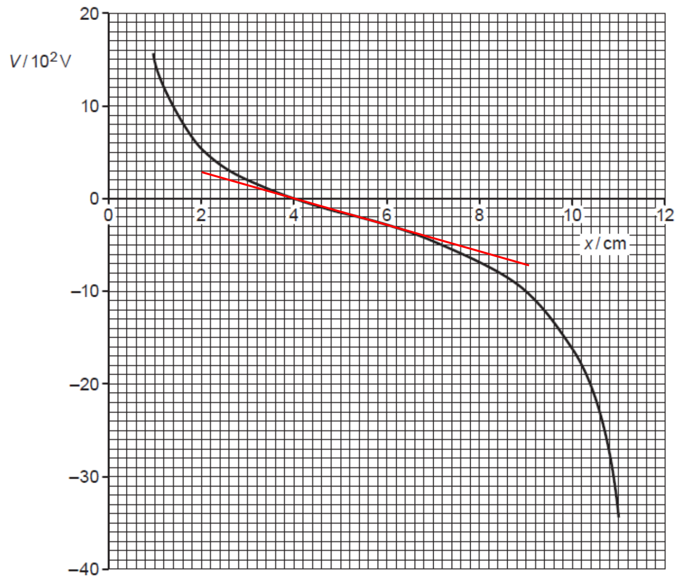
Anderson Serangoon Junior College 2022 JC2 H2 Physics Prelim Mark Scheme

Paper 2

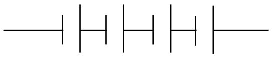
1a	According to Newton's 3rd Law, $F_{12} = -F_{21}$ … (1) Taking the time of collision to be t, Using Newton's 2nd Law, eqn (1) can be rewritten as, $\frac{\Delta p_2}{t} = -(\frac{\Delta p_1}{t})$ OR $\frac{m_2v_2 - m_2u_2}{t} = -(\frac{m_1v_1 - m_1u_1}{t})$ $m_2v_2 - m_2u_2 = -m_1v_1 + m_1u_1$ OR $m_1v_1 + m_2v_2 = m_1u_1 + m_2u_2$	B1 M1 A1
1bi	By conservation of momentum, the gain in momentum of body Q must be equal to the loss in momentum of body P. Since total momentum is conserved, when Q gains momentum (positive gradient), P loses momentum (negative gradient). Hence, the gradients of the graphs must have opposite sign. OR Gradient of the graph is the net force acting on the object. Since the 2 forces are action-reaction pair, hence they must be in the opposite direction.	B1
1bii	When there is no <u>net</u> external forces acting on the system.	B1
1biii	Total initial momentum = 20 + 16 = 36 kg m s^{-1} Total final momentum = 24 + 12 = 36 kg m s^{-1} Total momentum is conserved.	A1
1biv	Force acting on body P = rate of change of momentum of body P $= \frac{12 - 16}{(300 - 150) \times 10^{-3}}$ = −26.7 N = −27 N Magnitude of force = 27 N	 C1 A1
1bv	Impulse = $F\,t$ = 26.7 × 150 × 10^{-3} = 4.0 N s OR Impulse = change in momentum = 24 – 20 = 4.0 N s	A1
1bvi	Relative speed of approach = $u_p - u_Q = \frac{16}{2.0} - \frac{20}{4.0} = 3.0\ \text{m s}^{-1}$ Relative speed of separation = $v_Q - v_P = \frac{24}{4.0} - \frac{12}{2.0} = 0\ \text{m s}^{-1}$ RSS is not equal to RSA, and RSS is zero, so the collision is perfectly inelastic.	B1 B1 A1
2ai	Constant amplitude	B1
2aii	Period = 0.75 s $\omega = 2\pi / T$ ω = 8.4 rad s^{-1}	C1 A1

