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General Certificate of Education (A-level)
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Physics B: Physics in Context PHYB1

(Specification 2455)

Unit 1: Harmony and structure in the universe

Final

Mark Scheme

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Question	Part	Subpart	Marking guidance		Mark	Comment
1	(a)		Photon Weak (nuclear) / weak interaction / weak nuclear interaction/ weak force	**B1**	2	(right-hand box) TO for listing Must state name (left-hand box) TO for listing
1	(b)		Charge / (electric) charge	**B1**	1	TO for listing any other physical quantity Must be word ;do not accept symbol
1	(c)		Higgs (boson) / Higgs (particle) / Higgs (boson particle) Accept Higg/ Higs / Hig	**B1**	1	Not graviton TO for listing
2	(a)		Mixer Balance (relative strengths of) signals owtte	**B1** **B1**	2	Need idea of adjustment of more than one signal Not: increase / amplify (but allow amplify one more than the other) Not: adjustment of wavelength or frequency Not: combine two or more signals together

2	(b)		Cone aperture or diameter more closely matched to wavelength of sound Increases half beam width / increases diffraction/ same value for Θ when $\lambda \sim b$ Full range of frequencies heard (over wider area)	**B1** **B1** **B1**	3	Describes matching : e.g. short wavelength to small diameter / high frequency to small diameter Produces sufficient diffraction / one speaker then wavelengths wouldn't diffract as much/ Ensures that (frequencies are) diffracted effectively Allow wavelengths for frequencies

3	(a)		Calcium= 40 ,20 correct order Beta minus= 0 , -1 correct order Top line correct / bottom line correct	**B1** **B1** **B1**	2	MAX 2

3	(b)		Same energy released in (each) decay When beta less than max there is missing energy / missing energy cannot be accounted for by recoil of (daughter) nucleus / total energy of beta and recoil nucleus not constant (appears to be violation of conservation of energy) (Must be another particle) to carry away (missing) energy	**B1** **B1** **B1**	3	If only two particles there wouldn't be a range there would be a single value

4			Advantages: more secure / higher bandwidth/ lower attenuation/ much lighter / no crosstalk/no electromagnetic interference / safe near high voltage equipment/ long transmission lines without repeaters / more communication channels Disadvantage: new infrastructure required/ more difficult to mend or join together / can't carry electrical power, will break if bent too much	**B1** **B1**	2	Allow more information <u>per unit time</u> not faster transmission allow more signals <u>per unit time</u> lots of copper wiring already in place as inference of new infrastructure required

5	(a)		<u>Minimum</u> energy to remove an electron from a (metal) <u>surface</u>	**B1** **B1**	2	

5	(b)		Converts 2.28 (eV) to 3.6 x 10^{-19}(J) / 2.28 x 1.6 x 10^{-19} Use of $hf = \varphi_0$ *e.g.* $f = 2.28 / h$ *(*will need to see subject*)* or $2.28 = 6.6(3) \times 10^{-34} \times f$ or $f = 2.28 / 6.6(3) \times 10^{-34}$ (will need to see subject) allow equivalent substitution into $hf = \varphi_0 + KE_{max}$ *where* $KE = 0$ *(f* =) 5.5(0) x 10^{14}(Hz) cao	**C1** **C1** **A1**	3	Condone minus sign here on energy or charge Makes f <u>subject</u> or <u>substitutes</u> correctly for *h* and φ_0 Penalise minus sign on answer

6	(a)	(i)	(fret) S one octave higher is double frequency / half wavelength Halving length string doubles frequency (or halves λ) / frequency is (directly) proportional to reciprocal of length	**B1** **B1** **B1**	3	Must declare ratio to express an increase Or because $f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ (where *T* and *μ* are constants)

6	(a)	(ii)	Use of $f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ Correct rearrangement with T as subject $T = (2Lf)^2 \mu$ T = 66.2(N) to any number of significant figures Answer to 3 significant figures (with working)	**C1** **C1** **A1** **B1**	4	Correct substitution of f and μ including powers of ten (condone error in sub for L: allow 0.525/ 0.465 / 0.418 / 0.315 / 0.263) Condone power 10 error on sub for μ Either with symbols or with a correct substitution including L 66.21 (N)

