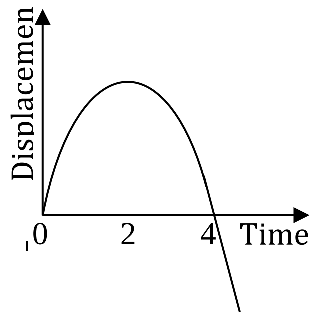
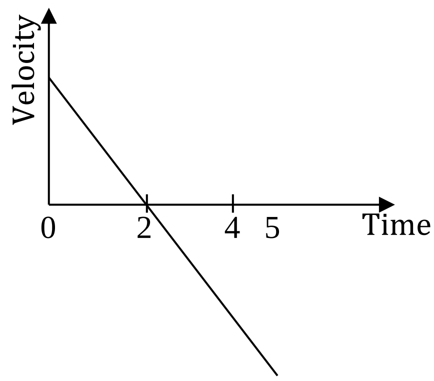
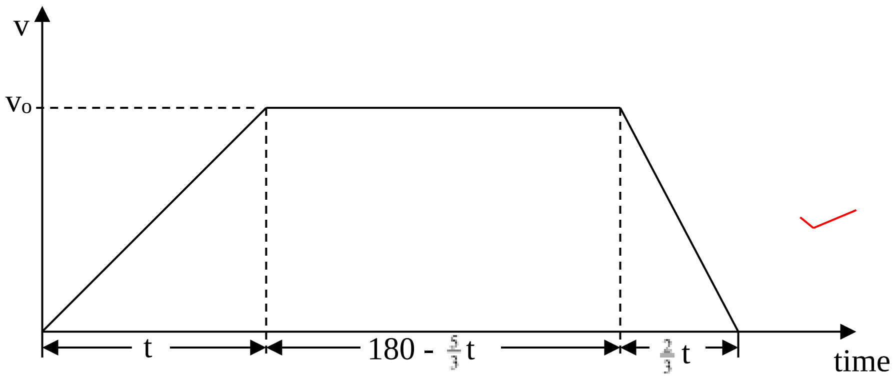
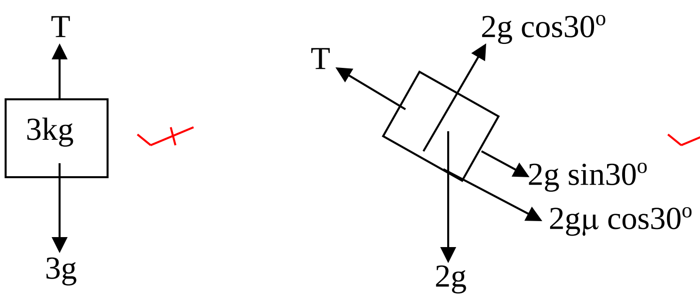
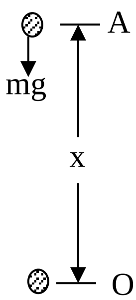
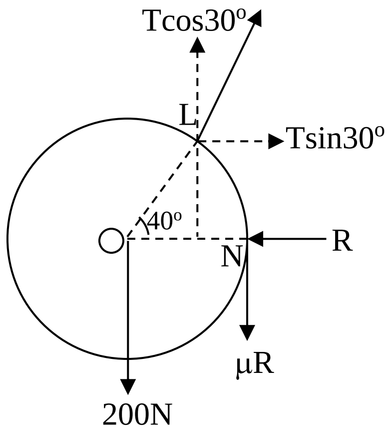
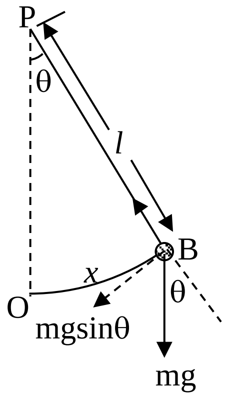
Qn	Answer	Marks
1. (a)	(i)  *Axes must be labelled*	1
	(ii) 	1
(b)	(i) 	1
	Let t = time during acceleration	
	Then time during retardation is $\frac{0.50}{0.75}t = \frac{2}{3}t$	½
	$\therefore$ time at constant speed $= 180 - t - \frac{2}{3}t = 180 - \frac{5}{3}t$	1
	The maximum speed, $v_o = 0.5t$	½
	Now, distance covered = area under curve	
	$\therefore \quad 1800 = \frac{1}{2}v_o\left(180 + 180 - \frac{5}{3}t\right)$	
	$= \frac{1}{2} \times 0.5t\left(360 - \frac{5}{3}t\right)$	1
	$\therefore \quad t^2 - 216t + 4320 = 0$	1
	$\therefore \quad t = 22.3$ s or 193.7 s	
	We take $t =$ **22.3 s**	1

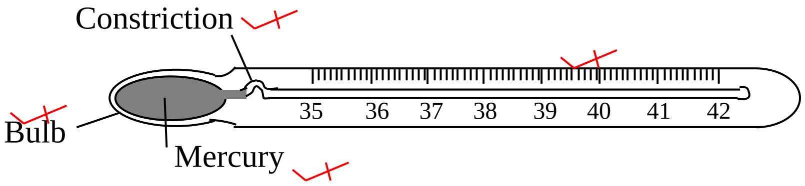
	(ii) $v_o = 0.5t$ $= 0.5 \times 22.3 = \mathbf{11.2\ m\ s^{-1}}$	1 1
(c)	(i) If no external force acts on a system of colliding bodies, the total momentum of the bodies remains constant.	1
	(ii) Suppose a particle of mass m_1 originally moving with velocity u_1 collides with another particle of mass m_2 which is originally moving with velocity u_2. Then m_1 exerts a force F_1 on m_2 to change the velocity of m_2 from u_2 to v_2 (according to the first law). Also m_2 exerts a force F_2 on m_1 to change the velocity of m_1 from u_1 to v_1. Suppose the collision lasts for time δt. Then, according to the second law $F_1 = k\frac{m_2(v_2 - u_2)}{\delta t}$, where k is a constant and $F_2 = k\frac{m_1(v_1 - u_1)}{\delta t}$ According to the third law, $F_2 = -F_1$ $\therefore \quad k\frac{m_1(v_1 - u_1)}{\delta t} = -k\frac{m_2(v_2 - u_2)}{\delta t}$ $\therefore \quad m_1v_1 - m_1u_1 = -m_2v_2 + m_2u_2$ $\therefore \quad \mathbf{m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2}$ $\therefore$ ***Total momentum before collision = Total momentum after collision***	½ ½ ½ ½ 1 1 1
