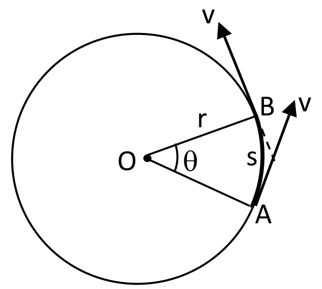
SOLUTIONS TO S.6 PHYSICS P1 REVISION QNS (26thJUNE 2020)

1(a)(i)



Suppose that in time t, a particle moves from A to B along a circle of centre O. The radius OA sweeps through angle θ, in radians.

The angular velocity, $\omega = \dfrac{\theta}{t}$ ……………….. (1) — 1

The period, T, is the time taken to describe the circle once.

Thus, using equation (1) $\omega = \dfrac{2\pi}{T}$

$\therefore \quad T = \dfrac{2\pi}{\omega}$ ……………………………… (2) — ½

If r is the radius of the circle, then the tangential velocity, $v = \dfrac{2\pi r}{T}$ — ½

Substituting for T from equation (1), we have that

$\boxed{v = r\omega}$ — 1

(ii) The frictional force provides the centripetal force on the coin

$\therefore \quad mr\omega^2 = \mu mg$ — 1

$r(2\pi f)^2 = ug$ — ½

$\therefore \quad f = \dfrac{1}{2\pi}\sqrt{\dfrac{\mu g}{r}}$ — ½

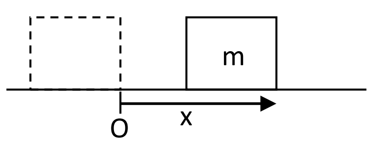
$= \dfrac{1}{2\pi}\sqrt{\dfrac{0.5 \times 9.8}{5 \times 10^{-2}}}$ = **1.58 Hz** — 1

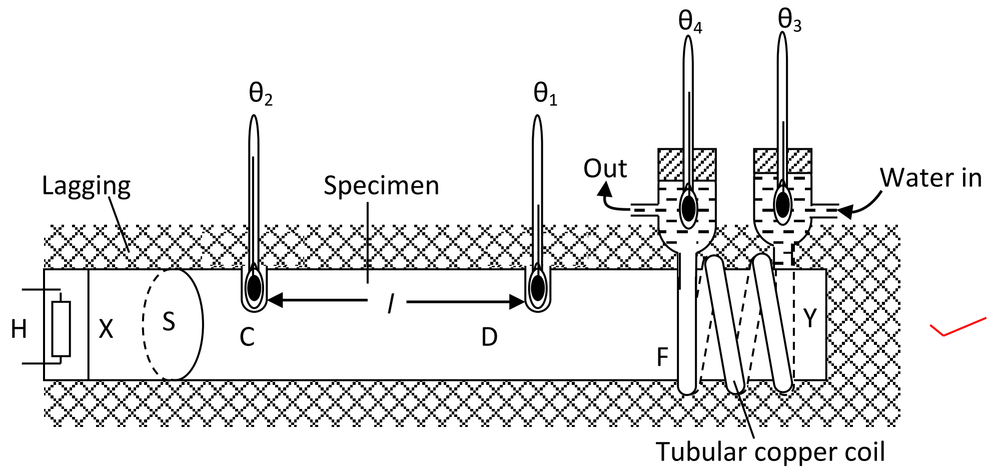
(b) (i) …the work done in moving a mass of 1 kg from infinity to a point. — 1

