NAME _____ DATE _____ CLASS _____

The Science of Physics

Problem A

METRIC PREFIXES

PROBLEM

The scanning tunneling microscope (STM) has a magnifying ability of 100 million and can distinguish between two objects that are separated by only 3.0×10^{-10} m, or about one-hundredth the diameter of an atom. Express 3.0×10^{-10} m in
a. nanometers.
b. picometers.

SOLUTION

Given: distance = 3.0×10^{-10} m

Unknown: distance = ? nm distance = ? pm

Build conversion factors from the relationships given in **Table 1-3.**

$$\frac{1 \text{ nm}}{1 \times 10^{-9} \text{ m}}$$

$$\frac{1 \text{ pm}}{1 \times 10^{-12} \text{ m}}$$

Convert from meters to nanometers by multiplying the distance by the first conversion factor.

$$\text{distance} = 3.0 \times 10^{-10} \cancel{\text{m}} \times \frac{1 \text{ nm}}{1 \times 10^{-9} \cancel{\text{m}}} = 3.0 \times 10^{-1} \text{ nm} = \boxed{0.30 \text{ nm}}$$

Convert from meters to picometers by multiplying the distance by the second conversion factor.

$$\text{distance} = 3.0 \times 10^{-10} \cancel{\text{m}} \times \frac{1 \text{ pm}}{1 \times 10^{-12} \cancel{\text{m}}} = \boxed{3.0 \times 10^{2} \text{ pm}}$$

ADDITIONAL PRACTICE

1. One of the more unusual of world wonders is the Plain of Jars in Laos. Several hundred huge stone jars, which do not seem to be made from local rock, are scattered across the plain. The largest of these jars has a mass of around 6.0×10^3 kg. Express this mass in
   a. milligrams.
   b. megagrams.

2. The French drink about 6.4×10^4 cm^3 of mineral water per person per year. Express this volume in
   a. cubic meters.
   b. cubic millimeters.

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3. The explosive energy of powerful explosives is measured in terms of "tons." The ton referred to is a ton of TNT (trinitrotoluene), one of the most powerful of chemical explosives. A ton of TNT will release 4.2×10^9 J (joules). Express this energy in

a. megajoules.

b. gigajoules.

4. A parsec, a distance measurement used by astronomers, is equal to 3.262 light years, where a light year is the distance light travels in one year. In SI units, a parsec equals 3.086×10^{16} m. Express this distance in

a. kilometers.

b. exameters.

5. An acre is a common unit used to measure the area of a portion of land. An acre is equal to about 4.0469×10^3 m^2. Express this area in

a. square kilometers.

b. square centimeters.

6. Electric charge is measured in terms of the coulomb (1 C), although this is a very large and not extremely practical unit of measurement. For example, the charge in a bolt of lightning is about 15 C. Express the charge in a lightning bolt in

a. millicoulombs.

b. kilocoulombs.

7. The wettest spot on Earth is generally considered to be Mt. Waialeale, on the island of Kauai, Hawaii. In one year, this long-extinct volcano receives 1.168×10^3 cm of rainfall. Express this quantity in

a. meters.

b. micrometers.

8. The United States Department of Defense is housed in the Pentagon, one of the largest office buildings in the world. The entire floor area of the Pentagon equals 0.344 279 km^2. Express this area in

a. square meters.

b. square millimeters.

9. The Earth is approximately 4.50 billion years old. Setting 1 year equal to 365.25 days, express the age of the Earth in

a. gigaseconds.

b. petaseconds.

10. One of the isotopes with the shortest half-life (the time it takes for half of a sample of the element to decay) is beryllium-8. Its half life is measured as 6.7×10^{-17} s. Express this time in

a. microseconds.

b. attoseconds.

Problem Bank Answers

The Science of Physics

Additional Practice A

Givens *Solutions*

1. mass = 6.0×10^3 kg

a. mass = $6.0 \times 10^3 \text{ kg} \times \frac{10^3 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ mg}}{10^{-3} \text{ g}} = \boxed{6.0 \times 10^9 \text{ mg}}$

b. mass = $6.0 \times 10^3 \text{ kg} \times \frac{10^3 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ Mg}}{10^6 \text{ g}} = \boxed{6.0 \text{ Mg}}$

2. Volume = 6.4×10^4 cm^3

a. volume = $6.4 \times 10^4 \text{ cm}^3 \times \left(\frac{1 \text{ m}}{10^2 \text{ cm}}\right)^3 = 6.4 \times 10^4 \text{ cm}^3 \times \frac{1 \text{ m}^3}{10^6 \text{ cm}^3} = \boxed{6.4 \times 10^{-2} \text{ m}^3}$

b. volume = $6.4 \times 10^4 \text{ cm}^3 \times \left(\frac{10 \text{ mm}}{1 \text{ cm}}\right)^3 = 6.4 \times 10^4 \text{ cm}^3 \times \frac{10^3 \text{ mm}^3}{1 \text{ cm}^3} = \boxed{6.4 = 10^7 \text{ mm}^3}$

