2024 YIJC JC2 Prelim Exam H1 Physics Paper 2 Solution

1	**(a)**		1. Initial speed or velocity is zero 2. (non-zero magnitude of) acceleration is constant (uniform) and in a straight line	**B1** **B1**
	(b)	**(i)**	magnitude of acceleration at t = 8.0 s is less than that at t = 14.0 s (due to gradient) direction of acceleration at t = 8.0 s is opposite that at t = 14.0 s (due to sign of gradient)	**B1** **B1**
		(ii)	a = gradient or $a = (v-u)/t$ or $a = \Delta v/\Delta t$ $\langle a \rangle = (0-(-10)) / 16$ $a = 0.625$ m s^{-2}	 **C1** **A1**
		(iii)	Net displacement (final position) from X = area under v-t graph $s = ½ (-10)(4) + ½ (20)(8)$ $= -20 + 80$ $= 60$ m	 **C1** **A1**

2	**(a)**		The principle of conservation of momentum states that the total momentum of a system is conserved throughout a collision if there is no net external force acting on the system.	**B1**
	(b)	**(i)**	$(\rightarrow +ve)$, assume v is to the right. $0.100(2.0)+0.200(0)=0.100(v)+0.200(1.3)$ $v=-0.60$ m s^{-1} (2sf) Magnitude = 0.60 m s^{-1} Since v is negative, the direction is to the left.	**C1** **A1** **B1**
		(ii)	relative speed of approach $=2.0-(0)$ $=2.0$ m s^{-1} relative speed of separation $=1.3-(-0.6)$ $=1.9$ m s^{-1} Since the relative speed of approach is not equal to the relative speed of separation, the collision is inelastic. OR total initial KE $=\frac{1}{2}(0.100)(2.0)^2+\frac{1}{2}(0.200)(0)^2$ $=0.20$ J total final KE $=\frac{1}{2}(0.100)(0.6)^2+\frac{1}{2}(0.200)(1.3)^2$ $=0.187$ J (3sf) Since the total initial kinetic energy is not equal to the total final kinetic energy, the collision is inelastic.	**M1** **M1** **A1** **(M1)** **(M1)** **(A1)**

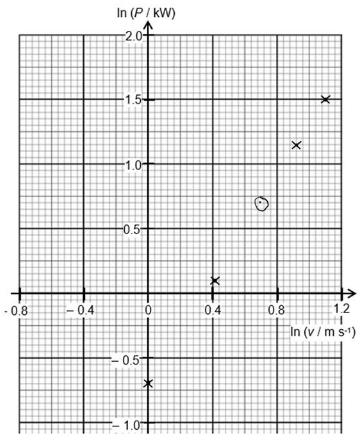
	(c)	By Newton's third law, the force that block A exerts on block B is equal in magnitude and opposite in direction to the force that block B exerts on block A. By Newton's second law, the (net) force (on block A) is the rate of change of momentum (of block A.) Hence, the rate of change of momentum of block A is equal in magnitude and opposite in direction to the rate of change of momentum of block B.	**M1** **M1** **A1**

3	**(a)**	**(i)**	The sum of forces in all directions is zero, and The sum of moments about any axis is zero.	**B1** **B1**
		(ii)	Taking moments about B, the weight of the table top exerts an anticlockwise moment. In order for the table to be in equilibrium, there must be an upward vertical (frictional) component of force acting at the hinge to produce a clockwise moment about B which is equal to the anticlockwise moment of the weight of the table top. OR If there is only a horizontal normal contact force at hinge A, there will be no moment provided by this force and the table will not be in equilibrium.	**B1** **B1** **(B1)**
	(b)		Taking moments about A, $(130)(0.30) = (T\sin 20°)(0.60)$ $T = 190\text{ N }(3\text{sf})$	**C1** **A1**
	(c)		$F_{vertical} + (190\sin 20°) = 130$ $F_{vertical} = 65.02\text{ N}$ $F_{horizontal} = 190\cos 20°$ $= 178.5\text{ N}$ $F = \sqrt{65.02^2 + 178.5^2}$ $= 190\text{ N }(3\text{sf})$ $\tan\theta = \dfrac{F_{vertical}}{F_{horizontal}} = \dfrac{65.02}{178.5}$ $\theta = 20.0°\ (3\text{sf})$	**C1** **C1** **A1** **A1**

