**Practice Exercises**

2.1 V = , the SI unit for radius, r, is meters, the numbers  and π do not have units. Therefore, the SI unit for volume is meter3 or m3.

2.2 Force equals mass × acceleration (*F = ma*), and acceleration equals change in velocity divided by change in time (*a* = ), and velocity equals distance divided by time (*v* = ). Put the equations together:

*F* = *m*

*F= m*= *m*

The unit for mass is kilogram (kg); the unit for distance is meter (m) and the unit for time is second (s). Substitute the units into the equation above:

Unit for force in SI base units = kg or kg m s–2

2.3 

2.4 

To convert from °F to K we first convert to °C.



TK = (273 °C + tC) = (273 °C + 20 °C) = 293 K

2.5 (a) 21.0233 g + 21.0 g = 42.0233 g: rounded correctly to 42.0 g

(b) 10.0324 g / 11.7 mL = 0.8574 g / mL: rounded correctly to 0.857 g / mL

(c)  = 148.57 cm: rounded correctly to 149 cm

2.6 (a) 32.02 mL – 2.0 mL = 30. mL

(b) 54.183 g – 0.0278 g = 54.155 g

(c) 10.0 g + 1.03 g + 0.243 g = 11.3 g

(d) 43.4 in ×  = 3.62 ft (1 and 12 are exact numbers)

(e)  = 0.48 m2

2.7 

2.8 (a) 

(b) 

(c) 

(d) 

2.9 Density = 

Density of the object =  = 16.5 g/cm3

The object is not composed of pure gold since the density of gold is 19.3 g/cm3.

2.10 The density of the alloy is 12.6 g/cm3. To determine the mass of the 0.822 ft3 sample of the alloy, first convert the density from g/cm3 to lb/ft3, then find the weight.

Density in lb/ft3 =  = 787 lb/ft3

Mass of sample alloy = (0.822 ft3) (787 lb/ft3) = 647 lb

2.11 density = mass/volume = (1.24 × 106 g)/(1.38 × 106 cm3) = 0.899 g/cm3

.

2.12 volume of one-carat diamond = 225 mg = 0.0639 cm3

**Review Questions**

2.1 Physical properties include boiling point, melting point, density, color, refractive index, mass and volume.

2.2 A chemical property describes a property that changes the chemical nature of a substance while physical properties describe properties that do not change the chemical nature of a substance. For example, boiling water does not change the chemical composition of water.

2.3 (a) Physical change. Copper does not change chemically when electricity flows through it: It remains copper.

 (b) Physical change. Gallium is changes its state, not its chemical composition when it melts.

 (c) Chemical change. This is an example of the Maillard reaction describing the chemical reaction of sugar molecules and amino acids.

 (d) Chemical change. Wine contains ethanol which can be converted to acetic acid.

 (e) Chemical change. Concrete is composed of many different substances that undergo a chemical process called hydration when water is added to it.

2.4 (a) Physical change. When corn is popped water is turned into steam by heating the corn. The pressure of the steam caused the kernel to pop open resulting in popped corn.

 (b) Physical change. Generally alloys are mixtures of substances and no chemical change occurs. On occasion, a chemical change can occur during the production of an alloy. An example is when iron and carbon are mixed together to make steel. During this process compounds of iron and carbon such as cementite, Fe3C , are produced.

 (c) Physical change. During the whipping process air is mixed with cream to increase its volume.

 (d) Physical change. During the production of butter fat molecules aggregate, due to the agitation of whipping, and separate from the water.

 (e) Physical change. The aluminum is not chemically altered during recycling.

2.5 Extensive properties, such as volume, and size, are properties that depend on the amount of substance or mass of substance while intensive properties, such as density, are not dependent on the amount of substance. The density of a milliliter of water is the same as the density of a liter of water at the same temperature.

2.6 (a) Extensive Obviously, mass is a mass dependent property.

(b) Intensive The boiling point of a substance is the same for a mL as it is for a L of the compound so

 it is mass independent.

