PEARSON EDEXCEL IGCSE PHYSICS · 4PH1

PHYSICS



MARK SCHEME

SECTION 8: ASTROPHYSICS (PACK 2)

SCORE	PERCENTAGE
/122	%

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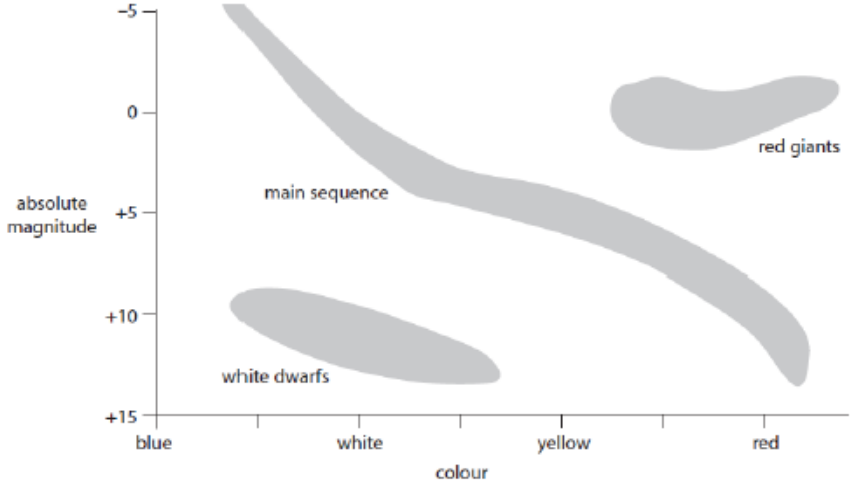
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Mark Scheme

Q1.

Question number	Answer	Notes	Marks
(a)	W marked between +10 and +15 absolute magnitude and between blue and white/yellow colour marks;		1
(b)	X marked between 0 and -5 absolute magnitude and between yellow/red and end of colour scale;		1
(c)	Y marked above and to the left of the Sun;	judge by eye	1
(d)	Z marked vertically in line with and below the Sun;	judge by eye	1
(e)	Any one from: MP1. idea that the Moon does not emit its own light; MP2. Idea that the Moon is not a star MP3. idea that the (surface) temperature of the Moon is too low / does not fit on the scale;		1

Q2.

Question number	Answer	Notes	Marks
(a)	(a measurement of) the brightness (of a star); at a standard distance;	allow measurement of luminosity/power of a star apparent magnitude allow at 10 pc/32.6 ly. condone incorrect distance.	2
(b)	correct absolute magnitude scale; x-axis labelled 'colour'; main sequence top-left to bottom-right with clear flatter region in the middle; white dwarf region in bottom-left corner with part of it in line with 'white' label on x-axis; red giant region in top-right corner with part of it in line with 'red' label on x-axis;  	i.e. going from +15 to -5 in regular intervals condone 'temperature'	5

Q3.

Question number	Answer	Mark
(a)(i)	B	1

Question number	Answer	Mark
(a)(ii)	A	1

Question number	Answer	Mark
(a)(iii)	A	1

Question number	Answer	Mark
(a)(iv)	A	1

Question number	Answer	Additional guidance	Mark
(b)	Any two suitable reasons: e.g. • stars are made mostly of hydrogen (1) • helium is formed during fusion (1) • carbon is formed during fusion (1) • hydrogen formed after Big Bang (1)	do not allow both helium from fusion and carbon from fusion allow helium formed after Big Bang	2

Question number	Answer	Additional guidance	Mark
(c)(i)	• Determination of λ_0 AND λ (1) • Determination of $\Delta\lambda$ (1) e.g. 760 nm, 655 nm $\Delta\lambda$ = 105 (nm)	allow ± 5 nm	2

Question number	Answer	Additional guidance	Mark
(c)(ii)	Rearrangement of equation $v = \frac{\Delta\lambda}{\lambda_0} \times c$ (1) substitution with correct power for c $v = \frac{3 \times 10^5 \times 105}{655}$ (1) evaluation 4.8×10^4 (km/s) (1)	allow ecf from (c)(i) if the answer is given in m/s, check that the power is 10^7 award full marks for correct numerical answer without working	3

Question number	Answer	Additional guidance	Mark
(d)	An explanation that makes reference to the following three points: • RHS shows red shift (1) • LHS shows blue shift (1) • the galaxy is spinning (1)	RHS moving away from the astronomer LHS moving towards the astronomer	3

(Total for question = 14 marks)

Q4.

