20. Problem

An observer rest in system K observes a light ray in the *y* direction. The observer rest in K' moves with $1.5x10^8$ m/s in the positive *x* direction relative to K. Find the speed of light ray relative to observer in K' and the direction of propagation.

19. Problem

Two spaceships A and B move in opposite directions. An observer on Earth measures the speed of A to be 0.75c and the speed of B to be 0.9c. Find the velocity of B relative to A.

18. Problem

An electron originally at rest is accelerated by 256kV potential difference. Calculate the ratio of the relativistic and rest mass for this electron. What is the speed of the accelerated electron? Calculate the de-Broglie wavelength.

26. Problem

The kinetic energy of an electron, whose speed is $2.4x10^8$ m/s is doubled. Calculate the speed of the electron after the acceleration.

15. Problem

Light strikes a sodium surface, causing photoelectric emission. The stopping potential for the ejected electrons is 5.0 V and the work function of sodium is 2.2 eV. What is the wavelength of the incident light?

16. Problem

Find the maximum kinetic energy of electrons ejected from a certain material if the material's work function is 2.3 eV and the frequency of the incident radiation is $3.0x10^{15}$ Hz. Find the maximum speed as well.

17. Problem

(a) If the work function for a certain metal is 1.8 eV, what is the stopping potential for electrons ejected from the metal when light of wavelength 400 nm shines on the metal? (b) What is the maximum speed of the ejected electrons?

21. Problem
The work function of tungsten is 4.50 eV. Calculate the speed of the fastest electrons ejected from a tungsten surface when light whose photon energy is 5.80 eV shines on the surface.

14. Problem
What is the de Broglie wavelength of an electron accelerated at 120 V potential difference? The charge of the electron $1.6x10^{-19}$C, the mass is $9.1x10^{-31}$kg, the Planck constant is $6.63x10^{-34}$Js.

1. Problem
The ${}^{3}_{1}H$ isotope of hydrogen, which is called tritium (because it contains three nucleons) is radioactive, has a half-life of 12.33 yr. It can be used to measure the age of objects up to about 100 yr. It is produced in the upper atmosphere by cosmic rays and brought to Earth by rain. As an application, determine approximately the age of a bottle of wine whose radiation activity is about 0.1 that activity present in new wine.

2. Problem
A living specimen in equilibrium with the atmosphere contains one atom of ^{14}C (half-life = 5 730 yr) for every 7.7×10^{11} stable carbon atoms. An archaeological sample of wood (cellulose, $C_{12}H_{22}O_{11}$) contains 21.0 mg of carbon. When the sample is placed inside a shielded beta counter with 88.0% counting efficiency, 837 counts are accumulated in one week. Assuming that the cosmic-ray flux and the Earth's atmosphere have not changed appreciably since the sample was formed, find the age of the sample.

3. Problem
The specific activity due to ^{14}C radioactive isotope of an old wooden tool is found only 6% of the specific activity of a sample of fresh wood. How old is the tool? The half-life of ^{14}C is 5 730 years.

4. Problem
After the sudden release of radioactivity from the Chernobyl nuclear reactor accident in 1986, the radioactivity of milk in Poland rose to

2000 Bq/l due to iodine-131 present in the grass eaten by dairy cattle. Radioactive iodine, with half-life 8.04 days, is particularly hazardous because the thyroid gland concentrates iodine. The Chernobyl accident caused a measurable increase in thyroid cancers among children in Belarus.
(a) For comparison, find the activity of milk due to potassium. Assume that one litre of milk contains 2.00 g of potassium, of which 0.0117% is the isotope ^{40}K with half-life 1.28×10^9 yr.(b) After what time interval would the activity due to iodine fall below that due to potassium?

5. Problem
A small building has become accidentally contaminated with radioactivity. The longest-lived material in the building is strontium-90. (molar mass 87.62 g/mol, and its half-life is 29.1 yr. It is particularly dangerous because it substitutes for calcium in bones.) Assume that the building initially contained 5.00 kg of this substance uniformly distributed throughout the building and that the safe level is defined as less than 10.0 decays/min (to be small in comparison to background radiation). How long will the building be unsafe?

6. Problem
To destroy a cancerous tumour, a dose of gamma radiation totalling an energy of 2.12 J is to be delivered in 30.0 days from implanted sealed capsules containing palladium-103. Assume that this isotope has half-life 17.0 d and emits gamma rays of energy 21.0 keV, which are entirely absorbed within the tumour. (a) Find the initial activity of the set of capsules. (b) Find the total mass of radioactive palladium that these "seeds" should contain.

7. Problem
In an experiment on the transport of nutrients in the root structure of a plant, two radioactive nuclides X and Y are used. Initially 2.50 times more nuclei of type X are present than of type Y. Just three days later there are 4.20 times more nuclei of type X than of type Y. Isotope Y has a half-life of 1.60 d. What is the half-life of isotope X?

8. Problem

A sealed capsule containing the radiopharmaceutical phosphorus - 32 ($^{32}_{15}P$), is a nuclide undergoing into negative beta decay, is implanted into a patient's tumour. The average kinetic energy of the beta particles (electrons) is 700 keV. The initial activity is 5.22 MBq. Determine the energy absorbed during a 10.0-day period. Assume that the beta particles are completely absorbed within the tumour. The half-life of ^{32}P is 14.26 days.

9. Problem

The ^{60}Co isotope, which emits gamma rays, is widely used in metallurgy and for transillumination of welds. The activity of a cobalt radiation source decreased by about 13% in the first year of its operation. Calculate the half-life time of cobalt.

10. Problem

A 2.71 g sample of KCl from the chemistry stockroom is found to be radioactive, and it is decaying at a constant rate of 44.90 Bq. The decays are traced to the element potassium and in particular to the isotope ^{40}K, which constitutes 0.0117% of normal potassium. Calculate the half-life of this nuclide. The molar masses are: M_K=39.102 g/mol, M_{Cl}=35.453 g/mol.

11. Problem

The table that follows shows some measurements of the decay rate of a sample of ^{128}I, a radionuclide often used medically as a tracer to measure the rate at which iodine is absorbed by the thyroid gland.

Time (min)	Activity (counts/s)
4	392.2
36	161.4
68	65.5
100	26.8
132	10.9
164	4.56
196	1.86

218	1.00

Find the disintegration constant and the half-life time for this radionuclide.

12. Problem

The plutonium isotope ^{239}Pu is produced as a by-product in nuclear reactors and hence is accumulating in our environment. It is radioactive, decaying with a half-life of 2.41×10^4 yr. (a) How many nuclei of Pu constitute a chemically lethal dose of 2.00 mg? (b) What is the decay rate of this amount?

13. Problem

The isotope ^{238}U decays to ^{206}Pb with a half-life of 4.47×10^9 yr. Although the decay occurs in many individual steps, the first step has by far the longest half-life; therefore, one can often consider the decay to go directly to lead. That is,

$$^{238}U \rightarrow {}^{206}Pb + \text{various decay products.}$$

A rock is found to contain 4.20 mg of ^{238}U and 2.135 mg of ^{206}Pb. Assume that the rock contained no lead at formation, so all the lead now present arose from the decay of uranium. How many atoms of (a) ^{238}U and (b) ^{206}Pb does the rock now contain? (c) How many atoms of ^{238}U did the rock contain at formation? (d) What is the age of the rock?