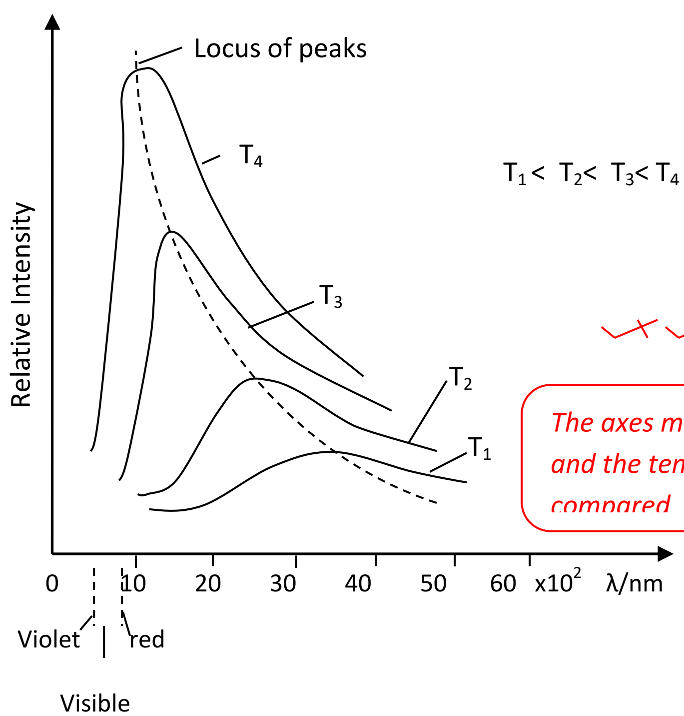
(ii) Total energy, E = p.e + k.e — 1

$= \dfrac{-GMm}{R} + \tfrac{1}{2}mv^2$

But $\dfrac{mv^2}{R} = \dfrac{GMm}{R^2}$, the centripetal force — 1

	$\therefore \quad \frac{1}{2}mv^2 = \frac{GMm}{2R}$ $\therefore \quad E = \frac{-GMm}{R} + \frac{GMm}{2R} = \frac{-GMm}{2R}$	1
	(iii) Due to friction in the Earth's atmosphere, the satellite energy decreases and consequently it falls to an orbit of smaller radius, say r_1. So its total energy changes from $\frac{-GMm}{2r_o}$ to $\frac{-GMm}{2r_1}$ In particular its kinetic energy changes from $\frac{GMm}{2r_o}$ to $\frac{GMm}{2r_1}$ Since $r_1 < r_o$, the final kinetic energy is greater. So the satellite speeds up and may heat up and even burn unless precautions are taken.	1 1 1 1
(c)	(i) ...the motion of a particle whose acceleration is directed towards a fixed point in its path and is directly proportional to the particle's displacement from that point.	1
	(ii) Let k = constant of the combination When a force, say F, is applied to the combination, the total extension, $e = \frac{F}{k} = \frac{F}{k_1} + \frac{F}{k_2}$ (the springs experience the same force) $\therefore \quad k = \frac{k_1 k}{k_1 + k_2}$  Suppose that at an instant, m is at a displacement x from the equilibrium position, O. Then, if a is the acceleration of m, considered positive away from O, we have that $ma = -kx$ $\therefore \quad a = -\frac{k}{m}x$ The negative sign means that the acceleration, a, is towards a fixed point O; and since k and m are constant, it follows that $a \propto x \Rightarrow$ simple harmonic motion. The expression may be written as $a = -\omega^2 x$, where $\omega = \sqrt{\frac{k}{m}}$ = angular frequency If T is the period, $\omega = \frac{2\pi}{T}$ $\therefore \quad \frac{2\pi}{T} = \sqrt{\frac{k}{m}}$	½ 1 1 ½ ½ ½

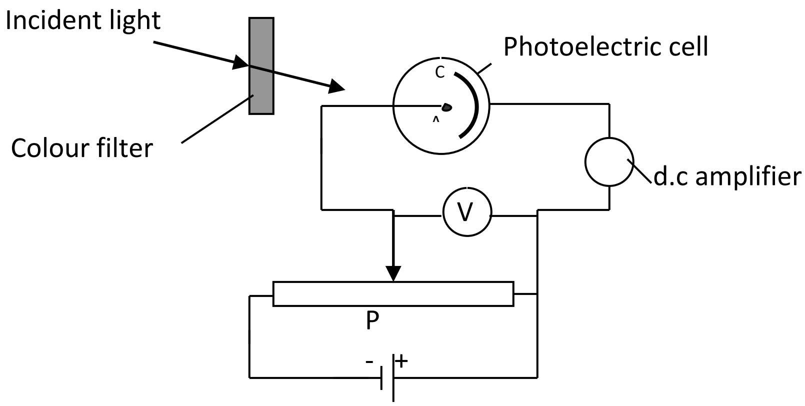
	$\therefore \quad T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{m(k_1+k_2)}{k_1 k_2}}$	1
	Total = 20	
2 (a)	(i) … the heat flow rate per unit area per unit temperature gradient.	1
	(ii) In metals conduction is predominantly due to freely moving electrons (in addition to lattice vibration). When a part 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.	1 1 ½ ½
	(iii) 	1
	The specimen XY is long compared with its diameter. All this is aimed at achieving a steep temperature gradient with a measurable heat flow rate. - The diameter of the bar is measured to determine its cross-sectional area, A, and the apparatus is set up as shown. - To measure the temperature gradient, thermometers are placed in holes C and D bored in the bar at a measured distance, *l*, apart. These holes are filled with mercury for good thermal contact. - The specimen is heated at end X while it is cooled by circulating water at Y. The setup is kept running until all the temperatures have become steady and they are measured. - Then the cooling water circulating is collected over a measured time interval and the mass of it, m, flowing per second is found. *Calculations:* Let k = thermal conductivity of the specimen	1 ½ ½ 1 ½

