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| **Qn** | **Answer** | **Marks** |
| 1 (a) | v = u + at  s = ut + at  v2 = u2 + 2as  where a = acceleration  *Provided the quantities are defined*  u = initial velocity  v = velocity after time t  s = displacement after time t | 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. i.e. the work done is independent of the path taken.  The work done by a non-conservative force depends on the path taken.  Conservative forces – gravity, magnetic force, electrostatic force. *Any two @½*  Non-conservative forces – friction, viscous force | 1  1  1  1 |
| (ii) In a closed system the total energy is constant.  OR Energy can neither be created or destroyed but can only change form  v  A  u  h  θ  O  Let the datum level be through the point of projection, O  Then, at O the p.e = 0 and k.e = ½mu2  = ½m()  = ½mu2(cos2θ + sin2θ)  ∴ at O the total m.e = p.e + k.e = 0 + ½mu2cos2θ + ½mu2sin2θ  At point A, where the velocity is v at an angle α to the horizontal, the total m.e  = mgh + ½mv2  But v2 = v2cos2α + v2sin2α  Now, v2cos2α = u2cos2θ (no change in horizontal velocity)  and v2sin2α = u2sin2θ - 2gh  ∴ v2 = u2cos2θ + u2sin2θ - 2gh  ∴ at A the total m.e = mgh + ½m(u2cos2θ + u2sin2θ - 2gh)  = mgh + ½mu2 – mgh  = ½mu2 …… as at point O | 1  ½  ½  ½  ½  ½  ½ |
| (c) | P  mg sinθ  θ  m  R  sinθ =  At maximum speed acceleration, a = 0  Let P = driving force  Then P – (R + mg sinθ) = 0  ∴ P = R + mg sinθ ……. (i)  On the level road  R =  ∴ R = 1200 N  Let v′ = maximum velocity on the slope  Then  = 1200 + 5 x 103 x 9.81 x  ∴ v′ = **9.49 m s-1** | 1  1  1  1 |
| (d) | (i) The moment of a force about a point is the product of the force and the perpendicular distance of its line of action from the point. | 1 |
| (ii)  s  50N  50N  θ  F = 50 N; s = 0.84 m  θ = n(2π) = 20 x 2π = 40π radians  Work done = Force x distance moved  = F x θs  = 50 x 40π x 0.84  = **5,278 N** | 1  1  1  1 |
| ***Total = 20*** | | |
| 2 (a) | (i) … the rate at which a line joining a point on the body to the centre of the circle sweeps through an angle. | 1 |
| (ii)  R1  R2  h  G  F1  F2  A  B  mg  Suppose a car of mass is moving with a velocity v round a horizontal circular track of radius.  Let R1 and R2 be the respective normal reactions at the wheels A and B, and F1 and F2 the corresponding frictional forces, which provide the centripetal force.  Then F1 + F2 =  ………. (1)  and R1 + R2 = mg ……... (2)  Taking moments about the centre of gravity, G, we have  (F­1 + F2)h + cR1 - cR2 = 0 .. (3)  Substituting for (F­1 + F2) in equation (3)  + cR1 - cR2 = 0 ……… (4)  Solving for R1 and R2 between equations (2) and (4), we get  R1 =  and R2 =  The car will overturn if R1 ˂ 0  ∴  ˂ 0  ∴ v > | 1  ½  ½  ½  ½  ½  ½  ½  ½ |
|  | (iii)    mg  R  For the water to remain in the bucket R > 0  ∴  > mg  ∴ v2 > rg  ∴ v >  ∴ v > **2.215 m s-1** |  |
| (b) | 1. The planets describe ellipses about the sun as one focus. 2. The line joining the sun and the planet sweeps out equal areas in equal times. 3. The squares of the periods of revolution of the planets are proportional to the cubes of their means distances from the sun. | 1  1  1 |
| (c) | (i) Gravitational field strength is the force acting on a mass of 1 kg placed in the gravitational field | 1 |
| (ii)  INSIDE  OUTSIDE  *x*  RE  O  g′  (at the surface)  Inverse square law  *x* ˂ RE  *x* > RE  g  At points inside the earth, the acceleration due to gravity is directly proportional to the distance from the centre of the earth.  At points above the earth’s surface, the acceleration due to gravity varies inversely as the square of the distance from the centre of the earth. | ½  1  ½  ½  ½ |
| (d) | Then, the energy needed, W = increase in potential energy and kinetic energy  This is equal to the k.e of the satellite at launch  ∴ , where vo is the velocity in the orbit …..(1)  But  ∴  …………….. (2)  But  Substituting for in equation (2) gives    **v2 =** |  |