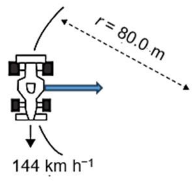
4	**(a)**		The net loss of the gravitational potential energy of the system is converted to the gain in kinetic energy of the system. or Gain in KE of blocks = Loss in GPE of 4.0 kg block – Gain in GPE of 2.0 kg block Not accepted: The GPE of the block/s is converted to KE of the blocks. (mention of net loss is not stated) due to the fact that the blocks are travelling in opposite directions.	**B1**
	(b)	**(i)**	To be at the same height, 4.0 kg block will descend by 10.0 cm while the 2.0 kg block will rise by **0.10 m**.	**B1**

		(ii)	Loss in GPE for 4.0 kg block = (4.0)(9.81)(0.100) = 3.92 J Gain in GPE for 2.0 kg block = (2.0)(9.81)(0.100) = 1.96 J Gain in KE = Net loss of GPE = 3.92 – 1.96 = 1.96 J ½ (2.0 + 4.0) v^2 = 1.96 → v = 0.81 m s^{-1}	**C1** **M1** **A1**

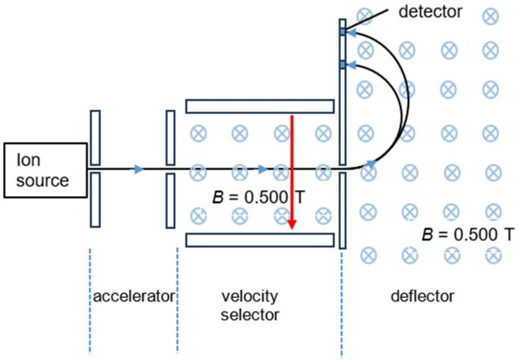
5	**(a)**	**(i)**	$I = \frac{ne}{t}$ $\frac{n}{t} = \frac{15}{1.6 \times 10^{-19}}$ $= 9.38 \times 10^{19}$ electrons per second (3sf)	**C1** **A1**
		(ii)	$R = \frac{\rho l}{A} = \frac{(1.72 \times 10^{-8})(3.0)}{\pi \left(\frac{1.63 \times 10^{-3}}{2}\right)^2}$ $= 0.0247\ \Omega$ (3sf)	**C1** **A1**
		(iii)	$V = IR = (15)(0.0247)$ $= 0.371\text{ V}$ (3sf)	**B1**
		(iv)	efficiency $= \frac{P_{\text{useful}}}{P_{\text{supplied}}} = \frac{V_{appliance} I}{V_{wire} I} = \frac{12.0 - 0.371}{12.0}$ $= 96.9\%$ (3sf)	**C1** **A1**
	(b)		Temperature increase, the <u>lattice ions vibrate more,</u> <u>causing more frequency of collision</u>. This <u>impedes the flow of electrons</u>. <u>Resistivity</u> of the wire <u>increases</u>.	**M1** **M1** **A1**

6	**(a)**		$v=\sqrt{\dfrac{2F}{c_D\rho A}}$ $=\sqrt{\dfrac{2(78000)}{(2.1)(1030)(14.7)}}$ v = 2.215 m s^{-1} $\dfrac{\Delta v}{v}=\dfrac{1}{2}\left(\dfrac{\Delta F}{F}+\dfrac{\Delta c_D}{c_D}+\dfrac{\Delta\rho}{\rho}+\dfrac{\Delta A}{A}\right)$ $=\dfrac{1}{2}\left(\dfrac{1}{100}+\dfrac{0.1}{2.1}+\dfrac{20}{1030}+\dfrac{0.3}{14.7}\right)$ $\Delta v = 0.1$ m s^{-1} v = (2.2 ± 0.1) m s^{-1} [minus 1m for wrong sf]	**C1** **A1** **C1** **A1**
	(b)	**(i)**	Since the boat is moving with constant velocity, it experiences no acceleration and <u>the net force on it is zero</u>. Thus, the motor provides <u>a forward force and the boat also experience a drag force</u>. The magnitude of these <u>two forces are equal but opposite in direction, resulting in net force of zero.</u>	**B1** **B1**
		(ii)	Using at least 2 sets of value, When m = 200 kg, P = 0.6 kW, P/m = 3 W kg^{-1} When m = 300 kg, P = 1.9 kW, P/m = 6.3 W kg^{-1} If power is proportional to the total mass, $P/m = k$ where k is a constant Since <u>P/m is not a constant</u>, P is not proportional to m	**M1** **A1**
		(iii)1.	Point plotted correctly (0.69,0.69)  Fig. 6.4	**C1**
		(iii)2.	Best fit straight line drawn <u>Linearising the equation</u> (ln$P$) = n(ln$v$) + ln$k$ Since the <u>plotted points follow a straight line</u> trend, ln$P$ and ln$v$ have a linear relationship and therefore the proposed relationship is supported.	**B1** **B1**

