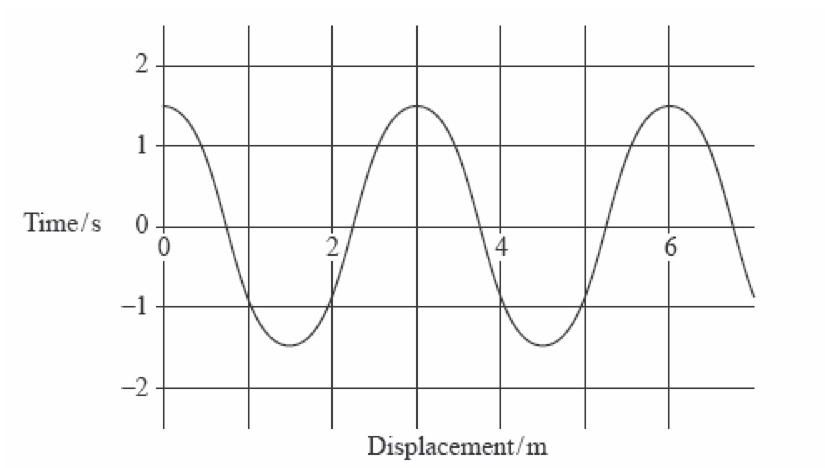
Unit 5: Physics from Creation to Collapse

Question Number	Question	
1	A valid set of units for specific heat capacity is	
	Answer	Mark
	C	**1**

Question Number	Question	
2	The gravitational field strength on the surface of the Earth is *g*. The gravitational field strength on the surface of a planet of twice the radius and the same density is	
	Answer	Mark
	B	**1**

Question Number	Question	
3	A child is playing on a swing. The graph shows how the displacement of the child varies with time.  The maximum velocity, in m s^{-1}, of the child is	
	Answer	Mark
	B	**1**

Question Number	Question	
4	Cosmic background radiation is a remnant of the big bang and appears to pervade the universe. It has a maximum wavelength in the microwave region of the electromagnetic spectrum. This can be calculated to correspond to a temperature of about 3 K. This calculation is based on the assumption that	
	Answer	Mark
	C	**1**

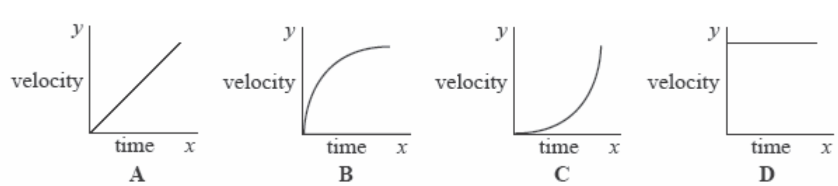
Question Number	Question	
5	A student is asked “What is meant by background radiation?” She writes “It is the radiation produced by the rocks in the ground.” This answer is	
	Answer	Mark
	C	**1**

Question Number	Question	
6	A car driver notices that her rear view mirror shakes a lot at a particular speed. To try to stop it she sticks a big lump of chewing gum on the back of the mirror. Which one of the following statements is correct?	
	Answer	Mark
	D	**1**

Question Number	Question	
7	The *x*-axis of a Hertzsprung-Russell diagram is log *T*. This is because	
	Answer	Mark
	A	**1**

Question Number	Question	
8	The spectrum of visible light from the Sun contains a number of dark lines known as Fraunhofer lines. This is due to	
	Answer	Mark
	B	**1**

Question Number	Question	
9	All quasars show large red shifts in the light received from them. This shows that they	
	Answer	Mark
	D	**1**

Question Number	Question	
10	A space rocket takes off vertically from the surface of the Earth. Assuming the thrust remains constant which graph best represents the variation of velocity of the rocket with time 10. If the universe expands forever it can be described as 	
	Answer	Mark
	C	**1**

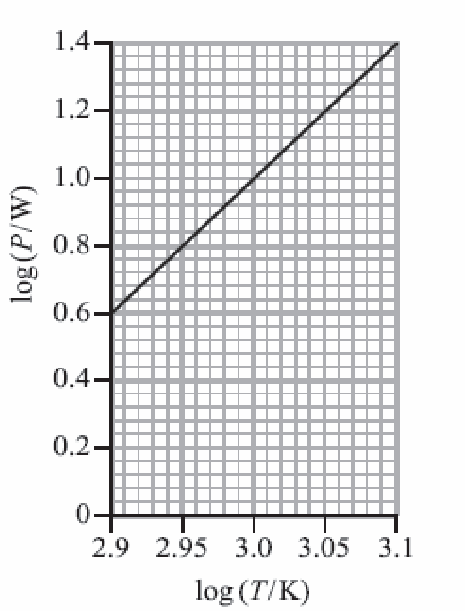
Question Number	Question	
11(a)	An ideal gas is contained in a volume of 2.0×10^{-3} m^3 . Explain why the internal energy of an ideal gas is only kinetic.	
	Answer	Mark
	as ideal gases do not have forces between molecules so no potential energy	**2**