6	(b)	(i)	String 2 Predominant (or lowest) frequency is 110 Hz	**M1** **A1**	2	All frequencies (or peaks or harmonics) are multiples of 110Hz (or differences are 110 Hz) when plucked at end highest intensity at 110 Hz/ first peak is at 110 Hz **not first frequency**

6	(b)	(ii)	Different quality / timbre / tone / richness Some extra <u>overtones</u> in second sound or Differences in overtones / harmonics **owtte** OR Louder when plucked at end Higher (average) (relative) intensity	**B1** **B1**	2	Not fuller Or relative amplitudes of <u>overtones</u> is <u>different</u> for each Or reverse argument Not just higher

7			The marking scheme for this question includes an overall assessment for the quality of written communication (QWC). There are no discrete marks for the assessment of QWC but the candidate's QWC in this answer will be one of the criteria used to assign a level and award the marks for this question. **Descriptor** – an answer will be expected to meet most of the criteria in the level descriptor. **Level 3 – good** -claims supported by an appropriate range of evidence -good use of information or ideas about physics, going beyond those given in the question -argument well-structured with minimal repetition or irrelevant points -accurate and clear expression of ideas with only minor errors of grammar, punctuation and spelling	**B1** **B1** **B1** **B1** **B1** **B1**	6	5-6: valid, detailed method – analysis will include how to minimise effect of random error –repeats 3-4: valid method lacks detail (lacks triggering / data logger / millisecond timer / how measure length) – will include analysis and repeat for reliability 1-2 : inappropriate method by lack of detail or provides incorrect detail – has some analysis- has some reliability MAX 2 for non-lab method MAX 4 for resonance tube method

			Level 2 – modest -claims partly supported by evidence, -good use of information or ideas about physics given in the question but limited beyond this the argument shows some attempt at structure -the ideas are expressed with reasonable clarity but with a few errors of grammar, punctuation and spelling **Level 1 – limited** -valid points but not clearly linked to an argument structure -limited use of information about physics -unstructured -errors in spelling, punctuation and grammar or lack of fluency **Level 0** -incorrect, inappropriate or no response Some points Appropriate apparatus listed or in diagram Measurements taken including instruments used Processing data to determine speed Reliability by repeating or reducing random error Mention of high skilled approach in method.			

8	(a)	(i)	Ultraviolet / uv	**B1**	1	TO for listing

8	(a)	(ii)	(In collision) atomic electron receives energy / Atomic electron rises to higher energy level Returns to lower energy level (losing energy) / relaxation occurs energy emitted as a <u>photon</u> of em radiation	**B1** **B1** **B1**	3	Accept excitation of the hydrogen atom Must be clear as to which electron is relaxing Maximum 1 mark from first two marks where terms used are excitation **and** relaxation without reference to electron

8	(a)	(iii)	Use of $c=f\lambda$ or $E = hf$ (condone powers of ten error) Or (energy level =) $-2.2 \times 10^{-18} + \Delta E$ $f = 2.5 (\times 10^{15})$ or sub into $E = hc/\lambda$ $\Delta E = 1.66 \times 10^{-18}$ $(-) 5.4(3) \times 10^{-19}$ (J) / 5.425×10^{-19}	**C1** **C1** **C1** **A1**	4	Makes f subject of formula ($f = c / \lambda$ seen) Or substitutes for c and λ into a correct formula Or partial sub in $E=hf$ seen : $(E=)$ $6.6(3)\times10^{-34} \times f$ *Or $E = hc/\lambda$ seen* *Using their value for ΔE but not* 2.4×10^{-19}, 1.4×10^{-19}, 8.8×10^{-20} Condone powers of 10 error Condone minus sign on ΔE *allow any number that rounds to* 1.7×10^{-18} Condone missing minus sign

8	(b)	(i)	Quasi-stellar radio source	**B1**	1	

8	(b)	(ii)	Extremely luminous / high luminosity still observable even though extremely distant/ large red shift but still observable	**M1** **A1**	2	TO on second mark where candidates states that they are <u>very</u> bright / brightest etc.

