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| **Qn** | **Answer** | | **Marks** |
| 1. (a) | Time  Displacement  0 2 4  (i)  *Axes must be labelled*  0 2 4 5  Time  Velocity | | 1 |
| (ii) | | 1 |
| (b) | v  vo  t  180 - t  t  time  (i)  Let t = time during acceleration  Then time during retardation is t = t  ∴ time at constant speed = 180 – t - t = 180 - t  The maximum speed, vo = 0.5t  Now, distance covered = area under curve  ∴ 1800 =  =  ∴ t2 – 216t + 4320 = 0  ∴ t = 22.3 s or 193.7 s  We take t =  **22.3 s** | | 1  ½  1  ½  1  1  1 |
| (ii) vo = 0.5t  = 0.5 x 22.3 = **11.2 m s-1** | | 1  1 |
| (c) | (i) If no external force acts on a system of colliding bodies, the total momentum of the bodies remains constant. | | 1 |
| (ii) Suppose a particle of mass m1 originally moving with velocity u1­ collides with another particle of mass m2 which is originally moving with velocity u2. Then m1 exerts a force F1 on m2 to change the velocity of m2 from u2 to v2 (according to the first law).  Also m2 exerts a force F2 on m1 to change the velocity of m1 from u1 to v1.  Suppose the collision lasts for time δt. Then, according to the second law  F1 = , where k is a constant  and F2 =  According to the third law, F2 = -F1  ∴  =  ∴ m1v1  - m1u1 = -m2v2 + m2u2  ∴  **m1u1 + m2u2 = m1v1 + m2v2**  ∴ ***Total momentum before collision = Total momentum after collision*** | | ½  ½  ½  ½  1  1  1 |
| (d) | 3kg  T  3g  T  2g cos30o  2gμ cos30o  2g sin30o  2g  3g – T = 3a ………… (1)  T – 2g sin30o – 2gμ cos30o = 2a ………… (2)  Eq(1) + eq(2): 3g – 2g sin30o – 2gμ cos30o = 5a  ∴ μ =  =  = **0.272** | | 1  1  1  1  1 |
| ***Total = 20*** | | | |
| 2. (a) | (i) Energy lost equals the work done | | 1 |
| (ii) Let u be the velocity as the ball hits the surface for the first time  Then u =  After the 1st bounce the velocity, v1 = eu = e  After the 2nd bounce the velocity, v2 = ev1 = e2  After the 3rd bounce the velocity, v3 = ev2 = e3  So after the nth bounce the velocity, vn = evn-1 = en  Now, total energy lost E = mgh -  = mgh -  = mgh(1 – e2n) | | ½  ½  ½  ½  ½  ½ |
| (iii) Some of the kinetic energy is converted into heat. | | 1 |
| (b) | (i) At any point, the gravitational potential is the work done in taking a mass of 1 kg from infinity to that point. | | 1 |
| (ii) At the earth’s surface the gravitational potential is  But at the earth’s surface the gravitational force on a mass m equals the mass’s weight there.  i.e.  = mg  ∴ GM = gr2  Thus the gravitational potential there =  = -gr | | 1  1  1 |
| (c) | (i) m1 = 300 g, m2 = 200 g  =  =  = 4.03 m s-1  ∴ u1 = 4.03 m s-1 and u2 = -4.03 m s-1  m1v1 + m2v2 = m1u1 + m2u2  300v1 + 200v2 = (300 x 4.03) + (200 x -4.03)  ∴ 3v1 + 2v2 = 4.03 ………………. (1)  Now v1 - v2 = -e(u1 - u2)  ∴ v1 - v2 = -0.6(4.03 - ˉ4.03)  v1 - v2 = -4.82 ……………. (2)  Eq(2) x 2: 2v1 - 2v2 = -9.64 ……………. (3)  Eq(1) + eq(3): 5v1 = -5.61  ∴ v1 = -1.12 m s-1  From (2) v2 = v1 + 4.82  = -1.12 + 4.82 = 3.7 m s-1  ΔE =  = ½[0.4 x 4.032 x 2 – 0.4 x 1.122 – 0.2 x 3.72]  = ½[13.0 – 0.502 – 2.738]  = **4.88 J** | | 1  1  ½  1  ½  1  1  1  1 |
| (ii) Let the angle be θ  Then the height risen is h = l - cosθ (since length = 1m)  Now ½mv2 = mgh = mg(1 - cosθ)  ∴ cos θ = 1-  = 1 -  = 1 – 0.698 = 0.302  ∴ θ = **72.4o** | | 1  1  1 |
| ***Total = 20*** | | | |
| 3. (a) | (i) Kinetic energy is the energy possessed by a body by virtue of its motion while  Potential energy is the energy possessed by a body by virtue of its position. | | 1  1 |