(d)	 $3g - T = 3a \quad \ldots\ldots\ldots\ldots \quad (1)$ $T - 2g\sin30^o - 2g\mu\cos30^o = 2a \quad \ldots\ldots\ldots\ldots \quad (2)$ Eq(1) + eq(2): $3g - 2g\sin30^o - 2g\mu\cos30^o = 5a$ $\therefore \quad \mu = \frac{3g - 5a - 2g\sin30^o}{2g\cos30^o}$ $= \frac{(3\times9.81) - (5\times3) - (2\times9.81\times0.5)}{2\times9.81\times0.866}$ $= \mathbf{0.272}$	1 1 1 1 1
	Total = 20	
2. (a)	(i) Energy lost equals the work done	1

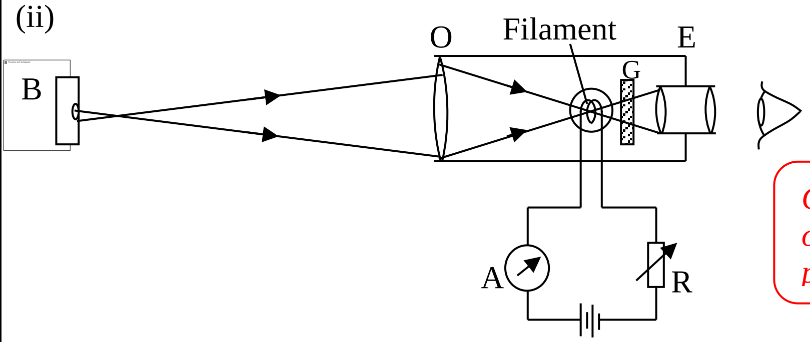
	(ii) Let u be the velocity as the ball hits the surface for the first time Then $u = \sqrt{2gh}$ After the 1st bounce the velocity, $v_1 = eu = e\sqrt{2gh}$ After the 2nd bounce the velocity, $v_2 = ev_1 = e^2\sqrt{2gh}$ After the 3rd bounce the velocity, $v_3 = ev_2 = e^3\sqrt{2gh}$ So after the nth bounce the velocity, $v_n = ev_{n-1} = e^n\sqrt{2gh}$ Now, total energy lost $E = mgh - \frac{1}{2}mv_n^2$ $= mgh - \frac{1}{2}m\left(e^n\sqrt{2gh}\right)^2$ $= mgh(1 - e^{2n})$	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 $\frac{-GM}{r}$ But at the earth's surface the gravitational force on a mass m equals the mass's weight there. i.e. $\frac{GMm}{r^2} = mg$ $\therefore GM = gr^2$ Thus the gravitational potential there $= \frac{-gr^2}{r} = -gr$	1 1 1
(c)	(i) $m_1 = 300$ g, $m_2 = 200$ g $\lvert u_1\rvert = \lvert u_2\rvert = \sqrt{2gl(1-\cos 80^o)} = \sqrt{2\times 9.81\times 1(1-\cos 80^o)} = 4.03$ m s^{-1} $\therefore u_1 = 4.03$ m s^{-1} and $u_2 = -4.03$ m s^{-1} $m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2$ $300v_1 + 200v_2 = (300 \times 4.03) + (200 \times -4.03)$ $\therefore 3v_1 + 2v_2 = 4.03$ .... (1) Now $v_1 - v_2 = -e(u_1 - u_2)$ $\therefore v_1 - v_2 = -0.6(4.03 - {}^-4.03)$ $v_1 - v_2 = -4.82$ .... (2) Eq(2) x 2: $2v_1 - 2v_2 = -9.64$ .... (3) Eq(1) + eq(3): $5v_1 = -5.61$ $\therefore v_1 = -1.12$ m s^{-1} From (2) $v_2 = v_1 + 4.82$ $= -1.12 + 4.82 = 3.7$ m s^{-1} $\Delta E = \frac{1}{2}mu_1^2 + \frac{1}{2}mu_2^2 - \frac{1}{2}mv_1^2 - \frac{1}{2}mv_2^2$ $= ½[0.4 \times 4.03^2 \times 2 - 0.4 \times 1.12^2 - 0.2 \times 3.7^2]$ $= ½[13.0 - 0.502 - 2.738]$	1 1 ½ 1 ½ 1 1 1

