CAMBRIDGE INTERNATIONAL AS & A LEVEL • PHYSICS 9702

Topical Questions

Unit 11: Nuclear Physics

Past Papers 2021 – 2025

MARK SCHEME 33 Questions

Prepared by

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A Level Physics Teacher

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Question 1 — Mark Scheme

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td rowspan="4">6(a)</td><td>α-particle mass given as 4u</td><td>B1</td></tr>
<tr><td>α-particle charge given as (+)2e</td><td>B1</td></tr>
<tr><td>both β-particles mass given as 0.0005 u</td><td>B1</td></tr>
<tr><td>β⁺ charge given as (+)e and β⁻ charge given as –e

(Completed table:
<table>
<tr><td></td><td>mass / u</td><td>charge / e</td></tr>
<tr><td>α</td><td>4</td><td>(+)2</td></tr>
<tr><td>β⁺</td><td>0.0005</td><td>(+)1</td></tr>
<tr><td>β⁻</td><td>0.0005</td><td>–1</td></tr>
</table>
)</td><td>B1</td></tr>
<tr><td>6(b)(i)</td><td>neutron decays into proton and an electron / β⁻ particle</td><td>B1</td></tr>
<tr><td>6(b)(ii)</td><td>down to up</td><td>B1</td></tr>
<tr><td rowspan="2">6(b)(iii)</td><td>(electron) antineutrino(s) emitted</td><td>B1</td></tr>
<tr><td>energy (released in decay)/momentum shared between antineutrino and β⁻ particle</td><td>B1</td></tr>
</table>

Question 2 — Mark Scheme

9702/22 Cambridge International AS & A Level – Mark Scheme **PUBLISHED** October/November 2021

Question	Answer	Marks
7(a)	(total) momentum before (decay) is zero **or** P has zero momentum	**B1**
	(total momentum after decay must be zero so) α-particle and Q have momenta in opposite directions (and therefore velocities are in opposite directions)	**B1**
7(b)	$p = 239\ (u) \times v$ **or** $4\ (u) \times 1.6 \times 10^{7}$	**C1**
	$239\ (u) \times v = 4\ (u) \times 1.6 \times 10^{7}$ $v = 2.7 \times 10^{5}\ m\ s^{-1}$	**A1**
7(c)	$E_{(K)} = ½mv^2$	**C1**
	$= ½ \times 4 \times 1.66 \times 10^{-27} \times (1.6 \times 10^{7})^2$	**C1**
	$= 8.5 \times 10^{-13}\ (J)$ $= 8.5 \times 10^{-13} / 1.60 \times 10^{-13}\ (MeV)$ $= 5.3\ MeV$	**A1**
7(d)(i)	**1.** R plotted at (95,147)	**B1**
	2. S plotted at (96,146)	**B1**
7(d)(ii)	(electron) antineutrino	**B1**

Question 3 — Mark Scheme

Question	Answer	Mark
6(a)(i)	(electron) neutrino	**B1**
6(a)(ii)	weak (nuclear force/interaction)	**B1**
6(a)(iii)	β^+ (particle)	**B1**
6(a)(iv)	(quark structure is) up up down **or** uud	**B1**
	$(2/3)e + (2/3)e - (1/3)e = (+)e$	**B1**
6(a)(v)	up up down changes to up down down **or** uud → udd **or** up changes to down **or** u → d	**B1**
6(b)(i)	$F = Eq$	**C1**
	ratio = 6 / 8 = 0.75	**A1**
6(b)(ii)	ratio = 0.75 × (16 / 12) = 1.0	**A1**
6(b)(iii)	horizontal straight line at a non-zero value of *a*	**B1**

Question 4 — Mark Scheme

Question	Answer	Marks
6(a)	the nucleus is charged	B1
	the majority of the mass (of atom) is in the nucleus	B1
6(b)	made up of quarks (so) not a fundamental particle	B1
6(c)	(Q =) $6.9 \times 10^{-9} \times 60$	C1
	number = $(6.9 \times 10^{-9} \times 60) / (2 \times 1.60 \times 10^{-19})$	C1
	= 1.3×10^{12}	A1
6(d)	(magnitude of electric) force is constant	B1
	(so magnitude of) acceleration is constant	B1
6(e)	(nuclei have) same charge/same number of protons	B1
	(so) same (magnitude of) force	B1