(c) Intensive The color of a substance does not change when you change the amount of substance.

(d) Intensive The physical state, gas, liquid, or solid, depends on temperature and pressure but not on

 the mass of the substance.

2.7 (a) Intensive The melting point of 1.0 g of water is that same as 100.0 thus melting point is not mass

 Dependent.

 (b) Intensive The density of 1.0 g of water is the same as 100.0 g if both samples are at the same

 Temperature. Thus, density is not dependent on the mass of substance.

 (c) Extensive The volume occupied by a substance is dependent on the mass of substance.

 (d) Extensive Surface area depends on the amount of substance. It also depends on the nature of the

 Substance. A bar of metal has a smaller surface area than that of the same bar ground

 Into fine particles.

2.8 (a) Gas Temperature, density, volume, viscosity

 (b) Liquid Temperature, density, volume, viscosity

 (c) Solid Temperature, density, volume

2.9 (a) Hydrogen is a gas at room temperature

 (b) Aluminum is a solid at room temperature

 (c) Nitrogen is a gas at room temperature

 (d) Mercury is a liquid at room temperature

2.10 (a) Potassium chloride is a solid at room temperature.

 (b) Carbon dioxide is a gas at room temperature.

 (c) Ethyl alcohol is a liquid at room temperature.

 (d) Methane is a gas at room temperature.

 (e) Sucrose is a solid at room temperature.

2.11 (a) Sodium chloride is a solid at room temperature.

 (b) Ozone is a gas at room temperature.

 (c) Teflon is a solid at room temperature.

 (d) Cholesterol is a solid at room temperature.

 (e) Silicon dioxide is a solid at room temperature.

2.12 Measurements involve a comparison. The unit gives the number meaning.

2.13 Kilogram

2.14 (a) 0.01 10–2

(b) 0.001 10–3

(c) 1000 103

(d) 0.000001 10–6

(e) 0.000000001 10–9

(f) 0.000000000001 10–12

(g) 1,000,000 106

2.15 (a) c (b) m (c) k (d) μ

(e) n (f) p (g) M

2.16 The melting points and boiling points of water at 1 atmosphere pressure. On the Celsius scale these points correspond to 0 °C and 100 °C respectively.

2.17 (a) 1 Fahrenheit degree < 1 Celsius degree

(b) 1 Celsius degree = 1 Kelvin

(c) 1 Fahrenheit degree < 1 Kelvin

2.18 The digits that are significant figures in a quantity are those that are known (measured) with certainty plus the last digit, which contains some uncertainty.

2.19 The *accuracy* of a measured value is the closeness of that value to the true value of the quantity. The *precision* of a number of repeated measurements of the same quantity is the closeness of the measurements to one another.

2.20 The minimum uncertainty that is implied in this measurement is ± 0.01 cm.

2.21 The problem with using the fraction 3 yd/1 ft as a conversion factor is that there are 3 feet in one yard. The conversion factor should be 1 yd/3 ft. For the second part of the question, it is not possible to construct a valid conversion factor relating centimeters to meters from the equation 1 cm = 1000 m, since 100 cm = 1 m.

2.22 To convert 250 seconds to hours multiply 250 by:



 To convert 3.84 hours to seconds multiply 3.84 hours by:



2.23 Four significant figures would be correct because the conversion factor contains exact values. The measured value determines the number of significant figures.

2.24 *d* = : *d* = density; m = mass; v = volume

2.25 10.5 g silver = 1 cm3 silver

 and 

**Review Problems**

2.26 (a) 0.01 m (b) 1000 m (c) 1012 pm

(d) 0.1 m (e) 0.001 kg (f) 0.01 g

2.27 (a) 10–9 (b) 10–6 (c) 103

(d) 106 (e) 10–3 (f) 0.1

2.28 (a) TF = (tC) + 32 °F = (57 °C) + 32 °F = 135 °F when rounded to the proper number of significant figures.

