Assessment Schedule – 2005

Physics: Demonstrate understanding of atoms, photons and nuclei (90522)

Evidence Statement

Judgements in italics indicate replacement evidence and so are not counted for sufficiency.

Q	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(a)	$E = hf$ $E = 6.63 \times 10^{-34} \times 6.16 \times 10^{14}$ $E = 4.08408 \times 10^{-19}$ J	Correct answer. A2		
1(b)	No electrons are emitted / nothing would happen / Photons energy is changed to heat.	Correct statement. A1		
1(c)	$E_K = 0.35 \times 1.6 \times 10^{-19}$ $= 5.6 \times 10^{-20}$ J $\phi = 4.08 \times 10^{-19} - 5.6 \times 10^{-20}$ $= 3.52 \times 10^{-19}$ J $f = \frac{\phi}{h}$ $= \frac{3.52 \times 10^{-19}}{6.63 \times 10^{-34}}$ $= 5.309 \times 10^{14}$ $= \mathbf{5.3 \times 10^{14}\ Hz}$	*Correct calculation of E_K in joules.* A2	*Correct f consistent with incorrect E_K / correct work function.* M2	Correct answer. E2
1(d)	Graph line is parallel to the one shown but displaced to the right.	Correct graph line. A1		
1(e)	In brighter light there will be more photons hitting the metal per second. As each photon releases an electron, more electrons will be released each second, hence greater current. OR – the light frequency is now below the threshold frequency and so no electrons are released regardless of brightness.	*ONE correct and relevant statement:* Brighter light means more photons / more photons so greater current/ brighter light means more electrons **AND** more current. A1	Link made between brighter light having more **photons**, and more photons emitting more electrons. **OR** below f_o no electrons as not enough energy per photon to release electrons regardless of brightness. M1	*In addition candidate refers to rate of photons hitting / rate of electrons being released*
1(f)	The cut-off voltage is a measure of the maximum kinetic energy of the emitted electrons in electron volts. Although there are more photons and hence more electrons released, each photon will release an electron with the same maximum KE. The cut-off voltage will therefore remain the same.	*ONE correct and relevant statement:* cut-off voltage depends on max KE of electrons / max KE of electrons stays the same even though brightness changes / no change in cut-off voltage. A1	Link made between cut-off voltage depending on KE of electrons, and brightness not affecting KE of electrons. M1	Explanation is clear, concise and accurate – clear understanding of voltage as energy per charge or as a measure of electron max KE. E1

Q	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(g)	According to the wave model, the brighter the light the greater the energy it carries. This suggests that a brighter light should release electrons with greater KE. In practice the energy of released electrons is independent of the brightness of the light. According to the wave model, frequency is independent of the energy of the wave and so all frequencies should release electrons with the same amount of energy. In practice, the energy of released electrons depends on the frequency of the light. As energy in a light wave is delivered in a smooth continuous way, it should take some time for electrons to be emitted. In practice electrons are emitted instantaneously.	*ONE behaviour that is not predicted by the wave model is given.* A1	TWO behaviours that are not predicted by the wave model are given. For ONE, the predicted behaviour is given. M1	
2(a)	*X* will be in ultraviolet region.	Correct statement. A1		
2(b)	$\frac{1}{\lambda} = R\left(\frac{1}{S^2} - \frac{1}{L^2}\right)$ $= 1.10 \times 10^7 \times \left(\frac{1}{1^2} - \frac{1}{2^2}\right)$ $\Rightarrow \lambda = 1.21 \times 10^{-7}$ m		Correct answer. (Accept energy difference calculation.) M2	
2(c)	Lines in the visible part of the spectrum are from transitions to the $n = 2$ level. Red light has a low frequency and so the energy difference between the levels of the transition must be low. A transition from the level immediately above will involve the least energy difference and so the red line is produced from an electron transition from the $n = 3$ to $n = 2$ level.	*ONE correct and relevant statement: from n = 3 to n = 2 / energy difference between the levels must be low / red line is produced from the least energy transition.* A1	Visible is jump to n=2 and Link made between the low frequency of red light and the need for a low energy difference between the levels. M1	Explanation is clear, concise and accurate – clear understanding of link between smallest energy gap and smallest frequency (longest wavelength) photon. E1
2(d)	Energy in ground state $= \frac{-hcR}{n^2}$ $= -2.1879 \times 10^{-18} = -2.19 \times 10^{-18}$ J $(= -13.7$ eV) (negative not required.)	Correct answer. A2 Rounded to 3 sig fig plus three answers given with correct unit. A1		
2(e)	$E_3 = \frac{-hcR}{3^2}$, $E_5 = \frac{-hcR}{5^2}$ $E_3 - E_5 = -hcR\left(\frac{1}{3^2} - \frac{1}{5^2}\right)$ $= -1.56 \times 10^{-19}$ J Photon energy = 1.56×10^{-19} J		Correct answer, ignore sign. M2	

