NAME ______________________ DATE ____________ CLASS ____________

The Science of Physics

Problem A

METRIC PREFIXES

PROBLEM

In Hindu chronology, the longest time measure is a *para*. One *para* equals 311 040 000 000 000 years. Calculate this value in megahours and in nanoseconds. Write your answers in scientific notation.

SOLUTION

Given: 1 para = 311 040 000 000 000 years

Unknown: 1 para = ? Mh

1 para = ? ns

Express the time in years in terms of scientific notation. Then build conversion factors from the relationships given in **Table 3.**

$$1 \text{ para} = 3.1104 \times 10^{14} \text{ years}$$

$$\frac{365.25 \text{ days}}{1 \text{ year}} \times \frac{24 \text{ h}}{1 \text{ day}} \times \frac{1 \text{ Mh}}{1 \times 10^{6} \text{ h}}$$

$$\frac{365.25 \text{ days}}{1 \text{ year}} \times \frac{24 \text{ h}}{1 \text{ day}} \times \frac{3600 \text{ s}}{1 \text{ h}} \times \frac{1 \text{ ns}}{1 \times 10^{-9} \text{ s}}$$

Convert from years to megahours by multiplying the time by the first conversion expression.

$$1 \text{ para} = 3.1104 \times 10^{14} \cancel{\text{years}} \times \frac{365.25 \cancel{\text{days}}}{1 \cancel{\text{year}}} \times \frac{24 \cancel{\text{h}}}{1 \cancel{\text{day}}} \times \frac{1 \text{ Mh}}{1 \times 10^{6} \cancel{\text{h}}}$$

$$= \boxed{2.7266 \times 10^{12} \text{ Mh}}$$

Convert from years to nanoseconds by multiplying the time by the second conversion expression.

$$1 \text{ para} = 3.1104 \times 10^{14} \cancel{\text{years}} \times \frac{365.25 \cancel{\text{days}}}{1 \cancel{\text{year}}} \times \frac{24 \cancel{\text{h}}}{1 \cancel{\text{day}}} \times \frac{3600 \cancel{\text{s}}}{1 \cancel{\text{h}}} \times \frac{1 \text{ ns}}{1 \times 10^{-9} \cancel{\text{s}}}$$

$$= \boxed{9.8157 \times 10^{30} \text{ ns}}$$

ADDITIONAL PRACTICE

1. One light-year is the distance light travels in one year. This distance is equal to 9.461×10^{15} m. After the sun, the star nearest to Earth is Alpha Centauri, which is about 4.35 light-years from Earth. Express this distance in

a. megameters.

b. picometers.

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2. It is estimated that the sun will exhaust all of its energy in about ten billion years. By that time, it will have radiated about 1.2×10^{44} J (joules) of energy. Express this amount of energy in

a. kilojoules.
b. nanojoules.

3. The smallest living organism discovered so far is called a *mycoplasm.* Its mass is estimated as 1.0×10^{-16} g. Express this mass in

a. petagrams.
b. femtograms.
c. attograms.

4. The "extreme" prefixes that are officially recognized are *yocto*, which indicates a fraction equal to 10^{-24}, and *yotta,* which indicates a factor equal to 10^{24}. The maximum distance from Earth to the sun is 152 100 000 km. Using scientific notation, express this distance in

a. yoctometers (ym).
b. yottameters (Ym).

5. In 1993, the total production of nuclear energy in the world was 2.1×10^{15} watt-hours, where a watt is equal to one joule (J) per second. Express this number in

a. joules.
b. gigajoules.

6. In Einstein's special theory of relativity, mass and energy are equivalent. An expression of this equivalence can be made in terms of electron volts (units of energy) and kilograms, with one electron volt (eV) being equal to 1.78×10^{-36} kg. Using this ratio, express the mass of the heaviest mammal on earth, the blue whale, which has an average mass of 1.90×10^{5} kg, in

a. mega electron volts.
b. tera electron volts.

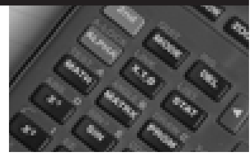
7. The most massive star yet discovered in our galaxy is one of the stars in the Carina Nebula, which can be seen from Earth's Southern Hemisphere and from the tropical latitudes of the Northern Hemisphere. The star, designated as Eta Carinae, is believed to be 200 times as massive as the sun, which has a mass of nearly 2×10^{30} kg. Find the mass of Eta Carinae in

a. milligrams.
b. exagrams.

8. The Pacific Ocean has a surface area of about 166 241 700 km^2 and an average depth of 3940 m. Estimate the volume of the Pacific Ocean in

a. cubic centimeters.
b. cubic millimeters.

