English for Electrical Engineers

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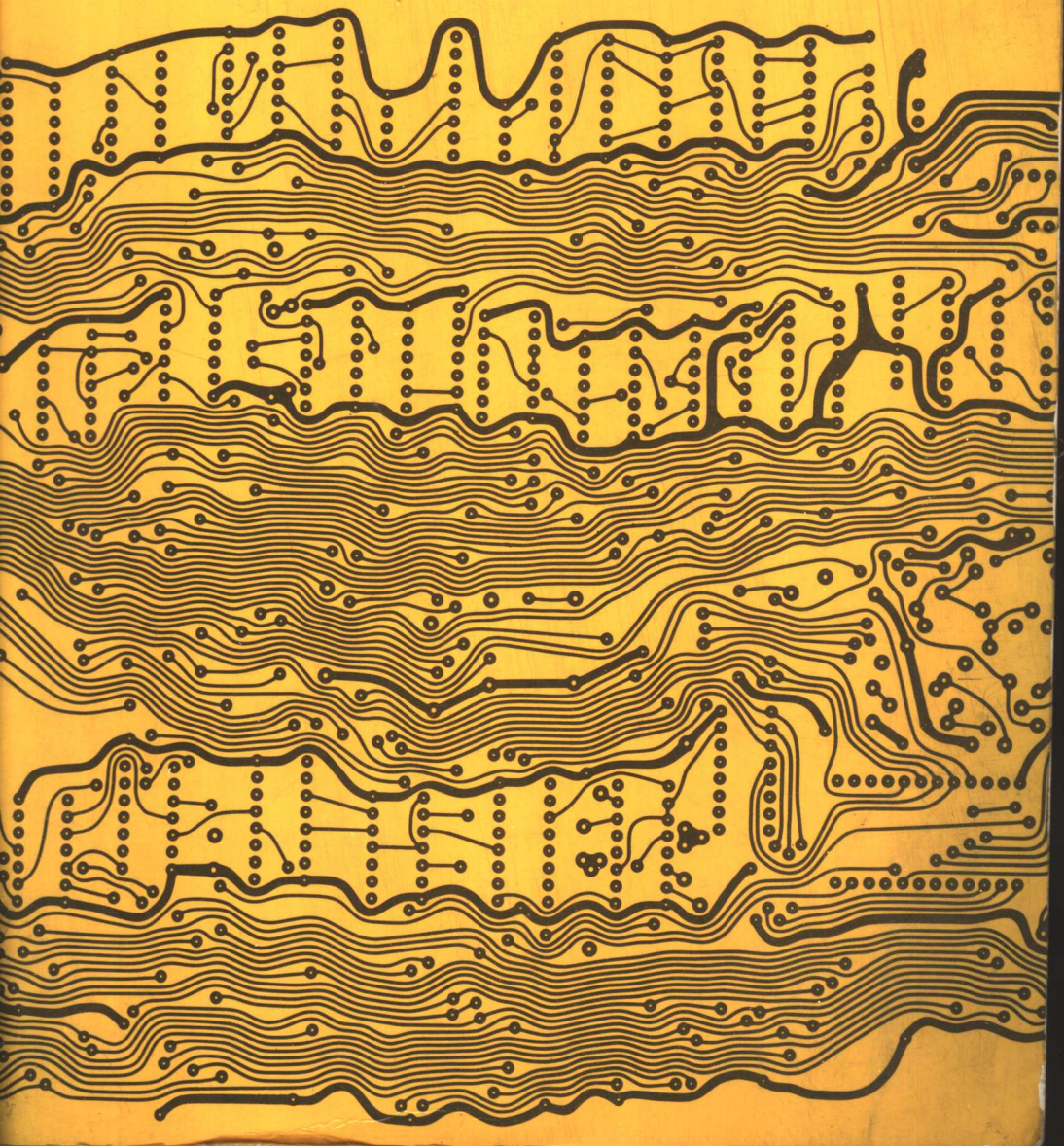

English for Electrical Engineers

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JMcA and GM

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Introduction

1 Purpose of this book

1.1 This book does two things. On the one hand, it gives an outline of electrical engineering and electronics, in English that is fairly simple at first but becomes more difficult. At the same time, it is an intermediate course in the English that electrical engineers will need.

