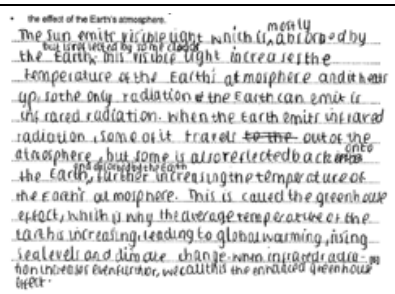
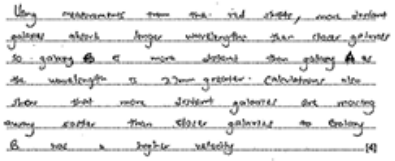
Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1	a		**Any two from:** Star **A** has higher (maximum) intensity than star **B** / Star **B** has lower (maximum) intensity than star **A** ✓ Star **A** graph intensity peaks at shorter wavelength than star **B** / Star **B** graph intensity peaks at longer wavelength than star **A** ✓	2 (2 × AO 3.1a)	**IGNORE** stronger/more radiation **If no other marks are scored:** **ALLOW** star **A** is hotter than star **B** / **ORA** **Examiner's Comments** Question 21 (b) required candidates to analyse the graph. It was well attempted, with most candidates gaining credit for identifying thatstar **A** has a higher intensity than star **B**. However, only the higher-achieving candidates were able to interpret the second difference, i.e. the graphs peaked in intensity at different wavelengths.
	b		**Level 3 (5–6 marks)** **A detailed explanation of the radiation absorbed and emitted by the Earth AND a detailed explanation of the effect of the Earth's atmosphere.** *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** **A clear explanation of the radiation absorbed and emitted by the Earth AND a clear explanation of the effect of the Earth's atmosphere.** **OR** **A detailed explanation of the radiation absorbed and emitted by the Earth AND a basic explanation of the effect of the Earth's atmosphere.**	6 (3 × AO 1.1) (3 × AO 3.1b)	**AO1.1- Demonstrate knowledge and understanding of scientific ideas to explain the radiation absorbed and emitted by the Earth.** • The Earth radiates (infrared) radiation back into space • The Earth emits less radiation than it absorbs. • If energy/radiation absorbed = energy/radiation emitted by the Earth, the temperature of the Earth stays constant • If energy/radiation absorbed > energy/radiation emitted by the Earth, the temperature of the Earth increases • The Earth absorbs UV/light/shorter wavelength (infrared) radiation • The Earth emits longer wavelength (infrared) radiation **AO3.1b - Analyse information and ideas to explain the effect of the**

			OR **A detailed explanation of the effect of the Earth's atmosphere AND a basic explanation of the radiation absorbed and emitted by the Earth.** *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** **A basic explanation of the radiation absorbed and emitted by the Earth** **OR** **a basic explanation of the effect of the Earth's atmosphere.** *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 mark** *No response or no response worthy of credit.*		**Earth's atmosphere on the actual temperature of the Earth.** • Atmosphere/greenhouse gases trap/reflect (infrared) radiation • Amount of greenhouse gases is increasing • Greenhouse effect is increasing • Without atmospheric/greenhouse gases, temperature of the Earth would be very cold • Greenhouse gases/CO_2 in atmosphere absorb some of the Earth's emitted (infrared) radiation • Greenhouse gases/CO_2 in atmosphere emit (infrared) radiation • Some of the (infrared) radiation emitted by the Earth is radiated/reflected back towards the Earth's surface • Some of the (infrared) radiation emitted by the Earth is radiated/reflected by the atmosphere/ (greenhouse) gases/CO_2 **<u>Examiner's Comments</u>** The Level of Response question was of higher demand and assessed AO1 and AO3. The question discriminated well, with onlysome of the higher-achievingcandidates giving detailed enough explanations to gain Level 3. Most candidates scored at least 2 marks for basic ideas about energy being trapped by the Earth's atmosphere instead of being emitted back into space. However, poor quality of communication, lack of a clear, logical structure and some misconceptions prevented them from gaining the higher marks. Exemplar 2

					 This response achieved Level 1, 2 marks. There are only basic ideas about the radiation emitted travelling out of the atmosphere, some radiation being reflected back and a mention of the greenhouse effect. To progress to Level 2, the candidate needed to include clear ideas about the Earth emitting less radiation than it absorbs, and more detail about what is reflecting the radiation back to the Earth.
	c		The Earth is accelerating ✓	1 (AO 1.1)	
			Total	**9**	
2			A	1 (AO 2.1)	
			Total	**1**	
3			**Any four from:** (Both lines show) redshift ✓ Redshift for galaxy B > redshift for galaxy A / **ORA** ✓ (Redshift means that) galaxy/galaxies are moving away (from the Earth) ✓ Galaxy B is further away (from the Earth than galaxy A) / **ORA** ✓ Galaxy B is moving faster (than galaxy A) / **ORA** ✓ Galaxy B is moving away from galaxy A ✓	4 (AO 3.1a) (AO 3.1a) (AO 1.1) (AO 3.2b)	**ALLOW** galaxy with longest wavelength for galaxy B throughout answer **DO NOT ALLOW** one galaxy moving towards (the Earth) **ALLOW** the more distant galaxy is moving faster / **ORA** **ALLOW** galaxy B is moving away faster (than galaxy A) / **ORA** for 2 marks (mp3 and mp5) **Examiner's Comments** This question assessed AO1 and AO3. Candidates had to use their

					knowledge of red-shift to interpret the data in the table. It was generally well attempted, although many answers were too vague, comparing only the wavelengths and not linking to the data in the table. Many lower scoring candidates only described red-shift, rather than explaining what the data showed about the motion of the two galaxies. The question differentiated well, with higher achieving candidates scoring well. **Assessment for learning** Candidates could benefit from highlighting the command word in the question. It is essential that candidates understand what they need to do for different command words.  This response achieved full credit. The explanation of the data in the table is very detailed, using correct scientific terminology to conclude that galaxy B is further away than galaxy A (marking point 4) and is moving away faster (marking points 3 and 5).
			Total	**4**	
4			**Any three from:** (Formed by clouds of) dust/gas ✓ Drawn together by gravitational force ✓ Gravitational potential energy transferred to kinetic energy ✓ The core becomes very hot/dense ✓	3 (3 × AO 1.1)	**ALLOW** nebula / formed from hydrogen **ALLOW** gravity for gravitational force

