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| **Qn** | **Answer** | **Marks** |
| 1. (a) | (i) …the point rays originally close and parallel to the principal axis appear to emerge from after reflection by the mirror. | 1 |
| A  θ  θ  θ  C F P  *f*  *r*  X  β  (ii) …the ratio of the height (or linear dimensions) of the image to the height (or linear dimensions) of the object | 1 |
| (b) | (i)  Imagine a ray AX, close and parallel to the principal axis, is incident at X.  Then it will be reflected through F, the principal focus. A normal at X must be passing through C, the centre of curvature  By the laws of reflection, ∠AXC = ∠FXC = θ  And ∠AXC = ∠XCF (Alternate angles)  Now, β = 2θ  All these are small angles. So β = tanβ and θ = tanθ  ∴  O  C  I  X  α  β  γ  N  P  v  r  u  θ  θ  ∴ f = r | ½  ½  ½  ½  ½  ½ |
| (ii)  Consider a point object O on the principle axis of a convex mirror.  A ray OX from O is reflected along XI.  A normal at X must be passing through the centre of curvature of the mirror. So C is the centre of curvature.  A ray OP, incident at the pole P, is reflected back along PO and the point I where the reflected rays meet is the image of O.  From the geometry of the figure  α + θ = β……….……………..(1)  Also β + θ = γ……….………………(2)  Therefore from (1) and (2)  α + γ = 2β …………………………(3)  Now, γ = h/IN = h/(IP) as I is virtual.  α = h/ON = h/(OP) as O is real  β = h/NC = h/(PC) as C is real  Substituting for α, β and γ in (3)  h/(OP) + h/(IP) = 2h/(CP)  So 1/OP + 1/IP= 2/CP  1/u + 1/v = 2/r      ALTERNATIVE DERIVATION  u  Q  R  O  P  S  v  f  I  h1  h2  F  Imagine an object OQ of height h1 at O.  A ray QR parallel to the principal axis is reflected through F, the principal focus.  A ray QP, incident at the pole, is reflected through S such that ∠QPO = ∠SPI and the point, S, where the two reflected rays meet is the image of Q.  Also I is the image of O since O is on the principal axis, and IS is the image of OQ.  Now ΔQPO is similar to ΔSPI    And ΔSIF is similar to ΔRPF  Image and object  O L P C  N  I  M  ***(Convex mirror approach is also acceptable)*** | ½  ½  ½  ½  ½  ½  ½  ½  ½  ½ |
| (c) | (ii)   * Using a convex lens L, a real image of an illuminated object O is formed at point C. Distance LC is noted. * The convex mirror is then placed between L and C with its reflecting surface facing the lens and is moved along the axis OC until a real image of O is formed at O. Distance LP is noted.   Under these conditions the rays from O must be striking the mirror normally e.g. at M and N.  Thus PC = r, the radius of curvature  Now PC = LC – LP  **∴** r = LC – LP  ∴ focal length, f = r = (LC – LP) | 1  1  ½  1  ½  ½  ½ |
| (d) | (i) Linear magnification =  =  = **0.125 or** | 1  1 |
| (ii) Using  we have  where  = 8 and u = 162 cm  So 8 + 1 =  ∴ f =  = **18 cm** | 1  1  1 |
| ***Total = 20*** | | |
| 2. (a) | Air  Water  A  B  B′  (i)  Rays of light from end **B** bend away from their normals, as shown in the diagram, and appear to come from **B′** as they enter the eye.  **B′**  is thus the image of **B** by refraction.  The same reasoning applies to any point on the immersed part of the stick. So the stick appears bent. | 1  1  ½  ½ |
| (b) | *Any one @1*  (i) – The light must be travelling from a denser to a less dense medium  - The angle of incidence must be greater than the critical angle | 1 |
| r r  θ  θ  *i* *i*  (ii)    At minimum deviation the ray passes symmetrically  **∴** i - r + i – r = D ………………..(1)  Now r + r = θ  **∴** r = θ  Substituting for r in equation (1) 2i = θ + D  **∴** i = (θ+D)  **∴** n = | ½  ½  ½  ½  1 |
