A-LEVEL

Physics

PHYA1 – Particles, Quantum Phenomena and Electricity
Mark scheme

2450
June 2015

Version V1: Final Mark Scheme

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

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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<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidance</th><th>Mark</th><th>ID details</th></tr>
<tr><td>1a</td><td>
<table>
<tr><th></th><th>$^{223}_{88}\mathrm{Ra}$</th><th>$^{224}_{88}\mathrm{Ra}$</th><th>$^{225}_{88}\mathrm{Ra}$</th><th>$^{226}_{88}\mathrm{Ra}$</th></tr>
<tr><td>Isotope with smallest mass number</td><td>(✓)</td><td></td><td></td><td></td></tr>
<tr><td>Isotope with most neutrons in nucleus</td><td></td><td></td><td></td><td>✓</td></tr>
<tr><td>Isotope with nucleus that has highest specific charge</td><td>✓</td><td></td><td></td><td></td></tr>
<tr><td>Isotope that decays by β^- decay to form $^{225}_{89}\mathrm{Ac}$</td><td></td><td></td><td>✓</td><td></td></tr>
<tr><td>Isotope that decays by alpha decay to form $^{220}_{86}\mathrm{Rn}$</td><td></td><td>✓</td><td></td><td></td></tr>
</table>
</td><td>one mark for each correct row (ignore first row as already ticked)
allow cross instead of tick and ignore any crossed out ticks
if more than one tick in a row then no mark</td><td>4</td><td></td></tr>
<tr><td>1bi</td><td>the atom has lost <u>two electrons</u>✓</td><td></td><td>1</td><td></td></tr>
<tr><td>1bii</td><td>(use of specific charge = charge ÷ mass)
mass = $3.2 \times 10^{-19} \div 8.57 \times 10^{5} = 3.734 \times 10^{-25}$ (kg)
mass number = $3.734 \times 10^{-25} \div 1.66 \times 10^{-27}$ ✓(= 225)
hence $^{225}_{(88)}\mathrm{Ra}$ OR 225✓✓
OR
calculate specific charge for each isotope✓
hence $^{225}_{(88)}\mathrm{Ra}$ OR 225✓✓</td><td>ignore any reference to electrons
first mark for deduction
bald correct answer scores 2 marks
don't need radium symbol or 88

wrong answer scores zero</td><td>3</td><td></td></tr>
</table>

Total			8

Question	Answers	Additional Comments/Guidance	Mark	ID details
2ai	X must have a <u>negative charge</u>✓ to conserve charge✓	second mark dependent on first i.e. conserve charge alone scores nothing can gain second mark by showing balanced equation	2	
2aii	X must be a baryon✓ to conserve baryon number✓	here two marks are independent i.e. conserve baryon number alone scores 1 mark can gain second mark by showing balanced equation	2	
2aiii	K^-: $s\bar{u}$ OR strange anti-up ✓ K^+: $u\bar{s}$ OR up anti-strange✓ K^0: $d\bar{s}$ OR $s\bar{d}$ OR down anti-strange OR strange anti-down✓	in each case the symbols or words can be in either order must be a bar over anti - quark can be upper case letters e.g. U	3	
2aiv	(strangeness on LHS is -1) strangeness on RHS without X is +2 /strangeness of X is -3 ✓ thus sss *OR* strangeness on RHS without X is +2 / strangeness of X is -1✓ thus sdd✓✓	correct strangeness without X on RHS is minimum working needed for first mark next two marks awarded for correct quark structure	3	

Total			10

Question	Answers	Additional Comments/Guidance	Mark	ID details
3a	**The student's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear.** The student'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. *Student names strong, weak and electromagnetic interactions. Identifies that only hadrons experience the strong interaction but hadrons and leptons experience weak interaction. Charged particles experience electromagnetic interaction. Is able to identify all exchange particles such as gluons, W+ and W- and virtual photons. Gives examples of two of the interactions i.e. electrons repelling, electron capture, beta decay.* **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	ignore any reference to gravity ignore any Feynman diagrams electrostatic not allowed as alternative for electromagnetic Properties of interactions • correct exchange particle($W^{(+/-)}$boson/Z_0 boson, (virtual) photon, gluon/pion) NB sign on W not required • correct group of particles affected (strong: baryons and mesons, weak: baryons, mesons and leptons, electromagnetic: charged particles) • example of the interaction Lower band 1 mark – two interactions OR one interaction and one property for that interaction 2 marks – two interactions and one property for one interaction Middle band	6	

	specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate.	3 marks - two interactions plus two properties 4 marks – two interactions plus minimum of four properties (e.g. 3 props plus 1 OR 2 props plus 2), if three interactions quoted then properties can be spread between the 3 e.g. one property for each (3) plus one additional Top band 5 marks – 3 interactions plus two properties for each 6 marks – must give first two properties for all three interactions AND correctly state two examples of interactions e.g. electron capture example of weak, strong nuclear responsible for binding protons/neutrons/baryons together		

	Student names strong, weak and electromagnetic interactions. Identifies that only hadrons experience the strong interaction but hadrons and leptons experience weak interaction. Charged particles experience electromagnetic interaction. Is able to identify some exchange particles such as gluons, W^+ and W^- and virtual photons. **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. *Student names strong, weak and electromagnetic interactions.*	A table may help:		

	strong	weak	EM
property 1			
property 2			
property 3			

	Identifies that only hadrons experience the strong interaction. *Identifies one exchange particle.* **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.** *names of interactions – strong, weak and electromagnetic* *hadrons experience strong* *hadrons and leptons experience weak* *charged particles experience electromagnetic* *identify exchange particles* *give examples of various interactions e.g. electron capture*			

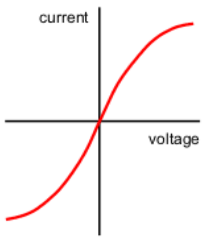
3b	(either weak interaction or electromagnetic or strong interaction) first mark conservation at left hand junction of charge, baryon and lepton number✓ second mark conservation at right hand junction of charge, baryon and lepton number✓ third mark for correct exchange particle✓	if exchange particle not identified but baryon and lepton numbers conserved on both sides – 1 mark ignore orientation of line showing exchange particle or any arrows on exchange particle line when awarding first two marks if arrows on incoming and outgoing interacting particles in wrong direction then lose mark if lines do not meet at a junction lose 1 mark **with third mark** orientation of exchange particle line must be consistent with exchange particle shown and no arrow required	3	

		if exchange particle line is horizontal (for weak) then must be a correct arrow arrow overrides slope		
Total			9	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4ai	the <u>minimum energy</u> required by an <u>electron</u>✓ to escape from a (metal)<u>surface</u>✓	if refer to atom/ionisation zero marks	2	
4aii	the (minimum) energy to remove an electron(from an atom)✓ from the <u>ground state</u>✓		2	
4b	(use of $hf=eV$) $6.63 \times 10^{-34} \times f = 5.15 \times 1.60 \times 10^{-19}$✓ $f = \frac{5.15 \times 1.60 \times 10^{-19}}{6.63 \times 10^{-34}}$ ✓$= 1.24 \times 10^{15}$(Hz)	if no working and 1.24×10^{15}(Hz) 1 mark	2	
4c	(use of $hf = E_k + \Phi$) $\Phi = 2.28 \times 1.60 \times 10^{-19} = 3.648 \times 10^{-19}$ (J) ✓ $E_k = 5.15 \times 1.60 \times 10^{-19} - 3.648 \times 10^{-19} = 4.59 \times 10^{-19}$ J ✓✓	3 sig figs if clearly used 1.2×10^{15} then final answer must be to 2 sig. figs. for last mark to be awarded accept 4.57 in place of 4.59	3	
4d	(use of $c=f\lambda$)	first mark minimum working - determination of wavelength	3	

	$\lambda = \dfrac{3.0\times10^{8}}{1.24\times10^{15}}$ =2.42 × 10^{-7}✓ $v = h/m\lambda$ = 6.63 × 10^{-34}/(9.11 × 10^{-31}×2.42 × 10^{-7} v = 3010 m s^{-1}✓✓	bald answer gets 2 marks range to 3 sig figs 2900 – 3030		