| (ii) Suppose a constant force, F, accelerates a body of mass m from rest to a velocity v in a distance s. Then, the work done by F is  W = Fs  = ma.s, where a = acceleration  Using 2as = v2 – u2, we have that as = v2  ∴ W = mv2  This is the kinetic energy of the body of mass m which is moving with a velocity v | | 1  1  1 |
| (b) | (i) A conservative force is one whose work done on a body depends only on the initial and final positions of the body | | 1 |
| (ii) Suppose a particle of mass m moving vertically upwards passes the datum level, O, with a velocity u.  Then the particle’s mechanical energy at O is  x  A  O  mg  m.e = k.e + p.e  = mu2 + 0 = mu2  When the particle is at point A its potential energy = mgh and its velocity, v, is given by v2 = u2 – 2gx.  Thus, its kinetic energy is mv2 = m(u2 – 2gx)  Hence, the total mechanical energy of the particle at A is  m.e = k.e + p.e  = m(u2 – 2gx) + mgx = mu2  which is the same as the total mechanical energy at O. | | 1  1  1  1 |
| (c) | (i) The moment of a force about a given point is the product of the force and the perpendicular distance from the point to the line of action of the force. | | 1 |
| (ii) Energy stored in the spring = work done by the couple  = torque x angle turned through in radians  = Fdθ  = 6 x2x 0.5 x  = **12.56 J** | | 1  1  1 |
| (d) | Tcos30o  N  L  40o  Tsin30o  R  μR  200N  (i)    Taking moments about N, we have  T cos 30o(0.5 – 0.5cos40o) + 0.5T sin30osin40o = 0.5 x 200  ∴ (0.2026 + 0.3214)T = 200  ∴ T =  = **381.7 N** | | 1  1  1 |
| (ii) R = T sin30o  = 381.7 sin30o = 190.9 N  μR = T cos30o – 200  = 330.7 – 200 = 130.7 N  ∴ μ =  = **0.685** | | 1  ½  1  ½  1 |
| ***Total = 20*** | | | |
| 4. (a) | (i) …the motion in which the acceleration of the particle is always directed towards a fixed point in the path of the particle and its magnitude is directly proportional to the displacement of the particle from the point. | | 1 |
| (ii) For s.h.m. the acceleration  = -ω2x (since accn = )  We may write  = -ω2x  ∴ v = -ω2x  ∴ vdv = -ω2xdx  ∴ ½v2 = -½ω2x2 + C  Now, v = 0 when x = a  So C = ½ω2a2  ∴ v2 = ω2(a2 – x2)  ∴ v = | **OR**  If the displacement, x = a sinωt  Then the velocity, v = = aω cosωt  So sinωt =  and cosωt =  Since sin2ωt + cos2ωt = 1, it follows that    ∴ ω2x2 + v2 = a2ω2  ∴ v2 = ω2(a2 – x2)  ∴ v = | ½  ½  ½  ½  1 |
| (b) | θ  P  O  B  θ  mg  *x*  mgsinθ  *l*  (i)  Let the string be of length *l* whose end is fixed at P, and to whose other end is fixed a mass m.  Suppose the mass m is freely oscillating such that at a certain instant the length of the arc OB is x when the string makes an angle θ with the vertical.  Then the force pulling m towards O along OB is mg sinθ.  Let a = acceleration of m (being positive in a direction away from O)  Then ma = -mg sinθ  But since θ is small ⇒ sin θ ≈ θ =  Thus ma = -mgθ = -mg  Since the acceleration is proportional to the displacement, x, from O and the negative sign implies it is towards O, the mass executes simple harmonic motion. | | 1  1  ½  ½  1 |
| (ii)   * A mass is freely suspended from a string. * The length, *l*, of the supporting string is measured. * The suspended mass is set to oscillate with small amplitude in a vertical plane. * The time for a suitable number of complete oscillations is measured, from which the period, T, is found. * The procedure is repeated for several different values of the length and the results are tabulated, including T2. * A graph of T2 against *l* is plotted and its slope, s, is found   Now, from above ω2 =  (But ω = )  ∴ T2 =  So the slope of the graph, s =  and g can be calculated | | ½  ½  ½  ½  ½  1  ½  ½  ½ |
