2018 Raffles Institution Preliminary Examinations – H2 Physics

Paper 1 Answers

1	C	**6**	B	**11**	C	**16**	D	**21**	B	**26**	D
2	D	**7**	D	**12**	B	**17**	C	**22**	B	**27**	B
3	C	**8**	C	**13**	C	**18**	D	**23**	C	**28**	A
4	A	**9**	A	**14**	A	**19**	D	**24**	B	**29**	D
5	D	**10**	A	**15**	B	**20**	A	**25**	C	**30**	A

Paper 1 Suggested Solutions

1 **C**

$$m_{Liq} = m_{Total} - m_{Beaker} = 70 - 20 = 50 \text{ g}$$

$$\triangle m_{Liq} = \triangle m_{Total} + \triangle m_{Beaker} = 1 + 1 = 2 \text{ g}$$

$$\rho = \frac{m_{Liq}}{V_{Liq}}$$

$$\frac{\Delta\rho}{\rho} = \frac{\Delta m_{Liq}}{m_{Liq}} + \frac{\Delta V_{Liq}}{V_{Liq}} = \frac{2}{50} + \frac{0.6}{10.0}$$

$$\Delta\rho = \left(\frac{2}{50} + \frac{0.6}{10.0}\right)(5.0) = 0.5 \text{ g cm}^{-3} \text{ (1 s.f.)}$$

2 **D** After first bounce,

$$KE_{left} = \left(1 - \frac{7}{16}\right)KE_{initial} = \frac{9}{16}KE_{initial} = \left(\frac{3}{4}\right)^2 \frac{1}{2}mv_0^2 \ = \frac{1}{2}m\left(\frac{3}{4}v_0\right)^2$$

where v_0 is the speed just before the ball hits the ground

If the height of the second triangle is now $\frac{3}{4}v_0$, time duration of the second triangle is $\frac{3}{4}t = 0.75t$ (due to similar triangles). Since air resistance is negligible, the time taken by the ball to move up after the first bounce is the same as the time taken to move down to the ground again.

OR

Since air resistance is negligible, the gradient of the velocity-time graphs will all be the same with the value of g.

$$\frac{v_0}{t} = g \quad \Rightarrow \quad v_0 = gt$$

$$KE_{left} = \left(1 - \frac{7}{16}\right)KE_{initial} = \frac{9}{16}KE_{initial} = \left(\frac{3}{4}\right)^2 \frac{1}{2}mv_0^2 \ = \frac{1}{2}m\left(\frac{3}{4}v_0\right)^2$$

speed after bounce, $v_1 = \frac{3}{4}v_0$

$$\triangle t = \frac{v_1}{g} = \left(\frac{3}{4}v_0\right)\left(\frac{1}{g}\right) = \left(\frac{3}{4}gt\right)\left(\frac{1}{g}\right) = \frac{3}{4}t = 0.75t$$

3 **C** Horizontal motion:

$$s_x = vt$$

$$t = \frac{s_x}{v} = \frac{4.0}{v}$$

Vertical motion:

$$s_y = \frac{1}{2}gt^2$$

$$1.5 - 1.1 = \frac{1}{2}g\left(\frac{4.0}{v}\right)^2$$

$$v = 14 \text{ m s}^{-1}$$

4 **A** This is a completely inelastic collision. Hence, total mechanical energy is **not** conserved.

5 **D** By Newton's second law,

$$\text{net force, } F - \frac{F}{5} = (m + 3m)a$$

$$a = \left(\frac{4}{5}F\right)\left(\frac{1}{4m}\right) = \frac{F}{5m}$$

Consider the forces acting on Y:

$$F_{XY} - \frac{F}{5} = 3m \times \frac{F}{5m}$$

$$F_{XY} = \left(3m \times \frac{F}{5m}\right) + \frac{F}{5} = \frac{4F}{5}$$

6 **B** There cannot be any normal reaction when the sphere is in equilibrium because it will be the only force with a horizontal component that is not balanced.

7 **D** Taking moments about the point on the base of the block through which R acts,

$$(5.0\cos 30^\circ)\,x = (5.0\sin 30^\circ)\left(10/2 \times 10^{-2}\right) + 1.0\left(8.0 \times 10^{-2}\right)$$

$$x = 0.0473 \text{ m} = 4.7 \text{ cm}$$

8 **C** Work done to stretch it 10 cm:

$$\frac{1}{2}k(0.10)^2 = 4.0$$

$$k = 800 \text{ N m}^{-1}$$

Work done to stretch it 20 cm:

$$\frac{1}{2}(800)(0.20)^2 = 16$$

Additional work required = 16 – 4 = 12 J

9 **A** $T\cos 40^\circ = mg$ --- (1)

$$T\sin 40^\circ = \frac{mv^2}{1.2\sin 40^\circ} \quad \text{--- (2)}$$

$$\frac{(2)}{(1)} \quad \tan 40^\circ = \frac{v^2}{g \times 1.2\sin 40^\circ} \quad \Rightarrow \quad v = 2.5 \text{ m s}^{-1}$$

10 **A** The equations for potential energy and kinetic energy are given by :

$E_p = -\frac{GMm}{R}$ and $E_k = \frac{GMm}{2R}$

As R increases, E_p increases (becomes less negative) and E_k decreases.

