

Pearson BTEC Levels 4 and 5 Higher Nationals in Engineering (RQF)

Unit 3: Engineering Science (core)

Unit Workbook 3

in a series of 4 for this unit

Learning Outcome 3

Engineering Materials

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Sample

INTRODUCTION

Explore the characteristics and properties of engineering materials

- **Material properties:**
 - Atomic structure of materials and the structure of metals, plastics and composites.
 - Mechanical and electromagnetic properties of materials.
- **Material failure:**
 - Destructive and non-destructive testing of materials.
 - The effects of gradual and impact loading on a material.
 - Degradation of materials and hysteresis.

GUIDANCE

This document is prepared to break the unit material down into bite size chunks. You will see the learning outcomes above treated in their own sections. Therein you will encounter the following structures;

Purpose

Explains *why* you need to study the current section of material. Quite often learners are put off by material which does not initially seem to be relevant to a topic or profession. Once you understand the importance of new learning or theory you will embrace the concepts more readily.

Theory

Conveys new material to you in a straightforward fashion. To support the treatments in this section you are strongly advised to follow the given hyperlinks, which may be useful documents or applications on the web.

Example

The examples/worked examples are presented in a knowledge-building order. Make sure you follow them all through. If you are feeling confident then you might like to treat an example as a question, in which case cover it up and have a go yourself. Many of the examples given resemble assignment questions which will come your way, so follow them through diligently.

Question

Questions should not be avoided if you are determined to learn. Please do take the time to tackle each of the given questions, in the order in which they are presented. The order is important, as further knowledge and confidence is built upon previous knowledge and confidence. As an Online Learner it is important that the answers to questions are immediately available to you. Contact your Unit Tutor if you need help.

Challenge

You can really cement your new knowledge by undertaking the challenges. A challenge could be to download software and perform an exercise. An alternative challenge might involve a practical activity or other form of research.

Video

Videos on the web can be very useful supplements to your distance learning efforts. Wherever an online video(s) will help you then it will be hyperlinked at the appropriate point.

3.1 Background

The behaviour of materials is based around Chemistry, the way they bond with each other is how the structure, strength and properties are determined. Taking these into consideration is how we develop the practical applications of the material, and the most appropriate method of manufacturing.

3.1.1 The Periodic Table of Elements

Developed by the famous Russian scientist Dmitri Mendeleev in 1869. The periodic table of elements is the system used to categorise the elements into their atomic weight and their “groups”. Table.3.1 shows the current periodic table of elements.

Table.3.1: Periodic Table of Elements

Group	1	2											3	4	5	6	7	8							
Period																									
1	1 H																								2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne							
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar							
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Co	27 Fe	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr							
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe							
6	55 Cs	56 Ba	57-71 Lanthanides	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn							
7	87 Fr	88 Ra	89-103 Actinides	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn													

Lanthanides	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Actinides	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Key

Atomic No.	1	X	X	X	X										
Symbol	H	Synthetic	Liquid	Solid	Gas										
Alkali Metals	Earth Metals	Transition Metals	Other Metals	Metalloids	Other Non-Metals	Halogens	Noble Gases	Lanthanides & Actinides							

As you can see, this is a substantial table with a lot of information in it, but you will find that elements in the same group will exhibit similar properties.

3.1.2 The Atom

The atom can be split into three distinct parts, the proton, neutron and electron. The protons and neutrons form the nucleus of the atom, while the electrons fly around the outside of the nucleus. A diagram of a Helium atom can be seen in Fig.3.1.

Proton: The number of protons is shown by the Atomic number in the periodic table. This number is the defining characteristic of an element. You cannot have a Hydrogen atom with two protons, that would make it a Helium atom. Since the protons are positive, they are electronically repellent, and so to keep an atom stable, neutrons are required.

Neutron: The neutron is a constituent part of the atom that uses the “residual strong force” to overcome the repelling electronic forces and keep the nucleus together.

Electron: Electrons keep the charge of an atom at zero, but they are also very important when it comes to chemical reaction and bonding.

Table.3.2 shows some of the characteristics of the constituent parts of the atom.