| (c) | (i) - Telescope adjustment  - Collimator adjustment  - Leveling the table | 1  1  1 |
| (ii)  T1  R  α  α  2(α+β)  β  β  P A 2A  T2  Q               * The telescope is first adjusted for use. * The prism is placed on the spectrometer table and its refracting edge, P, is turned so as to face the collimator lens, thus illuminating the two surfaces containing the refracting angle A with a parallel light. * The telescope is moved to position T1 in which the collimator slit is seen by reflection from face PQ. The angle corresponding to T1 is noted, say θ1. * The telescope is then moved to position T2 to receive the image of the slit again. The angular position is noted, say θ2.   The angle turned through between the two positions is (θ2 – θ1). It is equal to 2A. The diagram on the right helps to prove this | 1  ½  ½  ½  ½  ½  ½  1 |
| (d) | r  90o  65o  10o  c  n*l*  ng  nl sin 10o = 1.58 sin r ………. (1)  1.58 sin c = nl sin 90o  ∴ nl = 1.58 sin c ………… (2)  From (1) and (2) 1.58 sin c sin 10o = 1.58 sin(65o – c)  ∴ sin c sin 10o = sin 65ocos c – cos 65osin c  ∴ sin 10o = sin 65ocot c – cos 65o  ∴ cot c =  = 0.6578  ∴ c = 56.7o  ∴from (2) nl = 1.58 sin 56.7o  = **1.32** | 1  1  ½  ½  1  1 |
| ***Total = 20*** | | |
| 3. (a) | (i) … the piling of electrons on one side of a conductor, leaving a positive charge on the opposite side it, due to presence of a charge nearby. | 1 |
| (ii) The electric intensity at a point in an electric field is the force experienced by a positive charge of one coulomb placed at that point. | 1 |
| (b) | (i) X must be a conductor and Y an insulator | 1 |
| -  -  -  +  +  +  X  Y  - -  -  - -  -  - -  B  (ii)  X has mobile electrons while Y does not.  So when B is introduced between X and Y, electrostatic induction occurs in X, with electrons repelled to the remote side of X.  This leaves a net positive charge near B.  Because the positive charge is nearer the negatively charged body than the negative charge, a net attractive force develops between X and B | ½  ½  1  ½ |
| (c) | Suppose A is the point whose potential, VA, is required. Then imagine a small point charge q placed at point C, distance x from Q.  +Q ­A  z  δx  B  C  +q  x      Suppose q is now moved a small distance δx to B, δx being so small that the field due to Q is not affected.  Over this small distance, the force F may be regarded as constant. So the work done by the external agent over δx against the force of the field is  δW = F(-δx)    The total work done in bringing q from infinity to point A is    The potential VA at point A is the work done per unit positive charge brought from infinity to A. | ½  ½  1  1  1  1 |
| (d) | (i) Potential energy =  =  = -**1.08 J** | 1  1 |
| (ii) E1 =  =  = 2.7 x 106 NC-1  E2 =  =  = -1.8 x 106 NC-1  135o  E  E1  E2  E2 =  = (2.72 + 1.82 – 2 x 2.7 x 1.8 x cos45o) x 1012  = (7.29 + 3.24 – 6.87) x 1012  = 10.53 x 1012  ∴ E = **3.24 x 106 NC-1** | 1  1  1  1  1 |
| (iii) Let A be x cm from Q1  Then  =  ∴  ∴ 30 – 3x = 4x  ∴ x = **4.29 cm** | 1  1  1 |
| ***Total = 20*** | | |
| 4. (a) | (i) …. a device that stores charge. | 1 |
| (ii) … the maximum potential gradient the dielectric can be subjected to without its insulation breaking down. | 1 |
| (b) | The potential difference decreases.  Electrostatic induction occurs in the metal slice, with positive charge residing next to the negative plate and negative charge next to the positive plate.  This arrangement reduces the p.d between the plates. | ½  1  1  ½ |
