

**Question 1 [5]**

**1a. Briefly explain the increase in versatility of fibres from natural through regenerated to synthetics. [2]**

This is so because the natural fibres exist in their original state and can not be easily altered much in their properties down to the molecular chain level. Whereas synthetic fibres are the most versatile as their chains can be altered right from the first stage of polymerization. Regenerated fibres lie in the middle in terms of versatility because they use natural raw materials and are able to achieve varying outcomes through their modification in terms of molecular structure during wet spinning for instance.

**1b. Figure 1.1 shows the structure of Polyethylene, the simplest of all synthetic polymers that can be used to make fibres.**

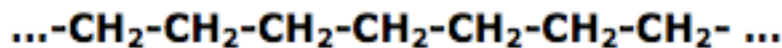


Fig 1.1

**Briefly explain the difference between the polymer chains in 'High Density Polyethylene' (HDPE) and 'Ultra High Molecular Weight Polyethylene' (UHMWPE) while emphasizing on their effect on the properties of the fibres. [3]**

The chemical structure for both fibers will be exactly the same as shown in figure 1.1, but by varying the degree of polymerization, making it extremely high in UHMWPE as compared to HDPE, the end properties of the fibres are vastly different. UHMWPE due to its extremely long straight chains has enhanced lateral forces between the chains thus making it extremely strong in terms of tensile strength. As a compromise, the fibre also become stiff by doing this and loses flexibility.

**Question 2 [8]**

**Figure 2.1 shows how the cuticle layers on wool can lock into adjacent fibres to cause felting.**

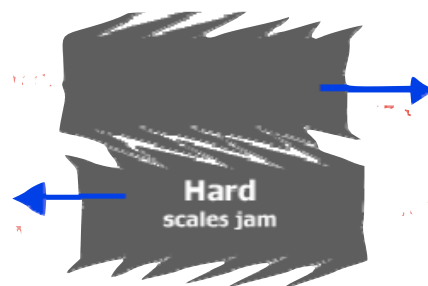


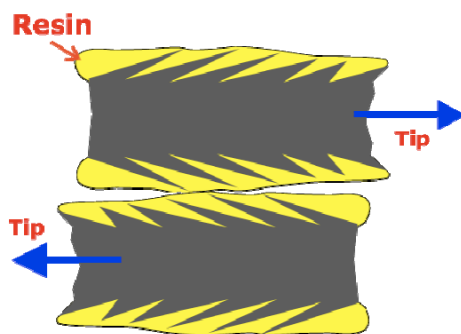
Fig 2.1

**2a. This property of felting in wool can be reduced or eliminated altogether by making changes on the surface of the fibres. Explain two types of changes that can be brought about on the surface of wool fibres to achieve this. [4]**

*(Use appropriate diagrams to supplement your argument. Focus your answer around the physical changes that will result in the desired outcome rather than their methods of application.)*

The property of felting as shown in fig 2.1 is a property of the surface scales of the wool fibres thus the felting properties of the fiber can be removed by either covering the scales with some sort of a resin or by removing the scales altogether through enzyme or plasma treatment.

The resin coating as shown on the next page will cover the scales thus preventing them from getting tangled with each other thus preventing felting.



The second instance of enzymatic treatment or plasma treatment removes the surface scales altogether. The wool fibre thus becomes smooth and there are no scales present to get locked into each other and promote felting. It must be noted that although plasma treatment and enzymatic treatment are different methods the end result for both is due to the same surface removal of scales.

**2b. Choose any one of the treatments you explained in 2a and highlight two other properties of wool fibre, yarn or fabric that might be affected due to the changes you brought about on the surface of the fibres. Give reasons as to why these properties will be affected as a result of your chosen surface modification. [4]**

The removal of surface cuticle layer by plasma treatment will result in the removal of the fine water repellent epicuticle on the wool fibres, thus making the fiber more hydrophilic. Also since the fibres will now be smoother and the cohesive forces between them will be lower the tensile strengths of yarns or fabrics made with treated fibres will record a reduction.