2aiii	Either use of gradient or $v = \omega y_0$ v = 0.168 m s^{-1} (allow ±0.02 for construction)	C1 A1
2bi	f = 1/T = 1/0.75 = 1.3 Hz	B1
2bii	at ½ f_0 'pulse' / energy is provided to mass on alternate/some oscillations so 'pulses' / energy build up the amplitude (don't accept maximum amplitude)	M1 A1
3ai	Transverse	A1
3aii	$t = \dfrac{\text{distance}}{\text{speed}}$ $= \dfrac{4.4 \times 10^{12}}{3.0 \times 10^{8}}$ $= 1.5 \times 10^{4}$ s	A1
3aiii	power received by dish aerial = intensity received × area of dish $P = \dfrac{\text{output (source) power}}{4\pi r^2} \times 280$ $= \dfrac{25}{4\pi(4.4 \times 10^{12})^2} \times 280$ $= 2.9 \times 10^{-23}$ W	C1 C1 A1
3aiv	The actual power is greater because the transmitting aerial is directing power towards the Earth instead of radiating uniformly in all directions as assumed in **(a)(iii)**.	A1
3bi	$v = f\lambda$ $\lambda = 0.040 \times 1.5$ λ = 0.060 m	C1 A1
3bii	path difference = (44 – 29) / 6.0 = 2.5 λ **either** waves have path difference = (n + ½) λ **or** waves have phase difference = π so destructive interference	M1 M1 A1
3ci	Incident sound wave from loudspeaker travels to the water surface and is reflected. The incident and reflected waves superpose / interfere / overlap to form a stationary wave.	B1 B1
3cii	distance = λ / 2 = 0.090 m	A1
3ciii	letter X shown at level B and at level A	A1
4a	Electric field lines are radial/normal to surface (of sphere) Electric field lines appear to originate from centre (of sphere) / intersect at the centre of the sphere when extrapolated	B1 B1

4bi1	Net electric potential = 0 at x = 4.0 cm $(2.0 \times 10^{-9}) / 4\pi\varepsilon_0(4.0 \times 10^{-2}) + Q / 4\pi\varepsilon_0(8.0 \times 10^{-2}) = 0$ $Q = -4.0 \times 10^{-9}$ C	C1 A1	
4bi2	change = $(2 - (-10)) \times 10^2 = 1200$ V	A1	
4bii	Loss in KE = Gain in EPE $\frac{1}{2} mu^2 - 0 = q\Delta V$ $\frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times u^2 = 2 \times 1.60 \times 10^{-19} \times 1200$ $v = 3.4 \times 10^5$ m s^{-1} Allow ecf from bi2 Deduct 1 mark if candidates use mass of proton 1.67×10^{-27} kg	 C1 A1	
4biii	Electric field strength is the least when the gradient of the V-x graph is the least, hence acceptable range is from 4.5 to 6.0 cm	A1	
4biv	 Gradient of tangent = $\frac{(3.0-(-7.0)) \times 10^2}{(2.0-9.0) \times 10^{-2}} = -1.4 \times 10^4$ Therefore, magnitude of E = 1.4×10^4 V m^{-1} acceptable range: $(1.1 \text{ to } 1.7) \times 10^4$ Accept calculation method (assuming x = 5.0 cm) $E = E_A + E_B$ $= (2.0 \times 10^{-9}) / 4\pi\varepsilon_0(5.0 \times 10^{-2})^2 + 4.0 \times 10^{-9} / 4\pi\varepsilon_0(7.0 \times 10^{-2})^2$ $= 1.45 \times 10^4$ V m^{-1}	**A**	C1 A1 C1 A1
5ai	More likely (higher probability) for electrons at the next higher energy level to de-excite to fill up the vacancy in the K shell.	**A**	A1
5aii	Due to the higher atomic number, the attraction between the nucleus and the inner shell electrons is stronger **OR** the inner shell electrons of tungsten is more stable due to the higher atomic number At low accelerating potentials, the energy of electrons is not sufficient **OR** At high enough accelerating potentials, the energy of electrons is sufficient	**D**	B1 B1

