2019 Preliminary Examinations H2 Physics Paper 1 Solutions

1 C
$$\text{volume} = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi(12)^3 = 7200 \text{ cm}^3$$

2 C Let t be the time from release of ball to moment of impact with floor of elevator, s be the distance travelled by elevator during time t and u be the initial speed of both ball and elevator at point of release.

$$s = ut + \frac{1}{2}(3.5)t^2$$
$$s + 2 = ut + \frac{1}{2}(9.81)t^2$$
$$ut + \frac{1}{2}(3.5)t^2 + 2 = ut + \frac{1}{2}(9.81)t^2$$
$$2 = \frac{1}{2}(9.81)t^2 - \frac{1}{2}(3.5)t^2$$
$$t = 0.796 \text{ s}$$

3 D Constant force (resultant) implies constant acceleration

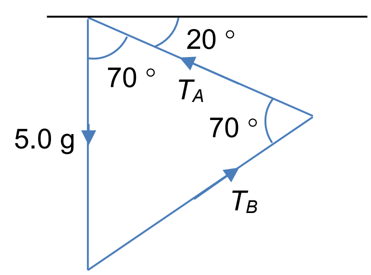
$$v^2 = u^2 + 2as$$
$$v^2 = 0 + 2ad$$
$$v = \sqrt{2ad}$$

Since $p = mv$, $\quad p = m\sqrt{2a}\sqrt{d}$

4 C

$$T_A \cos 20^\circ = T_B \cos 50^\circ$$
$$\frac{T_A}{T_B} = \frac{\cos 50^\circ}{\cos 20^\circ} = 0.68404$$
$$T_A \sin 20^\circ + T_B \sin 50^\circ = T_C = mg$$
$$0.68404 T_B \sin 20^\circ + T_B \sin 50^\circ = mg$$
$$T_B = mg = 5.0(9.81) = 49 \text{ N}$$

OR



Since the force triangle is isosceles, T_B = 5.0 g = 49 N

5 C difference in vertical height, $h = x \sin \theta$
$P_{\text{helium}} = P + \rho gh = P + x\rho g \sin \theta$

6 C
$$P = \frac{mgh}{t} + \frac{F_R \times h}{t} = (350)(9.81)\frac{110}{3.0 \times 60} + \frac{(1000)(110)}{3.0 \times 60} = 2700 \text{ W}$$

7 D Upon release, the mass will fall vertically downwards, stretching the spring. The mass will undergo oscillations losing GPE and gaining KE and EPE before coming to rest due to air resistance. Hence at any point during oscillation, the loss in gravitational potential energy = gain in elastic potential energy + gain in kinetic energy + energy dissipated. However, at its maximum displacement below its equilibrium position, kinetic energy is zero. Hence only option D is correct.

8 **B** $v = r\omega = \left(\frac{150}{2}\right)\left(\frac{2\pi}{30\times 60}\right) = 0.26 \text{ m s}^{-1}$

9 **B** $\frac{F_c}{W} = \frac{\frac{mv^2}{r}}{mg} = \frac{v^2}{rg} = \frac{700^2}{(85000)(9.81)} = 0.59$

10 **A** $\frac{g'}{g} = \left(\frac{r}{r'}\right)^2 = \left(\frac{6400}{6600}\right)^2 = 0.94$

Hence, g' is 6% less than g.

Alternatively, one can use $\frac{\Delta g}{g} \approx 2\left(\frac{\Delta r}{r}\right) = 2\times\left(\frac{200}{6400}\right) = 0.0625$. So the difference is about 6%.

11 **D** The rotation of the Earth results in the acceleration of free fall being smaller than the gravitational field strength.

12 **A** Total number of moles of gas is constant. Since $PV = nRT$, we take the initial number of moles in the smaller (A) and larger bulb (B) to be n and $8n$ respectively. Total number of moles = 9n.

At new equilibrium, the pressure will be the same for both.

$P_f V = n' RT_A = n' R(80 + 273.15)$

$P_f (8)V = (9n - n')RT_B = (9n - n')R(10 + 273.15)$

Dividing:

$$\frac{V}{8V} = \frac{n'(353.15)}{(9n - n')(283.15)}$$

$$\frac{9n - n'}{n'} = \frac{8\times 353.15}{283.15}$$

$$\frac{9n}{n'} = \frac{8\times 353.15}{283.15} + 1$$

$$n' = 0.8194n$$

$$\Delta n = n - 0.8194n = 0.18n$$

13 **C**

$$m_p c_p \Delta\theta + C_{cal}\Delta\theta = m_L c_L (150 - 25 - \Delta\theta)$$

$$(0.250)(2130)\Delta\theta + (21.7)(\Delta\theta) = (0.400)(130)(125 - \Delta\theta)$$

$$(532.5)\Delta\theta + (21.7)(\Delta\theta) = 52(125 - \Delta\theta)$$

$$\Delta\theta = 10.7\ ^\circ\text{C}$$

14 **D** At t = 0.4 s, a = 0 and $v = v_{max} = \omega x_o = \frac{2\pi}{T}\times x_o = 0.157 \text{ m s}^{-1}$

15 **B** The vertical displacement is given by $y = -A\cos\omega t$.