3. energy = 4.2×10^9 J

a. energy = $4.2 \times 10^9 \text{ J} \times \frac{1 \text{ MJ}}{10^6 \text{ J}} = \boxed{4.2 \times 10^3 \text{ MJ}}$

b. energy = $4.2 \times 10^9 \text{ J} \times \frac{1 \text{ GJ}}{10^9 \text{ J}} = \boxed{4.2 \text{ GJ}}$

4. distance = 1 parsec = 3.086×10^{16} m

a. distance = 1 parsec = $3.086 \times 10^{16} \text{ m} \times \frac{1 \text{ km}}{10^3 \text{ m}} = \boxed{3.086 \times 10^{13} \text{ km}}$

b. distance = 1 parsec = $3.086 \times 10^{16} \text{ m} \times \frac{1 \text{ Em}}{10^{18} \text{ m}} = \boxed{3.086 \times 10^{-2} \text{ Em}}$

5. area = 1 acre = 4.0469×10^3 m^2

a. area = 1 acre = $4.0469 \times 10^3 \text{ m}^2 \times \left(\frac{1 \text{ km}}{10^3 \text{ m}}\right)^2$

area = $4.0469 \times 10^3 \text{ m}^2 \times \frac{1 \text{ km}^2}{10^6 \text{ m}^2} = \boxed{4.0469 \times 10^{-3} \text{ km}^2}$

b. area = 1 acre = $4.0469 \times 10^3 \text{ m}^2 \times \left(\frac{10^2 \text{ cm}}{1 \text{ m}}\right)^2$

area = $4.0469 \times 10^3 \text{ m}^2 \times \frac{10^4 \text{ cm}^2}{1 \text{ m}^2} = \boxed{4.0469 \times 10^7 \text{ cm}^2}$

6. electric charge = 15 C

a. electric charge = $15 \text{ C} \times \frac{10^3 \text{ mC}}{1 \text{ C}} = \boxed{1.5 \times 10^4 \text{ mC}}$

b. electric charge = $15 \text{ C} \times \frac{1 \text{ kC}}{10^3 \text{ C}} = \boxed{1.5 \times 10^{-2} \text{ kC}}$

Givens *Solutions*

7. depth $= 1.168 \times 10^3$ cm

a. depth $= 1.168 \times 10^3 \text{ cm} \times \frac{1 \text{ m}}{10^2 \text{ cm}} = \boxed{1.168 \times 10^1 \text{ m} = 11.68 \text{ m}}$

b. depth $= 1.168 \times 10^3 \text{ cm} \times \frac{1 \text{ m}}{10^2 \text{ cm}} \times \frac{1\ \mu\text{m}}{10^{-6} \text{ m}} = \boxed{1.168 \times 10^7\ \mu\text{m}}$

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8. area $= 0.344\ \ 279 \text{ km}^2$

a. area $= 0.344\ \ 279 \text{ km}^2 \times \left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2 = 0.344\ \ 279 \times 10^6 \text{ m}^2 = \boxed{3.442\ 79 \times 10^5 \text{ m}^3}$

b. area $= 0.344\ \ 279 \text{ km}^2 \times \left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)^2 \times \left(\frac{10^3 \text{ mm}}{1 \text{ m}}\right)^2 = 0.344\ 279 \times 10^{12} \text{ mm}^2$

area $= \boxed{3.442\ \ 79 \times 10^{11} \text{ mm}^2}$

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9. time $= 4.50 \times 10^9$ years $\times$ $\frac{365.25 \text{ days}}{1 \text{ year}} \times \frac{24 \text{ h}}{1 \text{ day}} \times \frac{3600 \text{ s}}{1 \text{ h}}$ $= 1.42 \times 10^{17}$ s

a. time $= 1.42 \times 10^{17} \text{ s} \times \frac{1 \text{ Gs}}{10^9 \text{ s}} = \boxed{1.42 \times 10^8 \text{ Gs}}$

b. time $= 1.42 \times 10^{17} \text{ s} \times \frac{1 \text{ Ps}}{10^{15} \text{ s}} = \boxed{1.42 \times 10^2 \text{ Ps} = 142 \text{ Ps}}$

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10. time $= 6.7 \times 10^{-17}$ s

a. time $= 6.7 \times 10^{-17} \text{ s} \times \frac{10^6\ \mu\text{s}}{1 \text{ s}} = \boxed{6.7 \times 10^{-11}\ \mu\text{s}}$

b. time $= 6.7 \times 10^{-17} \text{ s} \times \frac{10^{18} \text{ as}}{1 \text{ s}} = \boxed{6.7 = 10^1 \text{ as} = 67 \text{ as}}$