Schaum's
题解精萃

化学
CHEMISTRY

影印版

David E. Goldberg

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内容简介

Schaum's 丛书是由麦格劳－希尔(McGraw－Hill)国际出版公司出版的著名的系列教学辅助用书，涵盖了高等教育各类各门学科和课程。每本书都汇集了该门学科课程中的精髓内容，并对基本理论和基本概念作了简明精炼的归纳和总结，还提供了由美国众多经验丰富的资深教师和学者推荐、讲解透彻的精选例题和形式多样的各类习题。

本书根据 Schaum's 系列丛书中《化学 3000 习题解答》第一版修订版原文影印出版。可供在校本科生、研究生以及社会各类科技人员参考使用。

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出 版 说 明

随着我国高等教育改革形势的发展，高等教育的人才培养模式及教学形式和教学方法正在发生重大变化，一个拓宽专业口径，实行弹性学习制度，允许分阶段完成学业，横向沟通、纵向衔接的教育体制正在逐步构建形成。为了促进高等教育的改革，活跃高等学校的教学工作，扩大学生的眼界，我们组织出版了这套“Schaum's 题解精萃”。

“Schaum's 丛书”是由麦格劳－希尔(McGraw－Hill)国际出版公司出版的著名的系列教学辅助用书，目前已出版了约 700 多个品种，涵盖了高等教育各类各门学科和课程。本套丛书的特点是：每本书都汇集了该门学科课程中的精髓内容，并对基本理论和基本概念作了简明精炼的归纳和总结；同时，还提供了由美国众多经验丰富的资深教师和学者推荐、讲解透彻的精选例题和形式多样的各类习题约 2000—4000 个。本套书在美国高等学校中颇具权威性，多年来持续畅销，目前在世界范围销售超过 3000 万册。

我们从“Schaum's 丛书”中经精心挑选，组合成“Schaum's 题解精萃”，以原版影印的形式介绍到国内，意在使学生在使用本书的同时，了解、熟悉相关学科和课程的英语专业词汇，提高英语专业阅读的速度和水平，锻炼使用英语学习、解题的能力。因为，当今时代，熟练掌握英语已成为 21 世纪人才必备的基本素质和能力。“Schaum's 题解精萃”第一批影印书内容涉及理工科各基础学科，今后我们将陆续影印出版该系列其他学科的图书。

本套书可供高等学校的理工科学生在学习各学科课程的同时，进行辅助学习和各类习题训练，有助于提高学生巩固学科基本知识和解题的综合能力，同时也可适用于各科教师在教学和辅导中参考。本套书同时还可作为在校本科生、研究生以及社会各类科技人员参加各类国际资格证书考试、国外留学考试(如 GRE)等的适用参考书。

我们相信，本套书的出版，将会对我国高等院校的学生、教师们提供丰富多彩、形式多样、卓有成效的参考资料。

出版者

2000 年 4 月

To the Student

The best way to ensure that you understand the concepts of General Chemistry is to solve many problems on each topic. You should attempt a large number of different problems, rather than merely reworking the same problems again and again, since you might have a tendency to memorize the solution in the latter case. Be sure to read each problem carefully, since a small difference in the wording of a problem can make a large difference in its solution.

Since there is no set order of topics in general chemistry texts, you will have to consult the Table of Contents in this book to find the problems you wish to do. The problems in each section start with the more basic ones and progress to those that are more difficult. In some chapters, you may find problems based on material which you have not yet covered in your course. Do not attempt to do these before you cover the material on which they are based. For example, some texts cover equilibrium before thermodynamics, while others cover it afterward. Do not attempt the section on the thermodynamics of equilibrium until you have been introduced to both topics in your course.

There are numerous methods to solve most problems. The solution methods are usually related to each other but may seem very different. In this book, some related problems are solved using one method, and some with another. Many of the problems, especially in the early chapters, use several solution methods. You should attempt to do the problems yourself before looking at the solutions given. If you get the correct answer using a reasonable method, you need not worry that you did not use the method selected here. If the method presented is clearer that the one you used, however, you might consider adopting it for future similar problems.

CONTENTS

CHAPTER 1
Measurement

1.1 EXPONENTIAL NUMBERS

1.1 List the powers of ten, from 10^{-4} to 10^6, together with their explicit meanings.

▮

$$10^0 = 1 \qquad 10^{-1} = \frac{1}{10} = 0.1$$

$$10^1 = 10$$

$$10^2 = 10 \times 10 = 100 \qquad 10^{-2} = \frac{1}{10^2} = \frac{1}{100} = 0.01$$

$$10^3 = 10 \times 10 \times 10 = 1000$$

$$10^4 = 10 \times 10 \times 10 \times 10 = 10\,000 \qquad 10^{-3} = \frac{1}{10^3} = \frac{1}{1000} = 0.001$$

$$10^5 = 10 \times 10 \times 10 \times 10 \times 10 = 100\,000$$

$$10^6 = 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 1\,000\,000 \qquad 10^{-4} = \frac{1}{10^4} = \frac{1}{10\,000} = 0.0001$$

In the expression 10^5, the *base* is 10 and the *exponent* is 5.

1.2 Express the following numbers in standard exponential form:

(*a*) 22 400 (*b*) 7 200 000 (*c*) 454 (*d*) 0.454
(*e*) 0.0454 (*f*) 0.000 06 (*g*) 0.003 06 (*h*) 0.000 000 5

▮ Any number may be expressed as an integral power of 10, or as the product of two numbers one of which is an integral power of 10 (e.g., $300 = 3 \times 10^2$).

