AQA

AS
Physics

PHYA1 – Particles, quantum phenomena and electricity
Mark scheme

2450
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<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>ID details</th></tr>
<tr><td>1 (a) (i)</td><td>particles that experience the strong (nuclear) force/interaction ✓</td><td>Condone additional mention of other interactions not unique to hadrons</td><td>1</td><td></td></tr>
<tr><td>1 (a) (ii)</td><td>(particles composed of) three quarks ✓</td><td>allow qqq or correct example</td><td>1</td><td></td></tr>
<tr><td>1 (a) (iii)</td><td>quark and antiquark ✓</td><td>Allow symbols or correct example</td><td>1</td><td></td></tr>
<tr><td>1 (b)</td><td>similarity: but the same (rest) mass or rest energy ✓
difference: opposite quantum states eg charge ✓</td><td>Allow 1 mark for stating mass (similarity) and charge (difference)</td><td>2</td><td></td></tr>
<tr><td>1 (c)</td><td><table><tr><th></th><th>charge/C</th><th>baryon number</th><th>quark structure</th></tr><tr><td>antiproton</td><td>-1.6×10^{-19}</td><td>–1</td><td>$\overline{u}\ \overline{u}\ \overline{d}$</td></tr></table></td><td>2 marks all 3 correct
1 mark at least 2 correct</td><td>2</td><td></td></tr>
<tr><td>1 (d) (i)</td><td>weak interaction ✓
strange not conserved ✓</td><td>Allow: there is a change/decay of quark (flavour)</td><td>2</td><td></td></tr>
<tr><td>1 (d) (ii)</td><td>any two
eg charge
baryon number
(muon) lepton number</td><td></td><td>2</td><td></td></tr>
<tr><td>Total</td><td></td><td></td><td>11</td><td></td></tr>
</table>

Question	Answers	Additional Comments/Guidance	Mark	ID details
2 (a)	repulsive then attractive ✓ short range (if distance quoted must be of order fm) ✓ correct distance for cross over (accept range 0.1 – 1.0 fm) ✓		3	
2 (b) (i)	(It is a) helium nucleus (emitted from an unstable nucleus) / accept 2p and 2n ✓	Not helium atom / $^{4}_{2}\mathrm{He}$ or $^{4}_{2}\alpha$ not enough Condone nuclei instead of nucleus	1	
2 (b) (ii)	$^{238}_{92}\rightarrow{}^{234}_{90}\mathrm{Th}$✓ + $^{4}_{2}\alpha$✓		2	
2 (c) (i)	same atomic number/proton number ✓ different number of neutrons/nucleons ✓	Condone mention of electrons	2	
2 (c) (ii)	weak (interaction) ✓		1	
2 (c) (iii)	(8 × 2 =) 16 seen✓ (92-16 =)**76** 0r 92 – 82 = 10 ✓ **6** (beta decays) ✓		3	
Total			**12**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
3 (a)	Diffraction ✓		1	
3 (b)	(use of $\lambda=h/mv$) $\lambda=6.63\times10^{-34}/(9.11\times10^{-31}\times2.7\times10^{5})$ ✓ condone POT error in substitution $\lambda=2.7\times10^{-9}$ m ✓ 2 sig figs ✓ (to score this mark, for an incorrect answer, working some working needs to be seen)	Correct answer alone (to 2 sig figs) gets 3 marks	3	
3 (c)	$v=2.7\times10^{5}/207$✓ v=1300 m s^{-1} ✓ **OR** Use of $\lambda=h/mv$ with v as subject of correct rearrangement $v=h/m\lambda$ or substitution ✓ v=1300 m s^{-1} ✓	Correct answer alone gets 2 marks Where answer quoted to 4 sig figs then range is from 1302 to 1304 with CE from 3(b) with CE from 3(b) Where answer quoted to 4 sig figs then range is from 1302 to 1304	2	
Total			**6**	

Question	Answers	Additional Comments/Guidance	Mark	ID detail
4 (a)	**The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. **High Level (Good to excellent): 5 or 6 marks** The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate provides a comprehensive and coherent description which includes a clear explanation of constant energy level differences and how atoms can be excited by electron collisions. The link between the energy of a photon and its frequency should be clear. The description should include a clear explanation of the reason atoms of a given element emit photons of a characteristic frequency **or** there is a clear link between constant energy differences and photon frequency/wavelength (eg E=hf). The candidate should relate the energy **difference** between levels to the energy of emitted photons and state the energy difference is fixed/constant. Photon energy = energy difference between levels during de-excitation Certain frequencies = certain energy photons= certain energy differences = certain energy levels available Answer addresses both aspects of quesion		Max 6	

Intermediate Level (Modest to adequate): 3 or 4 marks

The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.

The candidate provides an explanation of energy levels and how excitation takes place by electron collision with **atomic/orbital** electrons. The candidate explains how an orbital/atomic electron loses energy by emitting a photon.

Clear explanation of electron movement during excitation
Clear explanation of electron movement during de-excitation with link to emission

Answer addresses the process of excitation / de-excitation / photon emission

Low Level (Poor to limited): 1 or 2 marks

The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate.

