Answers to 2021 JC2 Preliminary Examination Paper 2 (H2 Physics)

Suggested Solutions:

No.	Solution	Remarks
1(a)	$a = g\sin\theta$ $= (9.81)\sin 30°$ $= 4.905$ $= 4.9 \text{ m s}^{-2}$ (shown)	[1] correct working shown
1(b)	$\sin 30° = \dfrac{h}{d}$ $d = \dfrac{0.50}{\sin 30°} = 1.0 \text{ m}$ $v^2 = u^2 + 2as$ $v^2 = 2(4.905)(1.0)$ $v = 3.13 \text{ m s}^{-1}$	[1] for correct d [1] correct equation and substitution [1] correct answer
1(c)	$s = ut + \dfrac{1}{2}at^2$ $2.0 = (3.13\sin 30)t + \dfrac{1}{2}(9.81)t^2$ $t = 0.50 \text{ s}$ horizontal distance $= 3.13\cos 30°(0.50)$ $= 1.35 \text{ m}$	[1] for correct equation and substitution [1] for correct t [1] for correct distance
1(d)(i)	In the system of object and trolley, there are <u>no external forces</u> acting on them in the horizontal direction. The only horizontal forces are contact forces (action-reaction pair) acting on each other when object hits the trolley. Hence, total momentum in the horizontal direction <u>remains constant (or is conserved)</u>.	[1] for explanation [1] for conclusion
1(d)(ii)	Applying conservation of momentum, rightward as +ve, $(0.35)(3.13\cos 30°) + (1.2)(-4.0) = (1.2 + 0.35)v_f$ $v_f = -2.48 \text{ m s}^{-1}$ final speed $= 2.48 \text{ m s}^{-1}$ Direction is to the left	[1] for correct equation and substitution [1] for correct answer [1] for correct direction
2(a)	From the given expression $p = \dfrac{1}{3}\rho\langle c^2\rangle$, we have $p = \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$ ----- (1) (where m is the mass of 1 molecule) Using the ideal gas equation $pV = NkT$, we have $p = \dfrac{NkT}{V}$ ------ (2)	

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	Equating (1) and (2), we have $\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle = \frac{NkT}{V}$ $\frac{1}{3}m\langle c^2\rangle = kT$ $\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$ Since k is the Boltzmann constant, the average kinetic energy $\frac{1}{2}m\langle c^2\rangle$ of a molecule of mass m, is directly proportional to the thermodynamics temperature T. (shown)	[1] for equating (1) and (2) [1] for correct derivation of expression [1] for the correct conclusion
2(b)(i)	Total pressure, $p_{\text{total}} = h\rho g + p_{\text{atm}}$ $= (15)(1.03\times10^3)(9.81) + 1.01\times10^5$ $= 2.526\times10^5$ $\approx 2.53\times10^5$ Pa	[1] for correct method and numerical substitution [1] for correct answer
2(b)(ii)	Using $pV = nRT$, $(p_2V_2)_{\text{water}} = (p_1V_1)_{\text{tank}}$ $V_2 = \frac{p_1}{p_2}V_1$ $= \frac{2.32\times10^7}{2.526\times10^5}\times9.4\times10^3$ $= 8.633\times10^5$ $\approx 8.63\times10^5$ cm^3	[1] for correct expression and numerical substitution [1] for correct answer
2(c)	Pressure at depth of 35 m, $p_2 = h\rho g + p_{\text{atm}}$ $= (35)(1.03\times10^3)(9.81) + 1.01\times10^5$ $= 4.547\times10^5$ Pa Volume of air at depth of 35 m and temperature of 19 °C, $\left(\frac{p_2V_2}{T_2}\right)_{35\text{m}} = \left(\frac{p_1V_1}{T_1}\right)_{15\text{m}}$ $V_2 = \frac{p_1}{p_2}\times\frac{T_2}{T_1}\times V_1$ $= \frac{2.526\times10^5}{4.547\times10^5}\times\frac{19+273.15}{24+273.15}\times8.633\times10^5$ $= 4.715\times10^5$ cm^3	[1] for correct method and numerical substitution [1] for correct volume