8	(b)	(iii)	Correct read off λ = 135.5 nm $\Delta\lambda$ = 15 / 16 / 135-120 / 136 -120 0r equivalent using λ from read off range seen Rearranges to make *v* subject with substitution for *c* : $v = (\Delta\lambda/\lambda) \times 3 \times 10^8$ seen (condone power 10 errors on $\Delta\lambda$ and λ) Subs into Doppler formula with correct powers of 10 <u>And</u> gives answer to more than 1 sf	**B1** **B1** **B1** **B1**	4	Range of read-off 135.5 to 135.8 Must see *v* as subject In any form of formula And answer in range 3.75×10^7 to 4.0×10^7

8	(b)	(iv)	Use of $v=H\,d$ (condone powers of ten errors) / use of speed = distance ÷ time by their distance ÷$3x10^8$ or rearranges to $t=d/c$ in symbols with subject Correct sub with v= $4x\ 10^4$ km s^{-1} or H = 65000 / converts H into other acceptable form (d =)5.96×10^8 to 6.15×10^8 (Pc) seen / correct sub into $v=H\,d$ with acceptable variant of H / (d=) 1.9 x 10^{25} (m) / their d x 3.26 / their d x 3.08 x 10^{16} 1.9 x 10^9 to 2.0 x 10^9 (years) condone 1 sf here	**C1** **C1** **C1** **A1**	4	or rearranges to $d = v / H$ in symbols with subject. ecf for v from 8b iii Other forms of H = 2.11×10^{-18} and 1.99×10^{-2} (with v = 4×10^7) ecf for v from 8b iii ecf for v from 8b iii Answer must be in this range

9	(a)	(i)	Allow any frequency in range from 40 MHz to 1 GHz	**B1**	1	$4x10^7$ Hz to $1x10^9$ Hz

9	(a)	(ii)	Limited diffraction / requires a line of sight / signal is blocked by hills etc. (Because of its) short wavelength / high frequency	**B1** **B1**	2	Treat satellites/ curvature of earth / skip zones as neutral

9	(b)	(i)	Appropriate diagram / (identifies as property of) transverse wave	**B1**	2	Where drawn, different vibrations should centre on same axis and have same wavelength Accept labelling of diagram with transverse

			Restricting (direction) of oscillations to a single plane	**B1**		Allow vibration for oscillation
9	(b)	(ii)	Must be aligned vertically / Must be pointing towards transmitter (Only receive strong signal when) aerial's alignment matches polarisation of transmitted wave / when aerial not in plane of transmitted wave then there is a reduction in strength of received signal / Aerial must have (maximum) alignment with the (electric field of) carrier wave	**B1** **B1**	2	Allow oscillation for transmitted wave Not satellite dish
10	(a)	(i)	Hadrons / hadron	**B1**	1	TO listing
10	(a)	(ii)	d = -1/3 (e) anti s = +1/3 (e) **and** -1/3 (e) + 1/3(e) = 0 *must see summing and equal to zero , in either order when d and anti s are identified*	**B1**	1	When d and anti s are not identified then need to see: -1/3 (e) + 1/3(e) = 0 *in this order*
10	(b)	(i)	(+)1 or +1/3+1/3+1/3 -1	**B1** **B1**	2	
10	(b)	(ii)	strangeness violation allowed in (weak)decay / conserve baryon number / conserve lepton number/ conserve charge/ must have a baryon number of zero / must have a lepton number of zero/fully describes charge conservation e.g. 0 = -1(e) + 1(e) or in words	**B1**	1	TO where incorrect listing
10	(b)	(iii)	Contains strange quark / has strangeness / doesn't decay by strong interaction because strangeness not conserved in	**B1**	1	Contains anti-strange quark

			decay			