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| **Qn** | **Answer** | **Marks** |
| 1. (a) | *Any two @1*  (i) - Laterally inverted  - Same size as the object  - Same distance behind the mirror as the object is in front of the mirror | 2 |
| (ii) …the distance between the pole of the mirror and the centre of the sphere of which the mirror is part. | 1 |
| (b) | u  Q  R  O  P  S  v  f  I  h  H  F  (i) | ½  ½  ½  ½ |
| (ii)  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.  So 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  So  …….. (1)  and ΔSIF is similar to ΔRPF  So  which leads to ……(2)  From (1) and (2)  Dividing through by v and rearranging, we have  u v  O M P I  I΄ | ½  ½  ½  ½  ½  ½  ½  ½ |
|  | - The pin O is placed to form an image I in the convex mirror.  - Then the small plane mirror, M, facing O is moved between O and P until the image, I΄, of the lower part of O coincides with I.  The distances OP and MP are measured.  Due to the plane mirror, OM = MI  **∴**v = OM – MP (virtual) and u = OP (real)  The procedure is repeated for several positions of O each time working out u and v.  A graph of 1/v against 1/u is plotted.  The intercept on each axis gives 1/f  u - 7  2(u – 7)  u = v = 2f | 1  ½  ½  ½  ½  ½  ½  1 |
| (d) | In the first setting the image distance equals the object distance. So both are at the centre of curvature.  i.e u = 2f ………………….(1)  In the second setting object distance, u2 = u – 7  and image distance v2 = 2(u – 7)  Using magnification, m = , we have  2 = ……. (2)  Substituting for u: 2 =  ∴ 2f = 4f – 14 – f  ∴ f = **14 cm** | 1  ½  ½  1  1 |
| (ii) Final object distance, u2 = u – 7 = 2f – 7  = 28 – 7 = **21 cm** | 1  1 |
| ***Total = 20*** | | |
| 2. (a) | (i) – Light must be travelling from a denser medium to a less dense medium  - The angle of incidence must exceed the critical angle | 1  1 |
| 180o  (ii)  Air  cc  cc  Water  If the water surface is calm, all the rays of light striking it are refracted in such a way that the fish’s eye can receive light from anywhere above the water surface. | 1  1  1 |
| (b) | Consider a ray PQ incident in air on a plane glass boundary and finally emerging along a direction RS in air.  P  *i*a  air  glass  Q  *i*g  *i*w  water  *i*w  R  S  air  *i*a  If the boundaries of the media are parallel, RS is parallel to PQ.  Let ia,ig, iw respectively be the angles made with the normals in glass and water media.  Then, looking at the upper side,  sin*i*a = angsin*i*g………………. (1)  and at the lower side sin *i*a = anwsin*i*w ………………. (2)  from (1) and (2) sin *i*a = angsin*i*g = anwsin*i*w  Since na = 1, it follows that ang = ng and anw = nw  So we can write na sin *i*a = angsin*i*g = anwsin*i*w  ∴**n sin *i* = constant** | ½  1  1  ½  ½  ½ |
| (c) | S  N M  C  A  L  *r*  *i*  *r*  *i*  P  D  B   * A concave mirror, S, is placed on a bench. * A pin is held above the mirror and a position along the principal axis is found where it coincides with its own image.   The height of the pin from the pole of the mirror is measure and noted. It is equal to the radius of curvature of the mirror.   * A little of the liquid is placed on a concave mirror and a position L is located by the no-parallax method where the image of a pin held over the mirror coincides in position with the pin itself.   The distance LP, between the pin and the mirror is measured.  In this case the rays are reflected back along the incident path and must therefore be striking the mirror normally.  A ray LN close to the axis LP is refracted at N along ND in the liquid, strikes the mirror normally at D, and is reflected back along DNL.  Thus if DN is produced it passes through the centre of curvature C.  Let ANB be the normal to the liquid surface at N.  Then ∠ANL = ∠ NLM = *i* (angle of incidence)  and ∠BND = ∠ANC = ∠NCM = r (angle of refraction)  The refractive index, n =  Since LN is a ray very close to the principle axis CP, LN is approximately = LM and CN = CM so that n =  But if the depth MP of the liquid is very small compared with LM and CM, CM = CP and LM = LP approximately.  Hence, approximately, n = , where CP is the radius of curvature. | 1  ½  1  ½  ½  ½  1  ½  ½ |