| 3 (a) | Dimensions of a physical quantity is the way a the physical quantity is related to the fundamental quantities, i.e. mass, length and time. | 1 |
| (b) | [p] = ML-2T-2, [η] = MT-1L-1  So  ∴ L3T-1 = (ML-2T-2)x.( MT-1L-1)y.Lz  ∴ L3T-1 = Mx+y.L-2x-y+z.T-2x-y  Comparing coefficients, we have  For L: -2x – y + z = 3 …. (1)  For M: x + y = 0 ….. (2)  For T: -2x – y = -1 …. (3)  From (1) and (3): **z = 4**  Eq(2) + Eq(3): -x = -1  ∴ **x = 1**  and **y = -1** | 1  1  1  1  1 |
| (c) | (i) Range is the distance, measured directly, between the point of projection and the point where the projectile lands.  Time of flight is the time between the instant of projection and landing. | 1  1 |
| Y  (ii)  (x,y)  u    α  X  O  Consider the bullet to be at point (x,y) on the trajectory  The horizontal distance, x, after time t is given by  x = (u cosα)t  ∴ t =  The vertical height attained is  y = (u sinα)t - ½gt2  ∴ y = x tanα -  ∴ y = x tanα - | 1  ½  ½  ½  1  ½ |
| (d) | U = 100 m s-1, θ = 60o, h = 800 m  θ  u  800m  Using h = ut sinθ - ½gt2  -800 = 100t sin60o - ½ x 9.81t2  4.905t2 - 50 t – 800 = 0  t = 24.35 s or -6.70 s  ∴ t = **24.35 s**  v =  vx = u cosθ = 100 cos60o = 50 m s-1  vy = u sinθ - gt = 100 sin60o – 9.81 x 24.35 = -152.27 m s-1  v =  = **160.27 m s-1**  Direction, α = tan-1 =  **-71.82o**  i.e. 71.82o below the horizontal | 1  1  1  1    1  1  1  1 |
| 4 (a) | (i)  A scalar is a quantity which is defined by only magnitude.  A vector is a quantity which is defined by both magnitude and direction  Scalars: mass, time, work volume, distance, etc.  Vectors: pressure, force, acceleration, velocity, impulse, etc. | 1  1  1  1 |
| 4N  8N  3N  30o  60o  (ii)    =  Resultant, F =  F  1.96 N  7.40 N  = **7.66 N**  Direction, θ = tan-1 = **14.9o** to 8N force | 1  1  1  1  1 |
| (b) | Laws of friction:   * The frictional force between two solid surfaces in contact opposes their relative motion. * The frictional force is independent of the area of contact of given surfaces. * The limiting frictional force is directly proportional to the normal reaction. | 1  1  1 |
| (c) | **Determination of μ between a block and a Surface**  B  mg  F  R  S  θ     * The block, B, is placed on the surface, S. * S is gently tilted until B is on the point of slipping down the plane. * The angle, θ, between the plane and the horizontal is measured.   The frictional force, F, is then equal to mgsinθ and the normal reaction  R = mgcosθ    NOTE: An alternative experiment that gives the same results shall be accepted. | ½  ½  1½  ½  ½  ½ |
| (d) | Let the acceleration of the system be a and the tension in the string be T.  2g  T  2gsin30o + μR  R  T  2gcos30o  2kg  2kg  30o  Applying F = ma, we have  2g – T = 2a ………. (1)  and T – (2gsin30o + μR) = 2a ……….. (2)  But R = 2gcos30o  Eq(1) + eq(2)  2g(1 – sin30o – 0.5 cos30o) = 4a  ∴ a = ½ x 9.81(1 – sin30o – 0.5 cos30o)  = 0.329 m s-2  From (1): T = 2 x 9.81 - 2 x 0.329 = **18.96 N** | 1  ½  ½  ½  ½  1 |
| ***Total = 20*** | | |
| 5 (a) | (i) A thermometric property is a physical property of a substance whose value changes continuously with temperature.  The triple point of water is a unique temperature at which pure water, pure ice and pure water vapour co-exist in equilibrium. | 1  1 |
| (ii)   * The emf, Etr, of the thermocouple at the triple point is measured. * The emf, Eθ, of the thermocouple at the triple point is measured.   The temperature, θ, is calculated from θ =  K | 1  1  1 |
| (iii) Rtr = 5.25Ω, Rθ = ?  Now 373 = x 273.16  ∴ R100 =  = **7.17 Ω** | 1  1 |
| (b) | Rt = Ro(1 + αt + βt2), α = 4.13 x 10-3, β = -6.4 x 10-7  t = x 100oC  = x 100oC  = x 100oC  = x 100oC = **858.34oC** | 1  1  1  1  1 |
| (c) | This is the quantity of heat required to convert 1 kg mass of a substance from liquid to vapour at constant temperature. | 1 |