Table.3.2: Constituent atomic parts

	Proton	Neutron	Electron
Mass	$1.673 \cdot 10^{-27}$ kg	$1.675 \cdot 10^{-27}$ kg	$9.11 \cdot 10^{-31}$ kg
Relative charge	+1	0	-1

3.1.3 The Electron

As mentioned, electrons orbit the nucleus, but not in a simple or random fashion. In fact, they orbit the nucleus in distinct groups, known as shells. Each shell can have a maximum number of electrons within it, determined by the principles of quantum physics, as follows;

Table.3.3: Atomic shells and subshells with maximum electron occupancy

Shell (known by a number)	Max. Electrons
1	2
2	8
3	18
4	32
5	50

Subshell (known by a letter)	Max. Electrons
s	2
p	6
d	10
f	14

The electrons are the determining factor between the groups, looking at Fig.3.1, it is clear that there are four electrons on the outer shell, and they are both in Group 4 in the periodic table, they also show similar properties (can conduct electricity in certain configurations, high melting points, etc.). The same applies for the other groups, all the noble gases are unreactive, while the alkali metals are very unstable.

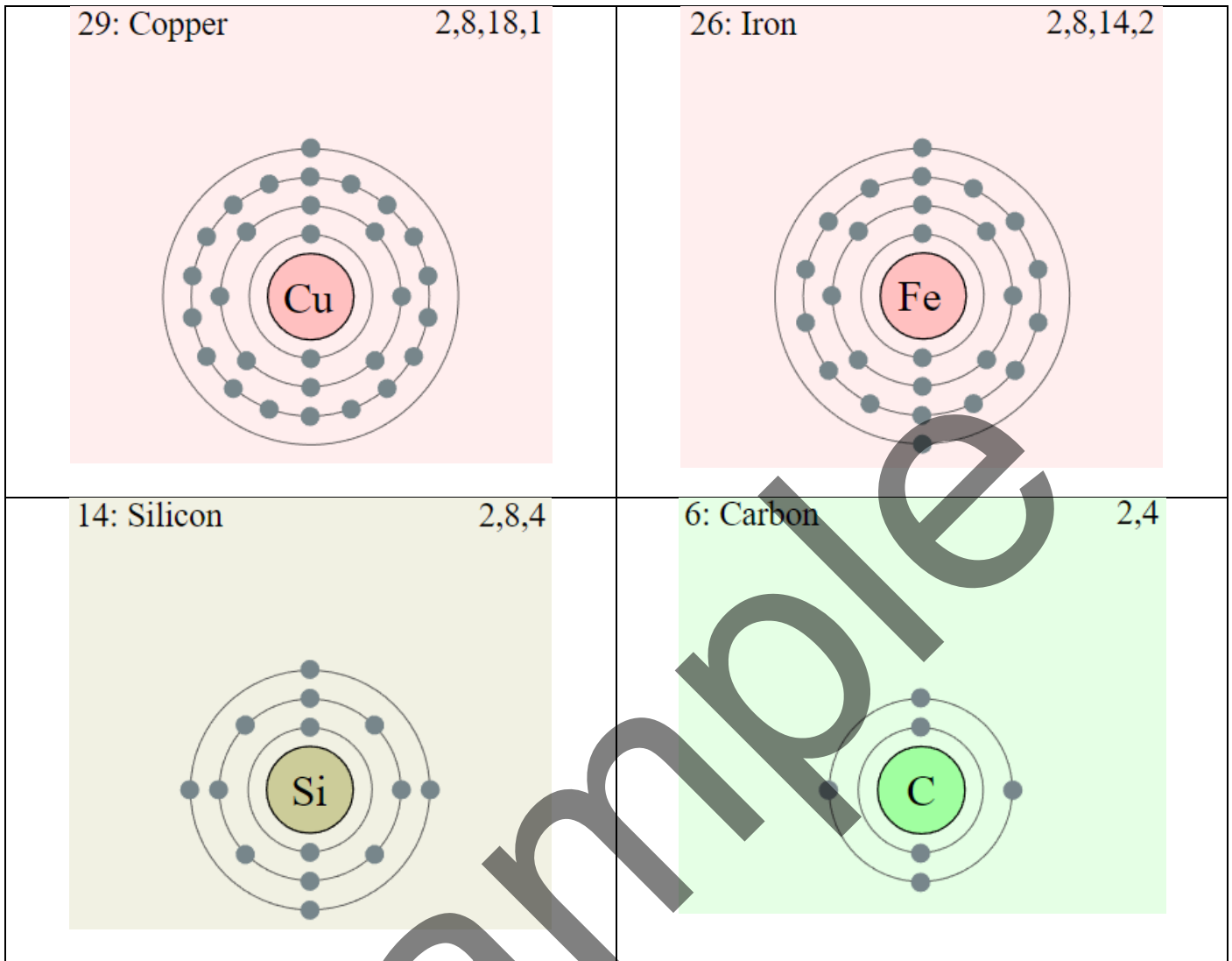


Fig.3.1: Atomic structure of some common elements