Problem Workbook Solutions



The Science of Physics

Additional Practice A

Givens	*Solutions*
1. $distance = 4.35$ light years	$distance = 4.35\ \cancel{\text{light years}} \times \dfrac{9.461 \times 10^{15}\ \text{m}}{1\ \cancel{\text{light year}}} = 4.12 \times 10^{16}\ \text{m}$
	a. $distance = 4.12 \times 10^{16}\ \cancel{\text{m}} \times \dfrac{1\ \text{Mm}}{10^{6}\ \cancel{\text{m}}} = \boxed{4.12 \times 10^{10}\ \text{Mm}}$
	b. $distance = 4.12 \times 10^{16}\ \cancel{\text{m}} \times \dfrac{1\ \text{pm}}{10^{-12}\ \cancel{\text{m}}} = \boxed{4.12 \times 10^{28}\ \text{pm}}$
2. $energy = 1.2 \times 10^{44}$ J	**a.** $energy = 1.2 \times 10^{44}\ \cancel{\text{J}} \times \dfrac{1\ \text{kJ}}{10^{3}\ \cancel{\text{J}}} = \boxed{1.2 \times 10^{41}\ \text{kJ}}$
	b. $energy = 1.2 \times 10^{44}\ \cancel{\text{J}} \times \dfrac{1\ \text{nJ}}{10^{-9}\ \cancel{\text{J}}} = \boxed{1.2 \times 10^{53}\ \text{nJ}}$
3. $m = 1.0 \times 10^{-16}$ g	**a.** $m = 1.0 \times 10^{-16}\ \cancel{\text{g}} \times \dfrac{1\ \text{Pg}}{10^{15}\ \cancel{\text{g}}} = \boxed{1.0 \times 10^{-31}\ \text{Pg}}$
	b. $m = 1.0 \times 10^{-16}\ \cancel{\text{g}} \times \dfrac{1\ \text{fg}}{10^{-15}\ \cancel{\text{g}}} = \boxed{0.10\ \text{fg}}$
	c. $m = 1.0 \times 10^{-16}\ \cancel{\text{g}} \times \dfrac{1\ \text{ag}}{10^{-18}\ \cancel{\text{g}}} = \boxed{1.0 \times 10^{2}\ \text{ag}}$
4. $distance = 152\ 100\ 000$ km	**a.** $distance = 152\ 100\ 000\ \cancel{\text{km}} \times \dfrac{1000\ \cancel{\text{m}}}{1\ \cancel{\text{km}}} \times \dfrac{1\ \text{ym}}{10^{-24}\ \cancel{\text{m}}} = \boxed{1.521 \times 10^{35}\ \text{ym}}$
	b. $distance = 152\ 100\ 000\ \cancel{\text{km}} \times \dfrac{1000\ \cancel{\text{m}}}{1\ \cancel{\text{km}}} \times \dfrac{1\ \text{Ym}}{10^{24}\ \cancel{\text{m}}} = \boxed{1.521 \times 10^{-13}\ \text{Ym}}$
5. $energy = 2.1 \times 10^{15}$ W•h	**a.** $energy = 2.1 \times 10^{15}\ \cancel{\text{W}}\bullet\cancel{\text{h}} \times \dfrac{1\ \text{J}/\cancel{\text{s}}}{1\ \cancel{\text{W}}} \times \dfrac{3600\ \cancel{\text{s}}}{1\ \cancel{\text{h}}} = \boxed{7.6 \times 10^{18}\ \text{J}}$
	b. $energy = 7.6 \times 10^{18}\ \cancel{\text{J}} \times \dfrac{1\ \text{GJ}}{10^{9}\ \cancel{\text{J}}} = \boxed{7.6 \times 10^{9}\ \text{GJ}}$
6. $m = 1.90 \times 10^{5}$ kg	$m = 1.90 \times 10^{5}\ \cancel{\text{kg}} \times \dfrac{1\ \text{eV}}{1.78 \times 10^{-36}\ \cancel{\text{kg}}} = 1.07 \times 10^{41}\ \text{eV}$
	a. $m = 1.07 \times 10^{41}\ \cancel{\text{eV}} \times \dfrac{1\ \text{MeV}}{10^{6}\ \cancel{\text{eV}}} = \boxed{1.07 \times 10^{35}\ \text{MeV}}$
	b. $m = 1.07 \times 10^{41}\ \cancel{\text{eV}} \times \dfrac{1\ \text{TeV}}{10^{12}\ \cancel{\text{eV}}} = \boxed{1.07 \times 10^{29}\ \text{TeV}}$

Givens | *Solutions*

7. $m = (200)(2 \times 10^{30}\ \text{kg}) = 4 \times 10^{32}\ \text{kg}$

a. $m = 4 \times 10^{32}\ \cancel{\text{kg}} \times \frac{10^3\ \cancel{\text{g}}}{1\ \cancel{\text{kg}}} \times \frac{10^3\ \text{mg}}{1\ \cancel{\text{g}}} = \boxed{4 \times 10^{38}\ \text{mg}}$

b. $m = 4 \times 10^{32}\ \cancel{\text{kg}} \times \frac{10^3\ \cancel{\text{g}}}{1\ \cancel{\text{kg}}} \times \frac{1\ \text{Eg}}{10^{18}\ \cancel{\text{g}}} = \boxed{4 \times 10^{17}\ \text{Eg}}$

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8. $area = 166\ 241\ 700\ \text{km}^2$

$depth = 3940\ \text{m}$

$V = volume = \text{area} \times \text{depth}$

$V = (166\ 241\ 700\ \cancel{\text{km}^2})(3940\ \text{m}) \times \left(\frac{1000\ \text{m}}{1\ \cancel{\text{km}}}\right)^2$

$V = 6.55 \times 10^{17}\ \text{m}^3$

a. $V = 6.55 \times 10^{17}\ \cancel{\text{m}^3} \times \frac{10^6\ \text{cm}^3}{1\ \cancel{\text{m}^3}} = \boxed{6.55 \times 10^{23}\ \text{cm}^3}$

b. $V = 6.55 \times 10^{17}\ \cancel{\text{m}^3} \times \frac{10^9\ \text{mm}^3}{1\ \cancel{\text{m}^3}} = \boxed{6.55 \times 10^{26}\ \text{mm}^3}$

II