1)

(a) A metal wire has an unstretched length L and area of cross-section A. When the wire supports a load F, the wire extends by an amount ΔL. The wire obeys Hooke's law.

Write down expressions, in terms of L, A, F and ΔL, for

(i) the applied stress,

....

(ii) the tensile strain in the wire,

....

(iii) the Young modulus of the material of the wire.

....
[3]

(b) A steel wire of uniform cross-sectional area 7.9×10^{-7} m^2 is heated to a temperature of 650 K. It is then clamped between two rigid supports, as shown in Fig. 5.1.

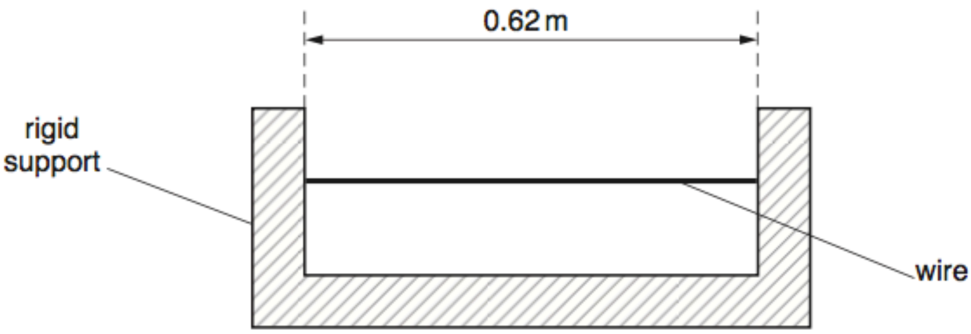

Fig. 5.1

The wire is straight but not under tension and the length between the supports is 0.62 m. The wire is then allowed to cool to 300 K.

When the wire is allowed to contract freely, a 1.00 m length of the wire decreases in length by 0.012 mm for every 1 K decrease in temperature.

(i) Show that the change in length of the wire, if it were allowed to contract as it cools from 650 K to 300 K, would be 2.6 mm.

[2]

(ii) The Young modulus of steel is 2.0×10^{11} Pa. Calculate the tension in the wire at 300 K, assuming that the wire obeys Hooke's law.

tension = ... N [2]

(iii) The ultimate tensile stress of steel is 250 MPa. Use this information and your answer in **(ii)** to suggest whether the wire will, in practice, break as it cools.

....

.... [3]

2)

(a) Fig. 3.1 shows the variation with tensile force of the extension of a copper wire.

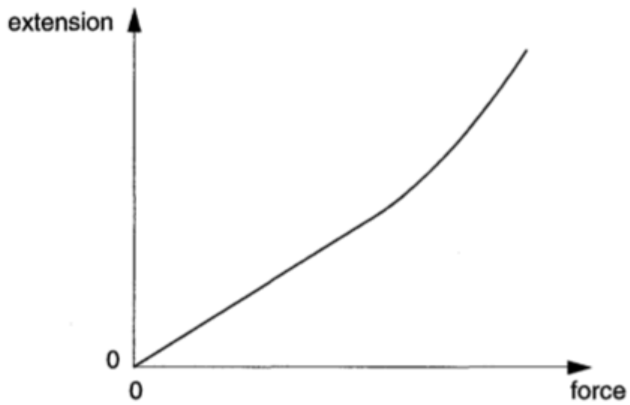

Fig. 3.1

(i) State whether copper is a ductile, brittle or polymeric material.

....

(ii) **1.** On Fig. 3.1, mark with the letter L the point on the line beyond which Hooke's law does not apply.

2. State how the spring constant for the wire may be obtained from Fig. 3.1.

....

....

[3]

(b) A copper wire is fixed at one end and passes over a pulley. A mass hangs from the free end of the wire, as shown in Fig. 3.2.

