Introduction to Chemistry textbook questions and answers:

Chapter 1: Essential Ideas

1. Chemistry in Context

Question 1-1.

Explain how you could experimentally determine whether the outside temperature is higher or lower than 0 °C (32 °F) without using a thermometer.

Solution

Place a glass of water outside. It will freeze if the temperature is below 0 °C.

Question 1-2.

Identify each of the following statements as being most similar to a hypothesis, a law, or a theory. Explain your reasoning.

(a) Falling barometric pressure precedes the onset of bad weather.

(b) All life on earth has evolved from a common, primitive organism through the process of natural selection.

(c) My truck's gas mileage has dropped significantly, probably because it's due for a tune-up.

Solution

(a) law (states a consistently observed phenomenon, can be used for prediction);
(b) theory (a widely accepted explanation of the origin of species);
(c) hypothesis (a tentative explanation, can be investigated by experimentation)

Question 1-3.

Identify each of the following statements as being most similar to a hypothesis, a law, or a theory. Explain your reasoning.

(a) The pressure of a sample of gas is directly proportional to the temperature of the gas.

(b) Matter consists of tiny particles that can combine in specific ratios to form substances with specific properties.

(c) At a higher temperature, solids (such as salt or sugar) will dissolve better in water.

Solution

(a) law (states a consistently observed phenomenon, can be used for prediction); (b) theory (a widely accepted explanation of the behavior of matter); (c) hypothesis (a tentative explanation, can be investigated by experimentation)

Question 1-4.

Identify each of the underlined items as a part of either the macroscopic domain, the microscopic domain, or the symbolic domain of chemistry. For any in the symbolic domain, indicate whether they are symbols for a macroscopic or a microscopic feature.

(a) The mass of a lead pipe is 14 lb.
(b) The mass of a certain chlorine atom is 35 amu.
(c) A bottle with a label that reads Al contains aluminum metal.
(d) Al is the symbol for an aluminum atom.

Solution
(a) macroscopic; (b) microscopic; (c) symbolic, macroscopic; (d) symbolic, microscopic

Question 1-5.

Identify each of the underlined items as a part of either the macroscopic domain, the microscopic domain, or the symbolic domain of chemistry. For those in the symbolic domain, indicate whether they are symbols for a macroscopic or a microscopic feature.

(a) A certain molecule contains one H atom and one Cl atom.
(b) Copper wire has a density of about 8 g/cm^3.
(c) The bottle contains 15 grams of Ni powder.
(d) A sulfur molecule is composed of eight sulfur atoms.

Solution
(a) symbolic, microscopic; (b) macroscopic; (c) symbolic, macroscopic; (d) microscopic

Question 1-6.

According to one theory, the pressure of a gas increases as its volume decreases, because the molecules in the gas have to move a shorter distance to hit the walls of the container. Does this theory follow a macroscopic or microscopic description of chemical behavior? Explain your answer.

Solution
Microscopic. The behavior is explained in terms of the behavior of microscopic particles (molecules).

Question 1-7.

The amount of heat required to melt 2 lbs of ice is twice the amount of heat required to melt 1 lb of ice. Is this observation a macroscopic or microscopic description of chemical behavior? Explain your answer.

Solution
Macroscopic. The heat required is determined from macroscopic properties.

2 Phases and Classification of Matter

Question 2-1.

Why is an object's mass, rather than its weight, used to indicate the amount of matter it contains?

Solution

An object's mass is used because the mass of the object is independent of outside forces on the object (that is, it is an intrinsic property of the object), whereas weight depends on the force of gravity and varies as gravity changes from location to location.

Question 2-2.

What properties distinguish solids from liquids? Liquids from gases? Solids from gases?

Solution

Liquids can change their shape (flow); solids can't. Gases can undergo large volume changes as pressure changes; liquids do not. Gases flow and change volume; solids do not.

Question 2-3.

How does a heterogeneous mixture differ from a homogeneous mixture? How are they similar?

Solution

Mixtures are defined as systems containing two or more components that can be separated by physical means. When components mix and blend in such a manner that all regions are the same, the system is homogeneous; soft drinks, sugar water, gasoline, brass, and sterling silver are common examples of such mixtures. Most mixtures in the environment and in our experience are not homogeneous. Instead, mixtures such as deposits of rocks and minerals, river water, blood, and fruit salad are heterogeneous. The mixtures are alike in that physical methods, rather than chemical methods, can be used to separate the components.

Question 2-4.

How does a homogeneous mixture differ from a pure substance? How are they similar?

Solution

The mixture can have a variety of compositions; a pure substance has a definite composition. Both have the same composition from point to point.

Question 2-5.

How does an element differ from a compound? How are they similar?

Solution

Compounds can be broken down by chemical means, whereas elements cannot be decomposed by chemical changes. They are similar in that they both have properties associated with matter.

Question 2-6.

How do molecules of elements and molecules of compounds differ? In what ways are they similar?

Solution

Molecules of elements contain only one type of atom; molecules of compounds contain two or more types of atoms. They are similar in that both are comprised of two or more atoms chemically bonded together.

Question 2-7.

How does an atom differ from a molecule? In what ways are they similar?

Solution

An atom consists of only one particle; a molecule consists of two or more atoms. They are similar in that both are composed of the basic building block in chemistry, the atom.

Question 2-8.

Many of the items you purchase are mixtures of pure compounds. Select three of these commercial products and prepare a list of the ingredients that are pure compounds.

Solution

Answers will vary. Sample answer: Gatorade contains water, sugar, dextrose, citric acid, salt, sodium chloride, monopotassium phosphate, and sucrose acetate isobutyrate.

Question 2-9.

Classify each of the following as an element, a compound, or a mixture:

(a) copper
(b) water
(c) nitrogen
(d) sulfur
(e) air
(f) sucrose
(g) a substance composed of molecules each of which contains two iodine atoms
(h) gasoline

Solution

(a) element; (b) compound; (c) element; (d) element; (e) mixture; (f) compound; (g) element; (h) mixture

Question 2-10.