**Question 3 [10]**

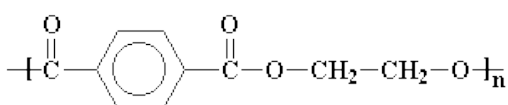


Fig 3.1a

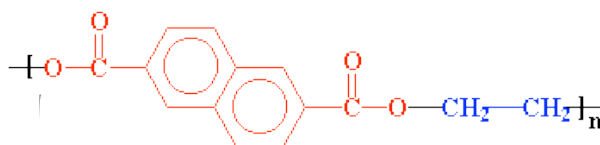


Fig 3.1b

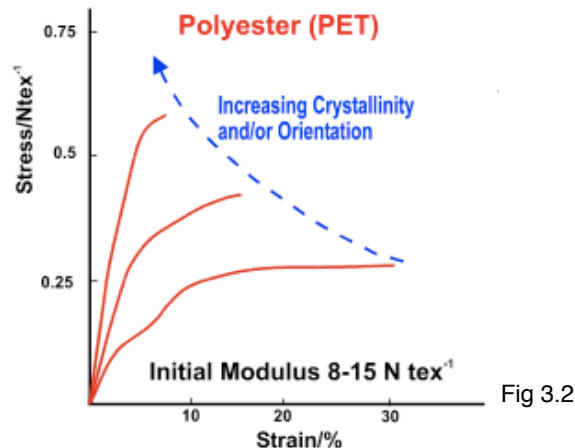
**3a. Figures 3.1a and 3.1b are both repeat units of polyester. Comment on the accuracy of this statement. [1]**

Figures 3.1 a and b both show repeat units of polyester. Polyesters are a class of polymers with ester links and Polyethylene terephthalate and others belong to this class.

**3b. Based on the differences in the structures of the polymers, present a comparison of the stiffness, glass transition temperature and melting point of the polymers shown in figure 1.1a and 1.1b. [3]**

The big bulky benzene ring is a stiff structure which adds stiffness to polymers. In addition it also provides the capacity for the chains to stack against each other better with stronger lateral interaction. Thus 3.1 b will be the stiffer structure. and with stronger interaction between chains it will be more difficult to pull them apart and melt them hence the melting for b will also be higher. Glass transition temperature is when the amorphous chains are able to transform to a glassy fluid state. Because the lateral forces in b will be stronger this will also be higher for the latter.

**3c. Figure 3.2 is a typical plot showing the tensile properties of a melt spun synthetic fibre achievable through processing.**



**Explain how the changes in crystallinity and/or orientation denoted by the dotted arrow may be achieved during melt spinning and subsequent drawing. [2]**

Slower cooling of the polymer after spinning will lead to the formation of more crystalline regions which coupled with more drawing will lead to better orientation. This is what gives rise to higher tenacity and stiffness as the crystallinity and orientation of the polymers in the fibres increases.

**3d. The initial modulus of Nylon 6 is 2-5 N/tex in contrast to that of PET, shown in figure 1.2. Explain this difference in terms of the molecular structures of Nylon and PET. [2]**

The structure of PET has big bulky benzene rings in contrast to Nylon 6 which has polar groups NH and CO. The result is that PET benzene rings can stack against each other to give it a stiffer structure. This gives PET its higher initial modulus as it is more difficult to slide apart the chains in PET which have stronger lateral forces acting between them.

**3e. Name one other property of PET (not shown in Fig 1.2) which might be affected as its crystallinity is increased and explain why it is affected. [2]**

The dyability of polyester will be reduced as its crystallinity increases. Since the overall percentage of ordered regions will increase there will be fewer disordered regions where disperse dye molecules might be able to penetrate and get locked between disordered chains.

#### Question 4 [6]

Figure 4.1 shows a hollow polyester fibre called Wellkey (developed by Teijin LTD) which has micro pores on its surface that allow liquids to seep through.

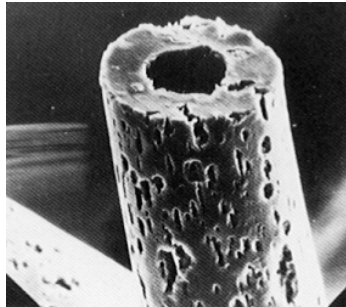


Fig 4.2

**4a. Explain one functional application of a knitted fabric made with staple fibre yarn of Wellkey fibres. Your answer must include how the fibre will be able to carry out your stated application. [2]**

Knitted fabric made of Wellkey fiber may be used to make functional T-shirts for sportsmen with the ability to wick moisture off skin and transport it to the core where it can be stored and then transported out of the fibre as it evaporates off the outer surface.

The resulting T-shirt will be lightweight, dry to the skin and capable of wicking moisture away thus comfortable for the wearer.

**4b. Suppose a fiber 'A' is sensitive to pressure and capable of conducting electricity when it is subject to pressure. Present one innovative use of such material and explain how it may be implemented. [2]**

If a fibre is capable of conducting electricity when it is subject to pressure it may be used to make switches based on simple stitches. In its simplest form the stitch could be placed on a fabric with a circuit made out of conductive fibres, a bulb and a battery. Applying pressure on the stitched switch by pressing with the finger will complete the circuit, hence lighting up the bulb.