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	Duration of time the air will last for the diver $t = \frac{4.715 \times 10^5}{8.633 \times 10^5} \times 45$ $= 24.58$ ≈ 24.6 min	[1] for correct answer
3(a)	If path difference of the sound waves along XY is <u>odd-integer of half-wavelength</u>, the waves meet <u>in antiphase</u> and results in destructive interference and hence minimum intensity.	[1] [1]
3(b)(i)	$\text{BR} = \sqrt{12.00^2 + 5.50^2}$ $= 13.20$ m	[1]
3(b)(ii)	R is first order maxima, path difference = 1λ $\lambda = \text{BR} - \text{AR}$ $= 13.20 - 12.50$ $= 0.70$ m	[1] [1]
3(b)(iii)	$v = f\lambda$ $= 470 \times 0.70$ $= 330$ m s^{-1}	[1] [1]
3(c)	Since $I \propto A^2$, for $I' = \frac{I}{3}$, the amplitude of the waves from B is $\frac{1}{\sqrt{3}}A$. At Q, the resultant amplitude of the wave interfering destructively is $A_{\text{resultant}} = A - \frac{1}{\sqrt{3}}A$ $A_{\text{resultant}} \approx 0.423A$ Hence, the resultant intensity is $I_{\text{resultant}} \propto (0.423A)^2 = 0.179I$	[1] amplitude of source B [1] resultant amplitude [1] answer
4(a)(i)	$P = IV$ $36 = I(12)$ $I = 3.0$ A	[1] for equation and substitution [1] for correct answer
4(a)(ii)	$Q = It$ $= (3.0)(20 \times 60)$ $= 3600$ C	[1] for correct equation and substitution [1] for correct answer

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4(a)(iii)	$E = Pt$ $= (36)(20 \times 60)$ $= 43200\ \text{J}$	[1] for equation, substitution and correct answer
4(a)(iv)	$R = \dfrac{V}{I}$ $= \dfrac{12}{3.0}$ $= 4.0\ \Omega$	[1] for equation, substitution and correct answer
4(b)(i)	$\dfrac{1}{R_{eff}} = \dfrac{1}{4.0} \times 3$ $R_{eff} = 1.33\ \Omega$ $I = \dfrac{12}{1.33} = 9.0\ \text{A}$	[1] for correct R_{eff} [1] for correct current
4(b)(ii)1.	There is no change to the potential difference across the lamps since they are all connected in parallel to an ideal battery. With the same potential difference and resistance, the power dissipated and brightness remain unchanged.	[1] correct explanation [1] correct conclusion
4(b)(ii)2.	Due to the internal resistance of the battery, the <u>potential difference across the lamps decreases</u>. Hence, the <u>brightness of the lamps decreases</u>.	[1] p.d. across lamps decreases [1] brightness decreases
5(a)	$B = \mu_0 n I = 4\pi \times 10^{-7}\left(\dfrac{400}{1.6}\right)3.8$ $= 3.8 \times 10^{-4}\pi$ $= 1.19381 \times 10^{-3}\ \text{T}$ $\Phi = NBA$ $= 80 \times \left(3.8 \times 10^{-4}\pi\right) \times \pi\left(\dfrac{0.040}{2}\right)^2$ $= 1.2 \times 10^{-4}\ \text{Wb}$	 [1] [1] for correct substitution
5(b)	mean e.m.f. $= \left\lvert -\dfrac{\Delta\Phi}{\Delta t} \right\rvert$ $= \dfrac{2 \times 1.2 \times 10^{-4}}{0.30}$ $= 8.0 \times 10^{-4}\ \text{V}$	[1] for correct substitution [1] for correct answer

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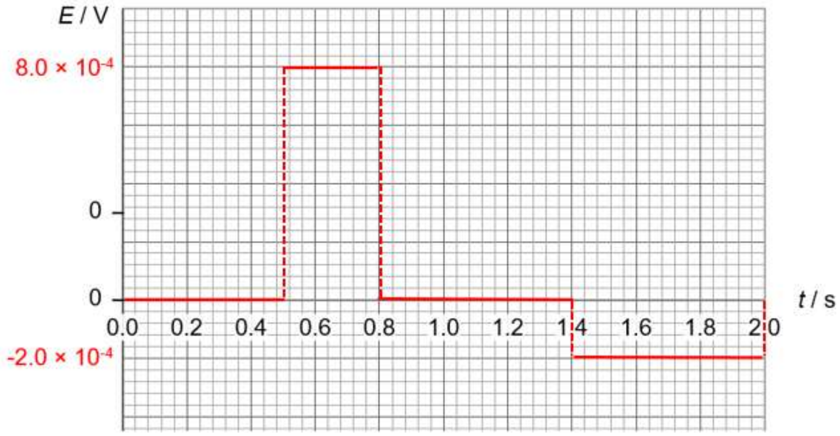
5(c)		[1] E = 0 V from t = 0 s to 0.5 s and 0.8 s to 1.4 s [1] $E = 8.0 \times 10^{-4}$ V from t = 0.5 s to 0.8 s [1] $E = -2.0 \times 10^{-4}$ V from t = 1.4 s to 2.0 s
5(d)	The iron core increases the magnetic flux density, resulting in a larger rate of change of flux linkage. Hence, the mean e.m.f. induced in coil Y is <u>larger</u>.	[1] for correct answer
6(a)(i)	Wave nature contradicts: Since energy is arriving in <u>continuous manner</u>, a certain time is needed for the electron to gather enough energy before it is ejected. Particulate nature supports: Energy of the incident photon will be <u>instantaneously transferred</u> to the absorbing electron in <u>a one-one interaction.</u>	[1] [1]
6(a)(ii)	Work function of a surface is the <u>minimum</u> energy required to liberate an electron from the surface.	[1]
6(a)(iii)	By Conservation of energy, Kinetic energy of electron = Energy of photon – Work done to emit an electron from the surface. But electrons can be ejected from <u>different layers of metal</u>, hence work done can vary, resulting in different KE. When the work done is minimum, KE will be maximum.	[1] using conservation of energy or Einstein's photoelectric equation [1] for any correct explanation.
6(b)	Energy of photon, 350 nm $= \frac{hc}{\lambda}$ $= \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{350 \times 10^{-9}}$ $= 5.6829 \times 10^{-19}$ J $= 3.55$ eV	[2] for any correct calculations

