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Mark Scheme

Home Economics
Unit HEC7

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Unit 7 Textiles Science and Technology HEC7

Question 1

a) **Standard moisture regain (SMR) –** the percentage increase in weight when a bone dry fibre or fabric sample is allowed to come into contact with air under standard conditions of 21°C and 65% relative humidty.

2 marks

Cotton – a hydrophyllic cellulosic fibre containing large numbers of water-absorbing hydroxyl groups. SMR almost 10%. Most clothing made from cotton is therefore cool and absorbent. Cotton is often called called the 'comfort fibre.'

2 marks

Polyester – a hydrophobic synthetic fibre. SMR less than 1%. In the past 100% polyester garments have been associated with poor comfort properties because of low moisture absorbency. Modern, appropriately designed, microfibre polyester garments are comfortable.

2 marks

b) **Elasticity** – the ability of a textile to return to its length after stretching

2 marks

Wool – a highly extensible fibre. The structure and special nature of the protein molecules it contains make wool fibres and fabrics highly extensible. As many wool garments are knitted, this adds to the elasticity of the garment.

2 marks

Cotton – an inelastic fibre with poor stretch and recovery properties. The molecular structure of the cellulosic fibres present makes most cotton garments and fabrics (unless they are knitted) rather firm and therefore an ideal choice of fabric for dress shirts and blouses.

2 marks

c) **Heat-setting** – the ability of a fabric containing more than 55% of a thermoplastic synthetic fibre, such as polyester, to be heat-treated in order to maintain it's shape and dimensional stability during use and cleaning.

2 marks

Cotton/polyester blends – blends rich in polyester are usually heated to about 180°C for 30 seconds on a stenter during finishing.

2 marks

The thermoplastic polyester fibres present relax under the influence of heat and the stresses and strains imposed on the fabric during finishing are removed. This process ensures that these fabrics do not shrink or change their shape to any great extent during their useful life.

2 marks

d) **Mercerisation** – a process which is used to improve the overall properties of 100% cotton yarns and fabrics. Cotton is immersed in concentrated (40%) sodium hydroxide solution and the fibres are modified by the action of the alkaline treatment.

2 marks

Cotton rapidly absorbs sodium hydroxide solution and the fibres swell. The fibres take up much more rounded structure and the internal structure of the cellulose polymers is changed from Cellulose 1 (normal cellulose) to Cellulose 2.

2 marks

After neutralisation, rinsing and drying, the cotton has a much more attractive appearance, it is shiny, stronger, more extensible and readily takes up dyes. Good quality sewing threads usually contain mercerised cotton yarns.

3 marks

Total 25 marks

Question 2

a) **Flammability of PES/cotton blends** – both fibres contain the potentially 'flammable' elements C, H and O and consequently they both ignite easily and burn in air. **Better candidates** may discuss LOI values for these fibres, i.e. fibres with low LOI values are more flammable than those with high LOI values.

2 marks

Fabrics containing 100% cotton easily ignite and burn quickly, 100% polyester fabrics are slightly less flammable than cotton but they will also burn in air. Because polyester is thermoplastic, it will tend to melt or shrink away from the flame and burning may not occur.

3 marks

However when the two fibres are present in an intimate blend and the fabric is exposed to an igniting source, the heat softens the polyester fibres and they may melt and coat the cotton.

2 marks

This effect called the 'scaffold effect' makes PES/cotton blends particularly dangerous in fires because the cotton supports the polyester and both fibres burn fiercely together with a very hot flame.

2 marks

b) **Acrylic and modacrylic fibres** – these synthetic fibres are based on the monomer acrylonitrile. Acrylic fibres are 100% acrolyntrile (CH_2CHCN) while modacrylic fibres contain up to about 30% additional chlorine in the polymer. It is the presence of this chlorine which changes the flammability properties of fabrics containing modacrylic fibres.

2 marks

Acrylic fibres are used mainly as staple and they are not as strong as polyester or polyamide but are stronger than wool. They are quite extensible and do not crease easily. Because they have a low Tg value they tend to stretch in warm moist conditions.

1 mark

Acrylics are generally knitted and warm to wear although not as warm as wool. Acrylics have a low SMR and dry quickly after washing. They do not soil or stain easily and are resistant to attack by most chemicals. Acrylic fibres are cheap, the cost is comparable to that of poorer grade wool.

1 mark

Unfortunately acrylic fibres are dangerously flammable and produce large amounts of hydrogen cyanide when they burn.

1 mark

Modacrylic fibres are 'modified acrylic' fibres and they contain chlorine in their structure. They are much less flammable than acrylic fibres and this property makes them useful when flammability considerations are important.