(*a*) $22\,400 = 2.24 \times 10^4$ (*b*) $7\,200\,000 = 7.2 \times 10^6$ (*c*) $454 = 4.54 \times 10^2$
(*d*) $0.454 = 4.54 \times 10^{-1}$ (*e*) $0.0454 = 4.54 \times 10^{-2}$ (*f*) $0.000\,06 = 6 \times 10^{-5}$
(*g*) $0.003\,06 = 3.06 \times 10^{-3}$ (*h*) $0.000\,000\,5 = 5 \times 10^{-7}$

Moving the decimal point one place to the right is equivalent to multiplying a number by 10; moving the decimal point two places to the right is equivalent to multiplying by 100, and so on. Whenever the decimal point is moved to the right by *n* places, compensation can be achieved by *dividing* at the same time by 10^n; the value of the number remains unchanged. Thus

$$0.0325 = \frac{3.25}{10^2} = 3.25 \times 10^{-2}$$

Moving the decimal point one place to the left is equivalent to dividing by 10. Whenever the decimal point is moved to the left *n* places, compensation can be achieved by *multiplying* at the same time by 10^n; the value of the number remains unchanged. For example,

$$7296 = 72.96 \times 10^2 = 7.296 \times 10^3$$

1.3 Evaluate:

(*a*) $a^3 \times a^5$ (*b*) $10^2 \times 10^3$ (*c*) 10×10
(*d*) $10^7 \times 10^{-3}$ (*e*) $(4 \times 10^4)(2 \times 10^{-6})$ (*f*) $(2 \times 10^5)(3 \times 10^{-2})$

▮ In multiplication, exponents of like bases are added.

(*a*) $a^3 \times a^5 = a^{3+5} = a^8$ (*b*) $10^2 \times 10^3 = 10^{2+3} = 10^5$
(*c*) $10 \times 10 = 10^{1+1} = 10^2$ (*d*) $10^7 \times 10^{-3} = 10^{7-3} = 10^4$
(*e*) $(4 \times 10^4)(2 \times 10^{-6}) = 8 \times 10^{4-6} = 8 \times 10^{-2}$ (*f*) $(2 \times 10^5)(3 \times 10^{-2}) = 6 \times 10^{5-2} = 6 \times 10^3$

1.4 Evaluate:

(*a*) $\frac{a^5}{a^3}$ (*b*) $\frac{10^2}{10^5}$ (*c*) $\frac{8 \times 10^2}{2 \times 10^{-6}}$ (*d*) $\frac{5.6 \times 10^{-2}}{1.6 \times 10^4}$

In division, exponents of like bases are subtracted.

(*a*) $\frac{a^5}{a^3} = a^{5-3} = a^2$ (*b*) $\frac{10^2}{10^5} = 10^{2-5} = 10^{-3}$

(*c*) $\frac{8 \times 10^2}{2 \times 10^{-6}} = \frac{8}{2} \times 10^{2+6} = 4 \times 10^8$ (*d*) $\frac{5.6 \times 10^{-2}}{1.6 \times 10^4} = \frac{5.6}{1.6} \times 10^{-2-4} = 3.5 \times 10^{-6}$

1.5 Evaluate the following expressions: (*a*) a^0 (*b*) 10^0 (*c*) $(3 \times 10)^0$ (*d*) 7×10^0 (*e*) 8.2×10^0

(*a*) $a^0 = 1$ (*b*) $10^0 = 1$ (*c*) $(3 \times 10)^0 = 1$ (*d*) $7 \times 10^0 = 7$ (*e*) $8.2 \times 10^0 = 8.2$

1.6 Express as radicals: (*a*) $10^{2/3}$ (*b*) $10^{3/2}$ (*c*) $10^{1/2}$ (*d*) $4^{3/2}$

(*a*) $10^{2/3} = \sqrt[3]{10^2}$ (*b*) $10^{3/2} = \sqrt{10^3}$ (*c*) $10^{1/2} = \sqrt{10}$ (*d*) $4^{3/2} = \sqrt{4^3} = \sqrt{64} = 8$

1.7 Simplify: (*a*) $(10^3)^2$ (*b*) $(10^{-2})^3$ (*c*) $(a^3)^{-2}$

(*a*) $(10^3)^2 = 10^{3 \times 2} = 10^6$ (*b*) $(10^{-2})^3 = 10^{-2 \times 3} = 10^{-6}$ (*c*) $(a^3)^{-2} = a^{-6}$

1.8 Take the square root of each of the following numbers, using exponential notation as an aid: (*a*) 90 000 (*b*) 3.6×10^3 (*c*) 4.9×10^{-5} Take the cube roots of the following numbers: (*d*) 8×10^9 (*e*) 1.25×10^5

To extract the square root of a power of 10, divide the exponent by 2. If the exponent is an odd number it should be increased or decreased by 1, and the coefficient adjusted accordingly. To extract the cube root of a power of 10, adjust so that the exponent is divisible by 3; then divide the exponent by 3. The coefficients are treated independently.

(*a*) $\sqrt{90\,000} = \sqrt{9 \times 10^4} = \sqrt{9} \times \sqrt{10^4} = 3 \times 10^2$ or 300
(*b*) $\sqrt{3.6 \times 10^3} = \sqrt{36 \times 10^2} = \sqrt{36} \times \sqrt{10^2} = 6 \times 10^1$ or 60
(*c*) $\sqrt{4.9 \times 10^{-5}} = \sqrt{49 \times 10^{-6}} = \sqrt{49} \times \sqrt{10^{-6}} = 7 \times 10^{-3}$ or 0.007
(*d*) $\sqrt[3]{8 \times 10^9} = \sqrt[3]{8} \times \sqrt[3]{10^9} = 2 \times 10^3$ or 2000
(*e*) $\sqrt[3]{1.25 \times 10^5} = \sqrt[3]{125 \times 10^3} = \sqrt[3]{125} \times \sqrt[3]{10^3} = 5 \times 10$ or 50

1.9 Calculate the value of $\frac{(4.0 \times 10^{-100}) + (2.0 \times 10^{-101})}{2.0 \times 10^{-200}}$

You must know the rules for handling exponents, because not all electronic calculators do this type of problem.

