PEARSON EDEXCEL IGCSE PHYSICS · 4PH1

PHYSICS



MARK SCHEME

SECTION 8: ASTROPHYSICS (PACK 1)

SCORE	PERCENTAGE
/199	%

STEMUP

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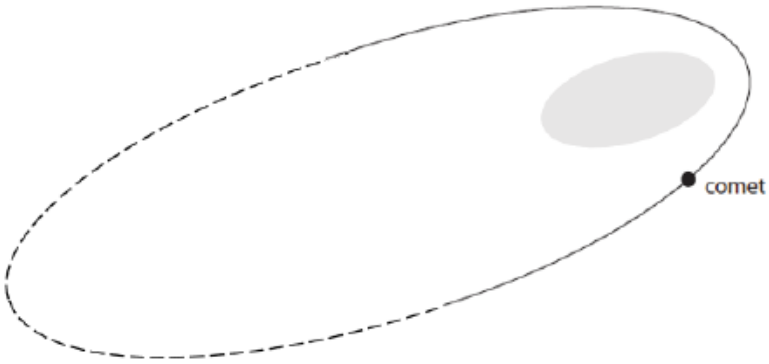
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Mark Scheme

Q1.

Question number	Answer	Notes	Marks
(a)			
(i)	centre of S marked in the grey region shown;	allow if centre of S marked in a similar position on the other side of the drawn orbit	1
(ii)	closed path drawn with curve; total size approximately twice size of original diagram;	curve should extend at least as far as the start of the word "diagram" in sentence below i.e.  	2
(iii)	X marked on part of path closest to candidate's S;	reject if another contradictory cross drawn	1

(b)	any three from: MP1. comet's orbit is more elliptical/oval; MP2. (orbital) path of comet is longer; MP3. idea that speed of comet varies but speed of planet does not; MP4. both planet and comet orbit a star; MP5. idea that orbital radius of comet varies but orbital radius of planet does not; MP6. plane of comet's orbit different to plane of planet's orbit; MP7. star is at centre of planet orbit but not at centre of comet orbit;	comparison needs to be seen allow planet's orbit is more circular allow distance for path allow period of orbit of comet is longer allow the Sun for star allow (star's) gravitational force is constant for planet but varies for comet	3
		Total for Question = 7 marks	

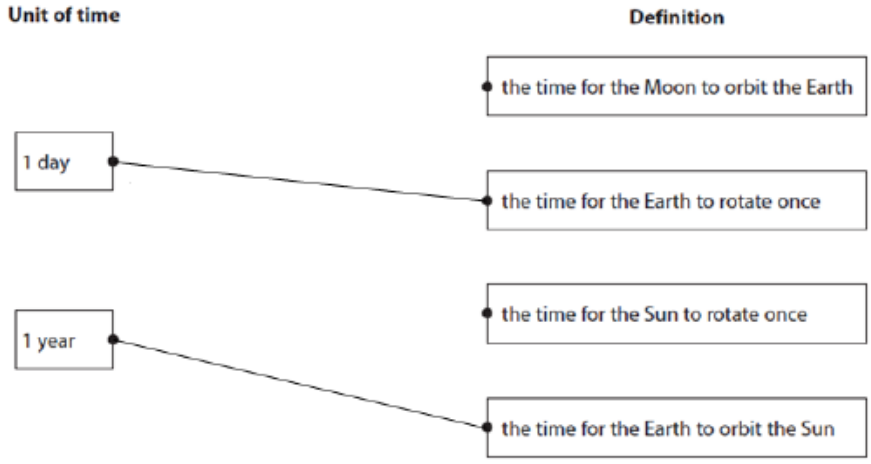
Q2.

Question number	Answer	Notes	Marks
(a)	D (the Sun); A is incorrect because a comet is the smallest object B is incorrect because the Earth is smaller than the Sun C is incorrect because the Earth and the Sun are larger than the Moon		1
(b)	A (alpha); B is incorrect because beta is less ionising than alpha C is incorrect because gamma is less ionising than alpha D is incorrect because gamma has a higher frequency than UV so is more ionising		1
(c)	B (ohm); A is incorrect because ampere is the unit for electric current C is incorrect because volt is the unit for voltage D is incorrect because watt is the unit for power		1
(d)	D (x-ray); A is incorrect because infrared has a longer wavelength than ultraviolet and x-ray B is incorrect because microwave has the longest wavelength C is incorrect because ultraviolet has a longer wavelength than x-ray		1
(e)	C (273 K); A is incorrect because this is subtracting 273, rather than adding 273 B is incorrect because this is adding 3, rather than adding 273 D is incorrect because this is adding 373, rather than adding 273		1
		Total for question = 5 marks	

Q3.