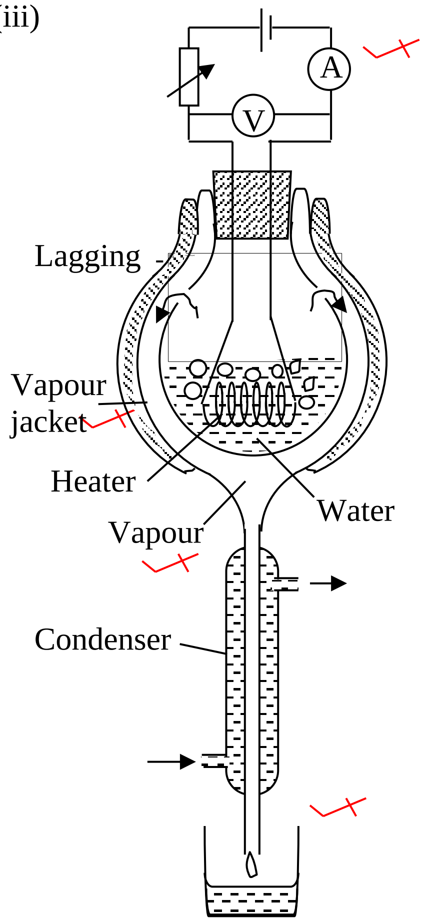
	$= \mathbf{4.88\ J}$	1
	(ii) Let the angle be θ Then the height risen is $h = l - \cos\theta$ (since length = 1m) Now $\frac{1}{2}mv^2 = mgh = mg(1 - \cos\theta)$ $\therefore \quad \cos\theta = 1 - \frac{v^2}{2g} = 1 - \frac{3.7^2}{2 \times 9.81} = 1 - 0.698 = 0.302$ $\therefore \quad \theta = \mathbf{72.4^o}$	 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 $2as = v^2 - u^2$, we have that $as = \frac{1}{2}v^2$ $\therefore \quad W = \frac{1}{2}mv^2$ 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 $m.e = k.e + p.e$ $= \frac{1}{2}mu^2 + 0 = \frac{1}{2}mu^2$ When the particle is at point A its potential energy = mgh and its velocity, v, is given by $v^2 = u^2 - 2gx$. Thus, its kinetic energy is $\frac{1}{2}mv^2 = \frac{1}{2}m(u^2 - 2gx)$ Hence, the total mechanical energy of the particle at A is $m.e = k.e + p.e$ $= \frac{1}{2}m(u^2 - 2gx) + mgx = \frac{1}{2}mu^2$ 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 $= Fd\theta$ $= 6 \times 2 \times 0.5 \times \frac{120\pi}{180}$ $= \mathbf{12.56\ J}$	 1 1 1

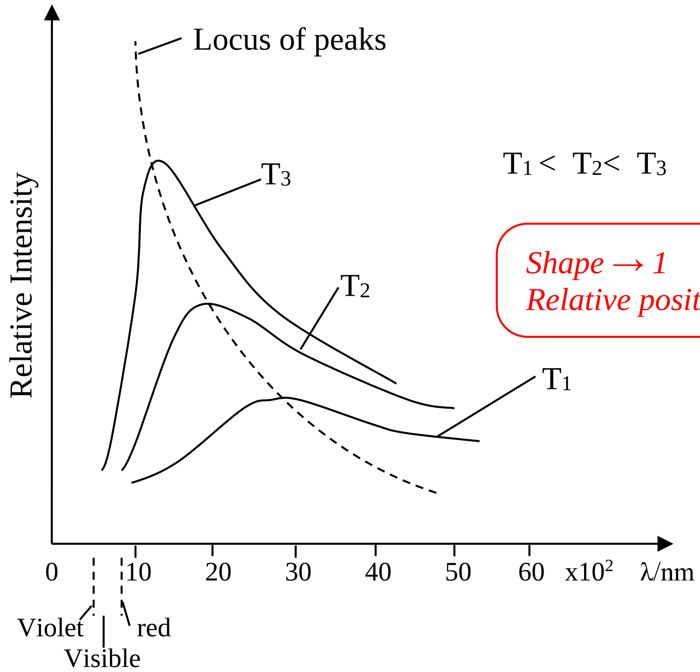
(d)	(i)  Taking moments about N, we have $T\cos 30^o(0.5 - 0.5\cos 40^o) + 0.5T\sin 30^o \sin 40^o = 0.5 \times 200$ $\therefore \quad (0.2026 + 0.3214)T = 200$ $\therefore \quad T = \frac{200}{0.524} = \mathbf{381.7\ N}$	1 1 1
	(ii) $R = T\sin 30^o$ $= 381.7\sin 30^o = 190.9\ N$ $\mu R = T\cos 30^o - 200$ $= 330.7 - 200 = 130.7\ N$ $\therefore \quad \mu = \frac{130.7}{190.9} = \mathbf{0.685}$	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 $\frac{d^2x}{dt^2} = \frac{dv}{dt} = -\omega^2 x \quad (\text{since accn} = \frac{dv}{dt})$ We may write $\frac{dv}{dt} = \frac{dv}{dx}\cdot\frac{dx}{dt} = -\omega^2 x$ $\therefore \quad v\frac{dv}{dx} = -\omega^2 x$ $\therefore \quad vdv = -\omega^2 xdx$ $\therefore \quad ½v^2 = -½\omega^2x^2 + C$ Now, $v = 0$ when $x = a$ So $C = ½\omega^2a^2$ $\therefore \quad v^2 = \omega^2(a^2 - x^2)$ $\therefore \quad v = \pm\omega\sqrt{a^2 - x^2}$ **OR** If the displacement, $x = a\sin\omega t$ Then the velocity, $v = \frac{dx}{dt} = a\omega\cos\omega t$ So $\sin\omega t = \frac{x}{a}$ and $\cos\omega t = \frac{v}{a\omega}$ Since $\sin^2\omega t + \cos^2\omega t = 1$, it follows that $\frac{x^2}{a^2} + \frac{v^2}{a^2\omega^2} = 1$ $\therefore \quad \omega^2x^2 + v^2 = a^2\omega^2$ $\therefore \quad v^2 = \omega^2(a^2 - x^2)$ $\therefore \quad v = \pm\omega\sqrt{a^2 - x^2}$	½ ½ ½ ½ 1

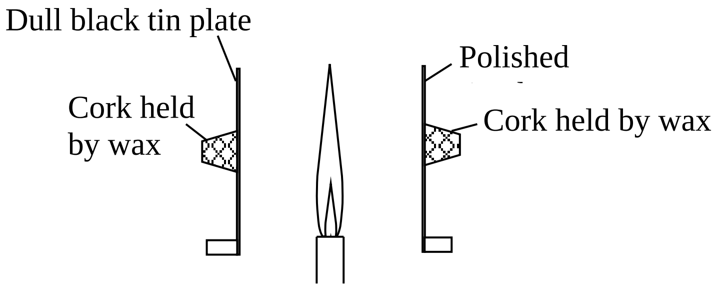
(b)	(i)  Let the string be of length l whose end is fixed at P, and to whose other end is fixed a mass m. Suppose the mass m is freely oscillating such that at a certain instant the length of the arc OB is x when the string makes an angle θ with the vertical. Then the force pulling m towards O along 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 $\Rightarrow \sin\theta \approx \theta = \frac{x}{l}$ Thus ma = -mgθ = $-mg\frac{x}{l}$ $\therefore \frac{-g}{l}x = -\omega^2 x, \quad where\ \omega^2 = \frac{g}{l}$ 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 T^2. - A graph of T^2 against l is plotted and its slope, s, is found Now, from above $\omega^2 = \sqrt{\frac{g}{l}}$ (But $\omega = \frac{2\pi}{T}$) $\therefore \quad T^2 = \frac{4\pi^2}{g}l$ So the slope of the graph, s = $\frac{4\pi^2}{g}$ 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 $\therefore \quad F = m\omega^2 a = \frac{4\pi^2}{T^2} ma$ $\therefore \quad T^2 = \frac{4\pi^2 ma}{F} = \frac{4\pi^2 \times 0.1 \times 3.6 \times 10^{-2}}{3.52} = 0.0404$ $\therefore \quad T = 0.\mathbf{201\ s}$	1 1
	(ii) The displacement, $x = (4.5 - 3.6) \times 10^{-2} = 0.9 \times 10^{-2} m$ Now $v = \omega\sqrt{a^2 - x^2}$ k.e $= ½mv^2 = ½m\omega^2(a^2 - x^2)$ $= ½ \times 0.1 \times \frac{4\pi^2}{0.0404}(3.6^2 - 0.9^2) \times 10^{-4}$ $= \mathbf{0.0594\ J}$	½ ½ ½ ½ 1
	(iii) Total energy $= ½m\omega^2 a^2 = ½ \times 0.1 \times \frac{4\pi^2}{0.0404} \times 3.6^2 \times 10^{-4}$ $= \mathbf{0.0633\ J}$	1 1