$$\frac{(4.0 \times 10^{-100}) + (2.0 \times 10^{-101})}{2.0 \times 10^{-200}} = \frac{(4.0 \times 10^{-100}) + (0.20 \times 10^{-100})}{2.0 \times 10^{-200}} = \frac{4.2 \times 10^{-100}}{2.0 \times 10^{-200}} = 2.1 \times 10^{100}$$

1.10 Units can also be expressed with exponents, both positive and negative. Show the dimensions of the result two ways when a mass in grams (g) is divided by a volume in cubic meters (m^3).

g/m^3 or $g \cdot m^{-3}$

1.11 Compute and state the answers in standard exponential form:

(*a*) $(2.0 \times 10^{13}) + (1.5 \times 10^{14})$ (*b*) $(8.0 \times 10^{-14})/(4.0 \times 10^{-13})$
(*c*) $(5.0 \times 10^{17})(2.0 \times 10^{-4})$ (*d*) $(6.6 \times 10^{15}) - (3.0 \times 10^{16})$

(*a*) 1.7×10^{14} (*b*) 2.0×10^{-1} (*c*) $10 \times 10^{13} = 1.0 \times 10^{14}$ (*d*) -2.3×10^{16}

1.12 Evaluate: (*a*) $10^4 \times 10^{-2}$ (*b*) $10^4/10^{-3}$ (*c*) $2.5 \times 10^7 \times 4.0 \times 10^3$

(*a*) In multiplication, add exponents algebraically: 10^2 (*b*) In division, subtract exponents algebraically: 10^7 (*c*) Multiply coefficients and exponential parts separately and simplify: $10 \times 10^{10} = 10^{11}$.

1.13 Simplify the following expressions:

(*a*) $\dfrac{48\,000\,000}{1200}$ (*b*) $\dfrac{0.0078}{120}$

(*c*) $(4 \times 10^{-3})(5 \times 10^4)^2$ (*d*) $\dfrac{(6\,000\,000)(0.00004)^4}{(800)^2(0.0002)^3}$

(*e*) $(\sqrt{4.0 \times 10^{-6}})(\sqrt{8.1 \times 10^3})(\sqrt{0.0016})$ (*f*) $(\sqrt[3]{6.4 \times 10^{-2}})(\sqrt[3]{27\,000})(\sqrt[3]{2.16 \times 10^{-4}})$

▮ (*a*) $\dfrac{48\,000\,000}{1200} = \dfrac{48 \times 10^6}{12 \times 10^2} = 4.0 \times 10^{6-2} = 4.0 \times 10^4$ or 40 000

(*b*) $\dfrac{0.0078}{120} = \dfrac{7.8 \times 10^{-3}}{1.2 \times 10^2} = 6.5 \times 10^{-5}$ or 0.000 065

(*c*) $(4 \times 10^{-3})(5 \times 10^4)^2 = (4 \times 10^{-3})(5^2 \times 10^8) = 4 \times 5^2 \times 10^{-3+8} = 100 \times 10^5 = 1 \times 10^7$

(*d*) $$\frac{(6\,000\,000)(0.000\,04)^4}{(800)^2(0.000\,2)^3} = \frac{(6 \times 10^6)(4 \times 10^{-5})^4}{(8 \times 10^2)^2(2 \times 10^{-4})^3} = \frac{6 \times 4^4}{8^2 \times 2^3} \times \frac{10^6 \times 10^{-20}}{10^4 \times 10^{-12}}$$
$$= \frac{6 \times 256}{64 \times 8} \times \frac{10^{6-20}}{10^{4-12}} = 3 \times \frac{10^{-14}}{10^{-8}} = 3 \times 10^{-6}$$

(*e*) $$(\sqrt{4.0 \times 10^{-6}})(\sqrt{8.1 \times 10^3})(\sqrt{0.0016}) = (\sqrt{4.0 \times 10^{-6}})(\sqrt{81 \times 10^2})(\sqrt{16 \times 10^{-4}})$$
$$= (2.0 \times 10^{-3})(9.0 \times 10^1)(4.0 \times 10^{-2})$$
$$= 72 \times 10^{-4} = 7.2 \times 10^{-3} \text{ or } 0.0072$$

(*f*) $$(\sqrt[3]{6.4 \times 10^{-2}})(\sqrt[3]{27\,000})(\sqrt[3]{2.16 \times 10^{-4}}) = (\sqrt[3]{64 \times 10^{-3}})(\sqrt[3]{27 \times 10^3})(\sqrt[3]{216 \times 10^{-6}})$$
$$= (4.0 \times 10^{-1})(3.0 \times 10^1)(6.0 \times 10^{-2})$$
$$= 72 \times 10^{-2} \text{ or } 0.72$$

1.14 Find the logarithm of each of the following numbers: (*a*) 4.56 (*b*) 1.70 (*c*) 9.75 (*d*) 1.07 (*e*) 3.16 (*f*) 1.00

▮ (*a*) 0.6590 (*b*) 0.2304 (*c*) 0.9890 (*d*) 0.0294 (*e*) 0.4997 (*f*) 0.0000

1.15 Find the antilogarithm of each of the following: (*a*) 0.4502 (*b*) 0.8579 (*c*) 0.7042 (*d*) 0.6080 (*e*) 0.9695

▮ (*a*) 2.82 (*b*) 7.21 (*c*) 5.06 (*d*) 4.055 (*e*) 9.322

1.16 Determine the antilog of each of the following: (*a*) 2.6170 (*b*) 7.42 (*c*) −2.0057 (*d*) −0.4776

▮ (*a*) $4.14 \times 10^2 = 414$ (*b*) 2.6×10^7 (*c*) 9.87×10^{-3} (*d*) $3.33 \times 10^{-1} = 0.333$

1.2 METRIC SYSTEM

1.17 Show the relationships among the metric units of length, volume, and mass and the common English units of these quantities.