Question number	Answer	Notes	Marks
(a)	D - a star; A and C cannot be correct because satellites orbit planets B cannot be correct because comets orbit stars		1
(b)	D - universe; A cannot be correct because there are billions of galaxies in the Universe B and C cannot be correct because there are billions of stars and their solar systems in each galaxy		1
(c)	B - moon; A cannot be correct as there are billions of stars and their solar systems in each galaxy C cannot be correct because moons orbit planets and those planets orbit stars D cannot be correct because a solar system includes stars planets and moons		1
(d)	Earth has a larger mass than the Moon;	accept reverse argument allow Earth has a larger density condone referring to Moon as a planet condone idea of different mass ignore reference to size	1
		(Total for Question = 4 marks)	

Q4.

Question number	Answer	Notes	Marks
(a)	Universe; galaxy Solar System;	 allow named galaxy e.g. Milky Way	3
(b) (i)	A; B is incorrect because it is further from the Sun and speed decreases with distance C is incorrect because it is further from the Sun and speed decreases with distance D is incorrect because it is further from the Sun and speed decreases with distance		1
(ii)	gravity;	allow gravitational force, gravitational pull reject gravitational potential, gravitational field strength, g	1
(c)	one mark for each correct line;;  	-1 for each additional line	2

Q5.

Question number	Answer	Mark
(a)(i)	Process includes: • rearrangement (1) • substitution (1) • evaluation of orbital radius (1) • answer to 3 s.f. (1) e.g. $r = v \times T/2\pi$ (1) $r = (7.66 \times 92.7 \times 60)2\pi$ (1) $r = 6781$ (km) (1) $r = 6780$ (km) (1)	4

Question number	Answer	Additional guidance	Mark
(a)(ii)	Earth radius = r − 409 = 6370 (km)	Allow ecf Allow 6 371 (km) Allow 6 372 (km)	1

(Total for question = 5 marks)

Q6.

Question number	Answer	Notes	Marks
(a)	Callisto drawn with a circular orbit around Jupiter; Jupiter positioned at the centre of the orbit;	judge circular shape by eye	2
(b)	conversion of time from hours to seconds; substitution into orbital speed formula; evaluation; final answer given to 3s.f.; e.g. time = (400 × 60 × 60 =) 1 440 000 (s) (orbital speed =) 2 × π × 1 880 000 / 1 440 000 (orbital speed =) 8.203... (km/s) (orbital speed =) 8.20 (km/s)	allow use of 1 440 000 seen anywhere allow ecf from incorrect time conversion mark independently	4
(c) (i)	any one from: MP1. Callisto has a larger radius; MP2. Callisto has a lower density; MP3. Callisto has a smaller core;	allow RA allow Callisto is larger ignore references to orbital radius/distance from Sun	1
(ii)	use of weight = mass × g; setting up ratio OR evaluation of mass of object; evaluation of weight on Callisto; e.g. $W = m \times g$ $W_c / g_c = W_m / g_m$ OR m = 37 (kg) (W_c =) 44 (N)	seen anywhere in working answer of 78-79 gets 2 marks allow 44.3, 44.25	3
		Total for Question = 10 marks	

Q7.

Question number	Answer	Mark
(a)	D	1

Question number	Answer	Mark
(b)	B	1

Question number	Answer	Mark
(c)	D	1

Question number	Answer	Mark
(d)	C	1

(Total for question = 4 marks)

Q8.

