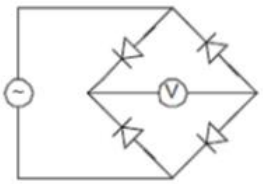
(A) The atoms must be ionized first.
(B) No deflection is observed for hydrogen atoms.
(C) Only one deflection is observed for hydrogen atoms.
(D) Two distinct deflections are observed for sodium (Z = 11) atoms.
(E) Three distinct deflections are observed for magnesium (Z = 12) atoms.

Problem 2:

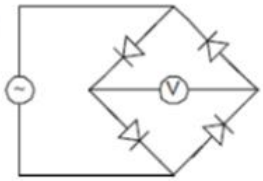


Which of the following circuits employing diodes constitutes a full-wave rectifier in which a sinusoidal input signal is converted to an output V(t), as shown in the diagram above?

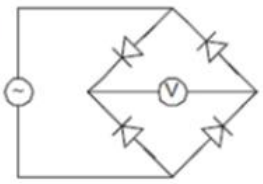
(A)



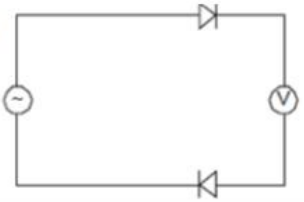
(C)



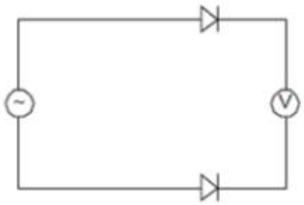
(B)



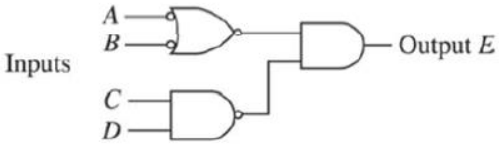
(D)



(E)



Problem 3:



For the logic circuit shown above, which of the following Boolean statements gives the output E in terms of inputs A, B, C, and D?

(A) $E = \overline{A + B} + \overline{C \cdot D}$
(B) $E = \overline{A + B} \cdot \overline{C \cdot D}$
(C) $E = \overline{\overline{A} + \overline{B}} \cdot \overline{C \cdot D}$
(D) $E = \overline{A \cdot B} \cdot \overline{C \cdot D}$
(E) $E = \overline{\overline{A} \cdot \overline{B}} \cdot \overline{C \cdot D}$

Problem 4:

In a Compton scattering experiment, a collimated beam of monochromatic x-rays of wavelength 0.7 angstrom impinges on a small cylindrical carbon scatter. The scattered radiation is investigated as a function of the angle between it and the primary beam. The scattered radiation contains

(A) no wavelength other than that of the primary beam

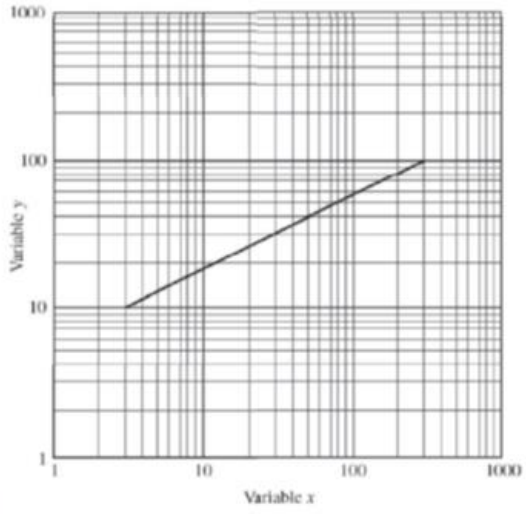
(B) a component shifted in wavelength by an amount that is independent of the wavelength of the primary beam

(C) a component shifted in wavelength by an amount that is independent of the scattering angle

(D) a component shifted in wavelength by an amount that decreases as the scattering angle increases

(E) two components with wavelength shifted up and down by equal amounts

Problem 5:



The figure represents a log-log plot of variable y versus variable x. The origin represents the point $x = 1$ and $y = 1$. Which of the following gives the approximate functional relationship between y and x?