▮
1 meter = 100 cm = 1000 mm = 0.001 km = 39.37 in.
1 kilogram = 1000 g = 2.2 lb
1 inch = 2.54 cm = 0.0254 m = 25.4 mm = 2.54×10^7 nm
1 foot = 12 in. = 12 × 2.54 cm = 30.48 cm = 0.3048 m = 304.8 mm
1 liter = 1 dm^3 = 10^{-3} m^3 = 1.06 quarts
1 yard = 3 ft = 91.44 cm = 914.4 mm = 0.9144 m
1 mile = 5280 ft = 6.336×10^4 in. = 1.609×10^5 cm = 1.609×10^3 m = 1.609×10^6 mm
1 pound = 0.4536 kg = 453.6 g = 4.536×10^5 mg
1 ounce = $\frac{1}{16}$ lb = $\frac{1}{16} \times 453.6$ g = 28.35 g = 0.02835 kg
1 metric ton = 1000 kg = 10^6 g

1.18 (*a*) Express 3.69 m in kilometers, in centimeters, and in millimeters. (*b*) Express 36.24 mm in centimeters and in meters.

(*a*) $(3.69\ \text{m})\left(\frac{1\ \text{km}}{10^3\ \text{m}}\right) = 3.69 \times 10^{-3}\ \text{km}$ (*b*) $(36.24\ \text{mm})\left(\frac{1\ \text{cm}}{10\ \text{mm}}\right) = 3.624\ \text{cm}$

$(3.69\ \text{m})\left(\frac{100\ \text{cm}}{\text{m}}\right) = 369\ \text{cm}$ $(36.24\ \text{mm})\left(\frac{1\ \text{m}}{10^3\ \text{mm}}\right) = 3.624 \times 10^{-2}\ \text{m}$

$(3.69\ \text{m})\left(\frac{10^3\ \text{mm}}{\text{m}}\right) = 3.69 \times 10^3\ \text{mm}$

1.19 (*a*) How many cubic centimeters are there in 1 m^3? (*b*) How many liters are there in 1 m^3? (*c*) How many cubic centimeters are there in 1 L?

(*a*) $1\ \text{m}^3 = (1\ \text{m})^3 = (100\ \text{cm})^3 = (10^2\ \text{cm})^3 = 10^6\ \text{cm}^3$

(*b*) $1\ \text{m}^3 = (10\ \text{dm})^3 = 10^3\ \text{dm}^3 \times 1\ \text{L/dm}^3 = 10^3\ \text{L}$ (*c*) $1\ \text{L} = 1\ \text{dm}^3 = (10\ \text{cm})^3 = 10^3\ \text{cm}^3$

1.20 Find the capacity in liters of a tank 0.6 m long, 10 cm wide, and 50 mm deep.

Convert to decimeters, since $1\ \text{L} = 1\ \text{dm}^3$.

$$\text{Volume} = 0.6\ \text{m} \times 10\ \text{cm} \times 50\ \text{mm} = 6\ \text{dm} \times 1\ \text{dm} \times 0.5\ \text{dm} = 3\ \text{dm}^3 = 3\ \text{L}$$

1.21 Convert: (*a*) 2.0×10^3 g to milligrams (*b*) $1.6 \times 10^{-3}\ \text{cm}^3$ to liters

(*a*) $(2.0 \times 10^3\ \text{g})\left(\frac{10^3\ \text{mg}}{\text{g}}\right) = 2.0 \times 10^6\ \text{mg}$ (*b*) $(1.6 \times 10^{-3}\ \text{cm}^3)\left(\frac{1\ \text{L}}{10^3\ \text{cm}^3}\right) = 1.6 \times 10^{-6}\ \text{L}$

1.22 How many millimeters are there in 15.0 cm?

$$(15.0\ \text{cm})\left(\frac{1\ \text{m}}{100\ \text{cm}}\right)\left(\frac{1000\ \text{mm}}{1\ \text{m}}\right) = 150\ \text{mm}$$

1.23 Convert: (*a*) 1.47 km to millimeters (*b*) 1.42 mL to cubic centimeters (*c*) 1.7×10^7 mg to kilograms (*d*) 1.54×10^{-3} L to milliliters (*e*) 70.5 g/L to grams per milliliter (*f*) 4.66 kg/L to grams per milliliter

(*a*) 1.47×10^6 mm (*b*) 1.42 cm^3 (*c*) 17 kg

(*d*) 1.54 mL (*e*) 0.0705 g/mL (*f*) 4.66 g/mL

1.24 Calculate the volume, in liters, of a rectangular bar which measures 0.10 m long, 2.0 cm thick, and 4.0 cm wide.

$$(0.10\ \text{m})(2.0\ \text{cm})(4.0\ \text{cm}) = (10\ \text{cm})(2.0\ \text{cm})(4.0\ \text{cm}) = (80\ \text{cm}^3)\left(\frac{1\ \text{L}}{1000\ \text{cm}^3}\right) = 0.080\ \text{L}$$

1.25 Convert: (*a*) 1.6×10^{-2} km to centimeters (*b*) 20.0 mL to liters (*c*) 16.2 g/cm^3 to kilograms per liter

(*a*) $(1.6 \times 10^{-2}\ \text{km})\left(\frac{10^3\ \text{m}}{\text{km}}\right)\left(\frac{10^2\ \text{cm}}{1\ \text{m}}\right) = 1.6 \times 10^3\ \text{cm}$ (*b*) $(20.0\ \text{mL})\left(\frac{1\ \text{L}}{1000\ \text{mL}}\right) = 0.0200\ \text{L}$

(*c*) $\left(\frac{16.2\ \text{g}}{\text{cm}^3}\right)\left(\frac{1\ \text{kg}}{1000\ \text{g}}\right)\left(\frac{1000\ \text{cm}^3}{\text{L}}\right) = 16.2\ \text{kg/L}$

1.26 Perform the following calculations: (*a*) $(2.0 \times 10^2\ \text{cm}) + (1.12 \times 10^{-1}\ \text{m})$ (*b*) $(0.10\ \text{m})(1.0 \times 10^{-4}\ \text{km})(1.0 \times 10^2\ \text{mm})$

(*a*) $(2.0 \times 10^2\ \text{cm}) + (0.112 \times 10^2\ \text{cm}) = 2.1 \times 10^2\ \text{cm}$ (*b*) $(10\ \text{cm})(10\ \text{cm})(10\ \text{cm}) = 10^3\ \text{cm}^3 = 1.0\ \text{L}$

1.27 The color of light depends on its wavelength. The longest visible rays, at the red end of the visible spectrum, are 7.8×10^{-7} m in length. Express this length in micrometers, in nanometers, and in angstroms.