Q	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
3(a)	396.92935 + 1.67493 = 398.60428 154.27837 + 235.64216 + 5 × 1.67493 = 398.29468 difference = 0.3091×10^{-27} kg $E = mc^2 = 0.3091 \times 10^{-27} \times 9.00 \times 10^{16}$ $= 2.7819 \times 10^{-11}$ J $= 1.74 \times 10^{8}$ eV		*Correct mass difference or correct answer consistent with incorrect method of calculating mass difference.* M2	Correct answer. E2
3(b)	Total binding energy $= 1.4567 \times 10^{-29} \times 142$ $= 2.0685 \times 10^{-27}$ J	Correct answer. A2		
3(c)	The binding energy per nucleon for plutonium is less than that for strontium and barium. This means that the nucleons in the plutonium nucleus are at higher energy levels than those in the nuclei of strontium and barium. This extra energy must be lost when the strontium and barium nuclei are formed. **OR** The binding energy per nucleon is the cause of the mass deficit per nucleon. As the number of nucleons is conserved and the products have a higher binding energy per nucleon, they also have greater mass deficit. The overall loss in mass is converted to kinetic energy and radiation.	*ONE correct and relevant statement:* nucleons in the plutonium nucleus have more energy than those in strontium and barium nuclei / higher binding energy per nucleon – less mass per nucleon. A1	Link made between the greater energy of the plutonium nucleons and the need to lose energy when barium and strontium are formed / link between binding energy per nucleon, mass deficit and energy change when Ba and Sr are formed. M1	Explanation is clear, concise and accurate. Ba and Sr higher binding energy nucleon – lower energy level nucleons – energy difference released on formation / Ba and Sr higher binding energy per nucleon – greater mass deficit hence mass lost on formation – mass loss converted to energy. E1

Question Analysis:

Italics indicates that this question has already appeared in the table so should not count towards total opportunities.

	Questions	A	M	E
C1	9	1(b) 1(d) 2(a) 2(d)	1(e) 1(f) 1(g) 2(c) 3(c)	*1(f) 2(c) 3(c)*
C2	7	1(a) 2(d) 3(b)	2(b) 2(e)	1(c) 3(a)

Judgement Statement

Criterion 1

Achievement	Achievement with Merit	Achievement with Excellence
THREE opportunities answered at Achievement level or higher. 3 × A1	FIVE opportunities answered with TWO at Merit level or higher. 3 × M1 *plus* 2 × A1	FIVE opportunities answered with TWO at Excellence level and ONE at Merit level or higher. 2 × E1 *plus* 1 × M1 *plus* 2 × A1

Criterion 2

Achievement	Achievement with Merit	Achievement with Excellence
TWO opportunities answered at Achievement level or higher. 2 × A2	THREE opportunities answered with ONE at Merit level or higher. 1 × M2 *plus* 2 × A2	FOUR opportunities answered with ONE at Excellence level and ONE at Merit level or higher. 1 × E2 *plus* 1 × M2 *plus* 2 × A2