Total = 20		
5. (a)	(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) *Any two*	1
	(ii) The property should - vary continuously with temperature, in value or otherwise, over a wide range - be observable - be measurable - have reproducible values at the respective temperatures - have distinguishable values even for small differences in temperature *Anv four @½*	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)	(i) 	½ ½ ½ ½

	The range of this thermometer is 35°-42° 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.	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)	$273 + 90 = \frac{2.000}{R_{tr}} \times 273.16$ $\therefore \quad R_{tr} = \frac{2.000 \times 273.16}{363}$ $= \mathbf{1.505\ \Omega}$	1 1 1
(e)	(i) …measurement of temperature of a body by observation of radiation from the body	1
	(ii)  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

			½
	(iii) 	The apparatus is set up as shown in the diagram.	1
		The setup is switched on and given time to attain steady conditions, with the liquid at its boiling point.	1
		Under these conditions, the heat supplied by the heater is used in evaporating the liquid and offsetting the losses.	1
		- The condensed liquid is then collected in a weighed beaker over a measured time interval.	½
		Let m_1 = mass of liquid collected per second V_1 = p.d across the heater coil I_1 = current through the coil h = heat lost per second L = specific latent heat of vaporisation of the liquid	1½
		Then $I_1V_1 = m_1L + h$ ....(1)	1
		- The experiment is repeated at new values I_2 and V_2 of current and p.d respectively. Let m_2 = new mass of liquid collected per second. Then $I_2V_2 = m_2L + h$ ....(2) From (1) and (2) $L = \frac{I_1V_1 - I_2V_2}{m_1 - m_2}$	½
(b)	(i) $Pt = (m_wc_w + m_cc_c)(100 - 25)$		1
	$\therefore\ t = \frac{(m_wc_w + m_cc_c)\times 75}{P}$		½
	$= \frac{[(4\times 4200)+(0.5\times 400)]\times 75}{1000}$		½
	= (16800 + 200) x 0.075 = **1275 s**		1