(A) $y = 6\sqrt{x}$

(B) $y = \frac{1}{2}x + 6$

(C) $y = 6x + 0.5$

(D) $y = \frac{1}{6}x^2$

(E) $y = 6x^2$

Problem 6:

The Franck-Hertz experiment and related scattering experiments show that

(A) electrons are always scattered elastically from atoms

(B) electrons are never scattered elastically from atoms

(C) electrons of a certain energy range can be scattered inelastically, and the energy lost by electrons is discrete

(D) electrons always lose the same energy when they are scattered inelastically

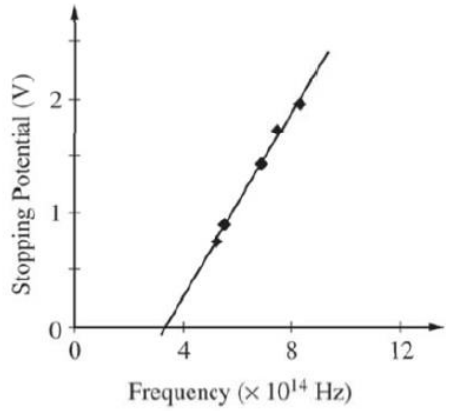
(E) there is no energy range in which the energy lost by electrons varies continuously

Problem 7:

A radioactive nucleus A has a mean life of 10 seconds. The nucleus decays into its daughter B. The mean life of B is 10 years. Starting with 10^{22} nuclei A at t = 0, the rate of decay of B at t = 1 year is most nearly

(A) 10^{22} per year
(B) 10^{21} per year
(C) 10^{20} per year
(D) 10^{19} per year
(E) zero

Problem 8:



In an experimental observation of the photoelectric effect, the stopping potential was plotted versus the light frequency, as shown in the figure . The best straight line was fitted to the experimental points. Which of the following gives the slope of the line? (The work function of the metal is ϕ.)

(A) $\frac{h}{\phi}$
(B) $\frac{h}{e}$
(C) $\frac{e}{h}$
(D) $\frac{e}{\phi}$
(E) $\frac{\phi}{e}$

Problem 9:

A certain experiment requires the maintenance of a vacuum of 10^{-2} atmospheres in a closed-off system. Which of the following is the simplest pumping arrangement that will meet this requirement?

(A) A mechanical pump only
(B) A mechanical pump and a oil-diffusion pump only
(C) A mechanical pump, a oil-diffusion pump, and a dry-ice trap
(D) A mechanical pump, a oil-diffusion pump, and a liquid-air trap
(E) A mechanical pump, a oil-diffusion pump, and a liquid-helium trap

Problem 10:

Two experimental techniques determine the mass of an object to be 11 ± 1 kg and 10 ± 2 kg. These two measurements can be combined to give a weighted average. The uncertainty of the weighted average is equal to which of the following?

(A) $\frac{1}{2}$ kg
(B) $\frac{2}{\sqrt{5}}$ kg
(C) $\frac{2}{\sqrt{3}}$ kg
(D) 2 kg
(E) $\sqrt{5}$ kg

Problem 11:

Which of the following is most useful for measuring temperatures of about 3,000K?

(A) Optical pyrometer
(B) Carbon resistor
(C) Gas-bulb thermometer
(D) Mercury thermometer
(E) Thermocouple

Problem 12:

A charged particle traverses a proportional counter. About 10^4 times as many electrons are collected as are formed by the particle in traversing the counter. This is the result of

(A) stimulated emission
(B) photoelectron production
(C) ionization by collisions
(D) magnetic resonance
(E) the Auger effect

Problem 13:

Which of the following lasers utilizes transitions that involve the energy levels of free atoms?

(A) Diode laser
(B) Dye laser
(C) Free-electron laser
(D) Gas laser
(E) Solid-state laser

Problem 14:

A necessary condition for a vector field **F** to be conservative is:

(A) $\nabla F = 0$
(B) $\nabla \cdot F = 0$
(C) $\nabla\nabla F = 0$
(D) $\nabla \cdot \nabla F = 0$
(E) $\nabla \times F = 0$

Problem 15:

The matrix $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix}$ has three eigenvalues λ_i defined by $Av_i = \lambda_i v_i$. Which of the statements is NOT true?

(A) $\lambda_1 + \lambda_2 + \lambda_3 = 0$
(B) λ_1, λ_2, and λ_3 are all real numbers.
(C) $\lambda_2\lambda_3 = +1$ for some pair of roots.
(D) $\lambda_1\lambda_2 + \lambda_2\lambda_3 + \lambda_3\lambda_1 = 0$
(E) $\lambda_i^3 = +1, i = 1, 2, 3$