Question Number	Question	
11(b)	The pressure of the gas is 1.2×10^5 Pa and its temperature is 27 °C. Calculate the number of molecules of gas within this container. Number of molecules =	
	Answer	Mark
	use of pv = NkT conversion of T to kelvin and answer = 5.8×10^{22} molecules	**2**

Question Number	Question	
12(a)	Smoke detectors contain an alpha emitting source. Describe how you would determine whether this radioactive source emits alpha particles only.	
	Answer	Mark
	use of counter (+GM tube) determine background count in absence of source place source **close** to detector and: place sheet of paper between source and counter (or increase distance from source 3-7 cm of air) reduces count to background	**4**

Question Number	Question	
12(b)	State why smoke detectors do not provide a radiation risk in normal use.	
	Answer	Mark
	alpha radiation only has range of 5 cm in air / wouldn't get through casing	**1**

Question Number	Question	
13	Two stars in the night sky appear equally bright to an observer. The Ancient Greeks thought that all stars were the same distance from the Earth. State and explain **two** reasons why these two stars do not need to be the same distance from the observer.	
	Answer	Mark
	reason (1) and consequence(1) reason (1) and consequence(1) 2 from: Could be different sizes; So larger one could be further away Could be different temperatures; So hotter one could be further away Different luminosities; So more luminous one could be further away	**4**

Question Number	Question	
14(a)	The graph shows how the logarithm of the electrical power *P* supplied to a filament lamp varies with the logarithm of the temperature *T* of the filament.  *P* is related to *T* by a power law: $P = k\,T^{n}$ Use the graph to determine n. n = …………………………………..	
	Answer	Mark
	attempt to find gradient eg evidence of triangle on graph or values of dy/dx (1) value of n (1)	**2**

Question Number	Question	
14(b)	A student suggests that this relationship is predicted by the Stefan-Boltzmann law. Comment on this statement.	
	Answer	Mark
	needs T^4 (1) (electrical) power P related to luminosity (1)	**2**

Question Number	Question	
15(a)	The Hubble constant is thought to be about 70 000 m s^{-1} Mpc^{-1}. Give one reason why the value of this constant is uncertain.	
	Answer	Mark
	difficult to measure distances to “far” objects accurately / difficult to measure speeds of far objects accurately (1)	**1**

Question Number	Question	
15(b)	State how an estimate of the age of the Universe can be calculated from the Hubble constant.	
	Answer	Mark
	appreciate 1/H is age of universe(1)	**1**

Question Number	Question	
15(c)	Explain how the ultimate fate of the Universe is associated with the Hubble constant.	
	Answer	Mark
	fate of universe depends on the density of the universe(1) link between gravity and density(1) Hubble “constant” is changing due to gravitational forces (1)	**3**

Question Number	Question	
16(a)	Potassium-40 ($_{19}$ K) is unstable. Calculate the binding energy per nucleon for potassium-40. Nuclear mass of potassium-40 = 39.953548 u Mass of one neutron = 1.008 665 u Mass of one proton = 1.007 276 u Binding energy per nucleon=	
	Answer	Mark
	19 protons identified(1) calculation of mass defect (1) Conversion to kg(1) use of $E = mc^2$ (1) divide by 40(1) $=1.37 \times 10^{-12}$ J(1) [eg 19 x 1.007276 = 19.138244 +21 x 1.008665 = 40.320209 – 39.953548 = 0.36666 $\times 1.66 \times 10^{-27} = 6.087 \times 10^{-28}$ $\times c^2 = 5.5 \times 10^{-11}$ $/40 = 1.37 \times 10^{-12}$ J]	**6**

Question Number	Question	
16(b)	Explain what is meant by the random nature of nuclear decay.	
	Answer	Mark
	cannot identify which atom/nucleus will be the next to decay can estimate the fraction /probability that will decay in a given time / cannot state exactly how many atoms will decay in a set time	**1**

Question Number	Question	
16(c)(i)	Scientists have worked out the age of the Moon by dating rocks brought back by the Apollo missions. They use the decay of potassium-40 to argon-40. The half-life of of potassium-40 is 1.3×10^9 years. Show that the decay constant of potassium-40 is about 5×10^{-10} y^{-1}.	
	Answer	Mark
	conversion of half life to decay constant [eg $\lambda = \ln 2 / 1.3 \times 10^9 = 5.3 \times 10^{-10}$ y^{-1}]	**1**

Question Number	Question	
16(c)(ii)	In one rock sample the scientists found 0.84 μg of argon-40 and 0.10 μg of potassium-40. Calculate the age of the rock sample in years.	
	Answer	Mark
	add both masses to find initial mass(1) use of $N = N_o e^{-\lambda t}$ (1) rearrange to make t subject(1) Answer = 4.2×10^9 years (1) (if 0.84 used instead of 0.94 3 max) [eg total initial mass 0.94 $t = \ln 0.1 / 0.94 / 5.3 \times 10^{-10}$ $= 4.2 \times 10^9$]	**4**