$(7.8 \times 10^{-7}\ \text{m})\left(\frac{10^6\ \mu\text{m}}{\text{m}}\right) = 0.78\ \mu\text{m}$, $(7.8 \times 10^{-7}\ \text{m})\left(\frac{10^9\ \text{nm}}{\text{m}}\right) = 780\ \text{nm}$, $(7.8 \times 10^{-7}\ \text{m})\left(\frac{10^{10}\ \text{Å}}{\text{m}}\right) = 7800\ \text{Å}$

1.28 When a sample of healthy human blood is diluted to 200 times its initial volume and microscopically examined in a layer 0.10 mm thick, an average of 30 red corpuscles are found in each 100 × 100 micrometer square. (*a*) How many red cells are in a cubic millimeter of blood? (*b*) The red blood cells have an average life of 1 month, and the adult blood volume is about 5 L. How many red cells are generated every second in the bone marrow of the adult?

▌ (*a*) $(100\ \mu m) \times (100\ \mu m) \times (0.10\ mm) = (0.10\ mm)^3 = 1.0 \times 10^{-3}\ mm^3$

$$\frac{30\ \text{corpuscles}}{1.0 \times 10^{-3}\ mm^3} \times 200 = 6 \times 10^6\ \text{corpuscles undiluted}$$

(*b*) $$(5\ L)\left(\frac{10^3\ cm^3}{L}\right)\left(\frac{10^3\ mm^3}{cm^3}\right)\left(\frac{6 \times 10^6\ \text{cells}}{mm^3}\right) = 3 \times 10^{13}\ \text{cells}$$

Since 3×10^{13} cells are required per month,

$$\left(\frac{3 \times 10^{13}\ \text{cells}}{\text{month}}\right)\left(\frac{1\ \text{month}}{30\ \text{days}}\right)\left(\frac{1\ \text{day}}{24\ h}\right)\left(\frac{1\ h}{3600\ s}\right) = 1 \times 10^7\ \text{cells/s}$$

1.3 SIGNIFICANT FIGURES

1.29 How many significant figures are there in each of the following numbers: (*a*) 17 (*b*) 103 (*c*) 1.035 (*d*) 0.0010 (*e*) 1.00×10^6 (*f*) π

▌ (*a*) two (*b*) three (*c*) four (*d*) two (*e*) three (*f*) an infinite number

1.30 Perform the following operations:

$$\begin{array}{r} 12.01\ \text{cm} \\ 17.3\ \ \text{cm} \\ +\ 0.11\ \text{cm} \\ \hline \end{array} \qquad \begin{array}{r} 133\ \ \text{g} \\ -\ 2.2\ \text{g} \\ \hline \end{array}$$

▌ The answers are 29.4 cm and 131 g rather than 29.42 cm and 130.8 g. The 2 in the hundredths column of the sum is farther to the right than the 3 of 17.3, and so it cannot be significant. It is dropped because it is less than 5. The 8 of the second example is not significant for the same reason, but it is over 5, so the answer is rounded up to the next higher integer.

1.31 (*a*) $12.7 \times 11.2 = ?$ (*b*) $108/7.2 = ?$

▌ In the first calculation, three significant figures may be retained since each factor has three. In the second, only two significant figures are retained in the answer. (*a*) 142 (*b*) 15

1.32 Underline each significant digit in the numbers below. If the digit is uncertain, place a question mark below it.

(*a*) 1.066 (*b*) 750 (*c*) 0.050 (*d*) 0.2070 (*e*) 50.0

▌ (*a*) $\underline{1.066}$ (*b*) $\underline{75}\underset{?}{\underline{0}}$ (*c*) $0.0\underline{50}$ (*d*) $0.\underline{2070}$ (*e*) $\underline{50.0}$

1.33 Calculate to the proper number of significant digits:

(*a*) $(4.50 \times 10^2\ m) + (3.00 \times 10^6\ mm)$ (*b*) $(4.50 \times 10^2\ cm)(2.00 \times 10^6\ cm)$

(*c*) $(4.50 \times 10^2\ mL) - (0.0225\ L)$

▌ (*a*) $(4.50 \times 10^2\ m) + (3.00 \times 10^3\ m) = 3.45 \times 10^3\ m$ (*b*) $9.00 \times 10^8\ cm^2$

(*c*) $(4.50 \times 10^2\ mL) - (0.225 \times 10^2\ mL) = 4.28 \times 10^2\ mL$

1.34 Explain why in calculations involving more than one arithmetic operation, rounding off to the proper number of significant figures may be done once at the end if all the operations are multiplications and/or divisions or if they are all additions and/or subtractions, but not if they are combinations of additions or subtractions with multiplications or divisions.

▌ There are different rules for the number of significant digits in the answer to an addition and to a multiplication, and so they must be applied separately when a mixed calculation is made.

