A Level AQA Physics

2 Particles and radiation – answers

Question	Answers	Extra information	Marks	AO	Spec reference
01.1	55 protons 55 electrons 82 neutrons		1 1 1	2	3.2.1.1
01.2	${}^{137}_{55}Cs \rightarrow {}^{137}_{56}Ba + {}^{0}_{-1}e + \bar{\nu}$	Antineutrino 56 Correct β^- symbol (${}^{0}_{-1}e$)	1 1 1	2	3.2.1.2
01.3	Weak interaction		1	1	3.2.1.3
01.4	The stable nucleus contains four more neutrons AND The same number of protons	owtte	1	3	3.2.1.1
01.5	133 The mass does not change/the electron has no mass		1 1	2	3.2.1.2
01.6	In β^- decay, a neutron changes to a proton In electron capture, a proton changes to a neutron		1 1	1	3.2.1.2
02.1	The carbon atoms have different numbers of neutrons AND same number of protons		1	1	3.2.1.2
02.2	Mass of nucleus = $6 \times 1.673\times10^{-27}$ kg + $6 \times 1.675\times10^{-27}$ kg = 2.009×10^{-27} kg Charge = +6e = $6 \times 1.60\times10^{-19}$ C = 9.60×10^{-19} C $\frac{\text{charge}}{\text{mass}} = \frac{9.60\times10^{-19}\text{ C}}{2.009\times10^{-27}\text{ kg}}$ = 4.779×10^{8} C kg^{-1}		1 1 1	2	3.2.1.1

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02.3	Scale on x-axis showing 1 fm per square Graph showing repulsive force below about 0.5 fm Attractive force (below axis) peaking at about 1 fm Tending to zero beyond 3 fm As nucleons are pushed together, the strong nuclear force maintains their distance.		1 1 1 1	1	3.2.1.2
02.4	6 positrons AND 6 antiprotons AND 6 antineutrons		1	2	3.2.1.3
02.5	No difference The difference between matter and antimatter is charge The strong nuclear force is charge independent		1 1 1	3	3.2.1.3
03.1	Similarity: the atomic number changes Difference: the mass number only changes in alpha decay		1 1	1	3.2.1.2
03.2	Atomic number is reduced by 6 Each alpha particle reduces the atomic number by 2, so five reduces it by 10 Difference is −4, so 4 β^- particles are emitted		1 1 1	2	3.2.1.2
03.3	The energy of alpha particles emitted from a radioactive element was approximately the same The energy of beta particles could vary from very small up to a maximum The difference in energy between the maximum and that of the beta particle was hypothesised to be carried by a particle called a neutrino		1 1 1	1	3.2.1.2
03.4	Neutrinos have no charge And a very small/negligible mass		1 1	1	
04.1	They have different charges But the same mass		1 1	1	3.2.1.3

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04.2	Total energy = $0.51 \times 2 \times 1.6\times10^{-13}$ J = 1.64×10^{-13} J Energy of one photon = 0.82×10^{-13} J $E = hf$ $f = \frac{E}{h} = \frac{0.82\times10^{-13}}{6.64\times10^{-34}\ \text{J s}}$ = 1.23×10^{20} Hz	$\frac{\text{Use of twice rest mass of electron energy}}{2}$	1 1 1	2	3.2.1.3
04.3	The frequency will be higher The rest masses of the proton and antiproton are higher, so the energy is higher		1 1	2	3.2.1.3
04.4	Total energy = 2×938.257 MeV $\times 1.6\times10^{-13}$ J MeV^{-1} = 3.002×10^{-9} J $E = \frac{hc}{\lambda}, \lambda = \frac{hc}{E}$ $= \frac{6.63\times10^{-34}\ \text{J s} \times 3.00\times10^{8}\ \text{m s}^{-1}}{3.002\times10^{-9}\ \text{J}}$ = 6.62×10^{-17} m		1 1 1	2	3.2.1.3
05.1	The electromagnetic interaction is a result of the exchange of virtual photons The ball represents the photon exchanged by two charged particles that are repelling each other The model does not work so well for particles that attract each other		1 1 1	3	3.2.1.4
05.2	Strong (nuclear) interaction Weak (nuclear) interaction		1 1	1	3.2.1.4
05.3	W^-		1	1	3.2.1.4
05.4	$p + e \rightarrow n + v$ The W boson is a virtual particle that mediates the force/decay		1 1 1	2	3.2.1.4