Question Number	Question	
17(a)(i)	Show that the acceleration of the hydrogen atom, *a*, is given by $a = -\frac{kx}{m}$ where *x* is the displacement of the hydrogen atom.	
	Answer	Mark
	Use of F= - kx (1) F = ma(1)	**2**

Question Number	Question	
17(a)(ii)	Hence derive the equation $T = 2\pi\sqrt{\frac{m}{k}}$ for the period of natural oscillations of the hydrogen atom.	
	Answer	Mark
	cf with $a = -\omega^2 x$ ie $\omega^2 = k/m$(1) use of $T = 2\pi / \omega$ to result (1)	**2**

Question Number	Question	
17(b)(i)	What name is given to this phenomenon?	
	Answer	Mark
	resonance(1)	**1**

Question Number	Question	
17(b)(ii)	State the condition for it to occur.	
	Answer	Mark
	natural freq = forcing frequency(1)	**1**

Question Number	Question	
17(b)(iii)	Calculate the frequency of infrared radiation of wavelength 3.3 μm.	
	Answer	Mark
	use of $c = f\lambda$(1) answer 9.1×10^{13} Hz(1)	**2**

Question Number	Question	
17(b)(iv)	Hence calculate the stiffness of the hydrogen chloride bond.	
	Answer	Mark
	use of T = 1/f eg $T = 1.1 \times 10^{-14}$(1) rearrange formula (1) to give 550 N/m(1)	**3**

Question Number	Question	
18(a)	A planet of mass m orbits a star of mass M. The radius of orbit is r. By considering the force required for circular motion in this situation, show that the period T of the orbit is given by $T^2 = \frac{4\pi^2 r^3}{GM}$	
	Answer	Mark
	equates F = GMm/ r^2 and mv ^{2} /r(1) Use of v = 2πr/T(1) Cancel m's To give $GMT^2 = 4\pi^2 r^3$ in any form(1)	**3**

Question Number	Question	
18(b)(i)	Measurements have shown that star HD70642 has a planet which orbits the star with a period of about 6 years. The → radius of the orbit is about 3× the radius of the Earth's orbit around the Sun. Use the formula in (a) to determine a value for the ratio $\frac{\text{mass of star HD70642}}{\text{mass of Sun}}$ = ...	
	Answer	Mark
	remove constants or cancel G 4π2(1) use of idea MT^2 / r^3 = Constant(1) substitution 27 /36 = M_{star} / M_{sun}(1)	**3**

Question Number	Question	
18(b)(ii)	Because of the presence of the planet, the star HD70642 does not remain at rest. Instead, the planet and star both orbit around their common center of mass. Explain why the orbiting speed of the star is very small in comparison to the speed of the planet.	
	Answer	Mark
	both will complete orbit in same time period(1) star covers small distance / orbit radius smaller compared to planet(1)	**2**

Question Number	Question	
18(c)	Astronomers discovered the planet by observing the "Doppler Wobble" effect. As the planet orbits the star, light from the star undergoes a Doppler shift in its frequency. Explain why this method is likely to only likely to detect **very large** planets.	
	Answer	Mark
QWC(i-iii)	The answer must be clear, use an appropriate style and be organised in a logical sequence Larger planets will move centre of mass towards planet / away from star centre (1) Star moves faster(1) Doppler shift greater for larger speeds(1)	**3**

Question Number	Question	
19(a)	Complete the equation which shows a typical part of the CNO process. $^{...}_{8}O + ^{...}_{...}H \rightarrow ^{14}_{...}N + ^{...}_{...}...$	
	Answer	Mark
	top row : 17 1 (14) 4 (1) bottom row: 8 1 7 2 (1) other product – helium (1)	**3**

Question Number	Question	
19(b)	What is a white dwarf? Suggest why hydrogen fusion in the white dwarf is likely to be the CNO process.	
	Answer	Mark
QWC(i-iii)	The answer must be clear, use an appropriate style and be organised in a logical sequence dead star / no longer any fusion(1) small dense hot / still emitting radiation/light(1) consisting of products of fusion such as carbon / oxygen / nitrogen(1)	**3**

Question Number	Question	
19(c)(i)	The temperature required for these processes is 10^7 K. Calculate the mean kinetic energy, in keV, of the particles involved.	
	Answer	Mark
	use of 3/2 kT (1) conversion to eV(1) answer [1.3 (keV)] (1)	**3**

Question Number	Question	
19(c)(ii)	Explain how this temperature arises.	
	Answer	Mark
	gravitational force does work on hydrogen(1) increases internal energy of gas(1)	**2**

Question Number	Question	
19(d)	Astronomers use novae as standard candles. Explain what a standard candle is, and suggest what this implies about the processes occurring in a nova.	
	Answer	Mark
QWC(i-iii)	The answer must be clear, use an appropriate style and be organised in a logical sequence A standard candle (in astronomical terms) produces a fixed amount of light /luminosity(1) Quantity of hydrogen (1) and fusion temperature (1) must be similar for various novae.	**3**