Classify each of the following as an element, a compound, or a mixture:

(a) iron
(b) oxygen
(c) mercury oxide
(d) pancake syrup
(e) carbon dioxide
(f) a substance composed of molecules each of which contains one hydrogen atom and one
chlorine atom
(g) baking soda
(h) baking powder

Solution

(a) element; (b) element; (c) compound; (d) mixture; (e) compound; (f) compound; (g) compound; (h) mixture

Question 2-11.

A sulfur atom and a sulfur molecule are not identical. What is the difference?

Solution

A sulfur molecule is composed of eight sulfur atoms.

Question 2-12.

How are the molecules in oxygen gas, the molecules in hydrogen gas, and water molecules similar? How do they differ?

Solution

In each case, a molecule consists of two or more combined atoms. They differ in that the types of atoms change from one substance to the next.

Question 2-13.

Why are astronauts in space said to be "weightless," but not "massless"?

Solution

Because the force of gravity is extremely small in space, and the lack of attraction between bodies that gives weight to the astronauts is essentially absent. Therefore, they are weightless. They maintain their intrinsic mass, however.

Question 2-14.

Prepare a list of the principal chemicals consumed and produced during the operation of an automobile.

Solution

Gasoline (a mixture of compounds), oxygen, and to a lesser extent, nitrogen are consumed. Carbon dioxide and water are the principal products. Carbon monoxide and nitrogen oxides are produced in lesser amounts.

Question 2-15.

Matter is everywhere around us. Make a list by name of fifteen different kinds of matter that you encounter every day. Your list should include (and label at least one example of each) the following: a solid, a liquid, a gas, an element, a compound, a homogenous mixture, a heterogeneous mixture, and a pure substance.

Solution

There are many possible answers. Some include air (gas, homogenous mixture), aluminum foil (solid, pure substance), cereal with milk (heterogeneous mixture), distilled water (liquid, compound, pure substance), gold ingot (solid, element, pure substance), iron (element), milk (liquid, homogenous mixture), penny (solid), salt (solid, compound), soft drink (liquid, homogeneous mixture), sugar (solid, compound).

Question 2-16.

When elemental iron corrodes it combines with oxygen in the air to ultimately form red brown iron(III) oxide called rust. (a) If a shiny iron nail with an initial mass of 23.2 g is weighed after being coated in a layer of rust, would you expect the mass to have increased, decreased, or remained the same? Explain. (b) If the mass of the iron nail increases to 24.1 g, what mass of oxygen combined with the iron?

Solution

(a) Increased as it would have combined with oxygen in the air thus increasing the amount of matter and therefore the mass. (b) 24.1 g – 23.2 g = 0.9 g

Question 2-17.

As stated in the text, convincing examples that demonstrate the law of conservation of matter outside of the laboratory are few and far between. Indicate whether the mass would increase, decrease, or stay the same for the following scenarios where chemical reactions take place:

(a) Exactly one pound of bread dough is placed in a baking tin. The dough is cooked in an oven at 350 °F releasing a wonderful aroma of freshly baked bread during the cooking process. Is the mass of the baked loaf less than, greater than, or the same as the one pound of original dough? Explain.

(b) When magnesium burns in air a white flaky ash of magnesium oxide is produced. Is the mass of magnesium oxide less than, greater than, or the same as the original piece of magnesium? Explain.

(c) Antoine Lavoisier, the French scientist credited with first stating the law of conservation of matter, heated a mixture of tin and air in a sealed flask to produce tin oxide. Did the mass of the sealed flask and contents decrease, increase, or remain the same after the heating?

Solution

(a) The mass would be less than one pound as water vapor and other molecules (aroma) are released from the cooking dough. (b) The mass of the magnesium oxide product would be greater than the original magnesium metal as the amount of magnesium remains the same, but having combined with oxygen, the total amount of matter increases. (c) The mass of the sealed flask and contents would remain the same as no reactants or products leave the flask, and therefore the quantity of matter in the flask does not change.

Question 2-18.

Yeast converts glucose to ethanol and carbon dioxide during anaerobic fermentation as depicted in the simple chemical equation below:

$$\text{glucose} \longrightarrow \text{ethanol} + \text{carbon dioxide}$$

(a) If 200.0 g of glucose is fully converted, what will be the total mass of ethanol and carbon dioxide produced?

(b) If the fermentation is carried out in an open container, would you expect the mass of the container and contents after fermentation to be less than, greater than, or the same as the mass of the container and contents before fermentation? Explain.

(c) If 97.7 g of carbon dioxide is produced, what mass of ethanol is produced?

Solution

(a) 200.0 g; (b) The mass of the container and contents would decrease as carbon dioxide is a gaseous product and would leave the container. (c) 200.0 g – 97.7 g = 102.3 g

3 Physical and Chemical Properties

Question 3-1.

Classify the six underlined properties in the following paragraph as chemical or physical: Fluorine is a pale yellow <u>gas</u> that <u>reacts with most substances</u>. The free element <u>melts at –220 °C</u> and <u>boils at –188 °C</u>. Finely divided <u>metals burn in fluorine</u> with a bright flame. <u>Nineteen grams of fluorine will react with 1.0 gram of hydrogen</u>.

Solution
physical; chemical; physical; physical; chemical; chemical

Question 3-2.

Classify each of the following changes as physical or chemical:

(a) condensation of steam
(b) burning of gasoline
(c) souring of milk
(d) dissolving of sugar in water
(e) melting of gold

Solution
(a) physical; (b) chemical; (c) chemical; (d) physical; (e) physical

Question 3-3.

Classify each of the following changes as physical or chemical:

(a) coal burning
(b) ice melting
(c) mixing chocolate syrup with milk
(d) explosion of a firecracker
(e) magnetizing of a screwdriver

Solution
(a) chemical; (b) physical; (c) physical; (d) chemical; (e) physical

Question 3-4.