1.2 The aim of this book is to help the non-English speaking student of electrical engineering to improve his knowledge of the English that he needs for his work. It will help him to read and understand English better, so that he can use technical books in English; and it will help him to write in English about electrical engineering.

2 Students who can use this book

2.1 The book can be used by students who have only a little knowledge of English, learnt over perhaps two or three years of part-time study.

2.2 It can be used in class with a teacher, and also by students who are working alone. The answers to all exercises and problems are included. (A dictionary is necessary, however; see 3.2.2 below.)

2.3 The book will be useful to students of electrical engineering and electronics in a university, polytechnic or professional (trade) school. It can also be used by qualified engineers and technicians who need to improve their understanding of the technical English that they meet in publications and at conferences.

3 The material in this book

3.1.1 The *technical* material can be used with a technical course (in the student's own language) that lasts for about two or three years. Each chapter in this book has enough technical material for between 4 and 6 hours' study.

3.1.2 The book has two parts. Part One deals with the most important topics of electrical engineering, and has 14 lessons. Part Two is on electronics; it has 10 lessons on many different topics, including basic circuit elements, television and digital computers.

3.2.1 The *linguistic* material in the first lessons is mainly on the correct forms of words. Later sections show how words are used in sentences, particularly 'logical links' – the connecting words that show the logical structure of a passage. The pronunciation of words and phrases is shown where there may be difficulties.

3.2.2 There are notes on difficult points, including vocabulary. But dictionaries are necessary for less difficult words that a student nevertheless may not know.

Every student should have an English dictionary, such as the *Oxford Advanced Learner's Dictionary of Current English* (OUP). A student who is working alone may also need a dictionary in English and his own language.

3.3.1 Each chapter begins with a reading passage that deals with one aspect of electrical or electronic theory, followed by notes and comprehension questions on the passage. The language work follows: it consists of notes on particular points of grammar, with exercises on those points and on other features (such as logical links) that are practised throughout the book. At the end of the chapter there is a summary of the reading passage, followed by the answers to the comprehension questions and language exercises.

3.3.2 In the first chapters, the reading passages have very short lines. Each grammatical part of a sentence comes on a new line. This helps the student to understand the structure of the sentence. Up to Chapter 10, the lines slowly become longer, with more sentence parts on each line. From Chapter 11, the material is presented in the ordinary way.

3.3.3 The summary of the passage can be used for revision of the technical content of the chapter, and (with a teacher) for language practice as dictation or pronunciation material.

4 How the book should be used

4.1 The technical material is complete in each lesson, and in most lessons the linguistic material is also complete; so it is not absolutely necessary to study the lessons in the order that they have in this book. However, both the technical and the linguistic topics move logically from one lesson to the next, so it is best to follow the book's order if possible.

4.2 *If you are using this book without a teacher*, you should work in the following way:

Stage 1

Read the summary of the chapter (at the end, before the answers to the exercises). Use a 'bilingual' dictionary (that is, one that gives the meaning of English words in your language) for any words that you do not understand.

Stage 2

Read the reading passage once, quickly. This will give you some idea of what it contains. Then read it again, slowly and carefully. Read the notes as you do this. (Where a word in the notes is shown with a phonetic transcription, practise saying it aloud several times by reading the transcription. See paragraph 5.3 for the symbols used.)

Stage 3

Do the comprehension exercise and check your answers. Read the note after the answers. If your score is good enough, go on to stage 4; if not, do all (or part) of stages 2 and 3 again.

Stage 4

Study the language notes in the chapter that you are working on, and do the exercises that follow. Then stop: you should not do stage 5 in the same study period as stage 4.

Stage 5

(Do not do this on the same day as stage 4.) Repeat the language exercises that you

did in stage 4, then check your answers. If your score is below 80 per cent, study again the passage or the note on the language point that the exercise deals with. (This may be in an earlier chapter, as some language exercises are for revision.) Then do the exercises again before you go on to stage 6.