Total			12

Question	Answers	Additional Comments/Guidance	Mark	ID details
5a	 ✓✓	first mark for linear at origin and decreasing gradient in either quadrant (linear region can be very small) second mark for symmetry plus no dip at end or extended horizontal section at end straight line scores zero	2	
5bi	resistance (of filament lamp) increases✓		1	
5bii	filament lamp is a non-ohmic conductor as current is not (directly) proportional to voltage /resistance is not constant✓	proportionality can be shown using graph	1	
5c	either circuit/total resistance increases✓ (hence) current decreases and pd/voltage across R decreases✓	implication that current is different in different parts of series circuits scores 0 implication that new total current is greater scores zero	2	

	OR resistance of PQ combination increases✓ (hence) greater share of pd/voltage across lamp P✓	voltage flowing loses second mark		
5di	(use of *energy* =*VIt*) (energy converted by X = 60 × 120 × 3600 =) 2.59×10^7 J ✓ (energy converted by Y = 11 × 120 × 3600 =) 4.75×10^6 J ✓	Accept answers to 1 sig. fig.	2	
5dii	in lamps energy is wasted as heat/thermal energy✓ specific lamp considered e.g. in lamp, X/ filament lamp more energy is wasted OR in X/filament lamp less energy is converted to light/luminosity✓		2	
Total			10	

Question	Answers	Additional Comments/Guidance	Mark	ID details
6a	emf is the work done/ energy transferred by a voltage source/battery/cell ✓per <u>unit</u> charge✓ OR electrical energy transferred/converted/delivered/produced✓ per <u>unit</u> charge✓ OR pd across terminals when no current flowing/open circuit✓✓	not <u>in</u> battery accept word equation OR symbol equation with symbols defined if done then must explain energy/work in equation for first mark	2	
6bi	by altering the (variable)<u>resistor</u>✓		1	
6bii	reference to correct internal resistance✓ terminal pd = emf – pd across internal resistance/lost volts✓ pd/lost volts increases as current increases OR as (variable)	e.g. resistance of potato (cell) accept voltage for pd	3	

	resistance decreases greater proportion/share of emf across internal resistance✓			
6biii	draws best fit straight line and attempts to use gradient✓ uses triangle with base at least 6 cm✓ value in range 2600 – 2800 (Ω)✓	stand-alone last mark	3	
6c	total emf is above 1.6 V✓ but will not work as current not high enough/less than 20 mA✓		2	

Total			11

Question	Answers	Additional Comments/Guidance	Mark	ID details
7a	Use of $\rho=RA/l$) cross sectional area= π× (3.7 × 10^{-3})^2 = 4.3 × 10^{-5} (m^2)✓ $\rho=\frac{3.3\times4.3\times10^{-5}}{1000}$ ✓= 1.4(2) × 10^{-7}✓Ω m✓	area : lose first mark if use diameter as radius or fail to convert to m^2 (if both errors still only lose 1 mark) CE area for next two marks but if uses diameter in place of area then lose first two marks if leave length in km lose 2nd mark but CE for answer UNIT stand-alone 4th mark	4	
7b	(current in) steel wire (is less than the current in an) aluminium wire as it has a higher resistivity/resistance OR aluminium is better conductor✓ the six aluminium wires are in <u>parallel</u> OR <u>total</u> cross-sectional area of aluminium is 6 times greater than steel wire✓ each aluminium wire carries three times as much current as		3	

	the (single) steel wire✓			
7c	resistance of 1 km of 6 Al cables in parallel = $\frac{1.1}{6}$=0.183 Ω✓ total resistance of the cable = 0.174 Ω✓ power loss per km = 32.3 kW (or 30.7 kW if they ignore the steel)✓ OR power loss in 1 km of steel = 1.70kW✓ power loss in 1 km each of Al cable = 5.11 kW✓ total power loss per km = 32.4 kW (or 30.7 kW if they ignore the steel)✓ OR calculate current in steel wire and aluminium wire (22.7 and 68.2)✓ calculate power loss in aluminium wire and steel wire(1700 and 5115)✓ calculate total power loss (1700 + 6 × 5115 = 32,4 kW)✓	if ignored the steel wire then can score first anf third mark Accept range 32 kW to 33 kW If ignored steel wire range for third mark is 30 kW to 31 kW if wires treated as series resistors then zero	3	

Total			10