2021 DHS H2 Physics Prelim Paper 3 Suggested Solutions

Section A

1 **(a)** change in velocity / time (taken) or rate of change of velocity **B1**

(b) **(i)** $v_X = (24 / 1.5) = 16$ m s^{-1} **A1**

(ii) $\tan 28° = v_Y / v_X$ or $v_X = v \cos 28°$ and $v_Y = v \sin 28°$ **M1**

$v_Y = 16 \tan 28°$ or $v_Y = 16 \times (\sin 28° / \cos 28°)$ so $v_Y = 8.5$ m s^{-1} **A0**

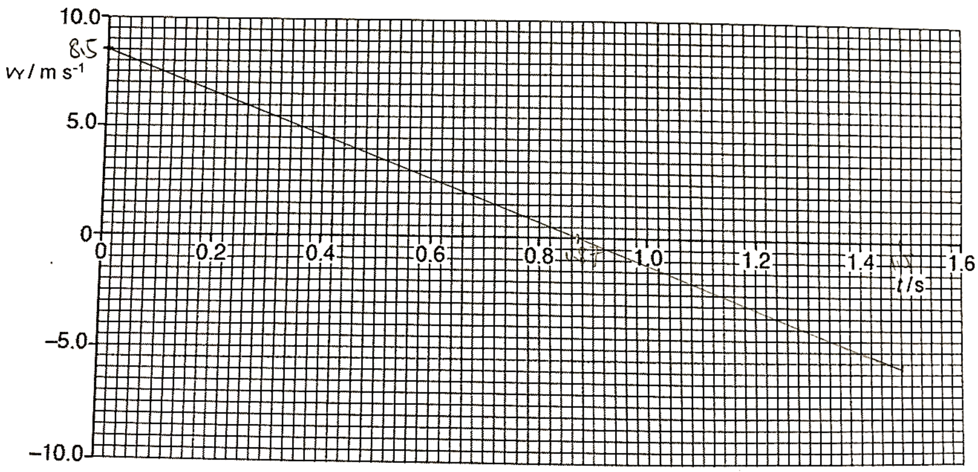
(iii) v = u + at **C1**

t = (0 - 8.5) / (-9.81)

= 0.87 s **A1**

(iv) straight line from positive v_Y at t = 0 to negative v_Y at t =1.5 s **M1**

line starts at (0, 8.5) and crosses t-axis at (0.87, 0) and does not go beyond t = 1.5 s. **A1**



(c) $v^2 = u^2 + 2as$

$0 = 8.5^2 + 2(-9.81)s$

or (s = ut + ½at^2) $s = 8.5 \times 0.87 + ½ \times (-9.81) \times 0.87^2$

or (s = vt – ½at^2) $s = 0 - ½ \times (-9.81) \times 0.87^2$

or (s = ½ (u + v)t or area under graph) $s = 0.5 \times 8.5 \times 0.87$ **C1**

s = 3.7 m **A1**

(d) acceleration (of freefall) is unchanged / not dependent on mass, and so no effect (on maximum height)

OR explanation in terms of energy:

(initial) KE $\propto$ mass, (Δ)KE = (Δ)PE, (max) PE $\propto$ mass, and so

no effect (on maximum height) **B1**

2 **(a)** Force experienced by a mass in a gravitational field **B1**

(b) **(i)** total downward force on the moving pulley

= 960 + (2.4 x 9.81) = 984 N **C1**

As the moving pulley is moving upwards at a constant speed,

net force = 0

$2T\cos 11.5^{\circ} = 984$ **C1**

T = 502 N **A1**

(ii) Cosine of angle (with vertical) decreases

OR angle of rope (with vertical) increase **M1**

Hence tension increases **A1**

(c) **(i)** rope / lower pulley has to be lifted up

OR load has kinetic energy (any one) **B1**

(ii) force applied is less than weight of load **B1**

3 **(a)** pV/T = constant

$T = (6.5 \times 10^6 \times 30 \times 300) / (1.1 \times 10^5 \times 540)$ **C1**