Question 5 — Mark Scheme

Question	Answer	Mark
7(a)(i)	most of the atom is empty space *or* the nucleus (volume) is very small compared to the atom	**B1**
7(a)(ii)	the nucleus is charged	**B1**
	the mass is concentrated in nucleus / small region / small volume / small core *or* the majority of the mass is in nucleus / small region / small volume / small core	**B1**
7(b)(i)	proton number = 84	**A1**
	nucleon number = 214	**A1**
7(b)(ii)	up down down changes to up up down / udd → uud *or* down changes to up / d → u	**B1**

Question 6 — Mark Scheme

Question	Answer	Marks
6(a)	particle with no internal structure / particle which cannot be broken down into anything smaller	**A1**
6(b)	charges: $u = (+)\frac{2}{3}(e)$ **or** $d = -\frac{1}{3}(e)$ **or** $s = -\frac{1}{3}(e)$	**C1**
	$(+)\frac{2}{3}(e) - \frac{1}{3}(e) - \frac{1}{3}(e) = 0(e)$	**A1**
6(c)(i)	• same/equal mass • same/equal (magnitude of) charge • both fundamental (particles) • opposite (sign of) charge • one is matter and the other is antimatter *Any two points, 1 mark each.*	**B2**
6(c)(ii)	neutron/baryon consists of three quarks	**B1**
	pion/meson consists of one quark and one antiquark	**B1**

Question 7 — Mark Scheme

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Question	Answer	Marks
7(a)	92 protons and 146 neutrons (in nucleus)	**B1**
	92 (orbital) electrons	**B1**
7(b)	charge = $2e$ (= $2 \times 1.60 \times 10^{-19}$ C)	**C1**
	mass = 4u (= $4 \times 1.66 \times 10^{-27}$ kg)	**C1**
	ratio = $(2 \times 1.60 \times 10^{-19}) / (4 \times 1.66 \times 10^{-27})$ = 4.8×10^{7} C kg^{-1}	**A1**
7(c)(i)	up down down / udd	**B1**
7(c)(ii)	up up up / uuu	**B1**

Question 8 — Mark Scheme

Question	Answer	Marks
6(a)	$^{14}_{7}X$	**B1**
	$^{0}_{-1}e^{-}$	**B1**
6(b)(i)	$d \rightarrow u + e^{-} + \bar{\nu}$ **or** $udd \rightarrow uud + e^{-} + \bar{\nu}$	**B1**
6(b)(ii)	$-1/3\,(e) = +2/3\,(e) - 1(e)$ (+ 0) **or** $2/3\,(e) - 1/3\,(e) - 1/3\,(e) = 2/3\,(e) + 2/3\,(e) - 1/3\,(e) - 1\,(e)$ (+ 0)	**B1**
6(c)(i)	electrons / β-particles (emitted from the nucleus) have a (continuous) range of / different (kinetic) energies	**B1**
6(c)(ii)	the (emitted) neutrinos take varying amounts of the (same total) energy (released in the decay)	**B1**

Question 9 — Mark Scheme

Question	Answer	Marks
7(a)(i)	P = 0 **and** Q = 137	**A1**
	R = –1 **and** S = 56	**A1**
7(a)(ii)	lepton(s)	**B1**
7(b)(i)	(charge of ddd / Y =) $-\frac{1}{3}(e)\ -\frac{1}{3}(e)\ -\frac{1}{3}(e) = -1(e)$	**B1**
	(charge of $\bar{u}$d / Z =) $-\frac{1}{3}(e)\ -\frac{2}{3}(e) = -1(e)$	**B1**
7(b)(ii)	meson: Z / $\bar{u}$ d because consists of a quark and an antiquark	**B1**
	baryon: Y / ddd because consists of three quarks	**B1**

Question 10 — Mark Scheme

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Question	Answer	Marks
7(a)(i)	$^{18}_{9}F \rightarrow {}^{18}_{8}O + {}^{0}_{(+)1}\beta^{(+)} + {}^{(0)}_{(0)}\nu_{(e)}$ ν **or** neutrino (B1) $^{0}_{(+)1}\beta^{(+)}$ (B1) $^{18}_{8}O$ (B1)	**B3**
7(a)(ii)	up quark to down quark	**B1**
7(b)(i)	must be three (anti)quarks as largest (negative) quark charge is (–)2/3 (*e*) **or** mesons can only have a charge of 0 or ±1(*e*)	**M1**
	(so hadron is) a baryon	**A1**
7(b)(ii)	any combination of three from: antiup (quark) / up antiquark and/or anticharm (quark) / charm antiquark and/or antitop (quark) / top antiquark	**B1**