| (c) | (i) At the extreme point the displacement, x = amplitude, a  Now force = mass x acceleration  ∴ F = mω2a =  ∴ T2 =  =  = 0.0404  ∴ T = 0.**201 s** | | 1  1 |
| (ii) The displacement, x = (4.5 – 3.6) x 10-2 = 0.9 x 10-2m  Now v =  k.e = ½mv2 = ½mω2(a2 – x2)  = ½ x 0.1 x  = **0.0594 J** | | ½  ½  ½  ½  1 |
| (iii) Total energy = ½mω2a2 = ½ x 0.1 x  = **0.0633 J** | | 1  1 |
| ***Total = 20*** | | | |
| 5. (a) | *Any two @½*  (i) - The range of the temperatures to be measured  - Whether the temperature is rapidly changing  - Whether the temperature is to be taken at a point (in a limited space) | | 1 |
| (ii) The property should   * vary continuously with temperature, in value or otherwise, over a wide range   *Any four @½*   * be observable * be measurable * have reproducible values at the respective temperatures * have distinguishable values even for small differences in temperature | | 2 |
| (b) | (i) …a universally chosen temperature for reference of any measured temperature at which all thermometers agree and at which temperature certain physical changes occur. | | 1 |
| (ii) … the temperature at which saturated water vapour, pure water and melting ice are all in equilibrium. | | 1 |
| (c) | Constriction  Bulb  35 36 37 38 39 40 41 42  Mercury  (i)  The range of this thermometer is 35o-42o because the human body temperature cannot lie outside this range. Such a short range makes the scale very sensitive since a single degree on it is large enough to be subdivided.  The constriction near the bulb prevents mercury from flowing back before the temperature is being read. | | ½  ½  ½  ½  1  1 |
| (ii)   * For high sensitivity the bulb is made large and the bore is made narrow. * For quick action, the walls of the bulb are made thin | | 1  1 |
| (d) | 273 + 90 = x 273.16  ∴ Rtr =  = **1.505 Ω** | | 1  1  1 |
| (e) | (i) …measurement of temperature of a body by observation of radiation from the body | | 1 |
| (ii)  O E  G  Filament  A  R  B  *Correct labeling of any 4 main parts @½*   * The optical pyrometer consists of a telescope, OE, and a lamp having a tungsten filament. G is a red filter through which light from the furnace, B, whose temperature is required passes. * The eyepiece, E, is focused upon the filament. * The furnace, B, is then focused by the objective lens O so that its image lies in the plane of the filament. * The temperature of the filament is adjusted using rheostat R until it “disappears” in the background of the radiation from B.   Now, the ammeter, A, which measures the current, has been calibrated directly in degrees, and gives the temperature of the furnace. | | 2  ½  1  1  ½ |
| ***Total = 2*** | | | |
| 6. (a) | (i) … the quantity of heat required to convert 1 kg of a substance from liquid to vapour at constant temperature. | | 1 |
| (ii) At the boiling point the kinetic energy of the molecules remains constant.  Instead the heat supplied is used to do work against the intermolecular attractions as the molecules are being completely freed.  Secondly, the gas so formed does work against the atmospheric pressure | | 1  1 |