Question number	Answer	Notes	Marks
(a) (i)	idea that kinetic store increases;	e.g. chemical transferred to kinetic	1
(ii)	idea that gravitational store increases;		1
(b)	two correct statements ticked;; Statement / Correct (✓) gravitational store increases ✓ gravitational store stays the same gravitational store decreases kinetic store increases kinetic store stays the same kinetic store decreases ✓	3 ticks scores 1 max 4 or more ticks scores 0	2
(c) (i)	gravitational (force);	allow weight, gravity	1
(ii)	substitution into given formula; evaluation; e.g. orbital speed = (2 × π × 7100) / 5800 (orbital speed =) 7.7 (km/s)	 allow 7.69... (km/s)	2

(d)	any four from: MP1. bars increase in temperature when facing towards Sun / decrease in temperature when facing away from Sun; MP2. (when pointed at the Sun,) black bar increases temperature faster than white bar; MP3. (because) black is a better absorber of radiation than white; MP4. (so) black bar reaches a higher temperature than white bar; MP5. (when pointed away from the Sun,) black bar decreases temperature faster than white bar; MP6. (because) black is a better emitter of radiation than white; MP7. convection/conduction plays no part in heat transfer (outside the spacecraft); MP8. (because) there are no particles outside the spacecraft;	accept any clear reverse argument allow energy, heat, IR for radiation allow energy, heat, IR for radiation	4

Q9.

Question number	Answer	Notes	Marks
	kinetic; main sequence; contract; expand; supernova; neutron star;		6

Q10.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to six of the following points: • **all** main sequence stars fuse H into He (1) • lower mass stars stay on the MS line for longer (1) • lower mass stars become red giants (1) • higher mass stars become red super giants (1) • red giant becomes a white dwarf (1) • supergiant becomes a supernova (1) • supernova becomes a neutron star (1) • supernova becomes a black hole (1)	accept numerical values allow red giant to planetary nebula	6

(Total for question = 6 marks)

Q11.

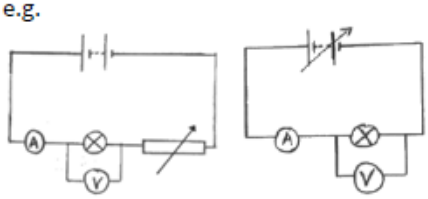
Question number	Answer	Notes	Marks
(a) (i)	downward force arrow labelled "weight"; upward force arrow labelled "drag" / "air resistance"; upward force larger than downward force by eye;	ignore starting position of arrows and any horizontal arrows allow "gravitational force", "gravitational pull", "force of gravity" reject "gravity" allow "friction" ignore "upthrust"	3
(ii)	any four from: MP1. air resistance increases (greatly) when parachute is opened; MP2. idea that air resistance is greater than weight; MP3. (therefore) resultant force is upwards; MP4. idea that as speed decreases, air resistance decreases; MP5. resultant force (eventually) becomes zero; MP6. constant speed achieved;	allow "drag" for air resistance throughout condone "gravity" for weight throughout allow "upwards force" for air resistance allow upward force is bigger than downward force allow deceleration / upwards acceleration ignore "it slows down" allow forces are balanced/equal air resistance = weight allow idea that there is no acceleration	4

(b)	attempted use of $v^2 = u^2 + (2 \times a \times s)$; correct substitution; rearrangement of formula / evaluation of v^2; evaluation of v; e.g. $v^2 = u^2 + (2 \times a \times s)$; $v^2 = 0.45^2 + (2 \times 3.4 \times 2.0)$; $v = \sqrt{(0.45^2 + (2 \times 3.4 \times 2.0))}$ OR $v^2 = 13.8$ (v =) 3.7 (m/s)	accept answers in terms of GPE lost = KE gained, whatever candidate chooses for mass can be implied from calculation reject if contradicted by another irrelevant formula and no further working seen allow if 13.8 seen allow 3.72, 3.715...	4
(c)	any one from: MP1. Mars has a smaller mass; MP2. Mars has a lower density; MP3. Mars has a smaller (iron rich) core;	allow RA allow Mars is less massive	1

Q12.

Question number	Answer	Notes	Marks
(a)	straight arrow drawn in line with the comet pointing from comet towards the star;	judge straightness by eye	1
(b)	use of weight = mass × g; substitution OR rearrangement; evaluation; unit; e.g. $W = m \times g$ $4.4 \times 10^9 = 2.2 \times 10^{14} \times g$ OR $g = W / m$ $(g =) 2.0 \times 10^{-5}$ N/kg	seen or implied allow m/s^2	4
(c)	any three from: MP1. distance of comet from star increases; MP2. gravitational field strength decreases; MP3. mass of comet remains constant; MP4. (therefore) gravitational force decreases; MP5. direction of force changes (because comet's direction changes);	 allow comet gets further from star allow mass decreases if suitably qualified	3

Q13.