The volume of a sample of oxygen gas changed from 10 mL to 11 mL as the temperature changed. Is this a chemical or physical change?

Solution
physical

Question 3-5.

A 2.0-liter volume of hydrogen gas combined with 1.0 liter of oxygen gas to produce 2.0 liters of water vapor. Does oxygen undergo a chemical or physical change?

Solution
Two different elements combine to form a different substance. The change is chemical.

Question 3-6.

Explain the difference between extensive properties and intensive properties.

Solution
The value of an extensive property depends upon the amount of matter being considered, whereas the value of an intensive property is the same regardless of the amount of matter being considered.

Question 3-7.

Identify the following properties as either extensive or intensive.

(a) volume
(b) temperature
(c) humidity
(d) heat
(e) boiling point

Solution
(a) extensive; (b) intensive; (c) intensive; (d) extensive; (e) intensive

Question 3-8.

The density (d) of a substance is an intensive property that is defined as the ratio of its mass (m) to its volume (V).

$$\text{density} = \frac{\text{mass}}{\text{volume}} \qquad d = \frac{m}{V}$$

Considering that mass and volume are both extensive properties, explain why their ratio, density, is intensive.

Solution
Being extensive properties, both mass and volume are directly proportional to the amount of substance under study. Dividing one extensive property by another will in effect “cancel” this dependence on amount, yielding a ratio that is independent of amount (an intensive property).

4 Measurements

Question 4-1.

Is one liter about an ounce, a pint, a quart, or a gallon?

Solution
a quart

Question 4-2.

Is a meter about an inch, a foot, a yard, or a mile?

Solution
about a yard

Question 4-3.

Indicate the SI base units or derived units that are appropriate for the following measurements:

(a) the length of a marathon race (26 miles 385 yards)
(b) the mass of an automobile
(c) the volume of a swimming pool
(d) the speed of an airplane
(e) the density of gold
(f) the area of a football field
(g) the maximum temperature at the South Pole on April 1, 1913

Solution
(a) meters; (b) kilograms; (c) cubic meters; (d) meters/second; (e) kilograms/cubic meter; (f) square meters; (g) kelvin

Question 4-4.

Indicate the SI base units or derived units that are appropriate for the following measurements:

(a) the mass of the moon
(b) the distance from Dallas to Oklahoma City
(c) the speed of sound
(d) the density of air
(e) the temperature at which alcohol boils
(f) the area of the state of Delaware
(g) the volume of a flu shot or a measles vaccination

Solution

(a) kilograms; (b) meters; (c) meters/second; (d) kilograms/cubic meter; (e) kelvin; (f) square meters; (g) cubic meters

Question 4-5.

Give the name and symbol of the prefixes used with SI units to indicate multiplication by the following exact quantities.

(a) 10^3
(b) 10^{-2}
(c) 0.1
(d) 10^{-3}
(e) 1,000,000
(f) 0.000001

Solution

(a) kilo-, k; (b) centi-, c; (c) deci-, (d) d; milli-, (e) m; mega-, M; (f) micro-, μ

Question 4-6.

Give the name of the prefix and the quantity indicated by the following symbols that are used with SI base units.

(a) c
(b) d
(c) G
(d) k
(e) m
(f) n
(g) p
(h) T

Solution

(a) centi-, $\times 10^{-2}$; (b) deci-, $\times 10^{-1}$; (c) Giga-, $\times 10^{9}$; (d) kilo-, $\times 10^{3}$; (e) milli-, $\times 10^{-3}$; (f) nano-, $\times 10^{-9}$; (g) pico-, $\times 10^{-12}$; (h) tera-, $\times 10^{12}$

Question 4-7.

A large piece of jewelry has a mass of 132.6 g. A graduated cylinder initially contains 48.6 mL water. When the jewelry is submerged in the graduated cylinder, the total volume increases to 61.2 mL.

(a) Determine the density of this piece of jewelry.
(b) Assuming that the jewelry is made from only one substance, what substance is it likely to be? Explain.

Solution
(a) 10.5 g/cm^3; (b) silver, because silver has density = 10.5 g/cm^3 (Table 1.4)

Question 4-8.

Visit https://www.simbucket.com/density/ and click the "turn fluid into water" button to adjust the density of liquid in the beaker to 1.00 g/mL.

(a) Use the water displacement approach to measure the mass and volume of the unknown material (select the green block with question marks).
(b) Use the measured mass and volume data from step (a) to calculate the density of the unknown material.
(c) Assuming this material is a widely available copper-containing gemstone, what is its likely identity? Compare the measured density to the values tabulated at https://www.gemsociety.org/article/select-gems-ordered-density/.

Solution
(a) m = 18.58 g, V = 5.7 mL; (b) d = 3.3 g/mL; (c) malachite (basic copper carbonate, d = 3.25-4.10 g/mL)

Question 4-9.

Visit https://www.simbucket.com/density/ and click the "reset" button to ensure all simulator parameters are at their default values.

(a) Use the water displacement approach to measure the mass and volume of the red block.
(b) Use the measured mass and volume data from step (a) to calculate the density of the red block.
(c) Use the vertical green slide control to adjust the fluid density to values well above, then well below, and finally nearly equal to the density of the red block, reporting your observations.

Solution
(a) m = 2.5 g, V = 4.1 mL; (b) d = 0.61 g/mL; (c) The block sinks in the fluid when $d_{block} > d_{fluid}$, it floats on the fluid surface when $d_{block} < d_{fluid}$, and it remains suspended within the fluid when $d_{block} \approx d_{fluid}$.

Question 4-10.

Visit https://www.simbucket.com/density/ and click the "turn fluid into water" button to adjust the density of liquid in the beaker to 1.00 g/mL. Change the block material to foam, and then wait patiently until the foam block stops bobbing up and down in the water.