11 **C** For a body to escape a planet's gravitational influence from its surface:

$$-\frac{GMm}{R} + \frac{1}{2}mv^2 \geq 0 \;\Rightarrow\; v_{escape} = \sqrt{\frac{2GM}{R}}$$

and since $M = \frac{4}{3}\rho\pi R^3$

$$v_{escape} = \sqrt{\frac{2G\left(\frac{4}{3}\rho\pi R^3\right)}{R}} = \sqrt{\frac{8G\rho\pi R^2}{3}}$$

$$v_{escape} \propto R\sqrt{\rho}$$

$$\therefore \frac{v_{escape,X}}{v_{escape,Y}} = \frac{R_x\sqrt{\rho_x}}{R_Y\sqrt{\rho_Y}} = \frac{R_x}{R_y}\sqrt{\frac{\rho_x}{\rho_Y}} = \left(\frac{3}{1}\right)\sqrt{\left(\frac{9}{4}\right)} = \frac{9}{2} = 4.50$$

12 **B** The components of the particle's motion in the horizontal *x*-direction is simple harmonic. Hence $a \propto -x$.

13 **C** Between 2.0 s and 2.5 s, the block is in contact with the spring and its motion is simple harmonic i.e. the graph is ¼ of a cosine graph.

Period when block is in SHM = 4 × 0.5 s = 2.0 s

$\Rightarrow \omega = 2\pi/T = 3.14$ rad s^{-1}

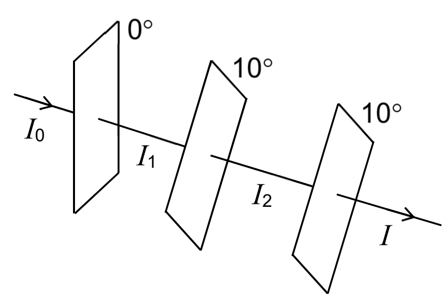
$x_o = v_o/\omega = 0.30/\pi = 0.095$ m

14 **A** Using Malus' law,

$I_2 = I_1\cos^2 10° = \frac{1}{2}I_0\cos^2 10°$

$I = I_2\cos^2\theta$

where θ is the angle between the axes of polarisation of the second and third filters



$I = I_2\cos^2\theta = \frac{1}{2}I_0\cos^2 10°\cos^2\theta$

$\frac{1}{3}I_0 = \frac{1}{2}I_0\cos^2 10°\cos^2\theta$

$\theta = \cos^{-1}\sqrt{\frac{2}{3\cos^2 10°}} = 33.99 = 34°$

15 **B**

distance travelled in 1 s = $10 \times \frac{1}{2}\lambda$

time taken to travel $\frac{1}{2}\lambda = \frac{1}{10}$ s

distance = speed $\times$ time

$$\frac{1}{2}\lambda = 2.0 \times \frac{1}{10}$$

$$\lambda = 2\left(2.0 \times \frac{1}{10}\right) = 0.40 \text{ m}$$

At initial position M, detector detects maximum intensity (antinode).
Minimum intensity detected will be ¼ wavelength away (node).

$$\text{distance moved} = \frac{1}{4}\lambda = \frac{1}{4}(0.40) = 0.10 \text{ m}$$

16 **D**

$$\tan\left(\frac{0.40°}{2}\right) = \frac{1.5 \times 10^{-2}}{2D}$$

$$D = \frac{1.5 \times 10^{-2}}{2\tan\left(\frac{0.40°}{2}\right)} = 2.1 \text{ m}$$

$$a\sin\theta = 2\lambda$$

$$a = \frac{2\left(600 \times 10^{-9}\right)}{\sin\left(\frac{0.40°}{2}\right)} = 3.44 \times 10^{-4} = 0.34 \text{ mm}$$

OR

$$x = \frac{\lambda D}{a}$$

$$a = \frac{\lambda D}{x} = \frac{600 \times 10^{-9} \times 2.1}{\left(1.5 \times 10^{-2}\right)/4} = 0.34 \text{ mm}$$