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>(a)</td><td colspan="2"><table>
<tr><th>Observation</th><th>Supports the Big Bang theory</th></tr>
<tr><td>Black holes are formed from extremely massive stars</td><td></td></tr>
<tr><td>Cosmic microwave background radiation is seen in all directions</td><td>✓</td></tr>
<tr><td>Cosmic rays from space are detected at the Earth's surface</td><td></td></tr>
<tr><td>Each galaxy contains billions of stars</td><td></td></tr>
<tr><td>Most galaxies show a red-shift in the light detected from them</td><td>✓</td></tr>
</table>
1 mark for each correct tick;
-1 for each additional tick if more than two ticks seen
5 ticks scores zero</td><td>2</td></tr>
<tr><td>(b)</td><td>B (decreases, increases);

A is incorrect because a red giant is more powerful than a main sequence star
C is incorrect because a red giant is cooler and more powerful than a main sequence star
D is incorrect because a red giant is cooler than a main sequence star</td><td></td><td>1</td></tr>
<tr><td>(c)</td><td>the brightness/luminosity (of an object);
idea of a standard distance;</td><td>allow 10 parsecs/32(.6) light years
condone incorrect distance</td><td>2</td></tr>
<tr><td colspan="4">Total for Question = 5 marks</td></tr>
</table>

Q5.

Question number	Answer	Notes	Marks
(a)	any two from: MP1. CMBR appears to be the same in all directions / is everywhere; MP2. (which) implies all parts of the Universe were in contact a long time ago; MP3. wavelength has increased (as the universe has expanded); MP4. Universe was (significantly) hotter long ago;	 allow implication of idea of coming from single point allow red-shift of radiation allow frequency has decreased allow RA	2
(b)	change in wavelength = 78 (nm); substitution; rearrangement; evaluation; e.g. (683 – 605 =) 78 (nm) 78 / 605 = v / c $v = 3.0 \times 10^8 \times (78/605)$ (v =) 3.9×10^7 (m/s)	ignore units -1 for POT error use of incorrect source wavelength gives 3.4×10^7 (m/s) = 3 marks allow $3.86... \times 10^7$ (m/s)	4
		(Total for Question = 6 marks)	

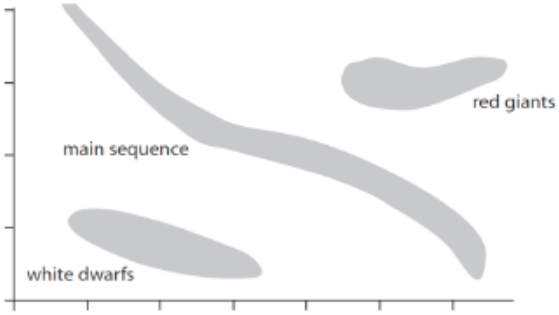
Q6.

Question number	Answer	Notes	Marks
(a)	Universe began as hot / dense point; Universe has expanded since the Big Bang; Universe has cooled since the Big Bang;	allow idea that Universe started as a single point	3
(b)	any four from: MP1. presence of cosmic microwave background radiation; MP2. CMBR comes from all directions; MP3. CMBR (began as gamma radiation and) wavelength increased (as Universe expanded); MP4. red-shift of galaxies; MP5. further/faster galaxies show a greater red-shift; MP6. red-shift indicates that galaxies are moving away from each other; MP7. relative abundance of helium; MP8. helium formed when Universe was hot enough to fuse protons;	 allow CMBR allow CMBR is uniform allow large amount of helium	4

Q7.