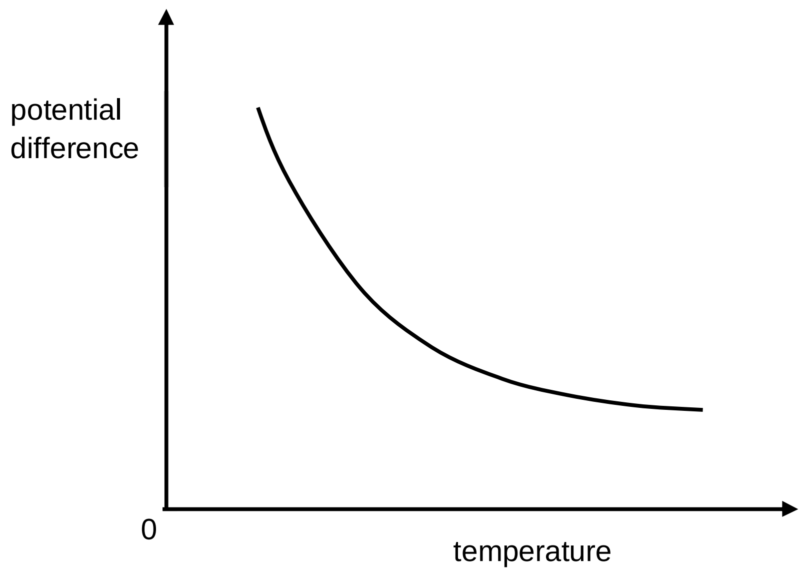
		(iii)3.	n = gradient of graph $= \dfrac{1.65-(-0.5)}{1.2-0.12} = 2.0$ Accepted range: 1.9 – 2.1	**B1**
		(iv)	$P = Fv$ $1900 = F(2.5)$ $F = 760$ N	 **C1** **A1**
	(e)		Total energy generated from 1.1 litres of fuel = 32 x 1.1 = 35.2 MJ Distance travelled for 1h = 2.5 x 3600 = 9000 m Total work done by the forward force = 760 x 9000 = 6.84 MJ Efficiency = 6.84/35.2 x 100% = 19 %	**C1** **C1** **A1**

7	**(a)**	**(i)**	$F = \dfrac{mv^2}{r} = \dfrac{(800)(144\times10^3/3600)^2}{80}$ $= 1.6\times10^4$ N	**C1** **A1**
		(ii)	To the right.  **Fig. 7.2**	**B1**
		(iii)	The direction of velocity is changing, so a net force is required to change the velocity. According to Newton's first law, in the absence of a net force, a moving object will continue to move with a constant speed in the same direction. Since the car is required to turn round the corner, a force must be acting perpendicular to the velocity to enable that manoeuvrer to change direction without changing the speed.	**B1**
		(iv)	The centripetal force is provided by the frictional force between the wheel and the ground.	**B1**
	(b)	**(i)**	For the satellite to always remain at the same place directly above the same spot on the Earth spinning below, the satellite must orbit in sync with the Earth's rotation on the same plane of rotation. Thus, the gravitational force on the satellite which is directed to the centre of the Earth must also be on the same plane as the equator. *At places other than at or near the equator, the satellite will be positioned sometimes at the northern hemisphere and sometimes in the southern hemisphere as the orbital plane and equatorial plane do not match.*	 **B1**