| (iii)  Lagging  A  V  Vapour  Vapour jacket  Heater  Water  Condenser  The apparatus is set up as shown in the diagram.  The setup is switched on and given time to attain steady conditions, with the liquid at its boiling point.  Under these conditions, the heat supplied by the heater is used in evaporating the liquid and offsetting the losses.   * The condensed liquid is then collected in a weighed beaker over a measured time interval.   Let m1 = mass of liquid collected per second  V1 = p.d across the heater coil  I1 = current through the coil  h = heat lost per second  L = specific latent heat of vaporisation of the liquid  Then I1V1 = m1L + h ……………(1)   * The experiment is repeated at new values I2 and V2 of current and p.d respectively.   Let m2 = new mass of liquid collected per second.  Then I2V2 = m2L + h ……………(2)  From (1) and (2)  L = | | ½  1  1  1  ½  1½  1  ½ |
| (b) | (i) Pt = (mwcw + mccc)(100 – 25)  ∴ t =  =  = (16800 + 200) x 0.075  = **1275 s** | | 1  ½  ½  1 |
| (ii) Time during boiling = tb =  =  = 9040 s  ∴ total time = 1275 + 9040 = **10,315 s** | | 1  1 |
| (iii) Cost = power in kW x hours x unit cost  = 1 x  = **1,762/=** | | 1  1 |
| (c) | Consider a body of volume V, surface area S and specific heat capacity c. If the body is at a temperature excess ∆θ and its material is of density ρ, then it is losing heat at rate  = kSΔθ  At a given temperature, ρ, c, k and ∆θ are constants.  Thus, the rate of cooling ∝  If the linear dimensions of the body are *x*, then  ∝  implying that  ∝  Therefore the smaller the body is, the higher its rate of cooling will be. | | 1  1  1 |
| ***Total = 20*** | | | |
| 7. (a) | Violet red  Visible  Locus of peaks  T3  T2  T1  T1 < T2< T3  Relative Intensity  0 10 20 30 40 50 60 x102 λ/nm  (i)  *Shape → 1*  *Relative positions → 1* | | 2 |
| (ii) At first the ball is invisible  It becomes dull red, then bright red and finally less red, tending to white.  This is because as the temperature rises, the intensity of the shorter wavelengths increases more rapidly.  So the peak intensity shifts from the red end of the spectrum into the visible spectrum, which is a narrow band. | | ½  1  1  ½ |
| (iii) The cavities approximate to black bodies.  So the radiation from the cavities is of higher intensity than that from the rest of the areas. | | 1  1 |
| (b) | (i) *Wien’s displacement law:*  The wavelength of the highest intensity is inversely proportional to the absolute temperature of the body.  *Stefan,s law*:  The total power radiated by a black body per m2 is directly proportional to the fourth power of the body’s absolute temperature | | 1  1 |
| (ii) According to Wien’s displacement law  λmT = 2.9 x 10-3 mK  ∴ T =  = **1933 K** | | ½  ½  1 |
| Cork held by wax  Cork held by wax  Dull black tin plate  Polished tin plate  (iii)   * Two sheets of tin plate, one polished and the other dull black, are set up vertically a short distance apart. * On the back side of each is fixed a cork by means of wax. * A bunsen burner is placed midway between the plates. * As the burner continues burning, eventually the wax on the back of the dull black plate melts and the cork falls while that on the polished plate remains.   *Conclusion:* The dull black plate must have absorbed heat faster than the polished one. So dull black surfaces are better absorbers than polished ones. | | 1  1  ½  ½  ½  ½ |
| (c) | (i) Let r = radius of the star = 7.0 x 108 m  R = distance between the star and the planet = 1.4 x 1011 m  Then at a distance R the total area catching the radiation from the star is 4πR2  So power radiated by the star = power received over an area 4πR2  ∴ σAT4 = 4πR2 x 1.4 x 103  ∴ σ.4πr2.T4 = 4πR2 x 1.4 x 103  ∴ T4 =  =  = 9.824 x 1014  ∴ T =  x 103  = **5599 K** | | 1  1  1  1 |
| (ii) - The star radiates as a black body  - No radiant energy lost in the space around. | | ½  ½ |
| ***Total = 20*** | | | |

**-END-**