Stage 6

Read the summary at the end of the chapter again, and make sure that you understand all of it.

Stage 7

Go back to the chapter *before* the one that you have just finished. Read the reading passage once, then write your own summary of it in English. Compare your summary with the summary in the book, and if possible show it to someone who knows English well.

4.3 *If you are working with a teacher of English*, section 4.2 will help you to plan your home study. For the teacher himself, section 4.2 will serve as a guide to the use of the book – though the procedure can of course be varied to suit individual needs.

5 Pronunciation

5.1 The pronunciation that we represent is Received Pronunciation, or 'RP'. This accent is common among educated speakers in England, although not in most other parts of Britain.

5.2 The table shows the symbols that we use. The consonant symbols are the same as those in most British books. For the vowels, we use a new system. This will be used in the new *Dictionary of Contemporary English* (Longman), and a very similar system will be used in the fully revised edition of the *English Pronouncing Dictionary* (Dent).

We show this system in the first column of the vowels list. In the second column, for comparison, we show the symbols used in the *Concise Pronouncing Dictionary of British and American English* by J. Windsor Lewis (OUP); this system is also used in the new (3rd) edition of the *Oxford Advanced Learner's Dictionary of Current English* (OUP). In the third column, we show the older system that is used, for example, in the current edition of the *English Pronouncing Dictionary*.

5.3 In RP, final [r] is pronounced when the next word begins with a vowel sound, but not otherwise. To show this, a small [ʳ] is printed *above* the ordinary line.

For example:

far [fɑːʳ]

This means that a phrase like *far down* is pronounced [ˌfɑː ˈdaʊn] while *far away* would be [ˌfɑːr əˈweɪ].

5.4 The sounds [m, n, ŋ, l, r] can be *syllabic* – that is, they can form a syllable without a vowel sound. For example, *travel* may be pronounced as either [ˈtrævl] or [ˈtrævəl]; in the former, the second syllable has [l] as a *syllabic consonant* without a vowel sound. We show this by printing the vowel in italic, [*ə*]. For example:

travel [ˈtræv*ə*l] *memory* [ˈmem*ə*rɪ]

This means that the consonant following may either be syllabic or have the vowel [ə] before it. In the case of *memory*, with a vowel after the consonant, the two-syllable pronunciation [ˈmemrɪ] is also possible. Pronunciations with a syllabic

consonant are recommended, but where this is difficult the other pronunciations may be used.

5.5 The mark [ˈ] is placed before the syllable that has *main stress* in a word, and [ˌ] comes before a syllable with *secondary stress*. For example:

understand [ˌʌndəˈstænd]

5.6 Consonants are made in many different ways. Some of these differences are important because they decide which endings should be added to nouns and verbs in speech, and we shall study this in the language lessons. However, we should mention here that the VOCAL CORDS vibrate when some consonants are made but they do not vibrate for others. Consonants that are made with vibration are called *voiced*, and those without vibration are *voiceless*. The voiceless consonants are:

p t k f θ s ʃ tʃ h

All the other consonants, and all the vowels, are voiced. We shall mention this difference several times.

Consonants		**Vowels**				
Symbol	*Key Word*	*Number*	*This Book*	*Concise Pronouncing Dictionary*	*English Pronouncing Dictionary (13th edition)*	*Key Word*
p	**p**ea	1	iː	i	iː	sheep
b	**b**ay	2	ɪ	ɪ	i	ship
t	**t**ea	3	e	e	e	bed
d	**d**ay	4	æ	æ	æ	bad
k	**k**ey	5	ɑː	ɑ	ɑː	calm
g	**g**ay	6	ɒ	o	ɔ	pot
		7	ɔː	ɔ	ɔː	caught
tʃ	**ch**eer	8	ʊ	ʊ	u	put
dʒ	**j**ump	9	uː	u	uː	boot
		10	ʌ	ʌ	ʌ	cut
f	**f**ew	11	ɜː	ɜ	əː	bird
v	**v**iew	12	ə	ə	ə	cupboard
θ	**th**ing					
ð	**th**en	13	eɪ	eɪ	ei	make
s	**s**oon	14	əʊ	əʊ	əu	note
z	**z**oo	15	aɪ	ɑɪ	ai	bite
ʃ	**sh**ing	16	aʊ	ɑʊ	au	now
ʒ	plea**s**ure	17	ɔɪ	ɔɪ	ɔi	boy
h	**h**ot	18	ɪə	ɪə	iə	here
		19	eə	eə	ɛə	there
m	**m**um	20	ʊə	ʊə	uə	poor
n	**n**un					
ŋ	sung	—	eɪə	eɪə	eiə	player
		—	əʊə	əʊə	əuə	lower
l	**l**et	—	aɪə	ɑɪə	aiə	tire
r	**r**ed	—	aʊə	ɑʊə	auə	tower
		—	ɔɪə	ɔɪə	ɔiə	employer
j	**y**et					
w	**w**et					