17 **C**

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$T_2 = P_2V_2\left(\frac{T_1}{P_1V_1}\right) = (1.25P)(0.75V_1)\left(\frac{T_1}{P_1V_1}\right) = 0.9375T_1$$

$$E_K = \frac{1}{2}mc^2 = \frac{3}{2}kT$$

$$c^2 \propto T \quad \Rightarrow \quad c \propto \sqrt{T}$$

$$c_2 = \sqrt{\frac{T_2}{T_1}}c = \sqrt{\frac{0.9375T_1}{T_1}}c = 0.97c$$

18 **D**

For a fixed mass of gas in the pump and basketball,

$$\Delta U = W + Q$$

Compression implies $W > 0$. Well-insulated pump/basketball implies $Q \approx 0$.
Hence, $\Delta U > 0$ (increases) and the temperature of the gas increases.

19 **D** Electric force acting on ion P is eE (in direction of the E field), and that acting on ion Q is also eE (but in the opposite direction to the E field).

Resultant force on the molecule is therefore zero.

$$\begin{aligned}\text{Torque of couple} &= Fd \\ &= qEd \\ &= \left(1.60\times10^{-19}\right)\left(4200\right)\left(0.12\times10^{-9}\right) \\ &= 8.1\times10^{-26}\text{ Nm}\end{aligned}$$

20 **A** When oil drop is at equilibrium,

$$\begin{aligned}qE &= mg \\ q\frac{V}{d} &= mg\end{aligned}$$

$$\begin{aligned}\text{When p.d. is 2V, net force} &= q\frac{2V}{d} - mg \\ &= 2mg - mg \\ &= mg \quad \text{(upwards)}\end{aligned}$$

Upward acceleration is thus g.

21 **B** $E = IVt = 2\times6\times10 = 120$ J

22 **B** Effective external resistance for max. power delivered = 5 Ω

$$\frac{1}{R}+\frac{1}{10}=\frac{1}{5}$$

$$\therefore R = 10\ \Omega$$

Potential difference across the 10 Ω resistor

$$= \frac{5}{10}(12) = 6\text{ V}$$

$$P = \frac{V^2}{R} = \frac{6^2}{10} = 3.6\text{ W}$$

23 **C** At d, the net field due to both wires is zero.
Hence the magnetic flux density of each wire is equal in magnitude and opposite in directions. This means I_X and I_Y are in opposite directions.

$$\begin{aligned}B_X &= B_Y \\ \frac{\mu_o I_X}{2\pi\left(L+d\right)} &= \frac{\mu_o I_Y}{2\pi d} \\ \frac{I_X}{I_Y} &= \frac{L+d}{d} = 4.00 \\ L &= 3d\end{aligned}$$

24 **B** Since both X and Y have the same mass to charge ratio,

$$\frac{KE_X}{KE_Y} = \left(\frac{v_X}{v_Y}\right)^2 = \left(\frac{R_X}{R_Y}\right)^2 = \left(\frac{1}{2}\right)^2 = 0.25$$

25 **C** Since $|E| = BLv = BL\frac{ds}{dt}$, the magnitude of E can be deduced from the gradient of the s-t graph.

26 **D** Resistance of heater $R = \frac{V_{AC}^{\ 2}}{P} = \frac{110^2}{800} = 15.125\ \Omega$

Power dissipated when d.c. supply is used $= \frac{V_{DC}^{\ 2}}{R} = \frac{156^2}{15.125} = 1609$ W

27 **B** $\frac{hc}{\lambda} = E + \Phi$ and $\frac{hc}{\lambda'} = 2E + \Phi$

$\Rightarrow \quad \frac{\lambda'}{\lambda} = \frac{E + \Phi}{2E + \Phi}$

Since $\frac{1}{2} < \frac{E + \Phi}{2E + \Phi} < 1 \quad \Rightarrow \quad \lambda/2 < \lambda' < \lambda$

28 **A** Shortest wavelength

$\lambda_{\text{min}} = \frac{hc}{eV}$

$\Rightarrow \quad \lg \lambda_{\text{min}} = \lg\left(\frac{hc}{e}\right) - \lg V$

Graph of $\lg \lambda_{\text{min}}$ against $\lg V$ is a straight line with negative gradient and positive intercept.

29 **D** The sample consists of the parent as well as the daughter nuclei.
β particles are electrons that have mass much smaller than that of the parent nuclei.
Hence the mass of the sample is only slightly smaller than its initial mass, differing only by the small mass of β particles emitted.

30 **A** energy released = (39.25) + (28.48) – (64.94) = 2.79 MeV
γ-ray energy = 2.79 – 2.31 = 0.48 MeV