Excitation of atom / De-excitation of atom / Links definite wavelengths to photons of discrete energy

Incorrect, inappropriate of no response: 0 marks
No answer or answer refers to unrelated, incorrect or inappropriate physics.

	The explanation expected in a competent answer should include a coherent account of the significance of discrete energy levels and how the bombardment of atoms by electrons can lead to excitation and the subsequent emission of photons of a characteristic frequency. electrons bombard atoms of vapour and give energy to electrons in atom electrons in atoms move to a higher energy level atoms are excited atomic electrons move down to lower energy levels losing energy by emitting photons photons have energy hf = energy difference between the levels that electron falls between Only certain photons (of characteristic frequencies) emitted from atoms of a particular element Only certain transitions available to electron this is because atoms have discrete energy levels which are associated with particular energy values			
4 (b) (i)	(minimum) energy required to (completely) remove an electron from atom/hydrogen (where atom is in its ground state)✓ minimum energy **and** ground state/lowest energy level ✓	1 mark for partial statement Must be clear that electron is removed from atom 2nd mark for detail added to statement 2nd mark dependent on first	2	
4 (b) (ii)	$13.6 \times 1.6 \times 10^{-19}$ ✓ 2.18×10^{-18} (J) ✓	Correct answer alone gets 2 marks	2	
Total			**10**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
5 (a)	Increased lost volts (owtte)✓ (Terminal pd decreases because) V = ε – Ir **or** (Terminal pd decreases because) emf is fixed **and** terminal pd is emf – lost volts✓		2	
5 (b) (i)	*y – intercept* 1.52 V (± 0.01 V) ✓		1	
5 (b) (ii)	identifies gradient as *r* **OR** use of equation by substitution or rearrangement with r as subject✓ substitution to find gradient **OR** substitution into equation with r as subject✓ *r* = 0.45 ± 0.02 Ω ✓	Allow **one** error in data read off graph in substitutions	3	
5 (c) (i)	same intercept ✓ double gradient (must go through 1.25, 0.40 ± 1.5 squares) ✓	Other points (1,0.6) or (1.5,0.16)	2	
5 (c) (ii)	same intercept horizontal line ✓		1	
5 (d) (i)	(use of $Q = It$) $Q = 1.2 \times 25 = 30$ ✓ C ✓ condone Coulombs		2	

5 (d) (ii)	use of $P = I^2r$ by substitution $P = 1.2^2 \times 0.45$✓ $P = 0.65\,\text{W}$ ✓ Or Use of $P = \frac{Ir \times Q}{25}$✓ $P = 0.65\,\text{W}$ ✓	CE from (b) (ii) CE from (b) (ii)	2	
Total			**13**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
6 (a)	a non-ohmic component does not have a constant resistance / a non-ohmic component does not obey Ohm's Law / pd across this component is not (directly) proportional to current in the component✓		1	
6 (b) (i)	attempt to make curved graph symmetric in two opposite quadrants ✓ curve of decreasing positive gradient with increasing V (positive quadrant), must be through origin (within 2mm) must have no linear section, must have no plateau, must have no turning points✓		2	

6 (b) (ii)	resistance **increases** (as pd increases/current increases) ✓	Condone reference to gradient	1	
6 (c) (i)	(use of $P = V^2/R$) $24 = 36/R$ or rearrangement with R as subject✓ $R = 1.5\ (\Omega)$ ✓		2	
6 (c) (ii)	reference to temperature change ✓ (resulting in) a lower resistance ✓ (hence) power rating would be greater ✓		3	
Total			**9**	

Question	Answers	Additional Comments/Guidance	Mark	ID details
7 (a) (i)	adding resistance values 90 (k Ω) or I = 9.0/ (45 000+39 000+6000) or $I = \frac{9}{\text{their R}}$ or $I = \frac{9}{90}$ (POT) ✓ 1.0×10^{-4} (A)✓	Their R must be determined by a recognisable calculation (resistors in parallel or error in resistors in series) before can be credited in I = V/R sub	2	
7 (a) (ii)	V=1.0 × 10^{-4} × 6000 ✓ condone POT error 0.60 (V)✓ condone 1 sf answer **OR** V=6 x 9 /90✓ condone POT error 0.60 (V) ✓	CE from (i) BALD answer full credit	2	
7 (b)	resistance of LDR decreases✓ reading increase because greater proportion/share of the voltage across R OR higher current✓	need first mark before can qualify for second	2	

7 (c)	I (= 0.82/6000) = 1.37×10^{-4} (A) or V_{var} = ε – their V_{LDR} – their V_R ✓ pd across variable resistor = (9.0–0.82 –4500 × 1.37×10^{-4} =) 7.56 (V) ✓ (*R*=7.56/1.37×10^{-4} =) 5.5(4) x 10^4 (Ω) ✓ **OR** I(= 0.82/=6000)= 1.37×10^{-4} (A) or R_{var} = their R_{total} – R_{LDR} - R✓ R_{total} = $9.0/1.37 \times 10^{-4}$ or R_{total} = 65 853 Ω (or 65693 or 64285 or 66000)✓ *R* (= 65 853 – 4500 – 6000) =)5.5(4) x 10^4 (Ω) ✓	Condone POT error Condone POT error Condone POT error Condone POT error	3	
Total			**9**	