Question number	Answer	Notes	Marks
(a) (i)	circuit with symbols for ammeter, voltmeter, lamp, any power supply all correct; voltmeter in parallel with lamp; ammeter in series with lamp; correct means of varying voltage of lamp i.e. variable power supply/rheostat/potentiometer; e.g. 	variable power supplies or variable number of cells can be shown using labelled standard symbols if no lamp in circuit, allow ammeter drawn in series with power supply allow variable resistor in series with lamp	4
(ii)	any four from: MP1. record ammeter and voltmeter reading; MP2. repeat readings (for each voltage) and find average; MP3. idea of changing the voltage / current; MP4. plot a graph of voltage and current; MP5. switch off current/circuit between readings;	allow 'measure voltage and current' allow repeating experiment to find average allow described method that would change voltage or current e.g. adding more cells, changing circuit resistance etc. ignore "let lamp cool between readings"	4

(b) (i)	ampere / amp / A / mA;	reject I	1
(ii)	correctly evaluated energy; given to 2 significant figures; e.g. 162 (J) gets 1 mark 160 (J) gets 2 marks	DOP	2
(iii)	red or orange;		1

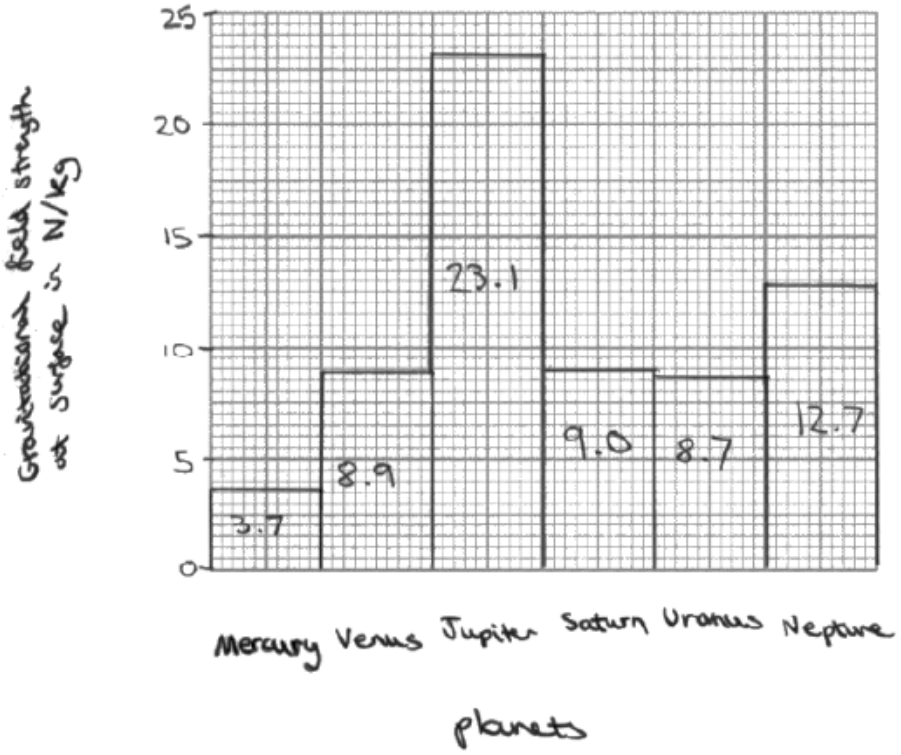
Q14.

Question number	Answer	Notes	Marks
(a)	A (blue-white); B is incorrect because orange stars are cooler than blue-white stars C is incorrect because red stars are cooler than blue-white stars D is incorrect because yellow stars are cooler than blue-white stars		1
(b)	any two from: gas collapses / gas particles attract each other; temperature (of the gas) increases; fusion **starts**/eq;	 condone 'dust' for 'gas' allow particles increase in KE	2
(c)	two (small) **nuclei**; join together (to produce a large nucleus); releasing energy;	 allow gamma radiation	3
(d) (i)	C (mass); A is incorrect because colour is determined by the surface temperature B is incorrect because distance determines its apparent brightness D is incorrect because temperature determines the spectral class		1
(ii)	any three from: MP1. Rigel will become a red supergiant; MP2. then contracts rapidly; MP3. (explodes as a supernova) leaving a neutron star; MP4. (or) black hole;		3

Q15.