1 mark

Acrylics are widely used as wool replacements in socks jumpers etc while the modacrylics are used mainly in blends for curtains, upholstery and fire-resistant clothing. They are also used as synthetic fur because modacrylic fibres have a very soft handle.

2 marks

c) **Fibre identification using burning tests and Shirlastains** – after microscopic examination of fibres these two tests are used to confirm the presence of particular fibres present in a fabric or yarn.

1 mark

Burning fibres in air is usually carried out using a few fibres or small sample of fabric held in tweezers and its reaction to an open flame is observed. The student observes what

happens as the sample is brought close to the frame, held in the flame, and removed from the flame.

1 mark

An examination of the residue can be helpful in determining the nature of the sample. The burning test is used to categorise fibres as cellulosic, protein, thermoplastic and mineral/inorganic. This test is only used when a single fibre type is present in the sample. Textile blends may give odd results. Students can refer to tables of data to the burning behaviour of fibres.

2 marks

Shirlastains were developed specially for the identification of fibres. They are essentially mixtures of water soluble dyes, each dye being specific for a particular fibre. There are three types of Shirlastain dyes available, Shirlastains A, D and E. White, finish-free samples of fabric are placed in test tubes and the Shirlastains added to the sample.

2 marks

Shirlastain dye colours produced in the cold and/or in the presence of heat are examined. Again, comparative tables of information and colour charts are available to help students identify specific fibres. Colours produced using Shirlastain A and mixtures of Shirlastain A and D and A and E are examined. Careful use of these Shirlastain stains can differentiate between cotton and viscose (both cellulosics) and between the different synthetic fibre types.

2 marks

Total 25 marks

Question 3

a) **Tactel-micro** - as the name clearly suggests, is a micro-filament fibre made from polyamide (nylon 6.6). The suffix micro has become the accepted term for describing a micro-fibre where each filament is less that 1 decitex. These extremely fine fibres are finer than the finest silk fibres and have been used in textiles for about 10 years now.

3 marks

Outdoor clothing requires that high quality, durable fibres be used in its construction.

1 mark

The ideal properties which outdoor clothing can provide are best supplied by using polyamide fibres especially in the outercovering. Micro polyamide fibres are ideal for this use as they are tough and extensible. The outer fabric is also windproof and waterproof. The use of microfibres also brings additional desirable properties to the garment. If fairly tightly woven, filament micro-polyamide yarns are used, the outer fabric exhibits properties similar to those shown by Goretex i.e. the fabric is microporous allowing water vapour to pass outwards through the fabric without

allowing rainwater to penetrate inwards. Thus, the wearer remains comfortable, warm and dry even in the most inclement conditions. In addition, because of the great fineness of the micro-polyamide fibres, the outer fabric is very smooth, soft and has the typical, extremely light, micro-fibre handle.

2 marks

b) **Teflon – water/stain repelling finish for upholstery fabrics**

Teflon is a special fluorocarbon finish which modifies the wetting characteristics of fabric surfaces.

2 marks

Many upholstery fabrics, especially if they contain hydrophilic cotton, viscose or wool fibres, can be easily stained and spoiled by water-borne stains.

1 mark

Fatty-based stains can also be a problem on upholstery fabrics when hydrophobic synthetic fibres are used in blends with cotton or wool.

1 mark

Because of its chemical structure, Teflon and similar finishes change the nature of the fabric surface. Both water and oil-based stains are unable to wet the treated fabric surface and consequently the fabric is not stained or damaged. Unfortunately, Teflon based finishes are not permanent and have to be replaced frequently during the useful life of the piece of furniture.

2 marks

c) **Perborate in washing powders**

Before perborate was introduced into the UK washing powder market in the 1950s, washing powders essentially contained phosphates (water softener) and active anionic detergents or soaps.

1 mark

Although these products were quite good at removing water and oil-based stains on cotton, often stains were very difficult to remove from the then recently introduced synthetic fibres nylon, acrylic and polyester.

2 marks

At this time the ‘boil wash’ was the only effective way of removing seated stains. The introduction of ‘Persil’ which contained sodium perborate, (oxygen bleach) improved the washing performance dramatically.

2 marks

The new washing powder used in new automatic washing machines was a great success. The Newcastle-based American company Proctor and Gamble rapidly introduced Daz in order to compete with Persil. The basis for the rapid growth and development of Lever Brothers and Proctor and Gamble at the time was based mainly on the sales of these two products. The great competition between these two companies continues today. For low-temperature washing (typically 40°C) today perborate activators are used**.**

2 marks

d) **Cationic and non-ionic surfactants in fabric softeners** – modern fabric softeners or conditioners are widely used to improve the softness of textiles (especially cottons) which have been washed in modern synthetic detergents and it is the cationic surfactant molecule which is the softening agent. The natural oils present in cotton, which give cotton its soft handle, are removed during washing by synthetic detergents especially the anionic and non-ionic surfactant mixtures present in modern washing powders.