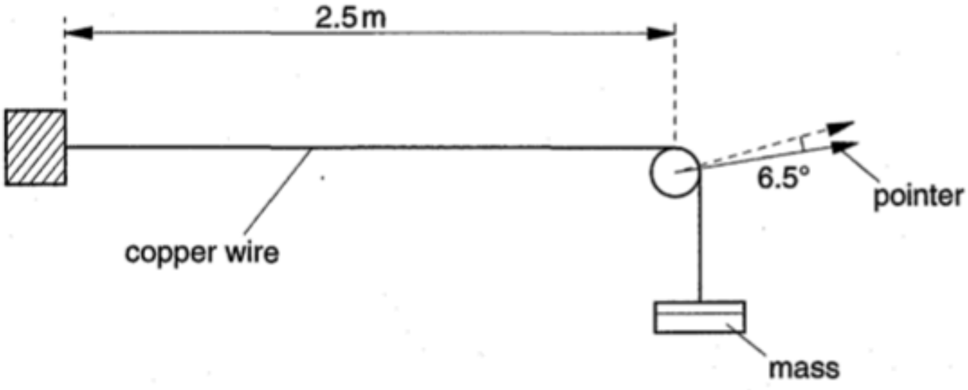

Fig. 3.2

The length of wire between the fixed end and the pulley is 2.5 m. When the mass on the wire is increased by 6.0 kg, a pointer attached to the pulley rotates through an angle of 6.5°. The pulley, of diameter 3.0 cm, is rough so that the wire does not slide over it.

(i) For this increase in mass,

1. show that the wire extends by 0.17 cm,

2. calculate the increase in strain of the wire.

increase in strain = ...

[4]

(ii) The area of cross-section of the wire is $7.9 \times 10^{-7}\,m^2$. Calculate the increase in stress produced by the increase in load.

increase in stress = ... Pa [3]

(iii) Use your answers to **(i) 2** and **(ii)** to determine the Young modulus of copper.

Young modulus = ... Pa [2]

(iv) Suggest how you could check that the elastic limit of the wire is not exceeded when the extra load is added.

....

.... [1]

3)

(a) In the following list of solids, underline those materials which are crystalline.

rubber copper nylon glass aluminium [2]

(b) The three graphs A, B and C of Fig. 5.1 represent the variation with extension x of the tension F in specimens of three different materials. One of the materials is polymeric, one is brittle and the other is ductile. They are not shown in that order in Fig. 5.1.