1.35 Add the following quantities expressed in grams, to the proper number of significant digits.

(*a*)	(*b*)	(*c*)	(*d*)
25.340	58.0	4.20	415.5
5.465	0.0038	1.6523	3.64
0.322	0.00001	0.015	0.238

▮

(a)	(b)	(c)	(d)
25.340	58.0	4.20	415.5
5.465	0.0038	1.6523	3.64
0.322	0.00001	0.015	0.238
31.127 g	58.00381 = 58.0 g	5.8673 = 5.87 g	419.378 = 419.4 g

1.36 (*a*) What is the usual method for correcting a calculated answer to the proper number of significant digits? (*b*) Do the following calculations: 2.48/1.24, 17 790/2.0. (*c*) Explain why the usual method given in part (*a*) is not used with either calculation in part (*b*).

▮ (*a*) Drop the extra digits and round the last digit retained according to the value of the first digit dropped. (*b*) 2.00 and 6400. (*c*) In 2.00, digits were added to obtain the proper number. In 6400, the last two digits were not dropped (or the value 64 would have resulted) but instead were changed to nonsignificant zeros.

1.37 Convert each of the following measurements to the basic unit (with no prefix), and express the result in standard exponential notation to the proper number of significant digits. (*a*) 9.50×10^{-1} kg (*b*) 4.40×10^{3} mm (*c*) 0.00102 cm (*d*) 400.0 mL

▮ (*a*) 9.50×10^{2} g (*b*) 4.40 m (*c*) 1.02×10^{-5} m (*d*) 4.000×10^{-1} L

1.38 $(1.20 \times 10^{-6}) + (6.00 + 10^{-5}) = ?$

▮

$$(0.120 \times 10^{-5}) + (6.00 \times 10^{-5}) = 6.12 \times 10^{-5}$$

1.39 Find the sum to the proper number of significant digits: 14.90 + 0.0070 + 1.0 + 0.091

▮

$$\begin{array}{r} 14.90 \\ 0.0070 \\ 1.0 \\ 0.091 \\ \hline 15.9_{980} \end{array} \rightarrow 16.0$$

1.40 Calculate to the correct number of significant digits: (14.90)(0.0070)/(0.091).

▮

$$(14.90)(0.0070)/(0.091) = 1.1$$

1.41 Calculate to the proper number of significant digits:

(*a*) (1.0042 − 0.0034)(1.23) (*b*) (1.0042)(0.0034)(1.23) (*c*) (1.0042)(−0.0034)/1.23

▮ (*a*) 1.23 (*b*) 4.2×10^{-3} (*c*) -2.8×10^{-3} When 0.0034 is subtracted from 1.0042, a number with five significant digits results. When this number is multiplied by 1.23, with only three significant digits, the result must be expressed to only three significant digits.

1.42 A solid has a volume of 1.23 cm^3. Its mass plus that of a piece of weighing paper is 10.024 g; the paper weighs 0.03 g. Calculate the density of the solid to the proper number of significant digits.

▮

$$\begin{array}{r} 10.024\ \text{g} \\ -\ 0.03\ \ \text{g} \\ \hline 9.99\not{4}\ \text{g} \end{array} \qquad \frac{9.99\ \text{g}}{1.23\ \text{cm}^3} = 8.12\ \text{g/cm}^3$$

The 4 must be dropped from the difference since the mass of the weighing paper is known only to the second decimal place.

1.43 Perform the following calculations to the proper number of significant digits. (*a*) $(2.00 \times 10^{-2}\ \text{km}) + (4.2 \times 10^{2}\ \text{cm})$ (*b*) $(1.5 \times 10^{1}\ \text{cm})(8.0 \times 10^{2}\ \text{cm})(0.0100\ \text{m})$

▮ (*a*) (20.0 m) + (4.2 m) = 24.2 m (*b*) $(1.5 \times 10^{1}\ \text{cm})(8.0 \times 10^{2}\ \text{cm})(1.00\ \text{cm}) = 1.2 \times 10^{4}\ \text{cm}^3$

1.4 CALCULATIONS WITH METRIC QUANTITIES

1.44 What volume will 300 g of mercury occupy? Density of mercury is 13.6 g/cm^3.

▮

$$\text{Volume} = \frac{\text{mass}}{\text{density}} = \frac{300\ \text{g}}{13.6\ \text{g/cm}^3} = 22.1\ \text{cm}^3\ .$$

1.45 Find the density of ethyl alcohol if 80.0 mL weighs 63.3 g.

▮
$$\frac{63.3\text{ g}}{80.0\text{ mL}} = 0.791\text{ g/mL}$$

1.46 Find the volume of 40 kg of carbon tetrachloride, whose density is 1.60 g/cm³.

▮
$$(40\text{ kg})\left(\frac{10^3\text{ g}}{\text{kg}}\right)\left(\frac{1\text{ cm}^3}{1.60\text{ g}}\right)\left(\frac{1\text{ L}}{10^3\text{ cm}^3}\right) = 25\text{ L} \quad \text{or else} \quad (40\text{ kg})\left(\frac{1\text{ L}}{1.60\text{ kg}}\right) = 25\text{ L}$$

1.47 An important physical quantity has the value 1.987 cal or 0.08206 L·atm. What is the conversion factor from liter·atmospheres to calories?

▮
$$\frac{1.987\text{ cal}}{0.08206\text{ L}\cdot\text{atm}} = 24.21\text{ cal/L}\cdot\text{atm}$$

1.48 Calculate the density, in grams per cubic centimeter, of a body that weighs 420 g (has a mass of 420 g) and has a volume of 52 cm³.

▮
$$\text{Density} = \frac{\text{mass}}{\text{volume}} = \frac{420\text{ g}}{52\text{ cm}^3} \doteq 8.1\text{ g/cm}^3$$

1.49 Calculate the volume of 400 g of gold (density = 19.3 g/cm³).

▮
$$(400\text{ g})\left(\frac{1\text{ cm}^3}{19.3\text{ g}}\right) = 20.7\text{ cm}^3$$

1.50 The density of a metal is 9.50 g/cm³. Calculate the number of (*a*) kilograms per cubic meter (*b*) cubic centimeters per gram.

