1. **Maximum of 6 marks**

Copernicus: heliocentric	[1]
Copernicus:circular orbits	[1]
Kepler: elliptical motion Sun at one focus	[1]
Kepler/ Copernicus correct reference to epicycles	[1]

Any 3 from:

Newton imagined gravitational forces between bodies/ gravitational force changes planetary path	[1]
Use Newton's law to predict position of planets/moons	[1]
force α mass	[1]
force α $1/ r^2$	[1]
universe static/universe infinite in extent	[1]

[total 6]

2.(a)

(i)planet less than ¼ way around	[1]
(ii)planet sweeps out equal areas in equal times	[1]
speed increases moving closer to Sun/ area swept out from P to X is ¼ total area of ellipse	[1]

(b)

T^2 / r^3 = constant	[1]
$80^2 / r^3 = T^2 / (0.4r)^3$	[1]
T = 20.2y	[1]

[total 6]

3.(a)	absolute magnitude/luminosity on y-axis (accept **M**)	[1]	
	temperature /spectral class on x-axis (accept **T**)	[1]	
	main sequence indicated in correct orientation	[1]	
	white dwarfs in bottom left, labelled correctly	[1]	
	red giants in top right, labelled correctly	[1]	
(b)	**any 4 from**:		
	end of H burning/red giant/supergiant	[1]	
	onset of He fusion/fusion of heavier nuclei	[1]	
	gravitational collapse of core	[1]	
	supernova explosion/ star explodes	[1]	
	suitable mass limit (chanderasekha limit 1.4M)	[1]	
	supported against gavity by neutron gas pressure/ ref to Fermi pressure	[1]	
	internal structure protons and electrons combined/ very thin atmosphere/ metallic crust	[1]	[4]
(c)	(i)volume = $4\pi\ (10{,}000)^3\ /3 = 4.2 \times 10^{12}$	[1]	
	density = $3.5 \times 10^{30} / 4.2 \times 10^{12}$ ecf	[1]	
	density = 8.4×10^{17} kg/m^3	[1]	
	(ii)any **two** from		
	density (very) much greater than material on Earth	[1]	
	quotes typical density on Earth $1 - 10^4$ kg m^{-3}	[1]	
	atomic structure collapsed / density same as atomic nucleus	[1]	[2]

[total 14]

4.(a) (i) apparent magnitude: brightness seen from Earth [1]
absolute magnitude: brightness at 10pc [1]

(ii) absolute magnitude uses same distance for all stars/
compares luminosities (true brightness/energy) of stars [1]

(b) (i) $m - M = 5 \lg (r / 10)$ [1]
substitution of m_2 and r_2 [1]

(ii) $m_1 = -26.7 + 5 \lg (2.7 \times 10^{17} / 1.5 \times 10^{8})$ [1]
$m_1 = 19.5(8)$ [1]

(iii) any two from
absorption by interstellar gas/ stellar objects in light path/
deflection of light by gravitational fields [2]

[total 9]

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5.(a) (i) energies/temperatures irreproducible on Earth / laws of Physics break down [1]

(ii)temperature decreases [1]

universe expanding/work done against attractive forces/ energy converted to mass [1]

(iii)**any 3** from

protons and electrons separate initially [1]

matter-radiation equilibrium/charge prevents passage of em waves [1]

proton-electron recombination /formation of atoms [1]

gamma/ em waves no longer absorbed [1]

[3]

(b) **any 5** from:

star-light shows red shift [1]

galaxies (stars) receding from Earth [1]

recessional velocity proportional to distance [1]

cosmological microwave background radiation (CMBR) [1]

uniform intensity in all directions [1]

small ripple [1]

(black body temperature) 2.7 K (3K) [1]

High ratio of helium to hydrogen [1]

Indicates very high temperatures existed [1]

ratio too high to originate from stellar fusion [1] [5]

[total 11]

6.(a) isotropic [1]
homogenous [1]

(b) (i)$H_0 = 75 / 3.1 \times 10^{19}$ [1]
$t_0 = 1 / H_0 = 4.13 \times 10^{17}$ s [1]
$t_0 = 4.13 \times 10^{17}$ s / 365 x 24 x 3600 $= 1.3 \times 10^{10}$y [1]