6 Other symbols and abbreviations

The other symbols, not used for pronunciation, and abbreviations are used according to *British Standard 1991: Part 1* (1967) and the *List of Symbols and Abbreviations* published by the Institution of Electrical Engineers. This information is also contained in *SI units in electricity and magnetism*, HMSO, London.

7 Cross-references

Many notes contain references to other notes in the book. A single number refers to a line in the same chapter; two numbers with a dot between them refer first to another chapter and then to a line in that chapter. For example:

(16) means 'look at line 16 in this chapter';

(2.28) means 'look at Chapter 2, line 28';

(6.184 and note) means 'look at chapter 6, line 184, and at the note for that line'.

Contents

Part One – Electrical Engineering

Chapter 1

Electrostatic forces and the structure of matter

Before beginning this chapter, read carefully section 4.2 of the Introduction

In 1785
Coulomb
carried out
a series
of experiments
on small charged bodies.
He observed
that two spheres,
each with an electric charge,
attract each other
when the two charges
are of opposite sign,
and repel each other
when the charges
are of the same sign.
Coulomb measured
the amount
of these forces
– called *electrostatic forces* –
and he proposed
the law
now known as
Coulomb's law.
This states
that the force
acting
between two charged bodies
in air
is proportional
to the product
of the charges,
and inversely proportional
to the square
of the distance
between them.

A knowledge
of the properties
of electrostatic forces
is fundamental
when we begin
to study
the problems
of electricity,
and we cannot introduce
the subject
without considering
the structure
of matter.
In fact,
to explain
macroscopic electrical phenomena
and their origin,
we must examine
the arrangement,
electric charge,
mass,
motion
and energy
of the smallest particles
of matter.
The *atom*

is the smallest amount
of a chemical element.
The theory
of atomic structure
is still
in evolution,
but to interpret
electrical phenomena
we can refer to
the model
described
by Bohr
and Rutherford.
This model
is only
an approximate one,
but it is easy
to understand.
It represents
an atom
as a loose structure
of electrons
which surrounds
a heavy core
– the *nucleus*.
The nucleus
is composed of
particles
with a positive charge
called *protons*,
and other particles
of about the same mass
but with no resultant electric charge.
These are called
neutrons.
The nucleus
and the electrons
are arranged
in the atom
like a very small planetary system.
The electrons
revolve
around the nucleus
in fixed orbits.
The nucleus
has a positive electric charge
that is always
a multiple
of the negative electric charge
of the electron.
This means
that the charge
of a proton
is numerically equal
to the charge
of an electron.

Almost all
the mass
of an atom
is in the nucleus.
In fact,
the mass
of the proton
is 1,836 times
the mass
of the electron.
Since the neutron
has no resultant electric charge,
it exerts
no electrostatic force
on either protons
or electrons.
There is,
however,
a very strong mechanical force
exerted
by the neutrons
on the protons
in an atom,
because of
the extremely short distances
between them.
This mechanical force
is so strong
that a chemical reaction
can never change
the number
of protons
in an atom.

In fact,

we need
an electrical apparatus
of the power
of a cyclotron
to overcome
this force.