(a) The foam block should be floating on the surface of the water (that is, only partially submerged). What is the volume of water displaced?
(b) Use the water volume from part (a) and the density of water (1.0 g/mL) to calculate the mass of water displaced.
(c) Remove and weigh the foam block. How does the block's mass compare the mass of displaced water from part (b)?

Solution
(a) displaced water volume = 2.8 mL; (b) displaced water mass = 2.8 g; (c) The block mass is 2.76 g, essentially equal to the mass of displaced water (2.8 g) and consistent with Archimedes' principle of buoyancy.

5 Measurement Uncertainty, Accuracy, and Precision

Question 5-1.

Express each of the following numbers in scientific notation with correct significant figures:

(a) 711.0
(b) 0.239
(c) 90743
(d) 134.2
(e) 0.05499
(f) 10000.0
(g) 0.000000738592

Solution
(a) three significant figures 7.110×10^2; (b) three significant figures 2.39×10^{-1}; (c) five significant figures 9.0743×10^4; (d) four significant figures 1.342×10^2; (e) four significant figures 5.499×10^{-2}; (f) six significant figures 1.00000×10^4; (g) six significant figures 7.38592×10^{-7}

Question 5-2.

Express each of the following numbers in exponential notation with correct significant figures:

(a) 704
(b) 0.03344
(c) 547.9
(d) 22086
(e) 1000.00
(f) 0.0000000651
(g) 0.007157

Solution
(a) 7.04×10^2; (b) 3.344×10^{-2}; (c) 5.479×10^2; (d) 2.2086×10^4; (e) 1.00000×10^3; (f) 6.51×10^{-8}; (g) 7.157×10^{-3}

Question 5-3.

Indicate whether each of the following can be determined exactly or must be measured with some degree of uncertainty:

(a) the number of eggs in a basket
(b) the mass of a dozen eggs
(c) the number of gallons of gasoline necessary to fill an automobile gas tank
(d) the number of cm in 2 m
(e) the mass of a textbook
(f) the time required to drive from San Francisco to Kansas City at an average speed of 53 mi/h

Solution
(a) exact; (b) uncertain; (c) uncertain; (d) exact; (e) uncertain; (f) uncertain

Question 5-4.

Indicate whether each of the following can be determined exactly or must be measured with some degree of uncertainty:

(a) the number of seconds in an hour
(b) the number of pages in this book
(c) the number of grams in your weight
(d) the number of grams in 3 kilograms
(e) the volume of water you drink in one day
(f) the distance from San Francisco to Kansas City

Solution
(a) exact; (b) exact; (c) uncertain; (d) exact; (e) uncertain; (f) uncertain

Question 5-5.

How many significant figures are contained in each of the following measurements?

(a) 38.7 g
(b) 2×10^{18} m
(c) 3,486,002 kg
(d) 9.74150×10^{-4} J
(e) 0.0613 cm^3
(f) 17.0 kg
(g) 0.01400 g/mL

Solution
(a) three; (b) one; (c) seven; (d) six; (e) three; (f) three; (g) four

Question 5-6.

How many significant figures are contained in each of the following measurements?

(a) 53 cm
(b) 2.05×10^8 m
(c) 86,002 J
(d) 9.740×10^4 m/s
(e) 10.0613 m^3
(f) 0.17 g/mL
(g) 0.88400 s

Solution
(a) two; (b) three; (c) five; (d) four; (e) six; (f) two; (g) five

Question 5-7.

The following quantities were reported on the labels of commercial products. Determine the number of significant figures in each.

(a) 0.0055 g active ingredients
(b) 12 tablets
(c) 3% hydrogen peroxide

(d) 5.5 ounces
(e) 473 mL
(f) 1.75% bismuth
(g) 0.001% phosphoric acid
(h) 99.80% inert ingredients

Solution
(a) two; (b) this is an exact number, so the concept of significant figures does not apply; (c) one; (d) two; (e) three; (f) three; (g) one; (h) four

Question 5-8.

Round off each of the following numbers to two significant figures:

(a) 0.436
(b) 9.000
(c) 27.2
(d) 135
(e) 1.497×10^{-3}
(f) 0.445

Solution
(a) 0.44; (b) 9.0; (c) 27; (d) 140; (e) 1.5×10^{-3}; (f) 0.44

Question 5-9.

Round off each of the following numbers to two significant figures:

(a) 517
(b) 86.3
(c) 6.382×10^{3}
(d) 5.0008
(e) 22.497
(f) 0.885

Solution
(a) 5.2×10^{2}; (b) 86; (c) 6.4×10^{3}; (d) 5.0; (e) 22; (f) 0.88

Question 5-10.

Perform the following calculations and report each answer with the correct number of significant figures.

(a) 628×342
(b) $(5.63 \times 10^{2}) \times (7.4 \times 10^{3})$
(c) $\dfrac{28.0}{13.483}$
(d) 8119×0.000023
(e) $14.98 + 27{,}340 + 84.7593$
(f) $42.7 + 0.259$

Solution
(a) 2.15×10^{5}; (b) 4.2×10^{6}; (c) 2.08; (d) 0.19; (e) 27,440; (f) 43.0

Question 5-11.

Perform the following calculations and report each answer with the correct number of significant figures.