Question 11 — Mark Scheme

Question	Answer	Marks
7(a)(i)	(electron) neutrino	B1
7(a)(ii)	nucleon number = 22	A1
	proton number = 10	A1
7(a)(iii)	up up down changes to up down down or up changes to down	B1
7(b)(i)	charge = $-\frac{2}{3}e$	A1
7(b)(ii)	antiup / anticharm / antitop	B1

Question 12 — Mark Scheme

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Question	Answer	Mark
7(a)	a (very) small proportion of (alpha) particles are deflected (back) through large angles / angles greater than 90°	B1
	a large proportion of (alpha) particles pass straight through / deflected by small angles	B1
7(b)	electromagnetic wave / electromagnetic radiation	A1
7(c)	neutrino classified as a lepton only and positron classified as a lepton only	B1
	neutron classified as a baryon and a hadron and not as a lepton	B1
7(d)(i)	1.32 u	A1
7(d)(ii)	working states or implies 3 quarks and each quark has a charge of (+) $\frac{2}{3}(e)$	B1
	any combination of 3 quarks comprised of one or more of up / charm / top	B1

Question 13 — Mark Scheme

Question	Answer	Marks
7(a)	only baryon **and** nucleon underlined	**B1**
7(b)	number of α-particles = 6	**B1**
	number of β^- particles = 4	**B1**
7(c)	charm antiquark (charge) = $-\frac{2}{3}(e)$ **or** $-\frac{2}{3}(e) + q = -1(e)$	**B1**
	(other quark $q = -\frac{1}{3}(e)$ so) down / strange / bottom	**B1**

Question 14 — Mark Scheme

Question	Answer	Marks
8(a)(i)	23: nucleon number **or** number of neutrons and protons	**B1**
	12: proton number **or** number of protons	**B1**
8(a)(ii)	both numbers correct for X: $^{23}_{11}X$	**B1**
	both numbers correct for beta-plus: $^{0}_{1}\beta^{+}$	**B1**
8(a)(iii)	lepton(s)	**A1**
8(b)	(the emitted particles) have a single (kinetic) energy **or** beta particles / decay have a (continuous) range of (kinetic) energies	**B1**

Question 15 — Mark Scheme

Question	Answer	Marks
8(a)(i)	Y and Z have equal numbers of protons and (so) they have the same charge	**B1**
8(a)(ii)	Y has (two) fewer protons (than X)	**M1**
	(so) Y has less charge (than X)	**A1**
8(b)	(total) momentum before decay is zero **or** X has zero / no momentum	**B1**
	(total momentum after decay must be zero so) Y must have equal (and opposite) momentum to α-particle (so cannot be stationary / must have speed/velocity)	**B1**

Question 16 — Mark Scheme

Question	Answer	Marks
8(a)(i)	number of protons: equal/same	**B1**
	number of neutrons: unequal/different	**B1**
8(a)(ii)	down (quark) changes to up (quark) **or** up down down (quarks) change to up up down (quarks)	**B1**
8(a)(iii)	(electron) antineutrino	**B1**
8(b)	charm (quark charge) is (+)2/3(e) **or** 2 charm (quark charges) is (+)4/3(e) **or** bottom (quark charge) is –1/3(e)	**C1**
	charge = +2/3(e) + 2/3(e) –1/3(e) = (+)1(e)	**A1**

Question 17 — Mark Scheme

Question	Answer	Marks
7(a)	down charge = –1/3(*e*) **and** charm charge = (+)2/3(*e*)	**B1**
	all antiquarks have opposite sign and same (non-zero) magnitude of charge as the corresponding quarks	**B1**
7(b)(i)	udd **or** cdd	**B1**
7(b)(ii)	$u\bar{d}$ **or** $c\bar{d}$	**B1**
7(c)(i)	lepton(s)	**B1**
7(c)(ii)	positron / neutrino / antineutrino	**B1**

Question 18 — Mark Scheme

Question	Answer	Marks
6(c)(iv)	current in (fixed / variable) resistor decreases	**B1**
	current in (resistance) wire is unchanged	**B1**
	(so) current in battery decreases, (same e.m.f. so) power decreases	**B1**