	to <u>knock electrons out of the inner shells</u> of the tungsten atom.		
5b	$E = \frac{hc}{e\lambda}$ $= \frac{(6.63\times10^{-34})(3.0\times10^{8})}{(1.6\times10^{-19})(6.6\times10^{-11})}$ $= 1.9 \times 10^{4}$ eV	**A**	C1 A1
6ai	Change in mass Δm = mass of product – mass of reactants = [(17.004507 + 1.008142) - (14.007525 + 4.003860)]u = 1.264 x $10^{-3}u$ = 2.09824 x 10^{-30} kg Change in rest-mass energy = Δmc^2 = 2.09824 x 10^{-30} (3.00 x $10^{8})^{2}$ = 1.888 x 10^{-13} J = 1.9 x 10^{-13} J	**A** **A**	M1 M1 A0
6aii	The increase in mass as shown in calculation in (**a)(i)** implies that energy has been converted to mass. Hence, the reaction is only possible if the alpha particle has kinetic energy that is at least equal to the value calculated in **(a)(i)**, which can be converted into mass.	**A**	M1 A1
6aiii1	Based on conservation of momentum, as the <u>total initial momentum is not zero</u>, since alpha particle is moving and nitrogen – 14 is stationary, <u>final momentum cannot be zero</u> and hence the <u>product particles must have kinetic energy after the reaction</u>.	**D**	A1
6aiii2	So, the alpha particle <u>needs to have more kinetic energy than 1.9 x 10^{-30} J,</u> so that while some of the <u>kinetic energy is converted to mass</u>, there is sufficient <u>kinetic energy left to move the product particles</u>.	**D**	A1
6bi	No. of Xenon particles initially N_0 = (6.02 x 10^{23}) (5.7 x 10^{-12} /140 x 10^{-3}) =2.451 x 10^{13} $A_0 = \lambda N_0$ =((ln 2)/16)(2.451 x 10^{13}) = 1.0618 x 10^{12} =1.06 x 10^{12} Bq $A = A_0 e^{-\lambda t}$ $= 1.06\times10^{12} e^{-\frac{\ln 2}{16}(60)}$ $= 7.8785\times10^{10}$ Bq $=7.88\times10^{10}$ Bq	**A**	M1 M1 A1
6bii	As the <u>products are also radioactive</u>, after Xenon decayed, the <u>products also produced activity</u> and thus is the actual activity is higher than the activity due to Xenon alone.	**A**	A1

7ai	Any one of the followings: Does not leak / longer cycle life / faster charging / higher degree of freedom in shape / higher current density / less flammable.	**A**	A1
7aii1	Any one of the followings: Electric vehicle / personal mobility device / car battery / electric scooter / solid-state solar cell or panel.	**A**	A1
7aii2	Any one of the followings: Pacemakers / radio frequency identification (RFID) / wearable devices / handphone or smart phone / smart card / implantable medical device e.g. implantable defibrillator / wireless sensor / remote control / calculator.	**A**	A1
7aiii	Any one of the followings: 1. Bulk solid-state battery can store more energy than thin film solid-state battery. 2. Thin film solid-state batteries have longer cycle life than bulk solid-state battery. 3. Thin film solid-state battery can be easily shaped based on application while bulk-solid state has more standard construction shape.	**A**	B1
7bi	Current per unit area	**E**	B1
7bii	Energy per unit mass	**E**	B1
7ci	Charge storage capacity = charge capacity × area $=3.6 \times 50$ $= 180$ C	**E**	 A1
7cii	Recommended max. discharge current = recommended max. discharge current density × area $= 0.15 \times 50$ $= 7.5$ mA	**A**	 A1
7ciii	$Q = It$ $180 = (7.5 \times 10^{-3})t$ $t = 24\,000$ s	**A**	 C1 A1
7civ	$E = QV$ $= (180)(2.5)$ $= 450$ J Alternatively. $E = VIt = (2.5)(7.5 \times 10^{-3})(24000)$ $= 450$ J	**A**	 C1 A1
7di	<u>Total charge supplied</u> to the cell	**A**	B1
7dii	Estimate area under graph, then use the area divided by total time 9 mA. Acceptable range: 8 – 10 mA, answer must be 1 – 2 sf.	 **A**	 A1
7e	Efficiency = (discharged energy / energy used to charge cell) x 100% $= (450 / 550) \times 100\%$ $= 82\%$	**A**	 C1 A1
7fi	Above 140 ^{o}C, cells may overheat and catch fire / result in burn hazard OR	**A**	B1

	Plastic film / lithium metal anode may melt.		
7fii	Water or water vapour within lithium cells may result in electric shocks / short circuit. OR Lithium reacts violently with water (producing a strong base that is harmful to human body / producing highly flammable hydrogen gas)	**A**	B1
7g	Since each cell has average e.m.f. of 2.5 V. Number of cells = 10 / 2.5 = 4 <u>4 cells arranged in series</u>  Since recommended max current density of 0.15 mA per cm^2 Electrode area = 300 / 0.15 = <u>2000 cm^2</u>	**D**	B1 B1