(b) TF = (tC) + 32 °F = (16 °C) + 32 °F = 61 °F

(c) TC = (tF – 32 °F) = (25.5 °F – 32 °F) = –3.61 °C

(d) TC = (tF – 32 °F) = (49 °F – 32 °F) = 9.4 °C

(e) TK = (tC + 273 °C) = 62 +273 = 335 K

(f) TK = (tC + 273 °C) = –31 + 273 = 242 K

2.29 (a) tC =  tF – 32 °F) = (96 °F – 32 °F) = 36 °C

(b) tC = (tF – 32 °F) = (–6 °F –32 °F) = –21 °C

(c) tF = (tC) + 32 °F = (–55 °C) +32 °F = –67 °F

(d) tC = (TK – 273 K) = (273 K – 273 K) = 0 °C

(e) tC = (TK – 273 K) = (299 K – 273 K) = 26 °C

(f) TK = (tC + 273 °C) = (40 °C + 273 °C) = 313 K

2.30 

This dog has a fever; the temperature is out of normal canine range.

2.31 Convert –96 °F to tc:

tC = (tF – 32 °F) = (–96 °F – 32 °F) = –71 °C

2.32 Range in Kelvins:





Range in degrees Celsius:

tC = (TK – 273 K) = (1.0 × 107 K – 273 K) ≈ 1.0 × 107 °C

tC = (TK – 273 K) = (2.5 × 107 K – 273 K) ≈ 2.5 × 107 °C

Range in degrees Fahrenheit:

tF = (°C) + 32 °F = (1.0 × 107 °C) + 32 °F ≈ 1.8 × 107 °F

tF = (°C) + 32 °F = (2.5 × 107 °C) + 32 °F ≈ 4.5 × 107 °F

2.33 Convert 111 K to tC:

tC = (TK – 273 K) = (111 K – 273K) = –162 °C

Convert –162 °C to tF

tF = (tC) + 32 °F = (–162°C) +32 °F = –260 °F

2.34 tC = (TK – 273 K) = (4 K – 273 K) = –269 °C

2.35 Convert 6000 K to tC:

tC = (TK – 273 K) = (6000 K – 273 K) = 5700 °C

This is hot enough to melt concrete, since it is hotter than 2000 °C.

2.36 (a) 4 significant figures (d) 2 significant figures

(b) 5 significant figures (e) 4 significant figures

(c) 4 significant figures (f) 2 significant figures

2.37 (a) 3 significant figures (d) 5 significant figures

(b) 6 significant figures (e) 1 significant figures

(c) 1 significant figures (f) 5 significant figures

2.38 (a) 0.72 m2 (d) 19.42 g/mL

(b) 84.24 kg (e) 858.0 cm2

(c) 4.19 g/cm3 (dividing a number with 4 sig. figs by one with 3 sig. figs)

2.39 (a) 2.06 g/mL (d) 0.276 g/mL

(b) 4.02 mL (e) 0.0006 m/s

(c) 12.4 g/mL

2.40 (a) 

(b) 

(c) 

(d) 

(e) 

(f) 

2.41 (a) μm3 = (92 dL) = 9.2 × 1015 μm3

(b) μg = (22 ng) = 0.022 μg

(c) nL = (83 pL) = 0.083 nL

(d) m3 = (230 km3) = 2.3 × 1011 m3

(e) km hr-2 = (87.3 cm s–2) = 1.13 × 104 km hr-2

(f) nm2 = (238 mm2) = 2.38 × 1014 nm2

2.42 (a) 

(b) 

(c) 

(d) 

(e) 

(f) 

2.43 (a) 

(b) 

(c) 

(d) 

(e) 

(f) 

2.44 (a) 

(b) 

(c) 

2.45 (a) m2 = (2.4 yd2) = 2.0 m2

(b) mm2 = (8.3 in2) = 5400 mm2

(c) L = (9.1 ft3) = 260 L

2.46  (stomach volume)

4.0 × 103 mL  0.9 mL = 4,000 pistachios (don’t try this at home)

2.47 To determine if 50 eggs will fit into 4.2 quarts, calculate the volume of fifty eggs, then compare the answer to the volume of the stomach:

Volume of 50 eggs = (50 eggs) = 2.8 qt

2.8 qt < 4.2 qt

Luke can eat 50 eggs.