Normally,
atoms are
electrically neutral systems
because
the number
of their electrons
is equal
to the number
of protons
in the nucleus.
Under particular conditions,
however,
an atom
can lose
one, two, three or four electrons,
and then
the system
has a positive electric charge
respectively equal to
one, two, three or four times
the electron charge.
In this case
we call it
a *positive ion*
or *cation*
and we say
it is
monovalent, bivalent,
trivalent or tetravalent
according to
the number
of electrons
it has lost.
In the same way,
if one
or more
electrons
are added
to a neutral atom,
then this acquires
a negative charge
equal to
one or more times
the electron charge.
Then
we call it
a *negative ion*
or *anion*.

The property
of different atoms
to lose
or acquire
electrons
depends on
the arrangement
of the electrons
in their orbits,
according to
the theories
of Sommerfeld and Pauli.
Different amounts
of energy
are necessary
to remove
an electron
from an atom,
according to
the orbital arrangement
of the electrons
in the atom.
We call
this energy
ionization energy.
For example,
the rare gases
are chemically very inert
and this shows
they have
very stable atomic structures.
This stability
is also shown
by the fact
that the ionization energy
is greater

for the rare gases
than for other elements.
On the other hand,
the ionization energy
of the halogen elements
is small.
If we have anions
and cations
together,
they attract
neighbouring ions
of opposite sign
because of
the electrostatic forces
among them.
We call
the force
of attraction
between ions
of opposite charge
the *ionic valence force*.
When these ions
unite
because of
these electrostatic forces,
they form
electrically neutral molecules.

A molecule
is the smallest particle
of any substance
which still has
the original chemical properties
of the substance.
Therefore,
a molecule
consists of
one or more atoms;
for example,
molecules of helium,
neon and argon
contain one atom each
and are therefore called
monatomic molecules.
Molecules of hydrogen,
oxygen and nitrogen
consist of
two atoms each
and are therefore called
diatomic.
A molecule
can also be
a group of atoms
of different elements,
for example
sulphuric acid (H_2SO_4).

Notes

Line		
2	*Coulomb* [ˈkuːlɒm]	Charles-Augustin de Coulomb (1736–1806), French scientist.
4	*series* [ˈsɪəriːz]	A set of things coming one after another. (Note that this word is the same in both singular and plural ('one series' and 'two series'): 'A series of experiments *was* carried out' and 'Two series of experiments *were* carried out'.)
6	*charged body*	Something that has an electric *charge* (9).
8	*sphere* [sfɪəʳ]	Body shaped like a ball.
9	*electric* [ɪˈlektrɪk]	Worked by, or using, electricity. (Note that *electricity* [ˌɪlekˈtrɪsətɪ] has two adjectives, *electric* and *electrical*; the second often means 'connected with the study of electricity'. So an '*electric* light' is a light that works by electricity, but '*electrical* engineering' is the part of engineering in which electricity is studied. We say '*electrical* phenomena' (51) and '*electrical* apparatus' (153), but '*electric* charge' as on this line.)
9	*charge* [tʃɑːdʒ]	Electricity on a body.