▮ (*a*)
$$\left(\frac{9.50\text{ g}}{\text{cm}^3}\right)\left(\frac{1\text{ kg}}{10^3\text{ g}}\right)\left(\frac{10^2\text{ cm}}{\text{m}}\right)^3 = \frac{9.50\times 10^3\text{ kg}}{\text{m}^3}$$
(*b*)
$$\frac{1\text{ cm}^3}{9.50\text{ g}} = 0.105\text{ cm}^3\text{/g}$$

1.51 Fool's gold is so called because it bears a visual similarity to real gold. A block of fool's gold which measures 1.50 cm by 2.50 cm by 3.00 cm has a mass of 56.25 g. How can this material be distinguished from real gold by means of its physical properties?

▮ It can be distinguished, among other ways, by its density, 5.00 g/cm³. (It would be extremely coincidental if the density of fool's gold were the same as that of real gold, 19.3 g/cm³.)

1.52 The density of platinum is 21.45 g/cm³. Calculate its density in kilograms per cubic meter.

▮
$$\left(\frac{21.45\text{ g}}{\text{cm}^3}\right)\left(\frac{1\text{ kg}}{1000\text{ g}}\right)\left(\frac{100\text{ cm}}{\text{m}}\right)^3 = \frac{21.45\times 10^3\text{ kg}}{\text{m}^3}$$

1.53 A block of platinum 6.00 cm long, 3.50 cm wide, and 4.00 cm thick has a mass of 1802 g. What is the density of platinum?

▮ The volume, V, of the block is determined by multiplying its length, l, times its width, w, times its thickness, t: $V = lwt = (6.00\text{ cm})(3.50\text{ cm})(4.00\text{ cm}) = 84.0\text{ cm}^3$. The density is the mass per unit volume:

$$d = \frac{m}{V} = \frac{1802\text{ g}}{84.0\text{ cm}^3} = 21.5\text{ g/cm}^3$$

1.54 What is the density of a steel ball which has a diameter of 7.50 mm and a mass of 1.765 g? [Volume of a sphere of radius r is $\frac{4}{3}\pi r^3$.]

▮
$$V = \left(\frac{4\pi}{3}\right)\left(\frac{7.50\text{ mm}}{2}\right)^3 = 221\text{ mm}^3$$
$$d = \frac{m}{V} = \frac{1.765\text{ g}}{221\text{ mm}^3} = \frac{1.765\times 10^{-3}\text{ kg}}{221\times 10^{-9}\text{ m}^3} = 7.99\times 10^3\text{ kg/m}^3$$

1.55 An alloy was machined into a flat disk, 31.5 mm in diameter and 4.5 mm thick, with a hole 7.5 mm in diameter drilled through the center. The disk weighed 20.2 g. What is the density of the alloy?

▮ The volume of the disk is

$$V = \pi r_1^2 h - \pi r_2^2 h = \pi h(r_1^2 - r_2^2)$$
$$= \pi(4.5\text{ mm})\left[\left(\frac{31.5}{2}\right)^2 \text{mm}^2 - \left(\frac{7.5}{2}\right)^2 \text{mm}^2\right] = 3308\text{ mm}^3 = 3.308\text{ cm}^3$$
$$d = \frac{m}{V} = \frac{20.2\text{ g}}{3.308\text{ cm}^3} = 6.11\text{ g/cm}^3 = 6110\text{ kg/m}^3$$

1.56 A glass vessel weighed 20.2376 g when empty and 20.3102 g when filled to an etched mark with water at 4 °C. The same vessel was then dried and filled to the same mark with a solution at 4 °C. The vessel was now found to weigh 20.3300 g. What is the density of the solution?

▮

$$\text{Mass of water} = (20.3102\text{ g}) - (20.2376\text{ g}) = 0.0726\text{ g}$$
$$\text{Mass of solution} = (20.3300\text{ g}) - (20.2376\text{ g}) = 0.0924\text{ g}$$

The density of water is 1.000 g/cm³ at 4 °C. Hence,

$$V = (0.0726\text{ g})\left(\frac{1\text{ cm}^3}{1.000\text{ g}}\right) = 0.0726\text{ cm}^3 \quad \text{and} \quad \text{density} = \frac{0.0924\text{ g}}{0.0726\text{ cm}^3} = 1.27\text{ g/cm}^3$$

1.57 A sample of concentrated sulfuric acid is 95.7% H_2SO_4 by weight and its density is 1.84 g/mL. **(a)** How many grams of pure H_2SO_4 are contained in 1.00 L of the acid? **(b)** How many milliliters of acid contains 100 g of pure H_2SO_4?

▮ **(a)** $(1.00\text{ L acid})\left(\frac{1.84\text{ kg acid}}{\text{L acid}}\right)\left(\frac{95.7\text{ kg } H_2SO_4}{100\text{ kg acid}}\right) = 1.76\text{ kg } H_2SO_4$

(b) $(100\text{ g } H_2SO_4)\left(\frac{100\text{ g acid}}{95.7\text{ g } H_2SO_4}\right)\left(\frac{1\text{ mL acid}}{1.84\text{ g acid}}\right) = 56.8\text{ mL acid}$

1.58 Analysis shows that 20.0 mL of concentrated hydrochloric acid of density 1.18 g/mL contains 8.36 g HCl. **(a)** Find the mass of HCl per milliliter of acid solution. **(b)** Find the percent by weight (mass) of HCl in the concentrated acid.

▮ **(a)** $\frac{8.36\text{ g HCl}}{20.0\text{ mL}} = 0.418\text{ g/mL}$ **(b)** $\frac{8.36\text{ g HCl}}{(20.0\text{ mL})(1.18\text{ g/mL})} \times 100\% = 35.4\%\text{ HCl}$

1.59 A piece of gold leaf (density 19.3 g/cm³) weighing 1.93 mg can be beaten further into a transparent film covering an area of 14.5 cm². **(a)** What is the volume of 1.93 mg of gold? **(b)** What is the average thickness of the transparent film, in angstroms?