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	Energy of photon, 700 nm $=\dfrac{hc}{\lambda}$ $=\dfrac{6.63\times10^{-34}\times3.00\times10^{8}}{700\times10^{-9}}$ $=2.8414\times10^{-19}$ J $=1.78$ eV To emit an electron, energy of photon must be greater than work function. So electrons will be emitted from potassium metal using light of 350 nm.	[1] for correct conclusion
7(a)(i)	Energy density is the amount of <u>energy</u> that can be released <u>per unit mass</u> of fuel.	[1] for correct answer
7(a)(ii)	Rate of consumption of natural gas $=\dfrac{\left(\dfrac{\text{total electrical power output}}{\text{efficiency of power stations}}\right)}{\text{energy density of natural gas}}$ $=\dfrac{\left(\dfrac{12600\times10^{6}}{0.27}\right)}{56\times10^{6}}$ $=\dfrac{12600}{0.27\times56}$ $=833$ ≈ 830 kg s^{-1}	[1] for correct method and numerical substitution [1] for correct answer
7(b)(i)	Solar intensity incident on Earth $I=\dfrac{\text{radiant power of the Sun, }P}{\text{area of perpendicular surface, }A}$ $=\dfrac{3.90\times10^{26}}{4\pi\times\left(1.50\times10^{11}\right)^{2}}$ $=1379$ ≈ 1400 W m^{-2}	[1] for correct expression and numerical substitution [1] for correct answer
7(b)(ii)	The Sun's energy is radiated/emitted uniformly in all directions.	[1] for correct answer
7(b)(iii)	1. Cloudy times / cloud cover / sun is not directly overhead all the time 2. Absorption in atmosphere due to ozone, carbon dioxide and water vapour/humidity 3. Distance between Earth and Sun is not constant.	[1] for correct answer [1] for correct answer
7(c)(i)	Connecting many PV cells in series increases the e.m.f. of the electrical supply (allow higher voltage).	[1] for correct answer

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7(c)(ii)	Currents from each parallel section of PV cells add up at the junction to the external circuit to provide a useful current supply. or The output current of the PV cell array is increased. If one PV cell is faulty the others still work and continue to supply energy. Connecting many PV cells in parallel lowers total resistance of the PV cell array, in the same principle that resistors in parallel result in an equivalent resistance that is always lower than every individual resistor.	[1] for correct answer [1] for correct answer
7(d)	$\frac{\text{solar power output from 37 km}^2\text{ of PV panels}}{\text{total power output from power stations}}$ $=\frac{780\times 37\times 10^6\times 0.20}{12600\times 10^6}$ $=0.4581$ ≈ 0.46	[1] for correct numerical substitution [1] for correct answer
7(e)(i)1.	Power produced by the PV panel $=$ average solar intensity $\times$ area of PV panel $\times$ efficiency of PV panel $=780\times 1.50\times 0.20$ $=234$ W	[1] for correct numerical substitution [1] for correct answer
7(e)(i)2.	Total number of sunshine hours in 2020 $=170+185+195+175+180+180$ $+190+180+155+155+130+135$ $=2030$ hours Electrical energy produced by the PV panel in 2020 $=\frac{234}{1000}\times 2030$ $=475.02$ ≈ 475 kWh	[1] for correct numerical substitution [1] for correct answer
7(e)(ii)	Cost of saving in electricity per year $=$ electrical energy produced by PV power $\times$ electricity tariff $=475\times 0.23$ $=\$109.25$ Payback period or no. of years to recover the cost of installing the PV panel	[1] for cost savings

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	$= \dfrac{750}{109.25}$ $= 6.9$ years It takes about 7 years for the payback period for the investment of the PV panel. This is about a third of the useful lifespan of 25 years for the PV panel. Hence, the calculations are for the use of solar power, in addition to the benefit of reducing the intensity of greenhouse gas emissions.	[1] for payback period [1] for conclusion with valid explanation