Question	Answer	Marks
7(a)(i)	X has same number of protons as Y (and so) charge of X is the same as the charge of Y	**B1**
7(a)(ii)	X has (one) more proton (than Z)	**M1**
	(so) X has greater charge (than Z)	**A1**
7(b)(i)	meson(s)	**B1**
7(b)(ii)	one quark and one antiquark	**B1**

Question 19 — Mark Scheme

Question	Answer	Marks
6(a)	mass of α (particle) is <u>much</u> greater (than β^+ particle)	**B1**
	both particles are positively charged	**B1**
	(magnitude of) charge on α (particle) is twice the charge (on β^+ particle)	**B1**
6(b)(i)	cross labelled Q at (82, 212)	**B1**
6(b)(ii)	particles emitted are: • beta-minus (particle) / electron • (electron) antineutrino either particle named	**B1**
	both particles named and no incorrect particles named	**B1**
6(c)(i)	$212(u) \times 1.3 (\times 10^5) \sin 68°$ **or** $4(u) \times 150 (\times 10^5) \sin \theta$	**C1**
	$4(u) \times 150 (\times 10^5) \times \sin \theta = 212(u) \times 1.3 (\times 10^5) \times \sin 68°$	**C1**
	$\sin \theta = 0.426$ $\theta = 25°$	**A1**
6(c)(ii)	$E = \frac{1}{2}mv^2$	**C1**
	$= \frac{1}{2} \times 4 \text{ u} \times (150 \times 10^5)^2$ $= \frac{1}{2} \times 4 \times 1.66 \times 10^{-27} \times (150 \times 10^5)^2$ $= 7.5 \times 10^{-13}$ J	**A1**

Question 20 — Mark Scheme

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Question	Answer	Marks
7(a)	up quark charge = (+) 2 / 3 **and** down quark charge = –1 / 3	**B1**
	strange quark charge = –1 / 3	**B1**
	up antiquark charge = –2 / 3 **and** down antiquark charge = (+) 1 / 3 **and** strange antiquark charge = (+) 1 / 3	**B1**
7(b)(i)	hadron(s)	**B1**
7(b)(ii)	baryons composed of three quarks **or** baryons composed of three antiquarks	**B1**
	mesons composed of one quark and one antiquark	**B1**
7(c)	up quark changes to a down quark	**B1**
	positron and (electron) neutrino (emitted)	**B1**

Question 21 — Mark Scheme

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Question	Answer	Marks
7(a)	$^{66}_{29}Cu$	B1
7(b)(i)	the energy of the decay is fixed / constant	B1
	the energies of the beta particles have a (continuous) range of values / varies / not constant	B1
	another particle / an (anti)neutrino must possess the extra / remaining energy (difference between energy of the decay and the β kinetic energy)	B1
7(b)(ii)	(electron) antineutrino	B1
7(b)(iii)	$^{66}_{29}Cu \rightarrow {}^{66}_{30}Zn + {}^{0}_{-1}\beta + {}^{0}_{0}\overline{\upsilon_e}$ values for Cu and Zn correct with no other extra particles on either side of the equation	B1
	second term correct ($^{0}_{-1}\beta$)	B1
	third term correct ($^{0}_{0}\overline{\upsilon_e}$)	B1

Question 22 — Mark Scheme

Question	Answer	Marks
7(a)	meson(s) **or** hadron(s)	B1
7(b)	Q: anti-up **or** anti-charm **or** anti-top	B1
	R: up **or** charm **or** top	B1

Question 23 — Mark Scheme

Question	Answer	Marks
6(a)	$^{147}_{62}Sm$	A1
6(b)(i)	the (kinetic) energy of the particles is discrete / has only one value (so must be alpha)	B1
	and beta particles have a (continuous) range of (kinetic) energies (so can't be beta)	B1
6(b)(ii)	$^{147}_{62}Sm \rightarrow {}^{143}_{60}Nd + {}^{4}_{2}\alpha$ values for Sm and Nd correct with no other extra particles on either side of the equation	A1
	$^{4}_{2}\alpha$ correct	A1
6(c)(i)	up quark charge is +(2 / 3) (*e*) **or** bottom quark charge is –(1 / 3) (*e*)	C1
	0 = +(2 / 3) (*e*) – (1 / 3) (*e*) + *q* (so) charge (on third quark must be) –(1 / 3) (*e*)	A1
6(c)(ii)	down **or** strange	A1