Question number	Answer	Notes	Marks
(a)	comet drawn in orbit around the Sun; orbital path is elliptical;	 judge by eye allow partially drawn ellipse Sun need not be at a focus of the ellipse, but should not be at the centre of the ellipse	2
(b)	attempted use of orbital speed formula; valid substitution into orbital speed formula; correct evaluation of time period for either planet; attempt to divide T for Saturn by T for Mars; correct final evaluation of ratio; e.g. $v = 2 \times \pi \times r / T$ $24.1 = 2 \times \pi \times 2.28 \times 10^8 / T$ $T_{Mars} = 5.94 \times 10^7$ (s) OR $T_{Saturn} = 9.26 \times 10^8$ (s) $n = T_{Saturn} / T_{Mars}$ 15.6	 allow for either planet seen anywhere in working $9.70 = 2 \times \pi \times 1.43 \times 10^9 / T$ 5.944... 9.2628... allow range of 15-16	5

Q16.

Question number	Answer	Notes	Marks
(a)	suitable linear scale chosen (>50% of grid used); axes labelled with quantities and unit; <u>all</u> bar plotting correct to nearest half square;  	ignore orientation of axes do not accept multiples of 3 for scale condone missing "planets" label if individual planets are written with bars reject if non-linear scale used bars do not need to be separated from each other or in the same order as the table condone stick graphs	3

(b)	any one from: different masses; different sizes; different densities;	ignore different orbital radius ignore weight allow different volume, radii, diameter ignore different (surface) area	1
(c)	as orbital radius increases, the orbital speed decreases;	condone idea that they are inversely proportional ignore negative correlation	1
(d)	$v = \frac{2 \times \pi \times r}{T}$ substitution into ; rearrangement; evaluation; e.g. $47.4 = 2 \times \pi \times 57.9 \times 10^6 / T$ $T = 2 \times \pi \times 57.9 \times 10^6 / 47.4$ (T =) 7.68×10^6 (s)	 -1 for POT error allow 1s.f. answer if supported by working allow 7.7×10^6, 7.67×10^6, 7675030.154 (s)	3
		Total for Question = 8 marks	

Q17.

Question number	Answer	Notes	Marks
(a) (i)	any one from: satellite orbits a planet/Earth, planet orbits a star/Sun; orbital radius/time period of planet is greater than satellite;	 both aspects of the comparison required allow RA allow planet's orbit is larger	1
(ii)	any one from: both orbit a planet/Earth; both have same shape of orbit;	 allow circular or elliptical	1
(b) (i)	substitution into $v = 2\pi \times r / T$; conversion of 24 hours into seconds; rearrangement and evaluation of orbital radius; evaluation of height; e.g. $3.1 = 2 \times \pi \times r / [24 \times (60 \times 60)]$ $T = (24 \times 60 \times 60 =) 86\,400$ (s) r = 42628 (km) (height = 42628 - 6400 =) 36 000 (km)	ignore units allow 86 400 seen anywhere allow 36228.05996 (km)	4
(ii)	any three from: MP1. speed of waves constant; MP2. if source moving away, wavefronts spread out / wavelength increases; MP3. speed = frequency × wavelength; MP4. (higher wavelength and constant speed of waves) gives lower frequency;	 allow RA for source approaching allow RA for source approaching	3
(iii)	idea that there is no (relative) motion between point on Earth's surface and satellite; (therefore) no wavelength/frequency change;	allow distance to satellite from Earth does not change DOP	2
		Total for Question = 11 marks	

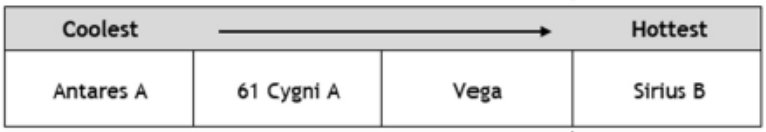
Q18.