= 985 K **A1**

(b) **(i)** The increase in the internal energy of a system is equal to the **B1**

sum of the thermal energy supplied to the system and work done on

the system. **B1**

(ii) no thermal energy supplied to system, thus increase in internal energy = work done on system **B1**

so U increases **B1**

U increases so kinetic energy of atoms increases

and hence T increases **B1**

(c) $KE \propto T$, hence $v \propto \sqrt{T}$, and so **C1**

ratio = $\sqrt{\frac{350}{300}} = 1.1$ **A1**

4 **(a)** **(i)** 0.050 m **A1**

(ii) $\omega = \frac{v_0}{x_0}$ **C1**

$T = \frac{2\pi}{\omega}$

$0.42 = \frac{2\pi \times 0.050}{T}$

C1

T = 0.75 s **A1**

(b) one point labelled P where ellipse crosses displacement axis **B1**

5 **(a)** When two or more waves of the same kind meet at a point at the same time,**B1**

the displacement of the resultant wave is the vector sum of the displacements of the individual waves at that point at that time.

B1

(b) **(i)** $\lambda = \frac{v}{f} = \frac{330}{200} = 1.65 \text{ m}$ **A1**

(ii) The distance of the upper loudspeaker from the man is

$\sqrt{9.3^2 + 4.0^2} = 10.124\, m$

$\therefore$ *the path difference between the waves reaching the man is*

$10.124 - 9.3 = 0.8237\, m$

C1

the path difference is $\frac{0.8237}{1.65} = 0.50\lambda$ **C1**

This means that the waves interfere destructively and the man will hence detect a **minimum** of sound intensity.

A1

(iii)1. increase the frequency of the sound **B1**

2. increase the separation between the two loudspeakers **B1**

6 **(a)** The electric force per unit positive charge experienced by a small stationary test charge placed at that point. **B1**

(b)(i) to the right / from the left / from A to B / in the same direction as electron velocity **B1**

(ii) $v^2 = u^2 + 2as$

$a = (1.5 \times 10^7)^2 / (2 \times 2.0 \times 10^{-2})$ **C1**

Other alternative calculations for the C1 mark:

e.g. $a = 1.5\times10^7 / 2.67\times10^{-9}$

e.g. $a = [(1.5\times10^7 \times 2.67\times10^{-9}) - 2.0\times10^{-2}] \times [2 / (2.67\times10^{-9})^2]$

e.g. $a = (2.0\times10^{-2} \times 2) / (2.67\times10^{-9})^2$

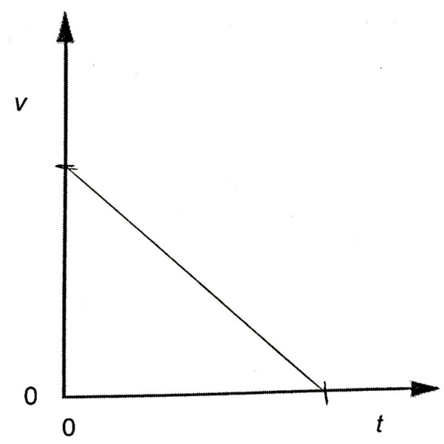
$= 5.6 \times 10^{15}$ m s^{-2} **A1**

(iii) $E = F / Q$

$= (9.11 \times 10^{-31} \times 5.6 \times 10^{15}) / 1.6 \times 10^{-19}$ **C1**

$= 3.2 \times 10^4$ V m^{-1} **A1**

(c) straight line with negative gradient starting at an intercept on the *v*-axis and ending at an intercept on the *t*-axis. **B1**



7 **(a)** Angular velocity is the <u>rate of change of angular displacement</u> of a radius joining the body to the axis of rotation. **B1**