	Then the heat flow rate, q = $\dfrac{kA(\theta_2 - \theta_1)}{l}$ This heat is carried away by the cooling water. If c_w is the specific heat capacity of water, then $\dfrac{kA(\theta_2 - \theta_1)}{l} = mc_w(\theta_4 - \theta_3)$ ∴ $k = \dfrac{mc_w(\theta_4 - \theta_3)l}{A(\theta_2 - \theta_1)}$	½ 1
(b)	(i) …a body which absorbs all radiation falling on it, without reflecting or transmitting any of it.  *The axes must be labelled and the temperatures compared*	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 wavelength 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
(c)	When the temperature is steady	

	Power radiated by the filament = power generated ∴ $0.85\sigma AT^4 = 1800$ ∴ $T^4 = \dfrac{1800}{0.85\pi dl\sigma} = \dfrac{1800 \times 10^8}{0.85 \times 1.5 \times 10^{-2} \times 0.3 \times 5.7}$ = **1273 K**	
Total = 20		
3 (a)	(i) X-RAYS / CATHODE RAYS Electromagnetic waves produced when a metal is struck by high-energy electrons / A stream of fast-moving electrons accelerated by a p.d. Carry no charge / Carry negative charge Not affected by magnetic or electric fields / Deflected by both magnetic and electric fields *Take the first one and any other @1*	2
	(ii) At the target more than 99% of the bombarding electrons' energy is converted into heat. So the target is made of tungsten with a high melting point The target is fitted in a thick anode made of copper so as to conduct away the heat as efficiently as possible. To better the cooling process a liquid circulates in passages made in the anode block and the anode ends in fins outside.	1 1 1 1
(b)	(i) When a parallel beam of X-rays of wavelength λ falls on a crystal lattice of interatomic spacing d at a glancing angle θ, reinforcement of the reflected beam occurs only when $2d\sin\theta = n\lambda$, where n is an integer	1
	(ii) λ must be small compared to 2d	1
	(iii) The maximum order will be investigated by first making $\sin\theta = 1$ ∴ $n = \dfrac{2d}{\lambda} = \dfrac{2 \times 3.00 \times 10^{-10}}{1.187 \times 10^{-10}} = 5.05$ So the maximum order is **5**	1 1 1
(c)	(i) …the minimum energy of incident light that will eject an electron from the metal surface concerned.	1

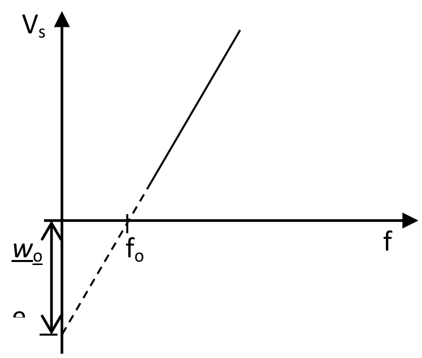
X-RAYS	CATHODE RAYS
Electromagnetic waves produced when a metal is struck by high-energy electrons	A stream of fast-moving electrons accelerated by a p.d.
Carry no charge	Carry negative charge
Not affected by magnetic or electric fields	Deflected by both magnetic and electric fields

(ii)



[1]

- The circuit is connected as shown in which P is a potential divider.
- Using different colour filters, the frequency, f, of the incident light is varied.
- For a given frequency the p.d V, picked from the potential divider P, is varied negatively until the current registered by the d.c amplifier just becomes zero. [1]
- The reading of the voltmeter is noted and it is the stopping potential, V_s, for the frequency f. [½]
- The procedure is repeated using different colour filters, each time noting the corresponding stopping potentials V_s. [½]
- A graph of V_s against f is plotted. A graph of V_s against f is plotted. [½]



[½]

From $V_s = \frac{h}{e}f - \frac{\omega}{e}$, the gradient of the graph is $\frac{h}{e}$ [1]

$\therefore$ h = e x gradient

(iii) $\omega_o = hf_1 - eV_1$ .... (1) [½]

and $\omega_o = hf_2 - eV_2$ .... (2) [½]

Eq(1) x f_2: $\omega_o f_2 = hf_1f_2 - eV_1f_2$ .... (3)

Eq(2) x f_1: $\omega_o f_1 = hf_1f_2 - eV_2f_1$ .... (4)

Eq(3) – Eq(4): $\omega_o(f_2 - f_1) = eV_2f_1 - eV_1f_2$ [½]

$$\therefore \quad \omega_o = \frac{e(V_2f_1 - V_1f_2)}{f_2 - f_1} = \frac{1.6\times10^{-19}(2.2\times6 - 0.6\times10)}{10-6}$$ [½]

= **2.88×10^{-19} J** [1]

Total = 20		