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| **Qn** | **Answer** | **Marks** |
| 1. (a) | (i) … the number of joules of energy supplied by the source to drive one coulomb of charge round the entire circuit including the source itself. | 1 |
| (ii) … the resistance per metre length of the material of cross-sectional area 1 m2. | 1 |
| (b) | The following circuit is connected.  A  V  R  P  E  I  E is a steady source, R a wire-wound resistor of low resistance and P a rheostat of the same order of resistance as R.  The voltmeter V and the ammeter A must be those whose calibration does not depend on Ohm’s law – otherwise the experiment then would not be valid.   * The current I is varied by adjusting P, and the potential difference V is measured at each value of current. * The procedure is repeated when the current is reversed. * A graph of V against I is plotted - It is a straight line through the origin.   +V  +I  -I  -V | 1  1  1  ½  1  ½ |
| (c) | (i) The current in the circuit is I =  The output power, Po = I2R =  For fixed values of E and r the maximum power output Pmax is obtained when    i.e. when  i.e when R = r  Substituting for R in (1), we have  Pmax = | ½  ½  1  1  1 |
| R  r  Po  (ii) | ½  1  ½ |
| (d) | (i) VAB =  = 1.8 V  Now VAD = emf of Y = 1.5 V  So AD =  = **83.3 cm** | 1  ½  ½  1 |
| (ii) When S is closed, let the p.d across the 3Ω resistor be V  Let r = internal resistance of Y.  Then  ∴ r =  = **0.57 Ω** | 2  1  1 |
| ***Total = 20*** | | |
| 2. (a) | Neutral conductor  (i)  Suppose the electroscope is positively charged.   * When a neutral conductor is brought near the cap, electrostatic induction occurs in the conductor so that the side near the cap acquires a negative charge. * This repels some electrons from the cap to the metal plate and the leaf, thus reducing the positive charge there. * This results in reduction of the divergence of the leaf. | 1  1 |
| (ii) Charging by contact depends on leakage of charge at the contact points.  However, even those surfaces which look perfectly flat to the eye are never flat at all.  They consist of hollows and heaps so that actual contact is at extremely few points.  This makes success with this method very difficult.  Charging by induction does not depend on points of contact but on nearness of the bodies | ½  1  ½ |
| (b) | (i) At Z the magnitudes of the electric intensities are equal.  Let x = distance of Z from the 6μC charge  i.e.  ∴  ∴ 3(400 – 40x + x2) = 2x2  ∴ x2 – 120x + 1200 = 0  ∴ x = (11.0 or 109)  But x must be smaller than 20  So x = **11.0 cm** | 1  1  1  1 |
| (ii) We imagine one of the charges, say Q2, to be moved relative to the other, Q1.  Work done = difference in potential energy of Q2 in the two positions  =  =  =  =  **2.34 J** | 1  1  1 |
| (c) | V  *C*  Sensitive galvanometer  Vibrating-reed switch  Protective resistor  A  G  B  The first capacitor, of capacitance C1, is connected between points A and B and the circuit set up as shown.  The supply is switched on and the current I1, read from the galvanometer, is noted.  The procedure is repeated with the other capacitor, of capacitance C2, and the current I2 is noted.  Let Q1 be the charge passed through the galvanometer during each time of switching when C1 is connected between A and B.  Then the current, I1 = Q1f, where f is the switching frequency of the reed  i.e. I1 = C1Vf ………….(1)  Similarly I2 = C2Vf ………….(2) | 1  1  ½  ½  ½  ½  1 |
| (d) | P.d across the 200μF is 6 V  ∴ energy stored in it = ½CV2 = ½ x 200 x 10-6 x 62 = **3.6 x 10-3 J**  P.d across the 300μF = 10 – 6 = 4 V  ∴ energy stored in it = ½CV2 = ½ x 300 x 10-6 x 42 = **2.4 x 10-3 J** | 1  1  1  1 |
| ***Total = 20*** | | |
| 3. (a) | (i) …the distance between the optical centre of the lens and the point from which rays originally close and parallel to the principal axis appear to diverge from after refraction by the lens. | 1 |
| (ii) …a pair of points such that if an object is placed at one, a real image of the object is formed at the other by the lens | 1 |
| (b) | I1(virtual object)  I (real) | 1  ½  ½ |
| (c) | L1 L2  P  O I I΄ C  u v  v΄  f1 f2  X  Let L1 and L2 be the lenses.  A ray OP passes through the middle undeviated and ray OX is refracted through the first lens A and would intersect OC at I΄.  However, it is refracted further by B to meet OC at I. So, I is finally the image of O.  Thus I΄ is the virtual object in lens B and in this case u = -v΄.  For the 1st lens L1…………………….(1)  For the 2nd lens L2 …………………….(2)  Adding equations (1) and (2) we have    Since I is the image of O by refraction through both lenses    where F is the focal length of the combined lenses.  Hence | 1  ½  ½  ½  ½  ½  ½  1 |
| (d) | * First of all the focal length f1 of the converging lens L is found by using the non-parallax method. * A small quantity of the liquid whose refractive index is required is then placed on the plane mirror and the lens L on top as shown in the diagram.   O I  Liquid  L  Plane mirror   * A position I is located where the image, I, of a pin O held over the lens coincides in position with the pin itself.   Then the distance from O to the lens must be the focal length, F, of the lens- liquid combination.  Let f2 be the focal length of the liquid lens.  Then  ∴  If n is the refractive index of the lens and r the radius of curvature of the lower surface of the lens, then  (r is negative for liquid lens)  Therefore  r can be determined by floating the lens on mercury. | 1  1  1  1  ½  1  ½ |
| (e) | Since the object is distant, the original image is formed in the focal plane of lens L1.  *Arrangement 1:*  L1  L2  10  f1 - 14  4  f1  I  F1  For L2 the object distance is –(f1 – 10) while the image distance is (f1 – 14)  Using  we have  ………….. (1)  *Arrangement 2:*  L1  L2  5  f1 – 12.5  7.5  f1  I  F1  Using  where v = (f1 – 12.5) and u = -(f1 – 5)  ………………… (2)  From (1) and (2): =  ∴  ∴ 3.5 …………………. (3)  ∴ f1 =  ∴ f1 = (11.5 or 20)  But f1 must be greater than 11.5. So f1 = **20 cm**  From (1)  ∴ ⇒ f2 = **15 cm** | 1  1  1  1  1 |
| ***Total = 20*** | | |