Question number	Answer	Notes	Marks
(a)	a (large) collection of (billions of) stars;	allow solar systems for stars	1
(b)	D (the universe); A is not the correct answer because a nebula is a gas cloud B is not the correct answer because a red giant is a star C is not the correct answer because a solar system consists of a star and planets		1
(c) (i)	galaxy A is moving towards Earth; galaxy B is moving away from Earth; galaxy B is moving faster than galaxy A;	allow 1 mark for galaxies moving in opposite directions if neither of these marks scored	3
(ii)	correct evaluation of $\Delta\lambda$; substitution into $\Delta\lambda/\lambda = v/c$; rearrangement; evaluation; $\Delta\lambda = (657.81 - 656.45 =) 1.36$ (nm) $1.36/656.45 = v/3\times10^8$ $(v =) 1.36 \times 3\times10^8 / 656.45$ (v =) 620 000 (m/s)	allow ECF from incorrect $\Delta\lambda$ if clear from working can be in nm or m -1 if 657.81 used as λ allow 3 marks max. if galaxy A used, giving v = 109 681... 729 693..., 731 473... score 2 marks 620 239 etc. scores 3 marks allow 621 524 etc.	4

Q8.

Question number		Answer	Notes	Marks
(a)	(i)	B - main sequence stars; A is not correct as black holes do not appear on the HR diagram C is not correct as neutron stars are not part of the main sequence. D is not correct as protostars are not part of the main sequence		1
	(ii)	bottom left area of the HR diagram;	unlabelled scores 0	1
	(iii)	top right hand area of HR diagram;  	unlabelled scores 0	1
	(iv)	a measure of brightness/luminosity; idea that a star would be at a standard distance (10 parsecs/32(.6) light years);	accept power ignore lack of or incorrect value for distance	2
(b)	(i)	C - ultraviolet; A is not correct as microwaves cause internal heating B is not correct as radio waves do not give skin burns D is not correct as visible light cannot harm skin cells.		1
	(ii)	A - sunbathing; B, C and D are not correct as all reduce the absorption of UV by skin.		1
			Total for Question : 7 marks	

Q9.

Question number	Answer	Notes	Marks
(a)	correct substitution KE = ½ (mass) × (speed)²; re-arrangement to give v; evaluation to show 5.8(4...) (m/s); e.g. KE = ½ m v² 0.29 = 0.5 × 0.017 × v² v² = 0.29 ÷ (0.5 × 0.017) = 34.1176471.. v = √34.1176471 = 5.8(4...) (m/s)	allow use of standard symbols e.g. KE = ½ m v² allow mass = 17 at this point	3
(b)	idea of conservation of momentum; idea that momentum before release was zero; evidence of re-arrangement; evaluation of large block speed giving 1.3 m/s; e.g. momentum of small block = 17 × 6 = 102 g m/s therefore momentum of large block = 102 g m/s momentum = mass × velocity = 75 v so v = 102/75 = 1.36 m/s	however expressed allow idea that momenta of two blocks is equal in magnitude allow 1.4 if v_{small} = 6 m/s ignore mass unit provided both masses consistent v=1.31 if v_{small} = 5.8 m/s v=1.32 if v_{small} = 5.84 m/s	4
(c)	substitution into given equation; idea of initial momentum = 0; evaluation; correct answer = 0.93 (N) e.g. force = change in momentum ÷ time taken force = ((0.017 × 6) - 0) ÷ 0.11 force = 0.102 ÷ 0.11 force = 0.9272... (N)	 allow use of init velocity = 0	3
(d)	substitution and re-arrangement of given equation; conversion of 17.6 cm to 0.176 m; evaluation; correct answer = 0.18(41...) (s) e.g. orbital speed=(2π × orbital radius)÷time period 6 = (2π × 0.176)÷T T = (2π × 0.176) ÷ 6 T = 0.1843... (s)	 accept 0.2 (s) accept use of v=5.84...(m/s) -1 POT error 0.092.. (s) for using 17.6 cm as a diameter scores 2 marks	3
		Total for Question : 13 marks	

Q10.