| (d) | A  A  16o  *i*1  r1  r2  *i*2  *i*2    Let ng = refractive index of glass  Then sin 16o = ngsin*i*1 ………….. (1)  and 1.33 sin r1 = ngsin*i*1 ………….. (2)  From (1) and (2) 1.33 sin r1 = sin 16o  ∴ sin r1 =  = 0.207  ∴ r1 = 11.9o  Also 1.33 sin r2 = ngsin*i*2 ………….. (3)  and sin 90o = ngsin*i*2 ………….. (4)  From (3) and (4): 1.33 sin r2 = sin 90o  ∴sin r2 =  = 0.752  ∴ r2 = 48.8o  Now, A = r1 + r2 = 11.9 + 48.8 = **60.7o** | ½  ½  ½  ½  ½  ½  ½  ½  1 |
| ***Total = 20*** | | |
| 3. (a) | (i) …a surface or volume over which the potential is constant. | 1 |
| (ii) The electric intensity (or field 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) | A  B  Charged sphere  Neutral conductor  C  P   * When a neutral conductor is brought in the vicinity of the charged sphere, P, electrostatic induction occurs in the conductor causing re-distribution of charge as shown in the diagram. * The electric potential at a point on the sphere, say A, is the sum of the potential VB and VC due to the charges at B and C respectively as well as the potential due to the charge on the sphere. * Since VB and VC have opposite signs and C is further away than B, then the potential at A is effectively reduced. | 1  ½  1  ½ |
| (c) | (i)  A  Suppose a pointed conductor A is charged positively.  Most of the charge concentrates at the tip, creating an intense electric field there.  This ionises the air there.  The negative ions are attracted to the tip and are neutralised while the positive ions are repelled.  The net result is that positive charge is being sprayed from the tip into the air. | 1  ½  ½  ½  ½ |
| E2  P2  S  Insulating cylinder  Silk belt  E1  P1  Motor  h.t  battery  (ii)  A Van de Graaf generator consists of a hollow metal sphere S supported on an insulating cylinder several metres high.  E1 and E2 are electrodes in form of sharply pointed combs.  *Action:*   * E1 is given a potential of about 10,000 volts, positive with respect to the earth, by a battery. * The high electric field at the points of E1ionises the air there, positive charges being repelled to the belt. * The belt, driven by a motor over pulleys P1 and P2, carries the charges up into the sphere. * The positive charge induces a negative charge on the points of E2 and a positive charge on the sphere. * The high electric field at the points of E2ionises the air there, and negative charge is repelled to the belt thereby discharging it before it passes over the pulley P2.   Thus, the sphere gradually charges up positively to millions of volts with respect to the earth. | ½  ½  ½  ½  ½  ½  1  ½  1  ½ |
| (d) | (i) The force =  =  = -**43.2 N**  The force is towards Q1. | ½  1  ½ |
| (ii) The work done = Potential difference due to Q1 in the two places x Q2  =  = -3 x 10-6 x 9 x 109x 4 x 10-6  = **0.81 J** | 1  1  1  1 |
| ***Total = 20*** | | |
| 4. (a) | (i) – The p.d between the plates (or charge stored by the capacitor)  - The capacitance of the capacitor | 1  1 |
| (ii) In order to move apart the oppositely charged plates so as to increase the separation, energy must be supplied to overcome the forces of attraction.  The energy supplied becomes the electrostatic potential energy of the system.  Hence the enrgy stored by the capacitor increases. | 1  ½  ½ |
| (b) | (i)  p.d  Current  Time | 1  1 |