▮ **(a)** $(1.93\text{ mg})\left(\frac{1\text{ g}}{10^3\text{ mg}}\right)\left(\frac{1\text{ cm}^3}{19.3\text{ g}}\right) = 1.00 \times 10^{-4}\text{ cm}^3$

(b) $\frac{1.00 \times 10^{-4}\text{ cm}^3}{14.5\text{ cm}^2} = (6.90 \times 10^{-6}\text{ cm})\left(\frac{1\text{ Å}}{10^{-8}\text{ cm}}\right) = 690\text{ Å}$

1.60 A piece of capillary tubing was calibrated in the following manner. A clean sample of the tubing weighed 3.247 g. A thread of mercury, drawn into the tube, occupied a length of 23.75 mm, as observed under a microscope. The weight of the tube with the mercury was 3.489 g. The density of mercury is 13.60 g/cm³. Assuming that the capillary bore is a uniform cylinder, find the diameter of the bore.

▮

$$m = 3.489\text{ g} - 3.247\text{ g} = 0.242\text{ g}$$
$$V = (0.242\text{ g})\left(\frac{1\text{ cm}^3}{13.60\text{ g}}\right) = 0.0178\text{ cm}^3$$
$$A = \frac{V}{l} = \frac{0.0178\text{ cm}^3}{2.375\text{ cm}} = 0.00749\text{ cm}^2 = \pi d^2/4$$
$$d = \sqrt{\frac{4(0.00749\text{ cm}^2)}{3.14159}} = 0.0976\text{ cm}$$

1.61 The General Sherman tree, located in Sequoia National Park, is believed to be the most massive of living things. If the overall density of the tree trunk is assumed to be 850 kg/m^3, calculate the mass of the trunk by assuming that it may be approximated by two right conical frustra having lower and upper diameters of 11.2 and 5.6 m, and 5.6 and 3.3 m, respectively, and respective heights of 2.4 and 80.6 m (see Fig. 1-1). A frustrum is a portion of a cone bounded by two planes, both perpendicular to the axis of the cone. The volume of a frustrum is given by $\pi h(r_1^2 + r_2^2 + r_1 r_2)/3$, where h is the height and r_1 and r_2 are the radii of the cone at the bounding planes.

▮

$$V_1 = \tfrac{1}{3}\pi(80.6\text{ m})[1.65^2 + 2.8^2 + (1.65)(2.8)] = 1281\text{ m}^3$$

$$V_2 = \tfrac{1}{3}\pi(2.4\text{ m})[5.6^2 + 2.8^2 + (5.6)(2.8)] = 138\text{ m}^3$$

So $V = 1419\text{ m}^3$ and $m = (1419\text{ m}^3)\left(\dfrac{850\text{ kg}}{\text{m}^3}\right) = 1.21 \times 10^6\text{ kg} = 1.21 \times 10^3$ metric tons

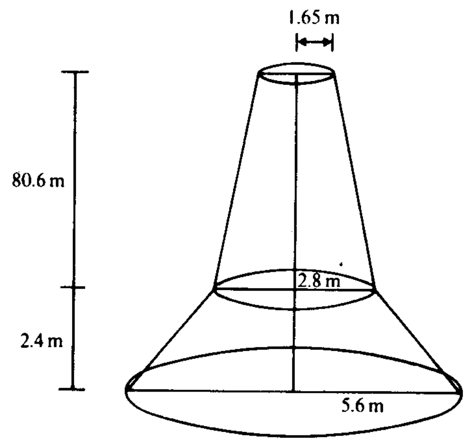

Fig. 1.1

1.62 Calculate the percent sodium in a breakfast cereal which is advertised to contain 110 mg of sodium per 100 g of cereal.

▮

$$\frac{110 \times 10^{-3}\text{ g Na}}{100\text{ g total}} \times 100\% = 0.110\%\text{ Na}$$

1.63 (*a*) Calculate the mass of pure HNO_3 per mL of the concentrated acid which assays 69.8% by weight HNO_3 and has a density of 1.42 g/mL. (*b*) Calculate the mass of pure HNO_3 in 60.0 mL of concentrated acid. (*c*) What volume of the concentrated acid contains 63.0 g of pure HNO_3?

▮ (*a*) 1.00 mL of acid has a mass of 1.42 g. Since 69.8% of the total mass of the acid is pure HNO_3, then the number of grams of HNO_3 in 1.00 mL of acid is $0.698 \times 1.42\text{ g} = 0.991\text{ g}$. (*b*) Mass of HNO_3 in 60.0 mL of acid = $60.0\text{ mL} \times 0.991\text{ g/mL} = 59.5\text{ g } HNO_3$. (*c*) 63.0 g HNO_3 is contained in

$$\frac{63.0\text{ g}}{0.991\text{ g/mL}} = 63.6\text{ mL acid}$$

1.64 The density of gold is 19.3 g/cm^3. Calculate the diameter of a solid gold sphere having a mass of 422 g.

▮ The result sought is a diameter, D, in centimeters. The data are a mass of gold (in grams), its density, d (in grams per cubic centimeter), and the shape of the object (spherical). The radius, r, of a sphere is related to its volume, V, by $r = \sqrt[3]{3V/4\pi}$, and the volume of this sphere is 422 g/(19.3 g/cm^3). Thus

$$D = 2r = 2\sqrt[3]{\frac{3(422\text{ g})}{4\pi(19.3\text{ g/cm}^3)}} = 3.47\text{ cm}$$

1.65 The density of aluminum is 2.70 g/cm^3. An irregularly shaped piece of aluminum weighing 40.0 g is added to a 100-mL graduated cylinder containing exactly 50.0 mL of water. To what height in the cylinder will the water level rise?