(a) 62.8×34
(b) $0.147 + 0.0066 + 0.012$
(c) $38 \times 95 \times 1.792$
(d) $15 - 0.15 - 0.6155$
(e) $8.78 \times \left(\dfrac{0.0500}{0.478}\right)$
(f) $140 + 7.68 + 0.014$
(g) $28.7 - 0.0483$
(h) $\dfrac{(88.5-87.57)}{45.13}$

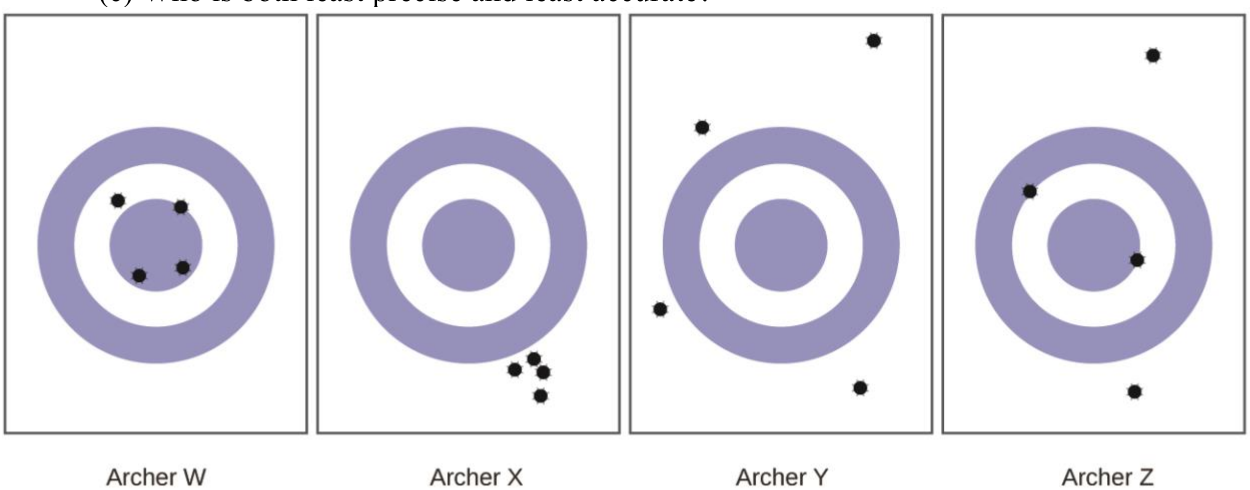
Solution

(a) 2.1×10^3; (b) 0.166 or 1.66×10^{-1}; (c) 6.5×10^3; (d) 14 or 1.4×10^1; (e) 0.918 or 9.18×10^{-1}; (f) either 148 or 150, depending on whether the ambiguous ones-place zero in 140 is significant (148) or not (150); (g) 28.7; (h) 0.02

Question 5-12.

Consider the results of the archery contest shown in this figure.

(a) Which archer is most precise?
(b) Which archer is most accurate?
(c) Who is both least precise and least accurate?



Solution

(a) Archer X; (b) Archer W; (c) Archer Y

Question 5-13.

Classify the following sets of measurements as accurate, precise, both, or neither.

(a) Checking for consistency in the weight of chocolate chip cookies: 17.27 g, 13.05 g, 19.46 g, 16.92 g

(b) Testing the volume of a batch of 25-mL pipettes: 27.02 mL, 26.99 mL, 26.97 mL, 27.01 mL
(c) Determining the purity of gold: 99.9999%, 99.9998%, 99.9998%, 99.9999%

Solution
(a) neither; (b) precise but not accurate; (c) both accurate and precise

6 Mathematical Treatment of Measurement Results

Question 6-1.

Write conversion factors (as ratios) for the number of:
(a) yards in 1 meter
(b) liters in 1 liquid quart
(c) pounds in 1 kilogram

Solution
(a) $\frac{1.0936\text{ yd}}{1\text{ m}}$; (b) $\frac{0.94635\text{ L}}{1\text{ qt}}$; (c) $\frac{2.2046\text{ lb}}{1\text{ kg}}$

Question 6-2.

Write conversion factors (as ratios) for the number of:
(a) kilometers in 1 mile
(b) liters in 1 cubic foot
(c) grams in 1 ounce

Solution
(a) $\frac{1.609\text{ km}}{1\text{ mi}}$; (b) $\frac{28.317\text{ L}}{1\text{ ft}^3}$; (c) $\frac{28.349\text{ g}}{1\text{ oz}}$

Question 6-3.

The label on a soft drink bottle gives the volume in two units: 2.0 L and 67.6 fl oz. Use this information to derive a conversion factor between the English and metric units. How many significant figures can you justify in your conversion factor?

Solution
Divide the total number of liters by the total number of fluid ounces.

0.030 L = 1 fl oz

$$\frac{2.0\text{ L}}{67.6\text{ fl oz}} = \frac{0.030\text{ L}}{1\text{ fl oz}}$$

Only two significant figures are justified.

Question 6-4.

The label on a box of cereal gives the mass of cereal in two units: 978 grams and 34.5 oz. Use this information to find a conversion factor between the English and metric units. How many significant figures can you justify in your conversion factor?

Solution
28.3 g = (exactly) 1 oz, three significant figures

Question 6-5.

Soccer is played with a round ball having a circumference between 27 and 28 in. and a weight between 14 and 16 oz. What are these specifications in units of centimeters and grams?

Solution

68–71 cm; 400–450 g

Question 6-6.

A woman's basketball has a circumference between 28.5 and 29.0 inches and a maximum weight of 20 ounces (two significant figures). What are these specifications in units of centimeters and grams?

Solution

72.4–73.7 cm; max. 5.7×10^2 g

Question 6-7.

How many milliliters of a soft drink are contained in a 12.0-oz can?

Solution

355 mL

Question 6-8.

A barrel of oil is exactly 42 gal. How many liters of oil are in a barrel?

Solution

$$1 \text{ qt} = 0.94635 \text{ L} = \frac{1}{4} \text{ gal}$$

$$42 \cancel{\text{gal}} \text{ (exact)} \times \frac{4 \cancel{\text{qt}}}{1 \cancel{\text{gal}}} \times \frac{0.9463 \text{ L}}{1 \cancel{\text{qt}}} = 159.00 \text{ L}$$

Question 6-9.

The diameter of a red blood cell is about 3×10^{-4} in. What is its diameter in centimeters?

Solution

8×10^{-4} cm

Question 6-10.

The distance between the centers of the two oxygen atoms in an oxygen molecule is 1.21×10^{-8} cm. What is this distance in inches?