		(ii)	The centripetal force is provided by the gravitation force. $F=\frac{GMm}{r^2}=mr\omega^2 \quad \Rightarrow \quad GM=r^3\omega^2$ $\left(6.67\times10^{-11}\right)\left(5.98\times10^{24}\right)=r^3\left(\frac{2\pi}{24\times3600}\right)^2$ r = 4.23×10⁷ m → $r = 4.23\times10^{7}$ m altitude = r-R = 3.59×10^{7} m	**B1** **M1** **A1**
	(c)	**(i)**	The <u>centripetal force is provided by the magnetic force</u> which acts perpendicular to the velocity of the positive ion. $\frac{mv^2}{r}=Bqv$ $r=\frac{mv}{Bq}$	**B1** **M1** **A0**
		(ii)	Since v, q and B are all constants, $r \propto m$ $\frac{r_{14}}{r_{12}}=\frac{14u}{12u}=1.17$	**A1**
		(iii)	The separation = d_{14}-d_{12} = $2.5\text{x}10^{-2}$ m Since $d = 2r$ r_{14}-r_{12} = $1.25\text{x}10^{-2}$ m solving for r_{14} and r_{12}, r_{14} = 0.0875 m r_{12} = 0.0750 m $r_{14}=\frac{m_{14}v}{Bq}$ $0.0875=\frac{(14\times1.67\times10^{-27})(v)}{(0.500)(1.60\times10^{-19})}$ $v = 2.99 \text{ x } 10^{5}$ m s^{-1}	**B1** **C1** **M1** **A1**
		(iv)	At the velocity selector, $F_E = F_B$ $Eq = Bqv$ $E/B = v$ $E = B\,v$ = $(0.500)(2.99\text{x}10^{5})$ = $1.50 \text{ x } 10^{5}$ V m^{-1}	**A1**

		(v)	Vertically downwards  Fig. 7.4	B1
		(vi)	$Vq = 1/2\ m\ v^2$ $V\ (1.60 \text{x} 10^{-19}) = 1/2\ (14 \text{x} 1.67 \text{x} 10^{-27})(2.99 \text{x} 10^5)^2$ $V = 6530$ V ECF allowed	 M1 A1

8	(a)	(i)	Fission is the <u>splitting of a</u> heavy <u>nucleus into of two or more lighter nuclei</u>, with a release of energy.	B1
		(ii)	X – 92 Y - 36	B1 B1
		(iii)1.	Nuclear binding energy per nucleon is the <u>average energy absorbed by each nucleon to separate into</u> its constituent <u>free/unbound protons and neutrons</u>.	B1
		(iii)2.	$\text{BE of U} = 235\left(7.6\times10^{6}\right) = 1.786\times10^{9}\ \text{eV}$ $\text{BE of Ba} = 141\left(8.3\times10^{6}\right) = 1.1703\times10^{9}\ \text{eV}$ $\text{BE of Kr} = 92\left(8.5\times10^{6}\right) = 0.782\times10^{9}\ \text{eV}$ [1 m for any of the calculation for BE of individual species] $\Delta E = BE_{\text{products}} - BE_{\text{reactants}}$ $= 1.1703\times10^{9} + 0.782\times10^{9} - 1.786\times10^{9}$ $= 0.1663\times10^{9}\ \text{eV}$ $= 0.1663\times10^{9}\times1.6\times10^{-19}$ J [1m for correct conversion] $= 2.66\times10^{-11}$ J	M1 M1 M1 A0
		(iii)3.	$\text{no. of reactions per unit time} = \dfrac{\text{total energy produced per unit time}}{\text{energy produced per reaction}}$ $= \dfrac{6.4\times10^{9}}{2.66\times10^{-11}}$ $= 2.41\times10^{20}\text{s}^{-1}$	C1 A1
		(iii)4.	1 reaction requires 1 uranium-235 nucleus $\text{no. of U-235} = 60\times60\times2.41\times10^{20}\ \left(=8.676\times10^{20}\right)$ $\text{total mass of U-235} = 8.76\times10^{20}\,(235)\left(1.66\times10^{-27}\right)$ $= 3.42\times10^{-4}$ kg	C1 C1 A1

	(b)	**(i)**	Resistance of thermistor = 0.6 ± 0.1 kΩ $R_{bottom} = \left(\frac{1}{R_t} + \frac{1}{3000}\right)^{-1} = \left(\frac{1}{600} + \frac{1}{3000}\right)^{-1}$ $(= 500\ \Omega)$ By potential divider rule, $V_t = \frac{R_{bottom}}{R_{bottom} + R_{top}} V = \frac{500}{500 + 1500}(5)$ $= 1.25\ \text{V}$	**B1** **C1** **C1** **A1**
		(ii)	<u>Resistance changes more for the same temperature change at lower temperatures than at higher temperatures</u>. The circuit provides a <u>more precise reading at lower temperatures</u>.	**M1** **A1**
		(iii)	At lower temp, the resistance of the thermistor is high, so the potential difference is higher. At higher temp, the resistance of the thermistor is low, so the potential difference is lower. As the decrease in resistance per unit rise in temperature is higher for lower temp, the <u>decrease in potential difference</u> per unit temperature is faster for lower temp. And the decrease in potential difference per unit temperature is lower for higher temperature.  Decreasing trend Decreasing gradient	 **M1** **A1**