Question number	Answer	Notes	Marks
(a)	any four correctly linked stages in star's evolution: MP1. nebula to protostar; MP2. protostar to main sequence; MP3. main sequence to red giant; MP4. red giant to white dwarf; MP5. white dwarf to black dwarf;	limit to 2 marks max. if incorrect stages given e.g. red supergiant, supernova, neutron star, black hole allow cloud of dust/gas for nebula allow main stage for main sequence allow 1 marking point if stage missing e.g. nebula to main sequence gets either MP1 or MP2 since protostar is missing	4
(b)	stars use <u>fusion</u>, reactor uses <u>fission</u>; fusion detail e.g.; • (fusion is the) joining of nuclei • involves light nuclei e.g. hydrogen fission detail e.g.; • (fission is the) splitting of nuclei • involves heavy nuclei e.g. uranium/plutonium	both needed condone atoms for nuclei condone atoms for nuclei	3
		Total for Question = 7 marks	

Q19.

Question number	Answer	Notes	Marks
(a)	;;; Coolest → Hottest B, A, Sun, Sirius, Rigel	1 star in correct place scores 1 mark 2 stars in correct places scores 2 marks 3 marks for all stars in correct places accept colours instead of names i.e. red, orange, yellow, white condone a mix i.e. Betelgeuse, orange, yellow, Sirius	3
(b)	any THREE from MP1. red supergiant; MP2. supernova; MP3. neutron star; MP4. (or) black hole;	 allow super red giant 2 marks max for any incorrect order including incorrect stages e.g. dust/gas cloud or protostar	3
(c)	any pair of readings from the graph; correct substitution into formula to find constant; different pair of readings used correctly to find constant; statement that the results agree with the conclusion; e.g. when temp = 10 kK wavelength = 280 nm 280 × 10 = 2800 140 × 20 = 2800 constants are the same so results agree with proposal	 allow ECF for this mark alone DOP allow idea that the constants are not the same so that the results do not agree with the conclusion	4
		(Total for Question = 10 marks)	

Q20.

Question number	Answer	Notes	Marks
(a) (i)	;;; all four stars in the correct positions = 3 marks any two stars in the correct positions = 2 marks any 1 star in the correct position = 1 mark  		3
(ii)	Antares (A);		1
(b)	any three from: MP1. nebula is (cold) cloud of dust/gas; MP2. gravity causes cloud to collapse/eq; MP3. temperature of cloud increases/eq; MP4. creating a protostar; MP5. idea that (main sequence star created when) fusion starts;		3
(c)	any four from: MP1. idea that hydrogen fusion stops (in core); MP2. core collapses; MP3. core temperature of star increases; MP4. (star expands to) become a red (super) giant; MP5. surface temperature of star decreases (during red giant phase) MP6. helium fusion begins; MP7. white dwarf formed when helium fusion stops (in core); MP8. idea of rest of star released (as a planetary nebula);	condone idea of hydrogen runs out allow star collapses	4

Q21.

Question number	Answer	Notes	Marks
(a)	earliest stage ↓ latest stage nebula main sequence red giant white dwarf ;;;	All correct: 3 marks Any two in correct box: 2 marks Only one correct box: 1 mark	3
(b)	galaxy;	allow any correctly named galaxy eg Milky Way, Andromeda	(1)
(c)	(surface) temperature;	allow description of temperature eg how hot it is	(1)

Q22.

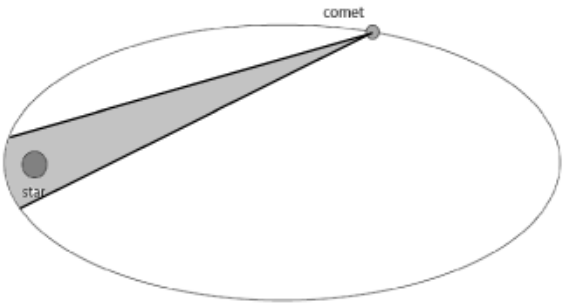
Question number	Answer	Notes	Marks
(a)	(nuclear) fusion;		1
(b)	Sun becomes a red giant; (then) a white dwarf;	 allow planetary nebula reject mention of supernova, neutron star or black hole for this mark	2
(c) (i)	(mass =) 5×10^{29} (kg);	allow 5.3×10^{29}, 5.2×10^{29}, 5.25×10^{29} (kg)	1
(ii)	evaluation of time; answer to 1 significant figure; e.g. (time = $5.25 \times 10^{29} / 9 \times 10^{19}$ =) 5.8×10^{9} (years) (time =) 6×10^{9} (years)	allow ecf from (c)(i) allow 5.56×10^{9} (years) allow 6 000 000 000, 6 billion years	2
			Total for question 5 = 6 marks

Q23.