10	*attract each other*	The first sphere attracts the second and the second sphere also attracts the first.
12	*opposite* [ˈɒpəzɪt] *sign*	Not the same sign; one *positive* [ˈpɒzətɪv] (+) and the other *negative* [ˈnegətɪv] (−).
13	*repel* [rɪˈpel]	Push away. The opposite is *attract* (10).
15	*the same sign*	Both positive (+) or both negative (−) (compare 12).
18	*force* [fɔːs]	Capacity to *attract* (10) or *repel* (13).
19	*electrostatic* [ɪlektrəʊˈstætɪk]	Concerning electric charges.
21	*law* [lɔː]	(here) A generalization about related facts.
29	*proportional* [prəˈpɔːʃənəl]	Corresponding in size or amount (see also 32).
30	*product* [ˈprɒdʌkt]	(in mathematics) The result when two quantities are multiplied; for example the *product* of 2×4 is 8, and the *product* of $a \times a$ is a^2.
32	*inversely* [ɪnˈvɜːslɪ] *proportional*	When one quantity becomes smaller as the other becomes greater.
33	*square* [skweəʳ]	(here) As in 'The *square* of 3 is 9 ($3^2 = 9$)'; see Language notes, 'Operations'.
37	*property* [ˈprɒpətɪ]	What something can do; quality or characteristic.
39	*fundamental* [ˌfʌndəˈmentl]	Basic; coming before anything else.
47	*structure* [ˈstrʌktʃəʳ]	The way parts are joined together.
48	*matter* [ˈmætəʳ]	That of which all things are made.
51	*macroscopic* [ˌmækrəʊˈskɒpɪk]	As seen without a microscope (compare *microscopic* [ˌmaɪkrəʊˈskɒpɪk], so small that a microscope is needed).
	phenomena [fɪˈnɒmɪnə]	Things whose cause is not clear. (Note singular *phenomenon* [fɪˈnɒmɪnən] US [fəˈnɒmənɒn]: 'a phenomenon' but 'two phenomena'.)
54–58	*arrangement . . . and energy*	This is a list; note how it is written, especially *and* with no comma before the last word.
59	*particle* [ˈpɑːtɪkəl]	A very small part.
63	*element* [ˈelɪmənt]	The simplest form of a substance; an *element* cannot be separated into simpler substances by ordinary chemical means.
66	*still* [stɪl]	Even at present – in the past and now. Do not confuse *still* and *always* (compare line 108): 'The theory is *still* in evolution' – it is not perfect yet; 'Thermionic valves are *still* used' – we have not stopped using them; 'The law is *always* called Coulomb's law' – we do not call it anything else; 'Thermionic valves are always used in this circuit' – we cannot use anything else. (Note: the opposite of *always* is *never*, and the opposite of *still* is *no longer*).
67	*evolution* [ˌiːvəˈluːʃən]	Development.
68	*interpret* [ɪnˈtɜːprɪt]	(here) Explain.
73	Niels *Bohr* [bəʊəʳ]	Danish physicist (1885–1962), winner of Nobel Prize 1922.
74	Lord Ernest *Rutherford* [ˈrʌðəfəd] (1871–1937)	British physicist, winner of Nobel Prize 1908.
77	*approximate* [əˈprɒksɪmət]	Near; not exact.
	one [wʌn]	Refers back to 'model' in line 75: 'This model is only an approximate *model*'.
86	*nucleus* [ˈnjuːklɪəs]	Note plural *nuclei* [ˈnjuːklɪ-aɪ] (one *nucleus*, two or more *nuclei*).

88	*composed (of)*	Made up (of).
94	*no resultant electric charge*	With the positive and negative charges of the same size so that no charge can be observed from outside.
96	*neutron* [ˈnjuːtrɒn]	Note spelling *neutron*; the word comes from *neutral* (line 160), not *nucleus*.
101	*planetary system* [ˈplænɪtrɪ ˌsɪstəm]	An arrangement like that of the *planets* (Earth, Mars, Venus etc.) round the Sun.
105	*orbit* [ˈɔːbɪt]	The path of a planet round the Sun, or electrons round the nucleus.
109	*multiple* [ˈmʌltɪpəl]	A number that contains another number an exact number of times (for example 4 is a multiple of 2 ($2 \times 2 = 4$), 12 is a multiple of 2, 3, 4 or 6).
130–2	*exert* [ɪgˈzɜːt] *no force on . . .*	Have no effect on.
132–3	*on either protons or electrons*	'On protons or on electrons'; note the form *either . . . or* for relating two things.
146	*chemical reaction*	The result of two or more substances coming together and producing a change.
153	*apparatus* [ˌæpəˈreɪtəs]	*Either* a piece of equipment (Countable noun) *or* equipment in general (Uncountable noun) – note that this word can be used in these two ways: 'It's a very heavy *apparatus*' (Countable, one thing); 'We've some new *apparatus*' (Uncountable, perhaps many single things).
154–5	*of the power of a cyclotron*	'That has as much power as a cyclotron.'
155	*cyclotron* [ˈsaɪklətrɒn]	An *accelerator* (an apparatus that makes the particles *accelerate* – go faster and faster) that gives energies of several million electron-volts to atomic-sized particles. (An *electron-volt* (eV) is a unit to describe the energy of a moving electron. For example, if one plate is 1,000 volts higher in potential than another and an electron is pulled from the second to the first, its energy when it reaches the first plate will be 1,000 electron-volts.)
160	*electrically neutral*	With no charge – not positive (+) or negative (−).
181	*ion* [aɪən]	An atom, group of atoms or a molecule that lacks its full number of electrons (positive) or has too many electrons (negative).
182	*cation* [ˈkætaɪən]	Positive ion.
185–6	*monovalent* [ˈmɒnəʊveɪlənt], also [-vælənt] in US	An ion that has lost one electron; *mono-* = 1. So also *bivalent* [ˈbaɪveɪlənt], *trivalent* [ˈtraɪveɪlənt] and *tetravalent* [ˈtetrəveɪlənt]: *bi-* = 2, *tri-* = 3, *tetra-* = 4.
187–9	*according to the number of electrons . . .*	'Depending on how many electrons . . .' (compare 215–6: *according to the theories*, 'as the theories state').
197	*acquire* [əˈkwaɪəʳ]	Obtain, get.
205	*anion* [ˈænaɪən]	Negative ion (see note to 181).
215–6	*according to the theories*	See note to 187–9.
217	Arnold *Sommerfeld* [ˈzɒməfelt] (1868–1951)	German physicist, winner of Nobel Prize 1924.
	Wolfgang *Pauli* [ˈvɒlfgæŋ ˈpaʊlɪ] (1900–1958)	Austrian atomic physicist, winner of Nobel Prize 1945.
230	*ionization energy* [ˌaɪənaɪˈzeɪʃən ˌenədʒɪ]	(Explained in lines 218–227.)
232	*the rare* [reəʳ] *gases*	Helium, neon, argon, krypton and radon.