Solution

1 in. = 2.54 cm

$$1.21 \times 10^{-8} \cancel{\text{cm}} \times \frac{1 \text{ in.}}{2.54 \cancel{\text{cm}}} = 4.76 \times 10^{-9} \text{ in.}$$

Question 6-11.

Is a 197-lb weight lifter light enough to compete in a class limited to those weighing 90 kg or less?

Solution
yes; weight = 89.4 kg

Question 6-12.

A very good 197-lb weight lifter lifted 192 kg in a move called the clean and jerk. What was the mass of the weight lifted in pounds?

Solution
1 lb = 0.45359 kg

$$192\ \cancel{\text{kg}} \times \frac{1\ \text{lb}}{0.45359\ \cancel{\text{kg}}} = 423\ \text{lb} = 4.23 \times 10^2\ \text{lb}$$

Question 6-13.

Many medical laboratory tests are run using 5.0 μL blood serum. What is this volume in milliliters?

Solution
5.0×10^{-3} mL

Question 6-14.

If an aspirin tablet contains 325 mg aspirin, how many grams of aspirin does it contain?

Solution

$$\frac{325\ \cancel{\text{mg}} \times 1\ \text{g}}{1000\ \cancel{\text{mg}}} = 0.325\ \text{g}$$

Question 6-15.

Use scientific (exponential) notation to express the following quantities in terms of the SI base units in Table1.3:

(a) 0.13 g
(b) 232 Gg
(c) 5.23 pm
(d) 86.3 mg
(e) 37.6 cm
(f) 54 μm
(g) 1 Ts
(h) 27 ps
(i) 0.15 mK

Solution
(a) 1.3×10^{-4} kg; (b) 2.32×10^{8} kg; (c) 5.23×10^{-12} m; (d) 8.63×10^{-5} kg; (e) 3.76×10^{-1} m; (f) 5.4×10^{-5} m; (g) 1×10^{12} s; (h) 2.7×10^{-11} s; (i) 1.5×10^{-4} K

Question 6-16.

Complete the following conversions between SI units.

(a) 612 g = ________ mg
(b) 8.160 m = ________ cm
(c) 3779 μg = ________ g

(d) 781 mL = ________ L
(e) 4.18 kg = ________ g
(f) 27.8 m = ________ km
(g) 0.13 mL = ________ L
(h) 1738 km = ________ m
(i) 1.9 Gg = ________ g

Solution
See Table 1.6

(a) $612\ \cancel{g} \times \dfrac{1000\ \text{mg}}{1\ \cancel{g}} = 6.12 \times 10^5\ \text{mg}$ $1\ \text{g} = 1000\ \text{mg}$

(b) $8.160\ \cancel{m} \times \dfrac{100\ \text{cm}}{\cancel{m}} = 8.160 \times 10^2\ \text{cm}$ $1\ \text{m} = 100\ \text{cm}$

(c) $3779\ \cancel{\mu g} \times \dfrac{10^{-6}\ \text{g}}{1\cancel{\mu g}} = 3.779 \times 10^{-3}\ \text{g}$ $1\mu\text{g} = 10^{-6}\ \text{g}$

(d) $781\ \cancel{mL} \times \dfrac{10^{-3}\ \text{L}}{1\cancel{mL}} = 7.81 \times 10^{-1}\ \text{L}$ $1\ \text{mL} = 10^{-3}\ \text{L}$

(e) $4.18\ \cancel{kg} \times \dfrac{1000\ \text{g}}{1\cancel{kg}} = 4.18 \times 10^3\ \text{g}$ $1\ \text{kg} = 1000\ \text{g}$

(f) $2.78\ \cancel{m} \times \dfrac{10^{-3}\ \text{km}}{1\cancel{m}} = 2.78 \times 10^{-2}\ \text{m}$ $1\ \text{m} = 10^{-3}\ \text{L}$

(g) $0.13\ \cancel{mL} \times \dfrac{10^{-3}\ \text{L}}{1\cancel{mL}} = 1.3 \times 10^{-4}\ \text{L}$ $1\ \text{mL} = 10^{-3}\ \text{L}$

(h) $1738\ \cancel{km} \times \dfrac{1000\ \text{m}}{1\cancel{km}} = 1.738 \times 10^6\ \text{m}$ $1\ \text{km} = 1000\ \text{m}$

(i) $1.9\ \cancel{Gg} \times \dfrac{10^9\ \text{g}}{1\cancel{Gg}} = 1.9 \times 10^9\ \text{g}$ $1\ \text{Gg} = 10^9\ \text{g}$

Question 6-17.

Gasoline is sold by the liter in many countries. How many liters are required to fill a 12.0-gal gas tank?

Solution
45.4 L

Question 6-18.

Milk is sold by the liter in many countries. What is the volume of exactly 1/2 gal of milk in liters?

Solution

$1\ \text{L} = 1.0567\ \text{qt};\ 1\ \text{gal} = 4\ \text{qt};\ \dfrac{1}{2}\ \text{gal} = 2\ \text{qt}$

$$2\ \cancel{qt} \times \frac{1\ \text{L}}{1.0567\ \cancel{qt}} = 1.892\ \text{L}$$

Question 6-19.

A long ton is defined as exactly 2240 lb. What is this mass in kilograms?

Solution

$$2240\ \cancel{\text{lb}}\ \text{(exactly)} \times \frac{0.45359\ \text{kg}}{1\ \cancel{\text{lb}}} = 1016.0\ \text{kg} = 1.0160 \times 10^3\ \text{kg}$$

Question 6-20.

Make the conversion indicated in each of the following:

(a) the men's world record long jump, 29 ft $4\frac{1}{4}$ in., to meters

(b) the greatest depth of the ocean, about 6.5 mi, to kilometers

(c) the area of the state of Oregon, 96,981 mi^2, to square kilometers

(d) the volume of 1 gill (exactly 4 oz) to milliliters

(e) the estimated volume of the oceans, 330,000,000 mi^3, to cubic kilometers.

