A-LEVEL
PHYSICS A

PHYA1 – Particles, quantum phenomena and electricity

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It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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COMPONENT NAME: Unit 1 Particles, quantum phenomena and electricity

COMPONENT NUMBER: PHYA1

STATUS: Pre-standardisation

Question	Part	Sub Part	Marking Guidance	Mark		Comments
1	a	(i)	$\bar{u}s$ / up and anti-strange✓	1		In any order Bar must only be over s only
1	a	(ii)	0 / zero/nothing✓	1		
1	a	(iii)	K^- / negative kaon / $\bar{u}s$ ✓	1		
1	b	(i)	classification: K^+ | ν_μ | μ^+ lepton: × | ✓ | ✓ charged particle: ✓ | × | ✓ hadron: ✓ | × | × meson: ✓ | × | ×	3		1 mark for each correct row
1	b	(ii)	conserved: baryon number OR lepton number ✓ not conserved: strangeness/kinetic energy✓	2		Mass in either loses mark

1	c	(i)	neutral pion✓	1		Indicated clearly in table in any way e.g. circled or cross. If more than one box used then must be a tick with neutral pion only
1	c	(ii)	must be neutral/no charge/0 charge to obey charge conservation OR cannot be baryon to obey conservation of baryon number OR cannot be lepton to obey conservation of lepton number✓	1		Can show by using equation and appropriate quantum numbers

2	a	(i)	Q/boron/B✓	1		

2	a	(ii)	P and R/ R and P✓	1		

2	a	(iii)	R✓ 6/14 is smallest fraction/0.43 smallest ratio/4.13×10^{7} C/kg✓	2		Cannot get second mark if not awarded first mark

2	a	(iv)	${}^{14}_{6}R \rightarrow {}^{14}_{7}X + {}^{0}_{-1}e + \overline{\nu_{(e)}}$ ✓✓✓	3		one mark for each correct symbol on rhs ignore –ve sign on e. Can have neutrino with 0,0 on answer lines ignore any subscript on neutrino
2	b	(i)	repulsive below/at 0.5 fm (accept any value less or equal to 1 fm)✓ attractive up to/at 3 fm (accept any value between 0.5 and 10 fm)✓ short range OR becomes zero OR no effect✓	3		Can get marks from labelled graph Don't accept negligible for 3rd mark
2	b	(ii)	interaction: electromagnetic/em✓ (virtual) photon/ γ✓	2		
3	a		(electron) diffraction / interference / superposition✓	1		Accept derfraction
3	b		(use of $\lambda=h/mv$) $\lambda=6.63 \times 10^{-34}/(9.11 \times 10^{-31} \times 2.5 \times 10^{5})$ ✓ $\lambda=2.9 \times 10^{-9}$ m ✓✓ (2 sig figs.)	3		

3	c		v=2.5 × 10^5/207✓ v=1200 m s^{-1}✓ OR use $v=h/m\lambda$ with CE from 3(b)	2		Answer alone gets 2 marks

4	a	(i)	ultraviolet / UV/ UV light/ ultra(-)violet✓	1		

4	a	(ii)	<u>electron</u>(in ground state) has moved/in to higher (energy) level/shell/orbital/state OR up level/shell/orbital/state✓	1		Ignore reference to photons

4	a	(iii)	(free) electrons collide with orbital electrons/mercury electrons/electrons in atom✓ transferring energy✓	2		Ignore any reference to photons

4	a	(iv)	(mercury) atoms have discrete/fixed/specific energy levels✓ when electrons change levels they lose an exact/fixed/specific/discrete/set amount of energy OR photons emitted with exact/fixed/specific/discrete/set amount of energy ✓ (leading to photons of) fixed/particular/certain/discrete/specific/unique frequencies✓	3		Each mark independent Don't accept characteristic for 3rd mark

4	b	(i)	(*use of* $\lambda=c/f$) f=3 × 10^8 /(254 × 10^{-9}) ✓ f= 1.18 × 10^{15} (Hz)✓	2		AE penalty if give answer to 1 sig fig