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Question	Answers	Extra information	Marks	AO	Spec reference
05.5	The range of the W boson is very short The range of the photon is infinite		1 1	2	3.2.1.4
06.1	24 – 11 = 13 neutrons		1	2	3.2.1.1
06.2	Mass of nucleus = $11 \times 1.673\times10^{-27}$ kg + $13 \times 1.675\times10^{-27}$ kg = 40.18×10^{-27} kg Charge = +11e = $11 \times 1.60\times10^{-19}$ C = 17.6×10^{-19} C $\frac{\text{charge}}{\text{mass}} = \frac{17.6\times10^{-19}\text{ C}}{40.18\times10^{-27}\text{ kg}}$ = $4.3(8)\times10^{7}$ C kg^{-1}	Calculation of mass Calculation of charge Specific charge	1 1 1	2	3.2.1.1
06.3	An alpha particle contains 2 protons and 2 neutrons, so must contain 11 + 2 = 13 protons, and 13 + 2 = 15 neutrons $^{28}_{13}\text{X}$	Both n and p numbers correct Both A and Z correct	1 1	3	3.2.1.2
06.4	The electrostatic force is repulsive between two protons, but does not affect neutrons The strong nuclear force between two protons and between two neutrons is the same The electrostatic force decreases with distance, but is infinite in range The strong nuclear force is constant, but has a very short (fm) range		1 1 1 1	3	3.2.1.4
06.5	$^{24}_{11}\text{Mg} \rightarrow {}^{24}_{12}\text{Mg} + {}^{0}_{-1}\text{e} + \bar{\nu}$	Correct A and Z antineutrino	1 1	2	3.2.1.2
06.6	2.76 MeV = $2.76 \times 1.6\times10^{-13}$ J = 4.42×10^{-13} J $\lambda = \frac{hc}{E} = \frac{6.63\times10^{-34} \times 3.00\times10^{8}}{4.42\times10^{-13}}$ = 4.5×10^{-13} m		1 1	2	3.2.1.3

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Question	Answers	Extra information	Marks	AO	Spec reference
06.7	Both emissions are part of the electromagnetic spectrum Both emissions are a result of the atom returning from an excited state to lower energy/ground state The energy of the excited state of the nucleus is much higher, so the frequency of the radiation emitted is in the gamma ray region of the electromagnetic spectrum Whereas emission of visible light is due to the transition of electrons from high to low energy levels		1 1 1 1	3	3.2.1.3 3.2.2.3 3.2.2.4
07.1	88 protons 138 neutrons		1	2	3.2.1.1
07.2	${}^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{86}\mathrm{Rn} + {}^{4}_{2}\alpha$	Symbol for alpha / Allow He A and Z for Rn	1 1	2	3.2.1.2
07.3	$E = hf = \frac{hc}{\lambda}$ $= \frac{6.63\times10^{-34} \times 3\times10^{8}}{532\times10^{-9}}$ $= 3.74\times10^{-19}$ J $= \frac{3.74\times10^{-19}\text{ J}}{1.6\times10^{-9}\text{ J}} = 2.23$ eV		1 1	2	3.2.1.3
07.4	Suggested mechanism, such as: The alpha particle collides with an atom in the paint An electron is excited to a higher energy level, and emits a photon when it returns to its ground state	Collision producing excitation Emission of photon	1 1	3	3.2.2.2 3.2.2.3
07.5	The mechanism involves energy levels, for which the evidence is line spectra/the line spectra of hydrogen		1	1	3.2.2.3

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OXFORD Revise

Question	Answers	Extra information	Marks	AO	Spec reference
08.1	Mass of electron/positron = 0.51 MeV Total energy of annihilation = 2 × 0.51 MeV = 1.02 MeV = 1.632×10^{-13} J Energy of one photon = $\frac{1.632\times10^{-13}\text{ J}}{2} = 8.16\times10^{-14}$ J $E = hf, f = \frac{E}{h} = \frac{8.16\times10^{-14}\text{ J}}{6.63\times10^{-34}\text{ J s}}$ $= 1.2(3)\times10^{20}$ Hz $\lambda = \frac{v}{f} = \frac{3\times10^{8}\text{ m s}^{-1}}{1.23\times10^{20}\text{ Hz}}$ $\lambda = 2.4(4)\times10^{-12}$ m	Use of energy of one particle Frequency Wavelength	1 1 1 1	2	3.2.1.3
08.2	Conservation of momentum Because no other particles are produced in the annihilation		1 1	2	3.2.1.7
08.3	Leptons		1	1	3.2.1.5
08.4	Leptons are fundamental particles Mesons are made of quarks, which are fundamental particles		1 1	1	3.2.1.5
08.5	$u\bar{s} \rightarrow u\bar{d} + u\bar{d} + X$ $+1 = \left(\frac{+2}{3} + \frac{+1}{3}\right) + \left(\frac{+2}{3} + \frac{+1}{3}\right) + (-1)$ The pion has a charge of –1	Evidence of use of quark structure	1 1	2	3.2.1.6
08.6	Quark structure of $\pi^- = \bar{u}d$ $u\bar{s} \rightarrow u\bar{d} + u\bar{d} + \bar{u}d$ $\bar{s} \rightarrow \bar{d} + u + \bar{u}$	Evidence of quark structure equation equation	1 1	2	3.2.1.6

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Skills box answers

Question	Answer
1(a)	2 s.f.
1(b)	3 s.f.
1(c)	3 s.f.
2(a)	specific charge = $\frac{1.6\times10^{-19}\,\text{C}}{9.11\times10^{-31}\,\text{kg}} = 1.8 \times 10^{11}\,\text{C kg}^{-1}$ (2 s.f.)
2(b)	specific charge = $\frac{\text{charge}}{\text{mass}}$ therefore: charge = specific charge × mass = $4.8\times10^{7}\,\text{C kg}^{-1} \times 6.68\times10^{-27}\,\text{kg} = 3.2\times10^{-19}\,\text{C}$ (2 s.f.)
2(c)	Using $E = hf$ (h is given in data table = 6.63×10^{-34} J s): $E = 6.63\times10^{-34}\,\text{J s} \times 750\times10^{12}\,\text{Hz} = 4.97\times10^{-19}$ J (3 s.f.)