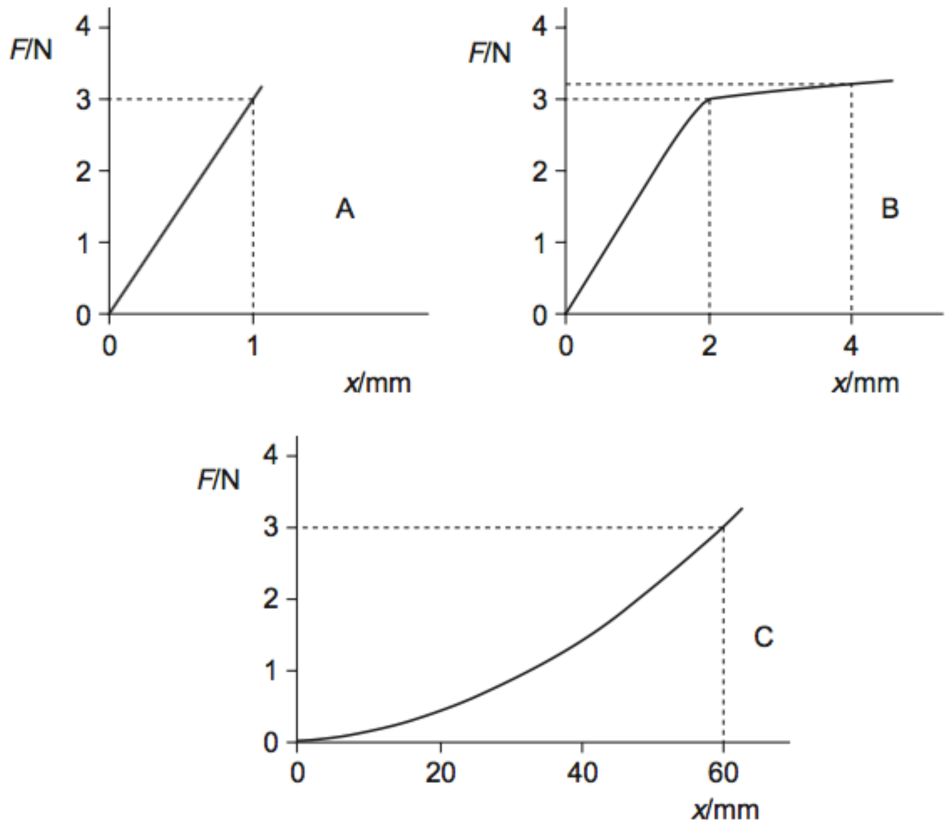

Fig. 5.1

(i) State the type of material which would produce the line shown in each graph.

Graph A is for a .... material.

Graph B is for a .... material.

Graph C is for a .... material. [2]

(ii) Use graph B to estimate the work done in stretching the specimen from 0 to 4 mm.

work done = ... J [3]

4)

An aluminium wire of length 1.8 m and area of cross-section $1.7 \times 10^{-6}\,m^2$ has one end fixed to a rigid support. A small weight hangs from the free end, as illustrated in Fig. 9.1.

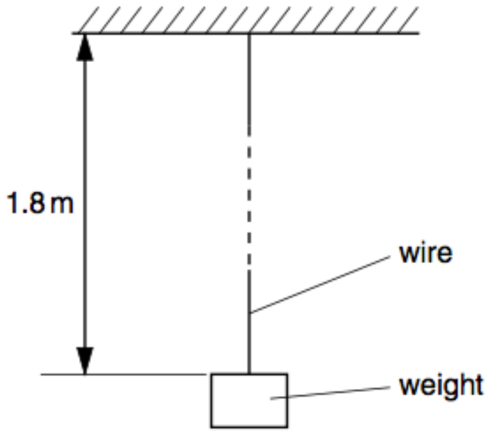

Fig. 9.1

The resistance of the wire is 0.030 Ω and the Young modulus of aluminium is 7.1×10^{10} Pa.

The load on the wire is increased by 25 N.

(a) Calculate

(i) the increase in stress,

increase = ... Pa

(ii) the change in length of the wire.

change = ... m

[4]

5)

A glass fibre of length 0.24 m and area of cross-section $7.9 \times 10^{-7}\,m^2$ is tested until it breaks. The variation with load *F* of the extension *x* of the fibre is shown in Fig. 4.1.