(ii)any two from
universe expands to a limit/ flat universe [1]
but never reaches that limit [1]
density of universe = critical density [1] [2]

(iii)curve: passes through P [1]
curves over and back to time axis [1]
iv)Universe not so old (no ecf from (iii)/ Universe will end
in big crunch(no ecf from iii) / universe has finite lifetime [1]
[total 10]

7.(a) Newton; measured/ (rate of) time is same for all observers/ everywhere [1]
Relativity: measured/ (rate of) clocks dependent on inertial frame [1]

(b) (i)both correct: - 0.65, -0.82. [1]

(ii)any 5 points correct [1]
sixth point correct [1]

(iii)best straight line drawn [1]

(iv)k = (-) gradient of graph [1]
value of k between - 1.6×10^{-4} and - 1.7×10^{-4} m^{-1} [1]

(v)$T_{1/2} = 0.693 / 3 \times 10^8 \times 1.6 \times 10^{-4}$ [1]
$T_{1/2}$ = s [1]

(vi) $1.44 \times 10^{-5} = t_0 / \sqrt{(1 - v^2/c^2)}$ [1]
$\sqrt{(1 - v^2/c^2)} = 0.11$ [1]
$t_0 = 1.54 \times 10^{-6}$ s [1]
(vi)ref. to experimental evidence for special theory of relativity [1]

[total 14]

2825 SYNOPTIC QUESTION JUNE 2006

8(a) Light energy is reflected or

Light energy is absorbed and converted to heat or thermal energy 1

(b)(i)

Minimum surface area = 360 / 1500 x 100/16 1

= 1.5 m^2 1

(ii) The satellite will sometimes be in the shadow cast by Earth - so no sunlight (or not in direct sunlight)

The electrical circuits or battery are not themselves 100% efficient - energy wasted as heat

Satellite requires extra power for position control or other stated function

Panels may not be perpendicular to sunlight

Radiation damage (from cosmic rays) reduces number of useful cells Any two 1, 1

(ignore any reference to any variation in solar output)

(c) The intensity of sunlight is too small (inverse square law) or
The area of panel required would be too large/massive to launch 1

(d)(i)

Energy required = V I t

= 12 x 5 x 120 x 60 1

= 4.32 x 10^5 J 1

(ii)

Steady power required = (4.32 x 10^5 x 100/25) ÷ 24 x 3600 1 1

= 20 W (18.5W if 0.40MJ used)

(or P = VI = 12 x 5 = 60W for 2h so only 5W for 24h if 100% efficient but = 5 / 0.25 = 20W)

(iii) Energy carried by alpha = 5 x 10^6 x 1.6 x10^{-19} = 8.0 x 10^{-13} J 1

Activity required = 20 ÷ (8 x 10^{-13})
= 2.5 x 10^{13} Bq 1

(or 0.432MJ / 8 x 10^{-13} J alphas per day = 0.432 MJ / 8 x 10^{-13} / 24 x 3600 alphas per sec)

(e) Decay constant of Pu 238 = 0.69 / $T_{½}$
= 0.69 / 88 x 365 x 24 x 3600 1 1

= 2.5 x 10^{-10} sec^{-1}

(allow mark for conversion of 88 years to 2.78 x 10^9 seconds)

	Number of nuclei required = A / λ = 2.5×10^{13} / 2.5×10^{-10} = 1.0×10^{23} (allow mark for formula A = λN) Mass required = 1.0×10^{23} x 238 / 6.02×10^{23} = 40 gms = 0.040 kg	1 1 1 1
(f)	On launch, the rocket gives the spacecraft a huge kinetic energy (in order to escape) Failure at this point could cause spacecraft and contents to "burn up" in atmosphere But plutonium would still be radioactive and being vaporised it could be ingested. Sensible comment on danger periods of launch (or re-entry) Sensible comment on mechanism of ingesting Plutonium Allow one sensible comment on no risks in the isolation of deep space	1 1