**SOLUTION FOR SECOND INTERNAL TEST**

**ELECTRICAL ENGINEERING MATERIALS - 6th Semester EEE**

**Each Question carries 10 Marks**

1. **Properties of a good Insulating material**

(a)Large insulating resistance.

(b)High dielectric strength.

(c)Should be uniform throughout.

(d)Least thermal expansion.

(e)When exposed to arcing should be non-ignitable.

(f)Low dissipation factor (Loss tangent).

(g)High mechanical strength and thermal conductivity.

(h)Low permittivity.

(i) Should be resistant to thermal and chemical deterioration. - 10 Marks

2. **Polarization** is a property applying to transverse waves that specifies the geometrical orientation of the oscillations. In a transverse wave, the direction of the oscillation is transverse to the direction of motion of the wave, so the oscillations can have different directions perpendicular to the wave direction. The different types of polarization are (1)Electric Polarization (2)Ionic Polarization (c)Dipolar Polarization - 3Marks

**Electronic Polarization** is more pronounced in the case of liquid and solid dielectrics than in gases. It decreases with rise in temperature due to thermal expansion. Here polarization sets in within an extremely short time. **Ionic polarization** does not give rise to an active current. When the atoms in a molecule have an excess positive or negative charge an electric field will tend to shift positive ions relative to negative ions. The time

taken by the ionic polarization is larger than electronic polarization. In **dipolar polarization,** polarization forces are strongly influenced by the structure of the molecules. In certain dielectrics, the molecules of the dielectric possess an electric dipole moment even when an external electric field is not applied. Such molecules have the centres of their positive and negative charges displaced with respect to each other forming a dipole. – 7 Marks

3. **Ageing in Insulators**

(a)The term ageing refers to the degradation of an insulator by different environmental effects and electrical stresses.

(b)The environmental effects include ultraviolet, moisture, heat, light, atmospheric pressure and biological degradation caused by micro organisms in air.

(c)Electrical stress include corona, arcing over the surface of insulators, roughness and erosion of the surface.

(d)Ageing of an insulator is the effect produced on it after a specified period of service.

(e)Ageing of polymeric insulators is mainly concerned with ageing of the outer sheath.

(f)Outdoor weathering is a natural phenomenon which ages all materials to some extent.

(g)Degradation of insulators is concerned with the breakdown of macromolecules causing reduction in molecular weight.

The breakdown of insulators can be caused by various environmental factors :

**1.** Biological degradation –Polymeric insulators are made up of organic materials. All organic materials have the property to support the growth of microorganisms in them.

2. Chemical pollutants – These include Sulphur dioxide, oxygen, ozone and $NO_2$

3. Environmental stresses – These include heat, light, moisture, wind, dust, rain, precipitation and UV light due to corona. – 10 Marks

4. **Properties of $SF_6$ gas**

(a)Sulphur hexafluoride is formed by burning sulphur in an atmosphere of fluorine.

(b)It is colourless, odourless and non-inflammable gas.

(c)It is one of heaviest known gases.(5 times than air).

(d)It has high dielectric strength.

(e)It has low solubility in water.

(f)It has has superior cooling properties compared to those of air and nitrogen.

(g)It can be liquefied by compression.

(h)Its dielectric strength increases at high pressure and may become equal to that of mineral transformer oil.

(i)Apparatus insulated with sulphur hexafluoride gas are higher in weight than those insulated with liquid dielectric.

(j)It is also used in transformers and electric switches.

(k)It has high chemical stability at normal pressure and at temperature up to $100^0$ C.

(l)It increases the interrupting capacity of circuit breakers.

(m)The presence of sulphur in molecules, under certain conditions, can cause corrosion of the contacting surfaces.