Question number	Answer	Notes	Marks
(a)	neutral particle has same number of protons and electrons; positive particle has more protons than electrons;	ignore neutral particle has no charge allow positive particle has lost electrons reject positive particle has gained protons	2
(b)	(sulfur particles are) attracted to negative plate/repelled by positive plate; (sulfur) particles experiences a (resultant) force (to the right);	accept correct use of "like charges repel" or "unlike charges attract"	2
(c) (i)	D - (into the page); A is incorrect because the force, direction of travel and magnetic field must be at right angles to each other B is incorrect because the force, direction of travel and magnetic field must be at right angles to each other C is incorrect because this would result in a force in the opposite direction to that shown		1
(ii)	substitution into given formula; rearrangement; evaluation; e.g. $2.9 \times 10^8 = (2 \times \pi \times 1.1(\times 10^3)) \div$ orbital period orbital period = $(2 \times \pi \times 1.1(\times 10^3)) \div 2.9 \times 10^8$ (orbital period =) 2.4×10^{-5} (s)	-1 for POT error allow $2.383... \times 10^{-5}$ (s)	3
		Total for Question = 8 marks	

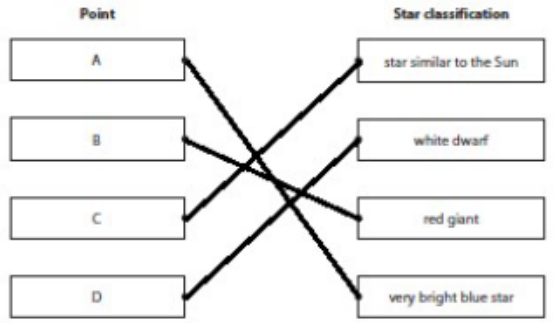
Q11.

Question number	Answer	Notes	Marks
(a)	idea that universe is expanding / getting larger; idea that universe is cooling;		2
(b)	MAX four from: MP1. identification of cosmic (microwave) background radiation (CMBR); MP2. CMBR appears to be the same in all directions/is everywhere; MP3. which implies all parts of the Universe were in contact a long time ago; MP4. wavelength has increased as the universe has expanded; MP5. universe was (significantly) hotter long ago; MAX four from: MP6. identification of red shift **of galaxies**; MP7. the further the galaxy is (from Earth), the greater the red-shift; MP8. larger redshift means faster movement of galaxies; MP9. (therefore) the further away, the faster the galaxy moves away; MP10. galaxies moving apart from each other implies expansion from a single point **or** since the Big Bang;	 allow idea of coming from single point or singularity allow 'frequency has decreased as the universe has expanded' allow RA condone "star" for "galaxy" for MP7-10 accept speed of galaxies increases (is directly proportional to) with increased distance; accept 'relationship between speed and distance' for 'galaxies moving apart from each other' allow singularity for single point	6
			Total for question = 8 marks

Q12.

Question number	Answer	Notes	Marks
(a)	Cosmic Microwave Background Radiation (CMBR) (Cosmological) Red shift of galaxies	Allow one missing word Accept reference to Hubble's Law. Allow higher level idea of ratio of hydrogen to helium as alternative to either marking point.	2
(b)	CMBR MAX TWO from MP1 CMBR appears to be the same in all directions/is everywhere; MP2 Which implies all parts of the Universe were in contact a long time ago; MP3 Wavelength has increased as the universe has expanded; MP4 universe was (significantly) hotter long ago; Red Shift of Galaxies MAX TWO from MP5 The further the galaxy is from Earth, the greater the red-shift; MP6 The greater the red-shift, the faster the galaxy is moving away; MP7 Speed of galaxies increases (is directly proportional to) with increased distance; MP8 Relationship between speed and distance implies expansion from a single point or since the Big Bang;	Allow implication of idea of coming from single point Allow frequency has decreased Allow RA Condone "star" for "galaxy" for MP5 Allow 'red shift' for 'speed of galaxies' Allow 'galaxies moving apart from each other' for 'relationship between speed and distance'	4

Q13.