(f) the mass of a 3525-lb car to kilograms

(g) the mass of a 2.3-oz egg to grams

Solution

(a) 8.95 m; (b) 1.0×10^1 km; (c) 2.5118×10^5 km^2; (d) 118.3 mL; (e) 1.4×10^9 $\text{km}^{3;}$, (f) 1,599 kg; (g) 65 g

Question 6-21.

Make the conversion indicated in each of the following:

(a) the length of a soccer field, 120 m (three significant figures), to feet

(b) the height of Mt. Kilimanjaro, at 19,565 ft the highest mountain in Africa, to kilometers

(c) the area of an 8.5 × 11-inch sheet of paper in cm^2

(d) the displacement volume of an automobile engine, 161 in.^3, to liters

(e) the estimated mass of the atmosphere, 5.6×10^{15} tons, to kilograms

(f) the mass of a bushel of rye, 32.0 lb, to kilograms

(g) the mass of a 5.00-grain aspirin tablet to milligrams (1 grain = 0.00229 oz)

Solution

(a) $120\ \cancel{\text{m}} \times \frac{1.0936\ \cancel{\text{yd}}}{1\ \cancel{\text{m}}} \times \frac{3\ \text{ft}}{1\ \cancel{\text{yd}}} = 394\ \text{ft}$

(b) $19{,}565\ \cancel{\text{ft}} \times \frac{12\ \cancel{\text{in.}}}{1\ \cancel{\text{ft}}} \times \frac{2.54\ \cancel{\text{cm}}}{1\ \cancel{\text{in.}}} \times \frac{1\ \cancel{\text{m}}}{100\ \cancel{\text{cm}}} \times \frac{1\ \text{km}}{1000\ \cancel{\text{m}}} = 5.9634\ \text{km}$

(c) $8.5\ \text{in.} \times 11\ \text{in.} = 93.5\ \cancel{\text{in.}^2} \times \frac{(2.54\ \text{cm})^2}{(1\ \cancel{\text{in.}})^2} = 6.0 \times 10^2$

(d) $161\ \cancel{\text{in.}^3} \times \left(\frac{2.54\ \cancel{\text{cm}}}{1\ \cancel{\text{in.}}}\right)^3 \times \frac{1\ \text{L}}{1000\ \cancel{\text{cm}^3}} = 2.64\ \text{L}$

(e) $5.6 \times 10^{15}\ \cancel{\text{short tons}} \times 907.185\ \text{kg}/\cancel{\text{short tons}} = 5.1 \times 10^{18}\ \text{kg}$

(f) $32.0\ \cancel{\text{lb}} \times \frac{0.45359\ \text{kg}}{1\ \cancel{\text{lb}}} = 14.5\ \text{kg}$

$$\text{(g) } 5.00\ \cancel{\text{grain}} \times \frac{0.00229\ \cancel{\text{oz}}}{1\ \cancel{\text{grain}}} \times \frac{28.349\ \text{g}}{1\ \cancel{\text{oz}}} = 0.324\ \text{g}$$

$$0.411\ \cancel{\text{g}} \times \frac{1000\ \text{mg}}{1\ \cancel{\text{g}}} = 324\ \text{mg}$$

Question 6-22.

Many chemistry conferences have held a 50-Trillion Angstrom Run (two significant figures). How long is this run in kilometers and in miles? ($1\ \text{Å} = 1 \times 10^{-10}\ \text{m}$)

Solution

5.0 km, 3.1 mi

Question 6-23.

A chemist's 50-Trillion Angstrom Run (see Exercise 78) would be an archeologist's 10,900 cubit run. How long is one cubit in meters and in feet? ($1\ \text{Å} = 1 \times 10^{-8}\ \text{cm}$)

Solution

$$5.0 \times \frac{10^3\ \text{m}}{10{,}900\ \text{cubit}} = 0.46\ \text{m/cubit or 1 cubit} = 0.46\ \text{m}$$

$$\frac{5000\ \text{m}}{10{,}900\ \text{cubit}} \times \frac{1\ \text{yd}}{0.9744\ \text{m}} \times 3\ \text{ft/yd} = 1.5\ \text{ft/cubit}$$

Question 6-24.

The gas tank of a certain luxury automobile holds 22.3 gallons according to the owner's manual. If the density of gasoline is 0.8206 g/mL, determine the mass in kilograms and pounds of the fuel in a full tank.

Solution

1 gal = 4 qt; 1 qt = 0.94635 L

$$1\ \cancel{\text{gal}} \times \frac{4\ \cancel{\text{qt}}}{1\ \cancel{\text{gal}}} \times 0.94635\ \text{L}/\cancel{\text{qt}} = 3.7852\ \text{L}$$

$$22.3\ \cancel{\text{gal}} \times 3.7852\ \cancel{\text{L}}/\cancel{\text{gal}} \times 0.8206\ \cancel{\text{g}}/\cancel{\text{mL}} \times \frac{1\ \text{kg}}{1000\ \cancel{\text{g}}} \times 1000\ \cancel{\text{mL}}/\cancel{\text{L}} = 69.3\ \text{kg}$$

$$69.3\ \cancel{\text{kg}} \times \frac{1\ \text{lb}}{0.45359\ \cancel{\text{kg}}} = 153\ \text{lb}$$

Question 6-25.

As an instructor is preparing for an experiment, he requires 225 g phosphoric acid. The only container readily available is a 150-mL Erlenmeyer flask. Is it large enough to contain the acid, whose density is 1.83 g/mL?

Solution

Yes, the acid's volume is 123 mL.

Question 6-26.

To prepare for a laboratory period, a student lab assistant needs 125 g of a compound. A bottle containing 1/4 lb is available. Did the student have enough of the compound?

Solution

Determine the number of grams in 1/4 lb; assume the same number of significant figures as in the 125-g sample, that is, 3.

$$0.250\ \cancel{\text{lb}} \times 453.59\ \text{g}/\cancel{\text{lb}} = 113\ \text{g}$$

And so, the student does not have enough compound.