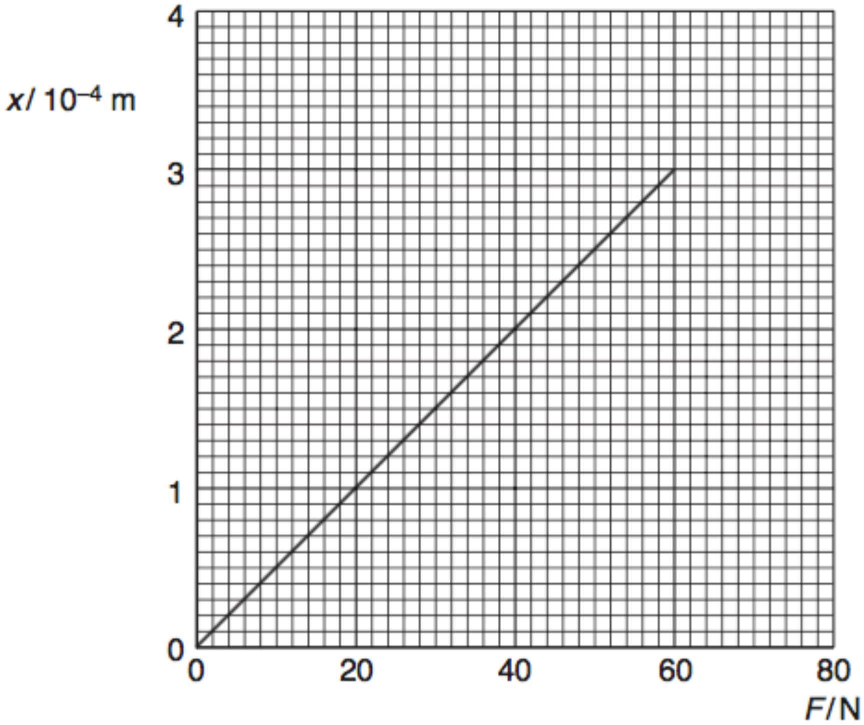

Fig. 4.1

(a) State whether glass is ductile, brittle or polymeric.

....[1]

(b) Use Fig. 4.1 to determine, for this sample of glass,

(i) the ultimate tensile stress,

ultimate tensile stress = ... Pa [2]

(ii) the Young modulus,

Young modulus = ... Pa [3]

(iii) the maximum strain energy stored in the fibre before it breaks.

maximum strain energy = ... J [2]

(c) A hard ball and a soft ball, with equal masses and volumes, are thrown at a glass window. The balls hit the window at the same speed. Suggest why the hard ball is more likely than the soft ball to break the glass window.

....

....

....

....[3]

6)

(a) Distinguish between the structure of a metal and of a polymer.

metal: ....

....

....

polymer: ....

....

.... [4]

(b) Latex is a natural form of rubber. It is a polymeric material.

(i) Describe the properties of a sample of latex.

....

....

.... [2]

(ii) The process of heating latex with a small amount of sulphur creates cross-links between molecules. Natural latex has very few cross-links between its molecules.

Suggest how this process changes the properties of latex.

....

....

.... [2]

7)

A straight wire of unstretched length L has an electrical resistance R. When it is stretched by a force F, the wire extends by an amount ΔL and the resistance increases by ΔR. The area of cross-section A of the wire may be assumed to remain constant.

(a) **(i)** State the relation between R, L, A and the resistivity ρ of the material of the wire.

....

.... [1]

(ii) Show that the fractional change in resistance $\frac{\Delta R}{R}$ is equal to the strain in the wire.

[2]

(b) A steel wire has area of cross-section $1.20 \times 10^{-7}\,\text{m}^2$ and a resistance of $4.17\,\Omega$.

The Young modulus of steel is $2.10 \times 10^{11}\,\text{Pa}$.

The tension in the wire is increased from zero to 72.0 N. The wire obeys Hooke's law at these values of tension.

Determine the strain in the wire and hence its change in resistance. Express your answer to an appropriate number of significant figures.

change = ... Ω [5]

8)

A sample of material in the form of a cylindrical rod has length *L* and uniform area of cross-section *A*. The rod undergoes an increasing tensile stress until it breaks.
Fig. 4.1 shows the variation with stress of the strain in the rod.