(n)To increase dielectric strength, the gas is to be used at high pressure which will require a sealed tank capable of withstanding the high pressure - 10 Marks

5. **Transformer oil** or insulating oil is an oil that is stable at high temperatures and has excellent electrical insulating properties. It is used in oil-filled transformers, some types of high-voltage capacitors, fluorescent lamp ballasts, and some types of high-voltage switches and circuit breakers. Transformer cores and chokes are commonly immersed in transformer oil. It has two main functions :

(a)It transfers heat by convection from windings and core to the cooling surfaces.

(b)It maintains the insulation of the windings.

When fire hazards are more prominent, a non – inflammable synthetic oil such as chlorinated Transformer oil is non – inflammable, has high permittivity and exhibits no tendency to emulsify with water.

**Properties of Transformer oil**

(a)Electric strength – 40kV when applied for one minute

(b)Specific gravity – 0.88

(c)Dielectric constant – 2.2

(d)Pour point – $40^0$ C

(e)Sludge value percent – 1.2

(f)Acidity after oxidation – 0.5

(h)Flash point temperature of fresh dry oil – $135^0$

(i)Ash content of fresh dry oil – 0.005%

(j)Freezing point of oil for switches and circuit breakers – not to be below $45^0$ C

(k)Resistivity - $10^{15}$ ohm cm. – 10 Marks

6. A **Piezoelectric material** is one in which an electric potential appears across a crystal if the dimensions of the crystals are changed by the application of mechanical force. The effect is reversible. Conversely if a varying potential is applied to the proper axis of the crystal, it will change the dimensions of the crystal thereby deforming it. This effect is known as Piezoelectric effect. – 3 Marks

**Working of Piezoelectric device**

Consider the force applied to a simple plate of a piezoelectric material. The magnitude and the polarity of the induced charge on the crystal surface is proportional to the magnitude and direction of applied force. The charge at the electrode gives rise to the voltage E, given by E = =gtF/A = gtP where g = Voltage sensitivity in Vm/N Here g = K/t where K = piezoelectric constant, t = thickness of the crystal. F = Force in Newton, A = Area of the crystal, P = Pressure = F/A in $N/m^2$ - 3 Marks

Diagram – 4 Marks

**7.** A shape-memory alloy (SMA, smart metal, memory metal, memory alloy, muscle wire, smart alloy) is an alloy that **"remembers"** its original shape and that when deformed returns to its pre-deformed shape when heated. – 2 Marks

**One way Memory Effect -** When a shape-memory alloy is in its cold state, the metal can be bent or stretched and will hold those shapes until heated above the transition temperature. Upon heating, the shape changes to its original.

**Two way Memory Effect -** The two-way shape-memory effect is the effect that the material A remembers two different shapes: one at low temperatures, and one at the high-temperature shape. material that shows a shape-memory effect during both heating and cooling is said to have two-way shape memory. This can also be obtained without the application of an external force. – 4 Marks

Diagrams – 4 Marks

**8.** (a)Hydrogels are water-swollen polymeric materials that maintain a distinct three- dimensional structure. Smart gels contain fluids (usually water) in a matrix of large, complex polymers.

(b)These polymers are special in that they respond to stimuli in an advanced way. Types of

(c)Types of stimuli that affect smart gels are physical and chemical factors.

(d)Temperature, light, electric forces, magnetic forces, and mechanical forces (shaking) are

types of physical interactions on the gel that will precipitate a reaction.

(e)Chemical stimuli are usually pH changes or solvent exchanges.

(f)The reaction of the smart gel is always an expansion or contraction within milliseconds upon stimulation.

(g) Essentially, when a gel swells, it absorbs additional fluid into it. Likewise, when it deflates, it expels this fluid out of its membrane.

(h)The expansion and contraction are usually caused by a change in the polymer; the stimulus alters the polymer by making it more or less hydrophilic.

(i)While smart gels do not depend on nanotechnology, in many cases their effects are greatly aided by using nanoparticles.

(j)While micro-particles usually allow the gel to function properly, smaller particles at the nano-scale increase intended effects dramatically. – 10 Marks