At $t = \tau$, $y = -\frac{1}{2}A$, $-A\cos\omega\tau = -\dfrac{1}{2}A$ $\Rightarrow \omega\tau = \dfrac{\pi}{3}$ $\Rightarrow \omega = \dfrac{\pi}{3\tau}$

$$\Rightarrow T = \frac{2\pi}{\omega} = 6\tau$$

16 **B** λ = 4 × 0.15 = 0.60 m
$v = f\lambda$
330 = f × 0.60
f = 550 Hz

17 **A** Separation between a node and the adjacent node is half a wavelength.
Energy at the antinode changes from kinetic to potential and back again.

18 **C** $d\sin\theta = n\lambda$
$d\sin 15° = 2\lambda$
$\dfrac{d}{\lambda} = 7.7$
For maximum order, $\sin\theta = 1$, $d = n_{max}\lambda$
$n_{max} = \dfrac{d}{\lambda} = 7.7 = 7$

19 **B** $E = \dfrac{-10-(-20)}{30\times10^{-3}} = 333 \text{ V m}^{-1}$

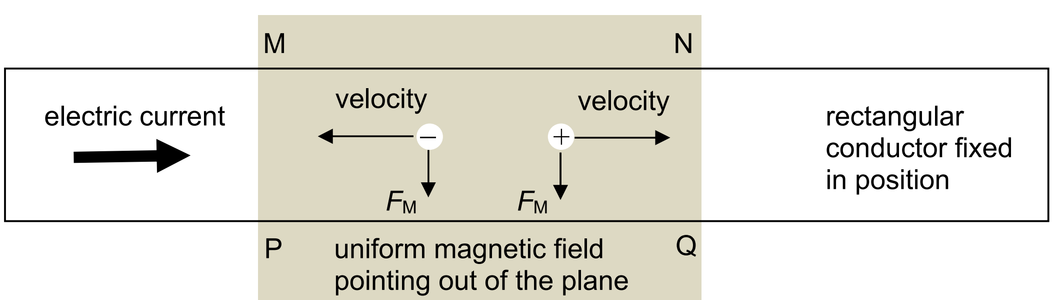
The electric force acting on the charge is $(5.0\times10^{-6})(333) = 1.67\times10^{-3}$ N, and it points upward. Since the charge is negative, the electric force is downward.
Work done by electric field $= qE\times d = (1.67\times10^{-3})(-0.012) = -2.0\times10^{-5}$ J

20 **D** Electric fields point in the direction of higher electric potential to lower electric potential (reference to a positive charge).

21 **A** As temperature of thermistor increases, resistance of thermistor decreases. Total resistance in circuit decreases, thus current I_1 increases and hence p.d. across R_1 increases. Therefore, potential difference across thermistor decreases and I_2 decreases.

22 **C** The readings of V_2 and V_3 are both zero. No current flows through the resistor that V_2 is connected across and the resistance of a diode is zero.

23 **C**



Negative charges move opposite to the current, whereas positive charges move parallel to the current. Using Fleming's left-hand-rule, both types of charges experience a downward magnetic force (as it should be, because both types of charges produce the same electric current to the right).

Hence, if the charge carriers are positive, PQ will be at a higher potential (because positive charges accumulate there), whereas if the charge carriers are negative, MN will be at a higher potential (because negative charges accumulate at PQ).

This is the famous Hall effect.

24 **D** Rotation about the *y*-axis leaves the wire perpendicular to the magnetic field, whereas rotation about the *x*-axis changes the perpendicular length of the current-carrying wire.

25 **A** At the starting position (as shown), the rate of change of flux linkage is the smallest, the induced emf (hence the induced current) is zero. The subsequent variation of the current is sinusoidal.

Note that the scenario in this question is similar to the typical situation of a coil rotating in a uniform field. The absence of the field in half of the space simply implies that the emf (hence current) induced is halved. The function form of the current should not change.

26 **B** $I_{\text{rms}} = \sqrt{(4^2 + 8^2 + 5^2 + 0^2)/4} = 5.12\text{ A}$

27 **B**

$$\text{Power } P = \frac{energy}{time} = \frac{N(hf)}{t}$$

$$\Rightarrow \frac{N}{t} = \frac{P}{hf} = \frac{1.00\times10^3}{6.63\times10^{-34}\times880\times10^3} = 1.71\times10^{30}$$

28 **A** When the tube voltage is increased the electrons striking the target have higher kinetic energies and more electrons are sufficiently energetic to dislodge the inner shell electrons from the target atoms which subsequently leads to the production of the characteristic X-ray spectrum.

Hence the <u>intensities</u> of the <u>characteristic wavelengths</u> (or peaks) will <u>increase</u>. However, since the <u>target</u> material is unchanged, the <u>wavelengths</u> of these peaks are <u>unchanged</u>.

29 **A** Energy released = BE of products − BE of reactants

$= (8.32\times136) + (8.58\times98) - (7.60\times235) = 186\text{ MeV}$

30 **D** In going from ${}^{238}_{92}\text{U} \rightarrow \ldots \rightarrow {}^{206}_{82}\text{Pb}$,

let *m* be the number of alpha decays and *n* be the number of beta decays.

Equating mass numbers on both sides of the equation

$$4m + 0 = 238 - 206 \qquad \Rightarrow m = 8$$

Equating atomic numbers on both sides of the equation

$$2m - n = 92 - 82 \qquad \Rightarrow 2\times8 - n = 10 \qquad \Rightarrow n = 6$$