$$\omega = \frac{2\pi}{T}$$

$$= \frac{2\pi}{(44.2 \times 365 \times 24 \times 3600)}$$ C1

(b)(i) $= 4.5 \times 10^{-9}$ rad s^{-1} A1

(ii) magnitude of the centripetal force about P is the same **M1**

$$M_1 x \omega^2 = M_2 (d - x) \omega^2$$

$$\frac{M_1}{M_2} = \frac{(d - x)}{x}$$ **A1**

(iii) $x = 0.4d$ **C1**

Consider S_2, gravitational force provides centripetal force

$$\frac{GM_1M_2}{d^2} = M_2 (d - x) \omega^2$$ C1

$$GM_1 = d^2 (d - x) \omega^2$$

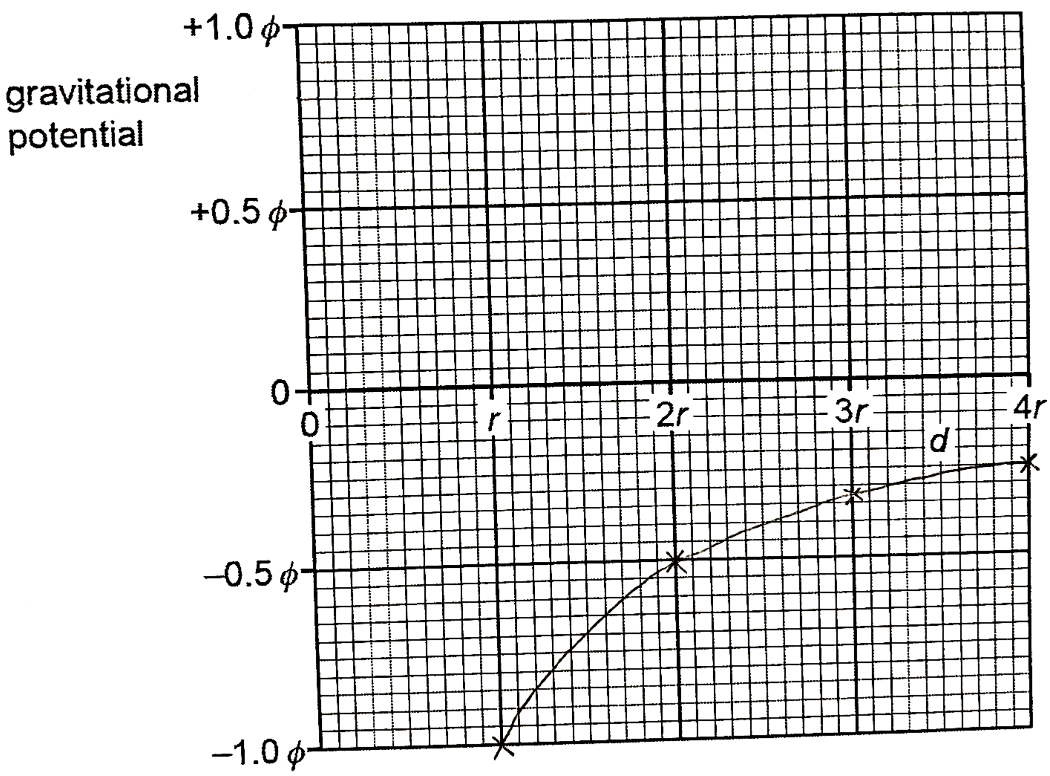
$$(6.67 \times 10^{-11}) M_1 = (1.0 - 0.4)(1.8 \times 10^{12})^3 (4.5 \times 10^{-9})^2$$ C1

$$M_1 = 1.1 \times 10^{30} \text{ kg}$$ A1

(c)(i) The work done per unit mass in bringing a small test mass from infinity to that point. **B1** **B1**

(ii) curve from r to $4r$, with gradient of decreasing magnitude and line showing potential is negative throughout **B1**

line passing through *(2r, -0.5ϕ) and (4r, -0.25ϕ)* **B1**



maximum kine

$hf_0 = \phi$

Section B

8 **(a)(i)** A photon is a discrete packet (quantum) of energy of electromagnetic radiation.
B1

(ii) The work function energy of a metal is the minimum energy of photon to cause emission of electron from the surface of a metal. **B1**

(b)(i)

