

LOCATION: SWANSEA

LEVEL 4

EXAMINATION PERIOD

JANUARY 2019

MODULE CODE: M4X01163

MATERIALS AND INTRODUCTION TO MANUFACTURING

TIME: 2 HOURS

ANSWER ALL QUESTIONS FROM SECTION A

ANSWER THREE QUESTIONS SECTION B

Equipment or materials required – Calculator

Constants $N_A = 6.022 \times 10^{23}$ $g = 9.81 \text{ms}^{-2}$

MATERIALS

density

$$\rho = \frac{m}{V}$$

Hooke's law $F = k \Delta L$

$$\rho = \frac{nA}{V_c N_A}$$

*Young
modulus*

$$= \frac{\text{tensile stress}}{\text{tensile strain}}$$

$$\text{tensile stress} = \frac{F}{A}$$

$$APF = \frac{\text{Volume of atoms in the unit cell}}{\text{Volume of Unit Cell}}$$

$$\text{tensile strain} = \frac{\Delta L}{L}$$

*energy
stored*

$$E = \frac{1}{2} F \Delta L$$

ANSWER ALL QUESTIONS

SECTION A

Multiple choice

1. A material has undergone plastic deformation when:
A The limit of proportionality has been exceeded
B The limit of proportionality has not been exceeded
C The material is between yield point 1 and yield point 2
D The breaking point has been exceeded
2. The quantity found by calculating the area of a stress (y axis) strain (x axis) will give a quantity with units of:
A Nm^{-1}
B mN^{-1}
C Nm^{-2}
D Nm^2
3. The co-ordination number of a BCC is:
A 2
B 4
C 6
D 8
4. A material with a high Young's modulus is likely to have:
A Cross-linking type bonds
B Low ductility
C A low degree of stiffness
D A polymer base
5. The area under a force-extension graph provides information on:
A Young's modules
B Spring constant for springs in a series arrangement
C Spring constant for springs in a parallel arrangement
D Stored elastic energy

SECTION B

1. a) An aerospace engineer has built two differently designed wings. One wing is made from an aluminium alloy and the other is made from a carbon fibre composite. The engineer tests a sample of each material by applying a varying stress (**figure 1**).

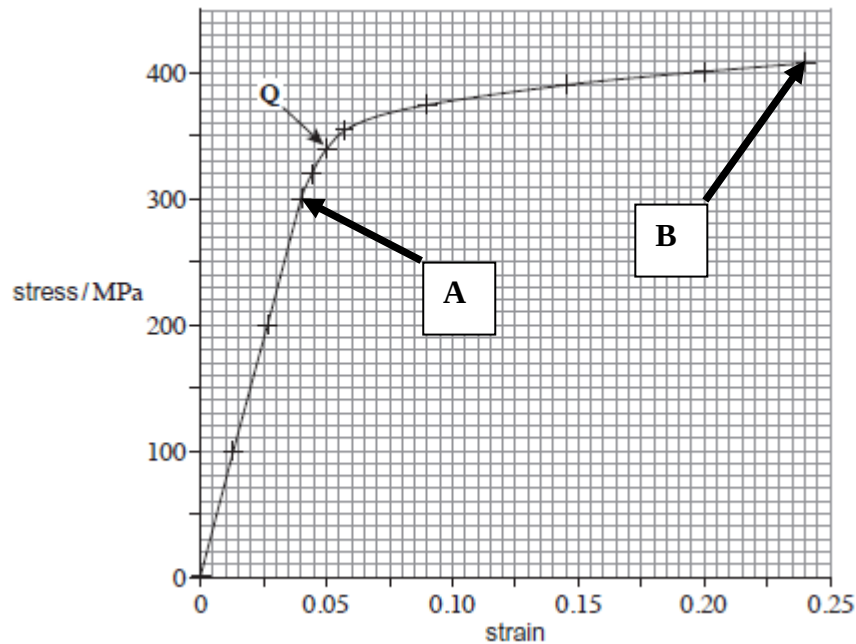


Figure 1

- i) State what characteristic of the material is given by Q and what is its effect on the material. [2]
 - ii) Explaining how you could use figure 1 to calculate the young's modulus [2]
 - iii) State what characteristic of the material is given by A and what is its effect on the material. [2]
 - iv) State what characteristic(s) of the material are given by B and what are their effects on the material [4]
- b) To carry out the above test, the engineer made a cylindrical sample of one of the materials. When a force of 100N was applied to a cylinder of length 1200mm and area $0.2 \times 10^{-4} m^2$ and extension of 1mm was observed. Given this information, calculate the young's modulus from these values and compare it to the young's modulus calculated from figure 1. *All workings should be shown.*

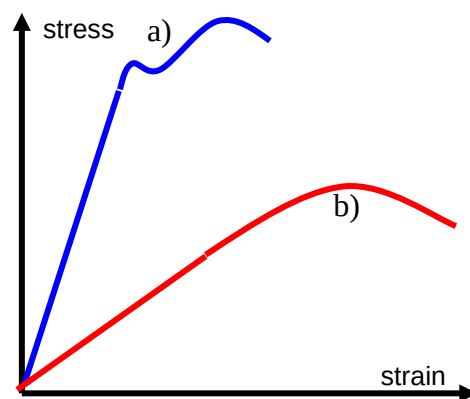
[5]

2. a) A wire of natural length 250cm and diameter 0.5 mm is extended by 5 cm by a force of 0.40kN. Calculate:

- (i) the tensile strain
- (ii) the tensile stress
- (iii) the force required to break the wire if its breaking stress is 1.5×10^9 Pa.

[6 marks]

b)



The stress strain curves, a) and b) shown above are for two different metals. By considering these curves suggest the types of metals that these could be, giving reasons for your choice. [4]

- c) i) A second wire of cross sectional area 0.7cm^2 breaks when the tensile stress exceeds 5×10^9 . What is the maximum load that can be lifted by the wire?
- ii) Given that the strain experienced by the wire at a stress of $5 \times 10^6 \text{ Nm}^{-2}$ is 1.75, calculate the Young's modulus of the wire.

3. Show that the atomic packing factor for BCC and FCC is 0.68 and 0.74 respectively [6]

Table 3.1 Atomic Radii and Crystal Structures for 16 Metals

<i>Metal</i>	<i>Crystal Structure^a</i>	<i>Atomic Radius^b (nm)</i>	<i>Metal</i>	<i>Crystal Structure</i>	<i>Atomic Radius (nm)</i>
Aluminum	FCC	0.1431	Molybdenum	BCC	0.1363
Cadmium	HCP	0.1490	Nickel	FCC	0.1246
Chromium	BCC	0.1249	Platinum	FCC	0.1387
Cobalt	HCP	0.1253	Silver	FCC	0.1445
Copper	FCC	0.1278	Tantalum	BCC	0.1430
Gold	FCC	0.1442	Titanium (α)	HCP	0.1445
Iron (α)	BCC	0.1241	Tungsten	BCC	0.1371
Lead	FCC	0.1750	Zinc	HCP	0.1332

^a FCC = face-centered cubic; HCP = hexagonal close-packed; BCC = body-centered cubic.

^b A nanometer (nm) equals 10^{-9} m; to convert from nanometers to angstrom units ($\text{\AA}$), multiply the nanometer value by 10.

4. Gold has a FCC crystal structure, an atomic radius of 0.1442nm, and an atomic weight of 196.96 g/mol. Calculate its theoretical density. [4]

5. Calculate the radius of a copper atom, given that it has a density of 8.96gcm^{-3} and an atomic weight of 63.55gmol^{-1} . [3]

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