1 mark

Cationic surfactants themselves are poor detergents and consequently for the cationic to go onto the cotton fibres in order to improve the softness, the fibre surfaces have to be 'clean' so that they can absorb the cationic surfactants rapidly.

1 mark

In order to wet and clean fibre surfaces, non-ionic surfactants are present in fabric softener formulations. Being very effective in removing greasy/fatty based substances and impurities, the non-ionics present, prepare the fibre surfaces for the rapid absorption of the cationic molecules present in solution.

2 marks

If the fibre surfaces were not 'clean' the cationic would not be absorbed and the fabric not softened. **Better candidates** may draw the chemical structures of these detergent molecules. Non-ionics are in these systems because anionics and cationics are incompatible.

2 marks

Total 25 marks

Question 4

a) **Dyeing polyester rich polyester/cotton blends** – because these two fibres differ significantly in their water-absorbing properties, water-soluble fibre-reactive dyes can be used only for the cotton component of the blend. For the polyester fibres present disperse dyes are used.

3 marks

The very hydrophobic nature of polyester presented considerable difficulties to the dyer.

1 mark

The specially-developed disperse dyes for polyester had to be applied in quite forcing conditions i.e. at high temperatures and in the presence of special dye carriers. In these conditions the dye molecules were 'forced' into the fibre structure and did not simply remain on the polyester fibre surfaces. Early on in the development of polyester/cotton blends, dyeing was a problem because each fibre type was dyed at a different time, this was expensive and very time-consuming. Today, both reactive dyes for the cotton component and disperse dyes for the polyester are applied to the fibres at the same time from the same dye bath using special dye-carriers and conditions which remain confidential.

2 marks

b) **Fading of silk fabrics** – silk being a protein-based fibre can be dyed with the dye types which are used for wool and wool blends.

1 mark

However silk is a monofilament fibre and has many of the properties which we associate with the synthetic fibres. The SMR of silk is high (11%) and the fibres are hydrophilic but, because of the very compact structure of the silk monafilaments, they are not easily penetrated by water-soluble substances including dyes.

2 marks

Again, because silk is rather sensitive to chemical attack and is easily damaged, forcing conditions cannot be used to increase the rate at which the dyes are made to penetrate the filaments.

1 mark

Unless great care is used in the dyeing of silk, the dyes used often remain on the surfaces of the filaments only, they do not penetrate into the filaments and simply wash off during laundering.

1 mark

In order to prevent significant colour loss occurring with silk garments they should be dry-cleaned or treated very carefully and washed at low temperatures, using a mild detergent product.

1 mark

c) **Dyeing viscose rayon fibres** – viscose fibres are essentially cellulosic in their nature, having being produced from non-textile sources of cellulose.

1 mark

However viscose fibres are not as robust as cotton and the dyeing of viscose needs to be controlled carefully i.e. especially the acidity/alkalinity conditions in the dyebath i.e. the pH. Because many dyes have been developed over the years for cotton textiles, the dyeing of viscose should not have been a problem when it was developed early in the 20th century.

2 marks

Although cotton will withstand highly alkaline conditions, this is not the case for viscose because the cellulose chains present in viscose are shorter than they are in cotton. This shortening of the cellulose chains in viscose arises out of the chemical process by which viscose is manufactured.

2 marks

Shorter cellulose chains in viscose means there is less intermolecular hydrogen bonding and consequently a considerable weakening in the strength of the fibres especially when they are wet. Many of the dyes which are used for cotton can be used for viscose **only if** care is taken with the conditions used. The high temperatures and highly alkaline conditions used for dyeing cotton cannot be used for dyeing viscose.

2 marks

d) **Dyeing wool fibres** – wool is a protein fibre and has many positively and negatively charged chemical groups present in the fibres. Because of this, both acid and basic dyes can be used to dye wool.

2 marks

Basic (or cationic) dyes are very substantive to protein fibres, especially wool, because the dye cation forms an ionic link with negatively-charged groups on the wool fibres.

i.e. WOOL -------- CO_2^- + D^+ → WOOL -------- $CO_2^- D^+$

Where D^+ is the coloured dye cation.

The attraction is so great between the dye and the wool that a retarding agent is often added so that an even colour is produced.

1 mark

Acid (or animonic dyes) are negatively charged and they combine with the positive sites on the wool fibres.

i.e. WOOL -------- NH_3^+ + A^- → WOOL -------- $NH_3^+ A^-$

Where A^- is the coloured dye anion.

1 mark

Both acid and basic dyes come in a wide range of colours and shades so woollen yarns and garments are available in almost any colour today.

2 marks

Total 25 marks