4	b	(ii)	(*use of E=hf*) E=6.63 × 10^{-34} × 1.18 × 10^{15}= 7.82 × 10^{-19}J✓ E= 7.82 × 10^{-19}/1.6 × 10^{-19}✓ = 4.9 (4.875) eV	2		CE b(i) Range 4.8 - 5.0 acceptable
4	c		coating <u>absorbs</u> photons/uv light✓ and re-emits (photons) of low(er) energy/long(er) wavelength/low(er) frequency✓	2		Ignore any description of mechanism
5	a		power increases to a maximum/(up) to 3.0 (2.8 -3.4) Ω / / (up)to 3.0 W✓ then decreases✓	2		
5	b	(i)	(*use of P=I^2R*) when R= 0.8 Ω power = 1.95 W✓ 1.9 =I^2 × 0.8✓ I=√2.375 = 1.5(4) (A)✓	3		Range 1.9 - 2.0 W for power (first mark) Current 1.5 – 1.6 A
5	b	(ii)	(*use of V=IR*) V=1.54 × 0.8✓ V= 1.2 V✓	2		CE from (i)
5	b	(iii)	(*use of ε=V+Ir)* 6.0= 1.2 +1.54 × r✓ r=(6.0 – 1.2)/1.54 = 3.1 (2.9 – 3.2)(Ω)✓	2		CE from (ii)

			use of maximum power theorem (quoted) as alternative method can get both marks i.e. read peak maximum from graph			

5	c		power would decrease (as R increased)✓ pd/voltage across R is now constant/equal to emf✓ and so power proportional to 1/R/ inversely proportional to R OR can quote $P=V^2/R$ but only if scored second mark✓	3		

6	a	(i)	resistivity is defined as $\rho = \frac{RA}{l}$ where *R* is the resistance of the material of length *l*✓ and <u>cross-sectional</u> area *A*✓	2		

6	a	(ii)	<u>below</u> the critical temperature/maximum temperature which resistivity/resistance ✓ is zero/becomes superconductor✓	2		Any reference to negligible/small/very low resistance loses second mark

6	b		(*use of* $\rho = \frac{RA}{l}$) $\rho=0.70 \times \pi \times 0.0005^2/4.8$ ✓$= 1.1(5) \times 10^{-7}$ (1.1 – 1..2) ✓✓ Ω m✓	4		First mark for substitution R and l Lose 1 mark if diameter used as radius and answer is 4 times too big (4.4 – 4.8) OR if power of ten error

7	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 measures V and temperature. They have a workable method of varying temperature from 0 °C to 100 °C. They explain why R is necessary and are able to use the thermistor to measure temperature using a graph and calibration curve.* **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 measures V and temperature. They have a workable method of varying temperature from 0 °C to 100 °C. Give some indication of how an unknown temperature is measured.* **Low Level (Poor to limited): 1 or 2 marks** The information conveyed by the answer is poorly organised and	6		LOWER BAND Measure/record voltage For different temperatures MIDDLE BAND Water bath used Over full range 0 – 100 °C e.g. use ice and Bunsen OR Need for R to form potential divider Use of graph to find

			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. *The candidate measures V and temperature. They vary the temperature.* **The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case.** measurement of V from the voltmeter use of a thermometer use of water bath use of ice importance of stirring explanation of the need for series resistor plotting of a calibration curve use of calibration curve to determine temperature of room			room temperature TOP BAND 3 out the 4 points in middle band 6 marks only if all 4 points in middle band plus reference to thermometer and some additional e.g. stirring, suggested intervals

7	b		reading changes in opposite way/voltmeter reading would increase as temperature increased ✓ as resistance of thermistor falls/current increases✓ hence greater share/proportion of pd/voltage across R OR greater current therefore larger pd/voltage across R OR total pd/voltage constant less pd/ voltage across thermistor (at higher temperatures) therefore greater pd/voltage across R✓	3		

Question	Specification	Topic	Assessment Criteria
1	3.1.1	Classification of Particles	AO1 : 8 AO2 : 2
2	3.1.1	Constituents of the atom	AO1 : 5 AO2 : 7
3	3.1.2	Particle Wave Duality	AO1:1 AO2: 5
4	3.1.2	Energy Levels and Photon emission	AO1 : 9 AO2 : 4
5	3.1.3	Circuits	AO2: 12
6	3.1.3	Thermistor	AO1 : 7 AO3 : 2
7	3.1.3	resistivity	AO1 :4 AO2: 4
		TOTALS	AO1 : 34 AO2 : 34 AO3: 2 TOTAL:70