| (d) | 500 x 10 x 60 = Cf.Δθ + mlcl. Δθ + mLv  300,000 = 840(78 – 28) + 2 x 2.5 x 103(78 – 28) + m x 8.54 x 103  300,000 = 42,000 + 250,000 + 8540m  ∴ m = **0.937 kg**  Assumptions:   * All heat is taken up by the flask and the liquid. * No heat is lost to the surroundings | 1  1  3  1  ½  ½ |
| ***Total = 20*** | | |
| 6 (a) | (i) The volume of a fixed mass of gas at constant temperature is inversely proportional to the pressure. | 1 |
| (ii) p =  Let m = mass of each molecule and N = number of molecules, V = volume of gas  Then p =  ∴ pV =  ∴ pV =  ∴ pV =  ∴ pV = NkT  Thus, at constant temperature pV = constant | ½  ½  ½  ½  1 |
| (b) | Oxygen = 20%; nitrogen = 80% Mo = 32, MN = 28  (i) Using p =  pV =  Now, Nm = M = molecular mass  For one mole of oxygen poV =  and for one mole of oxygen pnV =  ∴ at the same temperature, | 1  1  1 |
| (ii) Let Po = partial pressure due to oxygen  Pn = partial pressure due to nitrogen  no = number of oxygen molecules in the mixture  nn = number of nitrogen molecules in the mixture  mo = mass of each oxygen molecule  mn = mass of each nitrogen molecule  Then Po =  and Pn =  ∴  = | 1  2 |
| (c) | The total work done in expanding from V1 to V2 is    P  V1 V2 V  For n moles of gas    But P1V1 = P2V2 = nRT  ∴  ∴ W = P1V1loge = P1V1loge = - P1V1loge | 1  1  1 |
| (d) | V1 = 1 litre = 1 x 10-3m3 T1 = 27oC = 300 K P1 = 105 Nm-2  V2 = 2 x 10-3 m3 T2 = T1 P2 = ?  V3 = 4 x 10-3 m3 T3 = ? P3 = ?  P  V  AB = Isothermal  BC = Adiabatic  A  B  C  P1  P3  V1  V2  V3  T3  T1  P2  Along AB: P1V1 = P2V2  ∴ P2 =  = 5 x 104 Nm-2  Cp = 29.2 J mol-1 K-1  Cv = Cp – R  = 29.2 – 8.83  = 20.89 J mol-1 K-1  γ =  = 1.40  Using  P3 = 5 x 104  = **18,950 Nm-2**  Using  T3 = 300 = **227.4 K** | ½  ½  ½  ½  ½  ½  ½  ½  1  1½ |
| ***Total = 20*** | | |
| 7 (a) | (i) Thermal conductivity is the heat flow rate in a substance per unit area per unit temperature gradient. | 1 |
| (ii)   * In poor conductors heat is conducted by waves produced by lattice vibrations. * This happens, say, when heat is applied to one part of the solid, the kinetic energy of vibration of the molecules there is increased. * Because of the bonds between the molecules, the kinetic energy of vibration of the neighbouring molecules is in turn also increased. So the wave moves on. * In metals conduction is predominantly due to freely moving electrons (in addition to lattice vibration). * When a part of a metal is heated, the free electrons gain thermal energy and their velocities increase. * They distribute this energy by collision with positive ions in the lattice and increase the ions’ vibrational energy. * Because electrons are light, they are able to move quickly to the cooler parts of the solid. So this mode of heat transfer is much faster. | ½  ½  ½  ½  ½  ½ |
| (b) | Assume the heat flow rate through the layers to be same.  25oC θ1 θ2 15oC  kb ka kb  0.1m 0.02m 0.1m    ∴  ∴  ∴ 25 - θ1 = θ2 – 15  ∴ θ1 + θ2 = 40 ………… (1)  Also 7(25 - θ1) = 1.2(θ - θ2)  ∴ 8.2θ1 – 1.2θ2 = 175 …….. (2)  From (1): θ1 = 40 - θ2  Substituting for θ1 into (2):  8.2(40 - θ2) – 1.2θ2 = 175  ∴ 9.4θ2 = 153  ∴ θ2 = 16.3oC  ∴ Heat flow rate per m2  = **9.1 Wm-2** | ½  1  ½  ½  ½  ½  ½  1  1 |
| (c) | A pyrometer is used. What is shown below is an optical pyrometer  O E  G  Filament  A  R  B  *Correct labeling of any 4 main parts @½*   * It consists of a telescope, OE, and a lamp having a tungsten filament. G is a red filter through which light from the body, 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  ½  ½  ½ |
| (d) | Power output = 4.0 x 1026 W  ms = 1.97 x 1030; ρs = 1.4 x 103kg m-3  Assuming that the sun is spherical  Volume, V =  ∴ 3 x  ∴ rs =  = 6.952 x 108 m  Assume that the sun radiates as a black body  Then power radiated by the sun = 4.0 x 1026 W = σA  ∴ 4π = 4 x 1026  ∴  ∴ Ts =  = **5,838 K** | 1  1  1  1  1 |
| ***Total = 20*** | | |