Such switches can also be attached on car doors to roll up windows or for other applications depending on the complexity of the circuit used.

**4c. Briefly outline how genetic engineering has opened up new frontiers production of spider silk on an industrial scale. [2]**

Spider silk can and has been made by taking genes from spiders and implanting them in goats which produce the protein present in spider silk in their milk. The protein is then isolated and spun by wet spinning to produce spider silk.

### Question 5 [6]

Figure 5.1 shows a technique for making non woven nano-fibre fabric.

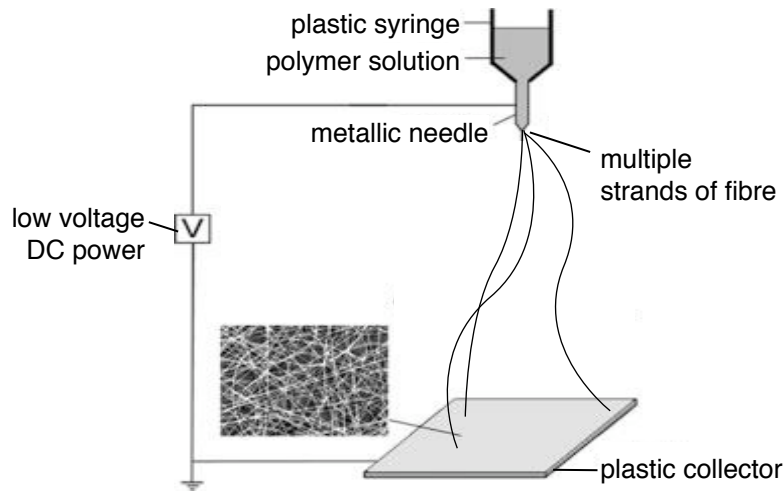


Fig 5.1

#### 5a. Identify and correct three mistakes in figure 5.1. [3]

The plastic collector should be a metallic collector.

The low voltage power supply should actually be a high voltage power supply.

When a DC voltage is applied only one strand of fibre emerges from the needle and not multiple strands.

#### 5b. Name the technique used to make fibres, shown in figure 5.1. [1]

The technique is called 'electrospinning.'

#### 5c. Explain one end use of non woven nano-fibre fabric. Your answer should be able to elucidate how the nano structure of the fabric is suited for your chosen application. [2]

Electrospun nano-fibre fabric can be used to make fabric for filtration. The nano spacing between the fibre will allow small molecules to pass through and stop anything larger than the the pore size from seeping through thus making it an effective filter.

### Question 6 [5]

6a. From the list below, choose any one technical textile product and use the 'TRIC Product Development Model' to present a case study on the type of fibres that can be used to make the product. Your answer must explain how your chosen fibre will have suitable properties to perform the required functions as well explain how the fibre will be incorporated into the end product (loose fibre, special yarn or woven or knitted fabric etc.). [5]

i. Geotextile for road lining,

ii. Artificial lungs,

iii. Bulletproof vest, or

iv. Clothing for clean room (dust free room where micro electronic components are assembled)

The TRIC product development model works according to the following scheme.

Choose product, conduct research to determine required properties according to application and finally develop product using a mix of production and finishing processes.

Geotextiles for road lining have several functions. They are primarily used to reinforce roads. They also ensure that the pressure applied by passing heavy traffic is spread out evenly on the lower bed so that the road doesn't dip at specific places. And finally they also help in preventing water logging by helping water seep through to the lower bed.

For such an application the required properties of the material will also depend on the properties of the soil the material has to be implanted in. We will consider each of these separately.

Self properties:

- a. Non biodegradable for long life application.
- b. Non absorbent
- c. Good compressional strength

Properties in relation to application area:

- a. Chemically compatible with soil in which it is to be implanted.

This eventually leads to the conclusion that the fibre employed must be a synthetic fibre which is non biodegradable with low or no absorbency and good compressional strength. The fibre must also be compatible with the soil where it is to be implanted and this can only be determined after thorough studies on the application site.

As a safe suggestion polypropylene non woven fabric is often used for such applications as it is chemically stable under most conditions, it is non biodegradable and has almost zero water absorption properties apart from being lightweight.

The non woven fabric in this case allows the fabric to spread pressure as well as provides support to the road structure.

However, other synthetic materials such as polyester and polyethylene can also be used.