1. f_0 correctly labelled **B1**

2. parallel line with same gradient and higher horizontal intercept **B1**

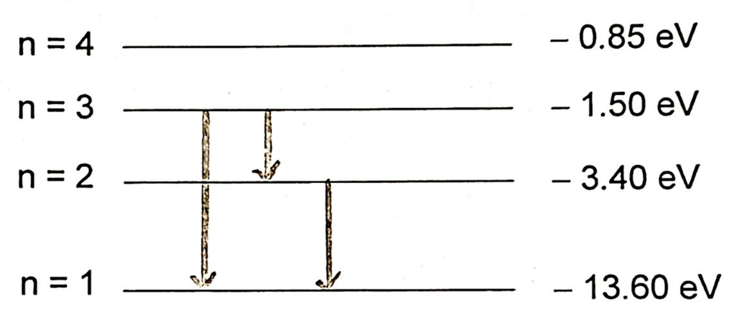
(ii) Planck constant **B1**

/lax KE corresponds to electrons emitted from surface
Energy is required to bring electron to surface **B1**

(iv) intensity determines number of photons arriving per unit time **B1** Hence determines number of electrons emitted per unit time,
and not energy. **B1**

(c)(i) 13.60 eV **B1**

(ii)1.



correct energy levels **B1**
correct direction of arrows **B1**

2. energy in Joules = $1.90 \times 1.6 \times 10^{-19} = 3.04 \times 10^{-19}$ **C1**

$E = hc/\lambda$

$\lambda = (6.63 \times 10^{-34})(3 \times 10^{8}) / (3.04 \times 10^{-19})$

$= 6.54 \times 10^{-7}$ m **A1**

Visible light region (red) **B1**

(d)(i) Wavelength that is associated with a particle that is moving. **B1**

(ii) $\lambda = h/mv$ **C1**

$v = (6.63 \times 10^{-34}) / (9.11 \times 10^{-31})(1.2 \times 10^{-10})$ **C1**

$= 6.1 \times 10^{6}$ m s^{-1} **A1**

(iii) wavelength is about the separation of atoms in a crystal **B1**
can be used in electron diffraction **B1**

9 **(a)(i)** The average time taken for the initial number of nuclei (or activity) of **B1**
a particular radioactive nuclide to reduce to half its original value. **B1**

(ii) Decay is not affected by external or environmental factors (such as pressure, temperature etc) **B1**

(iii)

$$\lambda = \frac{\ln 2}{t_{1/2}}$$

$$= \frac{\ln 2}{432.2 \text{ yrs}}$$

$$= \frac{\ln 2}{432.2 \times 365 \times 24 \times 3600 \text{ s}}$$

$$= 5.086 \times 10^{-11} \text{ s}^{-1}$$ **A1**

(iv)

Number of undecayed atoms,

$$N = \left(\frac{1.00 \text{ g}}{241 \text{ g mol}^{-1}}\right)(6.02 \times 10^{23} \text{ mol}^{-1}) = 2.4979 \times 10^{21}$$ C1

$$A = \lambda N$$

$$= (5.086 \times 10^{-11} \text{ s}^{-1})(2.4979 \times 10^{21})$$ C1

$$= 1.27 \times 10^{11} \text{ s}^{-1}$$

$$= 1.27 \times 10^{11} \text{ Bq}$$ A1

(v) Loss of mass

= 241.0568229 – (237.0481673 + 4.0026032) **C1**

= 6.0236×10^{-3} u

Energy = (0.0060524 u x 1.66 x 10^{-27} x (3.00 x$10^{8})^{2}$ **C1**

= 9.0423 x 10^{-13} J

= 5.65 MeV **A1**

(b) For nuclei having high nucleon numbers, the binding energy per nucleon decreases with larger nucleon numbers. **B1**

When two such nuclei fuse together, they will produce a daughter nucleus which has an even larger nucleon number and smaller binding energy per nucleon. **B1**

The total binding energy of the products is less than that of the initial nuclei, hence there is an increase in the total mass of the system, and energy has to be supplied for such a reaction to take place. **B1**

(c) **(i)** $^{4}_{2}\alpha$ **B1**

$^{1}_{1}H$ **B1**

(ii) 1. Initially alpha particle must have some kinetic energy. **B1**

2.

$1.1\ MeV = 1.1 \times 1.6 \times 10^{-13} = 1.76 \times 10^{-13}$ J C1

$E_k = \frac{1}{2}mv^2$ C1

$1.76 \times 10^{-13} = \frac{1}{2}(4 \times 1.66 \times 10^{-27} \times v^2)$ C1

$v = 7.3 \times 10^{6}$ m s^{-1} A1

~ THE END ~