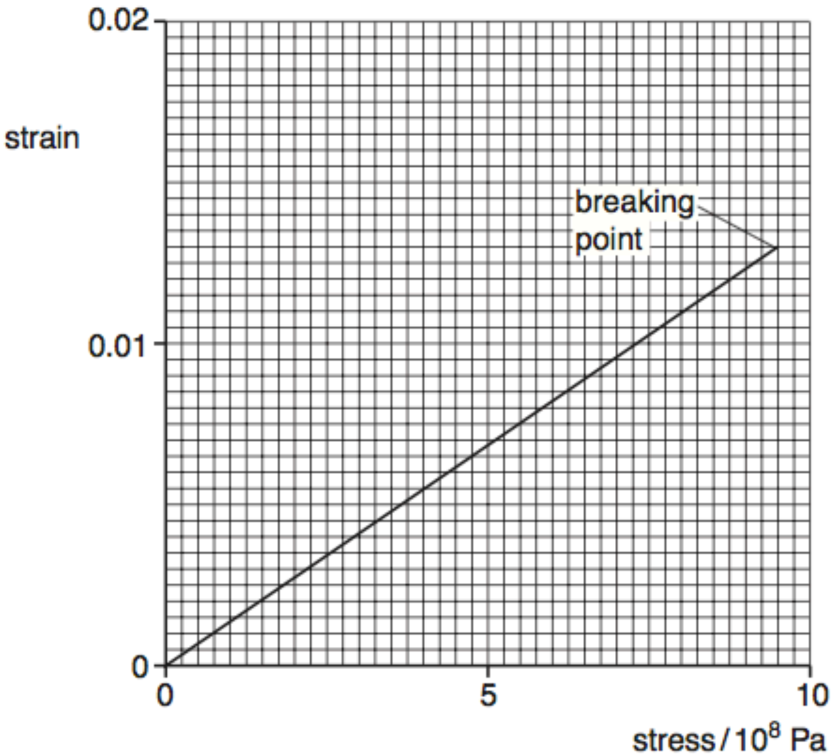

Fig. 4.1

(a) State whether the material of the rod is ductile, brittle or polymeric.

.... [1]

(b) Determine the Young modulus of the material of the rod.

Young modulus = ... Pa [2]

(c) A second cylindrical rod of the same material has a spherical bubble in it, as illustrated in Fig. 4.2.

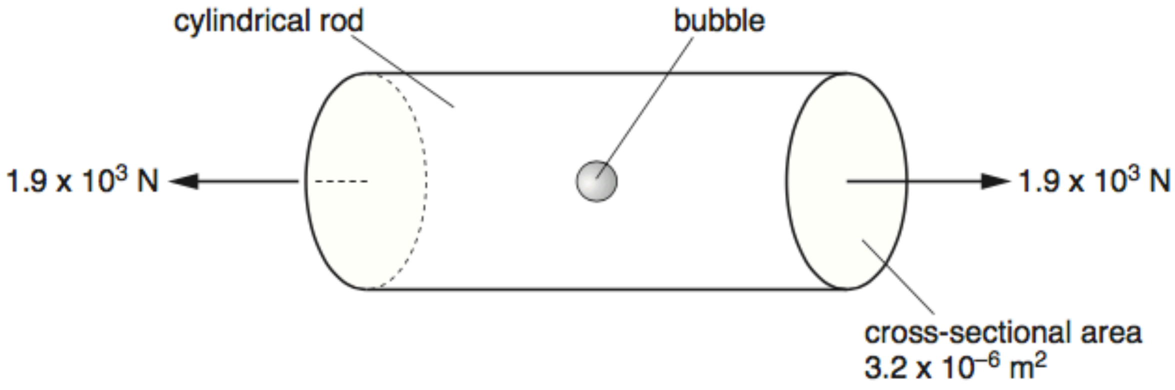

Fig. 4.2

The rod has an area of cross-section of $3.2 \times 10^{-6}\,m^2$ and is stretched by forces of magnitude $1.9 \times 10^3\,N$.
By reference to Fig. 4.1, calculate the maximum area of cross-section of the bubble such that the rod does not break.

area = ... m^2 [3]

(d) A straight rod of the same material is bent as shown in Fig. 4.3.

Fig. 4.3

Suggest why a thin rod can bend more than a thick rod without breaking.

....

....

.... [2]

9)

(a) **(i)** Define the terms

1. tensile stress,

....

....[1]

2. tensile strain,

....

....[1]

3. the Young modulus.

....

....[1]

(ii) Suggest why the Young modulus is not used to describe the deformation of a liquid or a gas.

....

....[1]