| (c) | (i) - distance between the plates  *Any two @1*  - overlapping area of the plates  - the dielectric used | 2 |
| V  C1  Sensitive galvanometer  Vibrating-reed switch  Protective resistor  X Y  G  (ii)   * A vibrating-switch circuit is set up as shown starting with of the capacitors, C1 in the circuit. When the vibrating reed makes contact with X, the capacitor gets charged and when it makes contact with Y, it is discharged. * The vibrating-reed is switched into operation and the current, I1, registered by the galvanometer is also noted.   Now, if f is the frequency of the reed switch and Q1 the charge acquired by C1 and discharged through G, the current I1 = fQ1.  Now Q1 = C1V, where V is the p.d across C1  So I1 = fC1V, thus C1 ∝ I1.   * The procedure is repeated when C1 is replaced with the other capacitor C2 and the corresponding current I2 is noted   C2 ∝ I2  So  ***NB: A ballistic galvanometer could have been used if the students had already covered it.*** | 1  1  ½  ½  ½  ½  1 |
| (d) | Imagine capacitors of capacitances C1, C2 and C3 are connected in parallel to a p.d V. The p.d V is the same across across the capacitors but each takes up charge according to its capacitance. If the respective charges are Q1, Q2 and Q3 then  +Q1 C1  +Q2 C2  +Q3 C3  V  Q1 = C1V, Q2 = C2V and Q3 = C3V  The total charge stored is  Q = Q1 + Q2 + Q3  = (Q1 + Q2 + Q3)V  The system is equivalent to a single capacitor, of capacitance  **C** = Q/V **= C1 + C2 + C3** | 1  1  1 |
| (e) | For the two 20μF in parallel, their equivalent capacitance is  = 10μF  So the circuit becomes the following  60V  40µF  20 µF  V1  V2  60V  40 µF  10µF  10 µF  Now V1 + V2 = 60 ……… (1)  and 40V1 = 20V2 …… (2)  ∴ V2 = 2V1  Substituting for V2 in (1) we have  V1 + 2V1 = 60  ∴ V1 = 20V  Energy stored in the 40μF capacitor, E = ½ x 40 x 10-6 x 202  = **8.0 x 10-3 J** | 1  ½  ½  ½  1  ½  1 |
| ***Total = 20*** | | |
| 5. (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 dissipative opposition to flow of current offered by the materials of the source. | 1 |
| (b) | (i) The lattice of a conductor is an assembly of ions in a “sea” of mobile electrons.  As electrons drift they collide with the ions, which are already vibrating about their mean positions, thereby increasing the ion’s k.e.  Hence the conductor heats up.  Whatever the direction of the electrons’ drift, the collisions do occur. So the heating effect is independent of the direction of current | 1  1  1 |
| (ii) At constant temperature, the current flowing through a wire is directly proportional to the potential difference between the ends of the wire *and the relationship is independent of the direction of current or potential difference.* | 1 |
| (ii) 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) | R1  R2  V  R3  I1  I2  I3  I  Imagine resistors of resistances R1, R2 and R3 are connected in parallel to a p.d V. The p.d V is the same across the resistors but each passes a current according to its resistance. If the respective currents are I1, I2 and I3 then  I1 = , I2 =  and I3 =  The toatl current in the circuit is  I = I1 + I2 + I3  ∴  =  +  +  ∴  =  +  + | 1  ½  ½  1 |
| (d) | r  2V  2Ω  R  2V  r  1A  (i)    R  2Ω  From the first circuit  ∴ r =  …………. (1)  From the second circuit  = r + 2+ R …….(2)  Substituting for r from (1)  5.8 = + 2 + R  ∴ 5.8(2 + R) = 8 + 4R + R2  ∴ R2 – 1.8R – 3.6 = 0  ∴ R = **3 Ω** | 1  1  1  1  1 |
|  | (ii) r =  = **0.8Ω** | 1 |
| ***Total = 20*** | | |