2.48 

2.49 km/h =  = 2672 km/h

2.50 

2.51 tons/day =  = 5.53 × 108 tons/day

2.52 1 light year =  = 9.47 × 1015 m

miles = 8.7 light years = 5.1 × 1013 mi

2.53 There are 360 degrees of latitude around the circumference of the earth.

statute miles =  = 2.49 × 104 statute miles

2.54 meters = 6033.5 fathoms = 11,034 m

2.55 pounds/in2 = 11,034 m = 16,200 lb/in2

tons/in2 = 162,000 lb/in2 = 8.10 ton/in2

2.56 density = mass/ volume = 36.4 g/45.6 mL = 0.798 g/mL

2.57 density =  d =  = 1.69 g/cm3

2.58 

2.59 mL = 

2.60 

2.61 



2.62 mass of silver = 62.00 g – 27.35 g = 34.65 g

volume of silver = 18.3 mL –15 mL = 3.3 mL or 3.3 cm3

density of silver = (mass of silver)/(volume of silver) = (34.65 g)/(3.3 cm3) = 11 g/cm3

2.63 volume of titanium = (1.84 cm)(2.24 cm)(2.44 cm) = 10.1 cm3

density of titanium = 45.7 g/10.1 cm3 = 4.54 g/cm3

2.64 density = 

sp. gr. of liquid hydrogen = 

density = 

2.65 

 

**Additional Exercises**

2.66 

2.67 Hausberg Tarn 4350 m = 4760 yd

Mount Kenya 4600 m = 5000 yd 4700 m = 5100 yd

Temperature ∆tF = (tC) = (4.0 °C) = 7.2 °F

2.68 If the density is in metric tons…



= 4.93 × 1014 g

If the density is in English tons…



= 4.47 × 1014 g

2.69 1 light year = 3.00 × 108 m/s  = 9.46 × 1015 m

Distance to Arcturus:

days = 3.50 × 1014 km  = 1.35 × 104 d

light years = 3.50 × 1014 km  = 37.0 light years

2.70 (a) In order to determine the volume of the pycnometer, we need to determine the volume of the water that fills it. We will do this using the mass of the water and its density.

mass of water = mass of filled pycnometer – mass of empty pycnometer

= 36.842 g – 27.314 g = 9.528 g

volume = (9.528 g) 

(b) We know the volume of chloroform from part (a). The mass of chloroform is determined in the same way that we determined the mass of water.

mass of chloroform = mass of filled pycnometer – mass of empty pycnometer

= 41.428 g – 27.314 g = 14.114 g

Density of chloroform = 

2.71 For the message to get to the moon:

s = 

The reply would take the same amount of time, so the total time would be:

1.28 s × 2 = 2.56 s

2.72 (a)   

(b) $ = 

(c) min = 

2.73 



2.74 

2.75 The experimental density most closely matches the known density of methanol (0.7914 g/mL). The density of ethanol is 0.7893 g/mL. Melting point and boiling point could also distinguish these two alcohols, but not color.

2.76 g/mL = 69.22 lb/ft3 = 1.1088g/mL

Since the density closely matches the known value, we conclude that this is an authentic sample of ethylene glycol.

2.77 tc = (TK – 273 K) = (5800 K – 273 K) = 5500 ºC

2.78 We solve by combining two equations:

tF = (tC) + 32 °F

tF = tC

If tF = tC, we can use the same variable for both temperatures:

tC =  (tC) + 32 °F

 =  (tC) + 32 °F

 = 32

tc = 32= –40, therefore the answer is –40 °C.