233	*chemically inert* [ɪˈnɜːt]	Not reacting chemically with other things (these 'inert gases' do not easily form any chemical compounds).
236	*stable* [ˈsteɪbəl]	Not easily changed.
237	*stability* [stəˈbɪlətɪ]	(noun) Being stable.
244	*on the other hand*	'In contrast'; 'by comparison'.
246	*the halogen* [ˈhæləʊdʒən] *elements*	Fluorine, chlorine, bromine, iodine and astatine.
252	*neighbouring* [ˈneɪbərɪŋ] *ions*	Ions that are in the same general position, close to each other (spelt *neighboring* in America).
254	*because of*	Due to; owing to.
257–62	*We call . . . ionic valence* [aɪˌɒnɪk ˈveɪləns] (also [ˈvæləns] in US) *force*	This name is given to the force by which ions of opposite charge attract each other.
264	*unite* [juːˈnaɪt]	Come together to make a single molecule.
271	*substance* [ˈsʌbstəns]	Element or compound.
277	*consist* [kənˈsɪst] *(of)*	Be made (of); see also *be composed of* (88).
284	*monatomic* [mɒnəˈtɒmɪk]	Having one atom (see 185–6 note for *mono-*).
290	*diatomic* [daɪəˈtɒmɪk]	Having two atoms (see 185–6 note for *di-*).
293–4	*a group of atoms of different elements*	This is a short way of saying 'a group of atoms *that consist* of different elements'.
296	*sulphuric acid* [sʌlˈfjʊərɪk ˈæsɪd]	(H_2SO_4) (US *sulfuric*)

Comprehension

Read section 4.2 of the Introduction before beginning this exercise.

Complete the following statements by choosing *a*, *b* or *c* from the three suggested possibilities. The correct answers are on page 14.

1 The molecule of an element is:
   a one atom or a group of atoms.
   b a group of ions.
   c a group of electrons.
2 The nucleus of an atom is composed of:
   a neutrons, electrons and protons.
   b protons and electrons.
   c neutrons and protons.
3 The force acting between two charged bodies in air is:
   a proportional to the product of the charges.
   b inversely proportional to the product of the charges.
   c proportional to the square of the charges.
4 The mass of an electron is:
   a smaller than the mass of a proton.
   b greater than the mass of a proton.
   c the same as the mass of a proton.
5 A cation is an atom which has:
   a lost one, two, three or four electrons.