	(ii) Time during boiling $= t_b = \frac{ml}{P} = \frac{4\times 2.26\times 10^6}{1000}$ = 9040 s		1
	∴ total time = 1275 + 9040 = **10,315 s**		1
	(iii) Cost = power in kW x hours x unit cost $= 1 \times \frac{10315}{3600}\times 615$		1
	= **1,762/=**		1

(c)	Consider a body of volume V, surface area S and specific heat capacity c. If the body is at a temperature excess $\Delta\theta$ and its material is of density ρ, then it is losing heat at rate $\frac{dQ}{dt} = V\rho c\frac{d\theta}{dt} = kS\Delta\theta$ At a given temperature, ρ, c, k and $\Delta\theta$ are constants. Thus, the rate of cooling $\frac{d\theta}{dt} \propto \frac{S}{V}$ If the linear dimensions of the body are x, then $\frac{S}{V} \propto \frac{1}{x}$ implying that $\frac{d\theta}{dt} \propto \frac{1}{x}$ Therefore the smaller the body is, the higher its rate of cooling will be.	1 1 1
Total = 20		
7. (a)	(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.	1

	Stefan,s law: The total power radiated by a black body per m^2 is directly proportional to the fourth power of the body's absolute temperature	1
	(ii) According to Wien's displacement law $\lambda_m T = 2.9 \times 10^{-3}$ mK $\therefore \quad T = \frac{2.9\times10^{-3}}{1.5\times10^{-6}}$ $= \mathbf{1933\ K}$	½ ½ 1
	(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 = 7.0×10^8 m R = distance between the star and the planet = 1.4×10^{11} m Then at a distance R the total area catching the radiation from the star is $4\pi R^2$ So power radiated by the star = power received over an area $4\pi R^2$ $\therefore \quad \sigma A T^4 = 4\pi R^2 \times 1.4 \times 10^3$ $\therefore \quad \sigma . 4\pi r^2 . T^4 = 4\pi R^2 \times 1.4 \times 10^3$ $\therefore \quad T^4 = \left(\frac{R}{r}\right)^2 \times \frac{1.4\times10^3}{\sigma}$ $= \left(\frac{1.4\times10^{11}}{7\times10^8}\right)^2 \times \frac{1.4\times10^3}{5.7\times10^{-8}} = 9.824 \times 10^{14}$ $\therefore \quad T = \sqrt[4]{982.4} \times 10^3$ $= \mathbf{5599\ K}$	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-