			A protostar forms ✓ (Nuclear) fusion began ✓		**ALLOW** nuclei start to fuse **Examiner's Comments** Candidates appeared very familiar with the formation of the Sun and more than half of the candidates gained full credit. Most marks were gained for the mention of clouds of dust/gas, and for the formation of a protostar. Some candidates wrote far more than was necessary, as they described the whole life cycle of a star. **Misconception** Some common misconceptions about the formation of a star included: • nuclear fission occurring • nuclear fusion happening at the very start • a proton star is formed.
			Total	**3**	
5			**A**	1 (AO 1.1)	
			Total	**1**	
6			**C**	1 (AO 1.1)	
			Total	**1**	
7	a	i	Smaller radius or closer to the Sun means larger (gravitational/centripetal) force/pull ✓ (smaller radius or closer to Sun or larger gravitational/centripetal force means) larger acceleration/speed ✓ **OR** Closer orbits have a lower GPE ✓	2 (2 × AO1.1)	**ALLOW ORA** in each case **ALLOW** smaller radius means more gravity **Examiner's Comments** This question assessed candidates' abilities to explain why the speed of a planet must change if the radius changes (P8.3g). The majority of candidates were given at least 1 mark, usually for describing the correct link between the radius and speed.

			(closer orbits have) higher KE ✓		However, the command word for this question was 'Explain' and only some candidates progressed to explain why the speed changes in terms of the gravitational force.
		ii	**Any two from:** (A statement explaining that if proportional, you would expect:) e.g. $T = kr$ **OR** $T \div r = k$ **OR** $T_A \div r_A = T_A \div r_A$ **OR** $r_A \div T_A = r_B \div T_B$ **OR** $T_A \div T_B = r_A \div r_B$ **OR** $T_B \div T_A = r_B \div r_A$ / **ORA** ✓ Correct calculation of k or ratio of variables ✓ (Idea that) planet A is (approximately) double the radius of B but (approximately) triple the time (to orbit the Sun) ✓ **BUT** Statement (comparing two correctly calculated values) showing values are not equal or k is not constant ✓ ✓ Correct calculation of k from planet A (or B) and used to show that this k does not give correct value for the other planet ✓ ✓	2 (2 × AO3.1b)	**ALLOW** <u>all</u> numbers substituted correctly in any version for 2 marks. e.g. $k = T_A \div r_A = 1.88 \div 2.28 \times 10^{11} = 8.25 \times 10^{-12}$ $k = T_B \div r_B = 0.62 \div 1.08 \times 10^{11} = 5.74 \times 10^{-12}$ e.g. $T_A \div r_A = 8.25 \times 10^{-12} \neq T_B \div r_B = 5.74 \times 10^{-12}$ $r_A \div T_A = 1.21 \times 10^{11} \neq T_B \div r_B = 1.74 \times 10^{11}$ $T_A \div T_B = 3.03 \neq r_A \div r_B = 2.11$ $T_B \div T_A = 0.330 \neq r_B \div r_A = 0.474$ **<u>Examiner's Comments</u>** This question was well answered and many candidates gained at least 1 mark with some scoring full marks. Candidates with the correct answer calculated one of the many different possible pairs of ratios to show that the time to orbit the Sun was not proportional to the radius of the orbit. Some candidates calculated the value of k for one planet's data and then showed that this value of k did not give the correct value for the radius or time to orbit for the other planet.
	b		**Any three from:** (Speed is constant because) (resultant) force is perpendicular to direction of motion / (resultant) force is a centripetal force / there is no displacement in direction of force ✓ No work is done on the planet ✓ (Velocity is changing because) the direction is changing ✓ (Resultant force) provided by gravitational pull of the sun (causes	3 (3 × AO1.1)	**ALLOW** (resultant) force is always towards the Sun/centre of circle **ALLOW** velocity is a vector and speed is a scalar **ALLOW** force provided by the gravity of the Sun **<u>Examiner's Comments</u>** Few candidates gained more than 1 mark for this question. The question required candidates to explain why the speed of a planet is constant but its

			the direction of motion to change) ✓ (So) planet is accelerating ✓		velocity is changing, using ideas about forces. Most candidates achieved 1 mark for mentioning that speed is a scalar and velocity is a vector or that the direction of the planet changes. Very few candidates also scored marks for the idea that the resultant force is provided by the gravitational pull of the Sun or that the planet is accelerating.
			Total	**7**	
8			C ✓	1 (AO2.1)	**Examiner's Comments** Many candidates used their knowledge of the paths of seismic waves through the Earth to correctly choose option C.
			Total	**1**	
9			A ✓	1 (AO2.2)	**Examiner's Comments** Many candidates did not demonstrate knowledge of how the intensity and wavelength distribution depends on the temperature of the object.
			Total	**1**	