Question 24 — Mark Scheme

Question	Answer	Marks
8(a)	lepton(s)	**B1**
8(b)(i)	up or top or charm	**B1**
8(b)(ii)	meson(s)	**B1**
8(c)(i)	β^- (particle) **or** electron	**B1**
8(c)(ii)	equal	**B1**
8(c)(iii)	(the charge of) R is greater (than Q)	**B1**

Question 25 — Mark Scheme

Question	Answer	Marks
6(a)(i)	numbers of protons and electrons both = 1	**A1**
	number of neutrons = 2	**A1**
6(a)(ii)	diagram shows 2 neutrons and 1 proton labelled and forming a nucleus	**B1**
	diagram shows 1 electron labelled and separated from the nucleus (not touching the proton and neutrons)	**B1**
6(b)(i)	helium nucleus: top line = 3 **and** bottom line = 2	**A1**
	beta particle: top line = 0 **and** bottom line = –1	**A1**
6(b)(ii)	(electron) antineutrino	**B1**
6(c)	proton: up up down **or** neutron: up down down	**C1**
	(tritium:) 4 up, 5 down	**A1**

Question 26 — Mark Scheme

Question	Answer	Marks
6(a)	(a particle that) cannot be divided / subdivided (into smaller particles)	**B1**
6(b)(i)	any combination of one quark and one antiquark	**C1**
	up / charm / top **and** antiup / anticharm / antitop **or** down / strange / bottom **and** antidown / antistrange / antibottom	**A1**
6(b)(ii)	$E_{(K)} = \frac{1}{2} mv^2$	**C1**
	$2.1 \times 10^{-16} = \frac{1}{2} \times 0.67 \times 1.66 \times 10^{-27} \times v^2$	**C1**
	$v = 6.1 \times 10^5$ m s^{-1}	**A1**
6(c)(i)	number of electrons = 88	**A1**
6(c)(ii)	(number of nucleons = 228 – 5 × 4 = 208) number of protons = 88 – (5 × 2) + 4 = 82	**A1**
	number of neutrons= 208 – 82 = 126 = 126	**A1**

Question 27 — Mark Scheme

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Question	Answer	Marks
6(a)(i)	numbers of protons and electrons both = 1	**A1**
	number of neutrons = 2	**A1**
6(a)(ii)	diagram shows 2 neutrons and 1 proton labelled and forming a nucleus	**B1**
	diagram shows 1 electron labelled and separated from the nucleus (not touching the proton and neutrons)	**B1**
6(b)(i)	helium nucleus: top line = 3 **and** bottom line = 2	**A1**
	beta particle: top line = 0 **and** bottom line = –1	**A1**
6(b)(ii)	(electron) antineutrino	**B1**
6(c)	proton: up up down **or** neutron: up down down	**C1**
	(tritium:) 4 up, 5 down	**A1**

Question 28 — Mark Scheme

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Question	Answer	Marks
6(a)(i)	W deflects upwards	**B1**
	W has deflection that is the mirror image of X	**B1**
	Y deflects downwards less than X **or** path of Y is parallel to particle Z	**B1**
6(a)(ii)	nucleus has most of the mass of the atom **or** nucleus is charged	**B1**
6(a)(iii)	atom is mostly empty space **or** nucleus occupies a very small proportion of the space in the atom	**B1**
6(b)	mass = 4 u	**A1**
	charge = (+)2*e*	**A1**
6(c)(i)	baryon	**B1**
6(c)(ii)	charge on up quark = $(+)\frac{2}{3}(e)$ **and** charge on down quark = $-\frac{1}{3}(e)$	**C1**
	(proton is up up down and neutron is up down down) $\left(2\times\frac{2}{3}\right)e-\left(1\times\frac{1}{3}\right)=1e$ **and** $\left(1\times\frac{2}{3}\right)e-\left(2\times\frac{1}{3}\right)e=0$	**A1**