Question 6-27.

A chemistry student is 159 cm tall and weighs 45.8 kg. What is her height in inches and weight in pounds?

Solution

62.6 in (about 5 ft 3 in.) and 101 lb

Question 6-28.

In a recent Grand Prix, the winner completed the race with an average speed of 229.8 km/h. What was his speed in miles per hour, meters per second, and feet per second?

Solution

142.8 mi/h, 63.84 m/s, 209.4 ft/s

Question 6-29.

Solve these problems about lumber dimensions.

(a) To describe to a European how houses are constructed in the US, the dimensions of "two-by-four" lumber must be converted into metric units. The thickness × width × length dimensions are 1.50 in. × 3.50 in. × 8.00 ft in the US. What are the dimensions in cm × cm × m?

(b) This lumber can be used as vertical studs, which are typically placed 16.0 in. apart. What is that distance in centimeters?

Solution

(a) 3.81 cm × 8.89 cm × 2.44 m; (b) 40.6 cm

Question 6-30.

The mercury content of a stream was believed to be above the minimum considered safe—1 part per billion (ppb) by weight. An analysis indicated that the concentration was 0.68 parts per billion. What quantity of mercury in grams was present in 15.0 L of the water, the density of which is 0.998 g/ml? $\left(1\ \text{ppb Hg} = \dfrac{1\ \text{ng Hg}}{1\ \text{g water}}\right)$

Solution

1.0×10^{-5} g

Question 6-31.

Calculate the density of aluminum if 27.6 cm^3 has a mass of 74.6 g.

Solution
2.70 g/cm^3

Question 6-32.

Osmium is one of the densest elements known. What is its density if 2.72 g has a volume of 0.121 cm^3

Solution

$$\text{density} = \frac{\text{mass}}{\text{volume}};\ \frac{2.7\ \text{g}}{0.121\ \text{cm}^3} = 22.5\ \text{g/cm}^3$$

Question 6-33.

Calculate these masses.

(a) What is the mass of 6.00 cm^3 of mercury, density = 13.5939 g/cm^3?
(b) What is the mass of 25.0 mL octane, density = 0.702 g/cm^3?

Solution
(a) 81.6 g; (b) 17.6 g

Question 6-34.

Calculate these masses.

(a) What is the mass of 4.00 cm^3 of sodium, density = 0.97 g/cm?
(b) What is the mass of 125 mL gaseous chlorine, density = 3.16 g/L?

Solution

$$\text{mass} = \text{volume} \times \text{density};\ \text{(a)}\ \text{Mass} = 4.00\ \cancel{\text{cm}^3} \times 0.97\ \text{g}/\cancel{\text{cm}^3} = 3.9\ \text{g};\ \text{(b)}$$

$$\text{Mass} = 125\ \cancel{\text{mL}} \times 3.16\ \text{g}/\cancel{\text{L}} \times \frac{1\ \cancel{\text{L}}}{1000\ \cancel{\text{mL}}} = 0.395\ \text{g}$$

Question 6-35.

Calculate these volumes.

(a) What is the volume of 25 g iodine, density = 4.93 g/cm^3?
(b) What is the volume of 3.28 g gaseous hydrogen, density = 0.089 g/L?

Solution
(a) 5.1 mL; (b) 37 L

Question 6-36.

Calculate these volumes.

(a) What is the volume of 11.3 g graphite, density = 2.25 g/cm^3?
(b) What is the volume of 39.657 g bromine, density = 2.928 g/cm^3

Solution

$$\text{volume} = \frac{\text{mass}}{\text{density}};\ \text{(a)}\ \frac{11.3\ \cancel{\text{g}}}{2.25\ \cancel{\text{g}}/\text{cm}^3} = 5.02\ \text{cm}^3 = 5.02\ \text{mL};\ \text{(b)}$$

$$\text{Volume} = \frac{39.657\ \cancel{\text{g}}}{2.2928\ \cancel{\text{g}}/\text{cm}^3} = 13.54\ \text{cm}^3 = 13.54\ \text{mL}$$

Question 6-37.

Convert the boiling temperature of gold, 2966 °C, into degrees Fahrenheit and kelvin.

Solution

5371 °F, 3239 K

Question 6-38.

Convert the temperature of scalding water, 54 °C, into degrees Fahrenheit and kelvin.

Solution

$°F = \frac{9}{5}(°C) + 32$; $K = °C + 273.15$; $°F = \frac{9}{5}(54) + 32 = 129\ °F$; $K = 54\ °C + 273.15 = 327\ K$

Question 6-39.

Convert the temperature of the coldest area in a freezer, –10 °F, to degrees Celsius and kelvin.

Solution

–23 °C, 250 K

Question 6-40.

Convert the temperature of dry ice, –77 °C, into degrees Fahrenheit and kelvin.

Solution

$°F = \frac{9}{5}(°C) + 32$; $K = °C + 273.15$; $°F = \frac{9}{5}(-77) + 32 = -138.6 + 32 = -107\ °F$; $K = -77\ °C + 273.15 = 196\ K$

Question 6-41.

Convert the boiling temperature of liquid ammonia, –28.1 °F, into degrees Celsius and kelvin.

Solution

–33.4 °C, 239.8 K

Question 6-42.

The label on a pressurized can of spray disinfectant warns against heating the can above 130 °F. What are the corresponding temperatures on the Celsius and kelvin temperature scales?

Solution

$°C = \frac{5}{9}(°F - 32)$; $K = °C + 273.15$; $°C = \frac{5}{9}(130 - 32) = \frac{5}{9}(98) = 54\ °C$; $K = 54 + 273.15 = 327\ K$

Question 6-43.

The weather in Europe was unusually warm during the summer of 1995. The TV news reported temperatures as high as 45 °C. What was the temperature on the Fahrenheit scale?

Solution

113 °F