Question number	Answer	Notes	Marks
(a)	1 mark for each correct line;;;;  	reject any box from the left with 2 lines	4
(b)	(a measure of) brightness; (of a star) at a {standard / fixed / same} distance;	allow power, luminosity, intensity allow correct distance e.g. 10 parsecs/32(.6) light years	2
		Total for Question = 6 marks	

Q14.

Question number	Answer	Notes	Marks
(a)	B – gravitational; A is incorrect because there are no charges C is incorrect because there are no magnetic fields D is incorrect because nuclear forces are short range		1
(b)	D – universe; A is incorrect because the universe contains billions of galaxies B is incorrect because each solar system contains several planets C is incorrect because galaxies contain billions of stars		1
(c)	A – absolute magnitude; B is incorrect because colour determines the surface temperature of a star C is incorrect because diameter determines the power of a star D is incorrect because temperature determines the power of a star		1

Q15.

Question number	Answer	Notes	Marks
(a)	use/substitution of distance = average speed x time; total distance travelled = 2 x distance to plane; evaluation of distance to at least 2s.f.; e.g. total distance = $1.9 \times 10^{-3} \times 3.0 \times 10^{5}$ total distance = 570 km = 2 x distance to plane distance to plane = 570/2 = 285 (km)	reject use of $v=f\lambda$ allow idea that time required is half of total time.	3
(b)	substitution into given equation $\Delta\lambda/\lambda = v/c$; rearrangement; evaluation; e.g. $1.1 \times 10^{-6} / 1.2 = v/3 \times 10^{8}$ $v = 3 \times 10^{8} \times 1.1 \times 10^{-6} / 1.2$ v = 280 (m/s)	 -1 POT error allow ecf from wrong change in wavelength condone premature rounding allow 275 (m/s)	3
		Total for Question = 6 marks	

Q16.

Question number	Answer	Notes	Marks
(a) (i)	substitution into given equation; rearrangement; correct evaluation of wavelength change;	 -1 POT error condone 1 sf	3
	correct answer: 8.1×10^{-8} (m)	8.06×10^{-8} to 3sf	
	e.g. (change in wavelength/6.2×10^{-7})= ($3.9 \times 10^{4}/3.0 \times 10^{5}$) change in wavelength = $6.2 \times 10^{-7} \times$ ($3.9 \times 10^{4}/3.0 \times 10^{5}$) change in wavelength = 8.1×10^{-8} (m)		
(ii)	candidate's answer to (i) + 6.2×10^{-7} (m); e.g. $8.1 \times 10^{-8} + 6.2 \times 10^{-7} = 7.0 \times 10^{-7}$(m)	ECF wavelength change condone 1sf	1
(b)	Any THREE from: MP1: the further the galaxy is from Earth, the greater the red-shift; MP2: the greater the red-shift, the faster the galaxy is moving away; MP3: speed of galaxies increases with increased distance; MP4: the speed and distance are directly proportional; MP5: relationship between speed and distance implies expansion; MP6: expansion implies there was a single point in the past;	 condone "star" for "galaxy" allow "galaxies moving apart from each other" condone RA for MP6	3

Q17.

Question number	Answer	Notes	Marks
(a)	An arrow drawn from left to right by eye;		1
(b)	Comparative statements for side containing A: Wavefronts closer together/EQ; (therefore) wavelength smaller; Same speed; ($v = f \times \lambda$ so) frequency larger;	Allow RA for B Allow e.g."waves more compressed together" Condone mention of the Doppler effect for 1 mark if no other mark scored.	4