2.79 Both the Rankine and the Kelvin scales have the same temperature at absolute zero: 0 R = 0 K.

For converting from tF to TR:

tC = (tF – 32 °F) and tC = (TK – 273 K)

therefore (TK – 273 K) = (tF – 32 °F)

at TK = 0 K = 0 R (0 K – 273 K) = (tF – 32 °F)

–273 °C =  (tF – 32 °F)

–491 °F = tF – 32 °F

tF = –459 °F at absolute zero

Also, TR at absolute zero is 0 R and TR = (tF + 459 °F)

So, the boiling point of water is 212 °F and in TR:

TR = (212 °F + 459 °F)  = 671 R

2.80 Sand d = 2.84 g/mL

Gold d = 19.3 g/mL

Mixture d = 3.10 g/mL

1.00 kg mixture = 1.00 × 103 g of mixture

1.00 × 103 g of mixture = msand + mgold

msand = (dsand)(Vsand)

mgold = (dgold)(Vgold)

1.00 × 103 g of mixture = (dsand)(Vsand) + (dgold)(Vgold)

1.00 × 103 g of mixture = (2.84 g/mL)(Vsand) + (19.3 g/mL)(Vgold)

Vmixture = Vsand + Vgold

d = 

 = 323 mL

Vsand + Vgold = 323 mL

Vsand = 323 mL – Vgold

1.00 × 103 g of mixture = (2.84 g/mL)(323 mL – Vgold) + (19.3 g/mL)(Vgold)

1.00 × 103 g of mixture = 917 g sand – (2.84 g/mL)(Vgold) + (19.3 g/mL)(Vgold)

1.00 × 103 g of mixture – 917 g sand = (16.5 g/mL)(Vgold)

5.0 mL = Vgold

1.00 × 103 g of mixture – 917 g sand = 83 g gold

% mass of gold =  =8.3% gold

2.81 Area of gold in cm2 = 14.6 ft2  = 1.36 × 104 cm2

Volume of gold in cm3 = 1.36 × 104 cm2 × 2.50 μm ×  = 3.39 cm3

Cost of gold = 3.39 cm3 ×  = $2367

2.82 Volume of cylindrical metal bar = π × r2 × h = π × × 2.33 cm = 1.04 cm3

Density of cylindrical metal bar =  =  = 8.10 g/mL

Density in lb/ft3 =  = 506 lb/ft3

2.83 Volume of diamond = 3.45 carat = 0.197 mL

2.84 Concentration of lead in blood in μg/dL =  = 25 μg/dL

This person is in danger of exhibiting the effects of lead poisoning since the 25 μg/dL is above the threshold of 10 μg of lead/dL.

2.85 Radius of ball bearing = 2.000 mm × (1/2) = 1.000 mm

Volume of ball bearing= 4/3 × π × r3 = 4/3 × π × (1.000 mm)3 = 4.189 mm3

Radius of ball bearing + gold = 1.000 mm + 0.500 mm = 1.500 mm

Volume of ball bearing + gold = 4/3 × π × r3 = 4/3 × π × (1.500 mm)3 = 14.14 mm3

Volume of gold = (volume of ball bearing + gold) – (volume of ball bearing) = 14.14 mm3 – 4.189 mm3 = 9.95 mm3

Mass of gold = 9.95 mm3  = 0.192 g

2.86 The question is asking to calculate the number of mile/gallon/person for a jet airliner and a car. The answer is:

Rate of fuel consumption = = 3.5 × 10–4 mile/gallon/person

Rate of fuel consumption for car =  = 11 mile/gallon/person

But a more insightful answer would be to calculate the number of gallons/person/mile which would give the number of gallons each person uses per mile.

Rate of fuel consumption = = 0.0088 gallon/person/mile

Rate of fuel consumption for car =  = 0.75 gallon/person/mile

This would indicate that the jet airliner has better fuel consumption.

Pounds of jet fuel = 3470 miles = 1.16 × 105 lb