| (ii) - When the insulating material is inserted between the plates of an isolated charged capacitor, the molecules of the material polarise, forming dipoles.  - Neighbouring dipoles cancel out in in the bulk leaving resultant charge at the edge of the insulator, whose sign is opposite that of the adjacent plate.  - So the potential difference falls | ½  1  ½ |
| (c) | V  *C*  Sensitive galvanometer  Vibrating-reed switch  Protective resistor  X Y  G  air  A high level of insulation is necessary in this experiment because of the high voltages used.   * So the capacitor, C, may be in form of a pair of large parallel perspex plates the inside surfaces of which are coated with aluminium foil. * The overlapping area, A, and the separation, d, of the plates are determined and noted. * The circuit is connected as shown in the diagram, in which the supply is a smooth d.c of hundreds of volts. * The vibrating-reed switch is switched on to alternately charge and discharge C. * The voltmeter reading, V, and the current, I, registered by the galvanometer are noted.   Now capacitance, C = εoA/d ………………..(1)  Suppose Q is the charge stored on the capacitor at the p.d is V.  Then Q = CV. So C = Q/V …………………..(2)  If f is the frequency of reed switch, the current, I =fQ, provided the capacitor is fully charged and discharged during each contact of the reed switch.  From (1) and (2):  =  ∴ εo = | 1  ½  ½  ½  ½  ½  ½  ½  ½ |
| (d) | (i)  200V  C2  C1  C3  C1 and C3 are in parallel: Cʹ = C1 + C3 = 20 + 10 = 30μF  ∴ Ceff =  =  = 15μF  Energy stored, W = ½ x 15 x 10-6 x 2002 = **0.3 J** | 1  1  1 |
| (ii) C2 becomes 2 x 30 = 60μF  The new effective capacitance =  = 20μF  Energy stored, Wʹ = ½ x 20 x 10-6 x 2002  = 0.4 J  Change in energy stored, ∆W = 0.4 – 0.3 = **0.1 J** | ½  ½  1  1  1 |
| ***Total = 20*** | | |
| 5. (a) | (i) …a resistor which converts all electrical energy delivered to it into heat. | 1 |
|  | (ii) Conduction in a metal is a drft of electrons in a lattice of ions which are vibrating in their mean positions.  At higher temperatures of the conductor the vibrations of the ions are more violent. This makes it more difficult for the electrons to drift through.  So the resistance of the conductor rises. | ½  1  ½ |
|  | (iii)  I  V  Ohmic conductor  *The axes must be labelled*  Non-ohmic conductor e.g  +I +I +I +I  +V +V +V  -I -I -I  (i) Junction diode (ii) Neon gas (iii) Diode valve  I  *Any one of these as long as the device is named*  V  (iv) Dilute H2SO4  (Pt electrodes) | 1  1 |
| (b) | (i) …the number of joules of energy given by the source to drive one coulomb of electricity throughout the external circuit connected to it. | 1 |
| (ii)  A  B  VAB  R  I  E  r  Consider the circuit shown in which E is the electromotive force of the source and r its internal resistance. Suppose R is the external load connected to the source and the current flowing is I.  Then the terminal p.d, VAB = E – Ir  The voltage, Ir, across the internal resistance increases with the current I  So VAB decreases as the current, I, increases | 1  1  1 |
| (c) | K  A  Crocodile clip  Metallic wire  V  Jockey  x  Cellotape   * Starting with a measured length, x, of the wire, the circuit is connected as shown in the diagram * The switch, K, is closed * The readings, I, of the ammeter and V of the voltmeter are noted. * The procedure is repeated for different values of x.   Now in each case the ratio is the resis, R, of the corresponding length of the wire.  A graph of R against x is plotted.  It is a straight line through the origin  So R ∝ x | 1  ½  1  ½  ½  ½  ½  ½ |
|  | 2Ω  4Ω  3Ω  6V  A  1Ω  I  IA  Resistance (2 + 4) Ω is in parallel with 3Ω  Effective resistance for the combination is R =  = 2Ω  Overall resistance in the circuit is 2 + 1 = 3Ω  The main current, I =  = 2A  So p.d across the 3Ω resistor V = E – Ir = 6 –(2 x 1) = 4V  So the ammeter reading, IA =  = **1.33 A** | 1  1  1  1  1  1 |
| ***Total = 20*** | | |