Question number	Answer	Notes	Marks
(a)	similarity - both have (approximately) circular orbits; difference - planets orbit stars, but moons orbit planets;	both marks can be awarded if clear in labelled diagram allow both have a constant orbital speed allow slightly elliptical for circular both needed for the mark ignore different speeds, radii, time periods	2
(b) (i)	idea that "planet" variable is categoric;	allow discontinuous, discrete for categoric allow idea that planet is not a continuous variable	1
(ii)	correct reading of either Jupiter or Uranus orbital speed; attempt at finding ratio; correct evaluation; e.g. Jupiter = 13.0 (km/s) OR Uranus = 6.75 (km/s) ratio = 13.0 / 6.75 ratio = 1.9	allow numbers seen anywhere in calculation Jupiter = 13.0, Uranus = 6.5-7.0 allow answers left as fractions inverted ratio = 0.50-0.54 = 2 marks allow 6.5-7.0 for Uranus allow 6.75 / 13.0 allow 1.85-2.00	3
(iii)	Earth is the closest planet to the Sun;	allow gravitational pull/strength (of Sun) greatest for Earth allow shortest time period	1
		Total for question = 7 marks	

Q24.

Question number	Answer	Notes	Marks
(a) (i)	C (white); A is incorrect because its temperature is the second lowest B is incorrect because its temperature is the lowest D is incorrect because its temperature is the second highest		1
(ii)	D (white dwarf); A is incorrect because the Sun is not massive enough to form a black hole B is incorrect because the Sun is not massive enough to form a neutron star C is incorrect because the Sun is not massive enough to form a supernova		1
(iii)	C (supernova); A is incorrect because this is during the middle of the life cycle B is incorrect because this is an early stage of the life cycle D is incorrect because this is a late stage in the life cycle of stars like our Sun		1

(b)	arrow pointing from the comet to the star; force labelled 'gravitational';  	accept any arrow pointing from comet to star within shaded area ignore starting position of arrow allow 'gravity' or 'weight'	2
		Total for Question = 5 marks	

Q25.

Question number	Answer	Notes	Marks
(a)	planet;		1
(b)	comet;	accept planet	1
(c)	substitution into given formula; conversion of 35 days into seconds; evaluation; e.g. $v = 2 \times \pi \times 1.5 \times 10^{11} / (35 \times 24 \times 60 \times 60)$ $v = 310\,000$ m/s	 allow full credit for 2.6927937×10^{10} if unit changed to m/day. 311665.93(7)8 Answer for incorrect/no conversion of days→ seconds 2.69etc x 10^{10} scores 2 -1 for POT error	3
		(Total for Question = 5 marks)	

Q26.

Question number	Answer	Notes	Marks
(a)	planet drawn with approximately circular orbit with Sun at its centre; comet drawn with elliptical orbit with Sun at one of its foci;	planet must be labelled comet must be labelled	2
(b) (i)	nebula / gas cloud;	allow protostar, dust cloud reject planetary nebula	1
(ii)	colour will become red; (because) the (surface of) Sun will cool down;	allow orange allow 'Sun will become a red giant'	2
(c) (i)	any three from: MP1. beta is negatively charged <u>and</u> alpha is positively charged; MP2. beta has lower/less mass; MP3. beta has 1 charge but alpha has 2 charges; MP4. beta is an electron <u>and</u> alpha is 2 protons and 2 neutrons; MP5. beta is less ionising (with distance); MP6. beta has longer range; MP7. beta has higher penetration power;	 allow they are oppositely charged allow RA allow beta has less charge allow alpha is helium nucleus allow RA allow RA allow RA	3
(ii)	any two from: MP1. radioactive source has not been in contact with spacecraft; MP2. idea that spacecraft was not contaminated; MP3. idea that spacecraft has only been irradiated;	 allow spacecraft does not contain any radioactive isotopes allow spacecraft has only been exposed to radiation	2
		Total for question = 10 marks	