Question 29 — Mark Scheme

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td rowspan="3">7(a)</td><td>$^{12}_{7}\text{N} \rightarrow {}^{12}_{6}\text{C} + {}^{0}_{1}\beta^{+} + {}^{(0)}_{(0)}\text{n}$

beta-plus shown</td><td>B1</td></tr>
<tr><td>neutrino shown</td><td>B1</td></tr>
<tr><td>symbols, nucleon numbers and proton numbers all correct</td><td>B1</td></tr>
<tr><td>7(b)(i)</td><td>+1</td><td>B1</td></tr>
<tr><td>7(b)(ii)</td><td>Lepton(s)</td><td>B1</td></tr>
<tr><td rowspan="4">7(b)(iii)</td><td><table><tr><th>flavour</th><th>charge / e</th></tr><tr><td>up / u</td><td>$-\frac{2}{3}$</td></tr><tr><td>up / u</td><td>$-\frac{2}{3}$</td></tr><tr><td>down / d</td><td>$(+)\frac{1}{3}$</td></tr></table></td><td></td></tr>
<tr><td>3 correct quark flavours</td><td>B1</td></tr>
<tr><td>Charge on anti-up quark –⅔(e)</td><td>B1</td></tr>
<tr><td>Charge on anti-down quark (+)⅓(e)</td><td>B1</td></tr>
</table>

Question 30 — Mark Scheme

Question	Answer	Marks
7(a)	(a particle that) cannot be divided/subdivided (into smaller particles)	**B1**
7(b)(i)	$(p \times e) / (14u) = 4.1 \times 10^{7}$	**C1**
	$p = (4.1 \times 10^{7} \times 14 \times 1.66 \times 10^{-27}) / (1.60 \times 10^{-19})$	**C1**
	$p = 6$ (answer should be an integer)	**A1**
7(b)(ii)	${}^{14}_{6}X \rightarrow {}^{14}_{7}Z$	**B1**
	${}^{0}_{-1}e^{(-)}$ or ${}^{0}_{-1}\beta^{(-)}$	**B1**
	${}^{0}_{0}\overline{\nu}_{(e)}$	**B1**
7(c)	(the nuclei are undergoing) β^{+} decay	**B1**
	A correct explanation in terms of charge **and** a correct explanation in terms of energy Explanations in terms of charge: • (particles / decay) positively charged so cannot be β^{-} • (particles / decay) positively charged so could be / is β^{+} • β^{-} (particles / decay) are negatively charged • β^{+} (particles / decay) are positively charged Explanations in terms of energy: • range of energies so not α (particles / decay) • range of energies so is β (particles / decay) • β (particles / decay) have a range of energies • α (particles / decay) have discrete energies / not range of energies	**B1**

Question 31 — Mark Scheme

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>8(a)</td><td>
<table>
<tr><th>flavour</th><th>charge / e</th></tr>
<tr><td>up / u</td><td>$-\frac{2}{3}$</td></tr>
<tr><td>down / d</td><td>$(+)\frac{1}{3}$</td></tr>
<tr><td>down / d</td><td>$(+)\frac{1}{3}$</td></tr>
</table>
</td><td></td></tr>
<tr><td></td><td>3 correct quark flavours</td><td>B1</td></tr>
<tr><td></td><td>Charge on anti-up quark –⅔(e)</td><td>B1</td></tr>
<tr><td></td><td>Charge on anti-down quark (+)⅓(e)</td><td>B1</td></tr>
<tr><td>8(b)</td><td>particle: (electron) neutrino</td><td>B1</td></tr>
<tr><td></td><td>antiparticle: positron</td><td>B1</td></tr>
</table>

Question 32 — Mark Scheme

9702/24 Cambridge International AS & A Level – Mark Scheme May/June 2025
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Question	Answer	Marks
7(a)	• (electron) neutrino • (electron) antineutrino • electron • positron Any two, 1 mark each	**B2**
7(b)	only meson <u>and</u> neutron are underlined	**B1**
7(c)	(quark composition is) up, up, down / uud (charge =) $\frac{2}{3}e + \frac{2}{3}e - \frac{1}{3}e = (+1)e = (+)\,1.6 \times 10^{-19}$ (C)	**B1**
	or (charge =) $1.07 \times 10^{-19} + 1.07 \times 10^{-19} - 5.33 \times 10^{-20} = (+)\,1.6 \times 10^{-19}$ (C)	**A1**

Question 33 — Mark Scheme

Question	Answer	Marks
7(a)	nucleon number of Q = 226 and proton number of R = 86	B1
7(b)	$4(u) \times 1.5 \times 10^7$ or $222(u) \times v$	C1
	$v = 4(u) \times 1.5 \times 10^7 / 222(u)$	C1
	$= 2.7 \times 10^5\ m\ s^{-1}$	A1

Question	Answer	Marks
7(c)	Any three from: • momentum • charge • nucleon number • neutron number • proton number	B3

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