Question	Answer	Marks	Guidance
1 a	**any two from** (short wavelength radiation) penetrates atmosphere / heats Earth / AW [1] Earth emits heat or radiation of **longer wavelength** [1] Emitted radiation absorbed by atmosphere or greenhouse gas(es) [1]	2	**Accept** correct answers in terms of **lower frequency** Allow emitted radiation cannot escape, gets trapped or reflects back (to Earth) [1] **ignore** 'ozone'.
b i	(water) – weather / water cycle / evaporation / (aerobic) respiration / transpiration / (natural) combustion (CO_2) – respiration / (natural) combustion / volcanoes (methane) – decomposition / rotting 3 rows correct [2] 1 or 2 rows correct [1]	2	**Allow** clouds / breathing (out) / volcanoes [1] **allow** breathing (out) / forest fires / deforestation [1] **allow** dead plants / animals or named animal / manure / animal gas emissions / rubbish tips / excretion / digestion / volcanoes / rice fields / wetlands / permafrost (region) / mining [1]
ii COMMON	idea that global warming has happened **/ more** CO_2 **in the** (distant) **past** [1]	1	answer must indicate idea of in the past / before man / before the industrial revolution etc. Eg 'the ice age', 'tropical eras'. **allow** large fluctuations in temperature **in the past** [1] **allow** had peaks and troughs **in the past** / had peaks and troughs before the industrial revolution [1] **allow** idea that global warming has always been there [1]

iii COMMON	**any one from** short life (in atmosphere) [1] variability of water vapour levels / [1]	1	 **Eg.** 'not in atmosphere long enough to measure properly' [1]. (Vapour only) lasts a few days [1] **eg.** 'they are not sure what the number is' [1] **eg.** only an approximation / number changes [1]
c COMMON	**any one from the following comparisons:** less in atmosphere / less methane [1] lasts for less time / does not last as long [1]	1	**assume answer refers to methane unless otherwise stated** more CO_2 [1] **but allow** CO_2 lasts longer [1] **allow figures used from the table to illustrate a comparison**
	Total	**7**	

Question	Answer	Marks	Guidance
2 a i	when (the orbit is) near Sun / Earth (1) (because) it is illuminated (by Sun) / has trail or tail / reflects light (from the sun)(1)	2	**allow** when it is not too far away (from the Earth) to be seen (1) **ignore** answers about night and day **allow** reverse argument
ii	(shape is) elliptical (1) (so it) speeds up approaching the sun **/** has greater KE near Sun / ORA (1) gravity or gravitational force is greater / AW (1)	3	**from diagram** approximately elliptical orbit **ignore** sun position for shape **ignore** oval as description

Question	Answer	Marks	Guidance
b i	(relatively) small / far away(1) reflect little light / do not emit light (1)	1	 **ignore** dark
ii	**max two from advantages** destroys the asteroid / breaks it into small fragments(1) but the smaller fragments created will burn up in the atmosphere (2) (idea that) as it is very distant if the first attempt misses the asteroid there will be time for a second attempt (1) as very distant a small deflection can still miss the Earth (1) **maximum two from disadvantages** (needs to be very accurate otherwise) it may miss the asteroid (1) if could cause more fragments to hit Earth/satellite or could cause smaller more unpredictable parts (1) if the asteroid is large unlikely to have an effect or deflect path enough / may not work (1)	3	**maximum three marks** **allow** may deflect it (so that it misses the Earth) (1) **allow** So far away difficult to hit the asteroid (1) **allow** Could cause more fragments to be pulled towards Earth/ remains of asteroid may fall to Earth (1) **allow** Could deflect towards the earth (1)
	Total	9	

Question	Answer	Marks	Guidance
3 a	**Any two from**: Above equator [1] Above fixed point / AW [1] Orbits in 24 hours / same rate as Earth / AW [1] **AND** (idea of) transmitter points in same fixed position / provides a constant signal / line of sight [1]	3	Eg 'above the same point on the equator' scores [2] **Ignore** orbits at same speed as Earth **Allow** rotates with Earth / in sync with Earth[1] **allow** satellite dishes don't have to move [1] **allow** 'to give good coverage / AW [1]
b i	(idea that) only orbits once every 90 minutes [1] (idea that) shorter time would be lower orbit and unsafe [1]	1	e.g. It is not always above storm cloud / covers other parts of Earth/ needs to complete a full orbit [1] **ignore** dangerous to be near the storm
ii	Any three from: Low polar orbit faster than geostationary orbit / ORA [1] (attraction of) gravitational force is greater / ORA [1] Centripetal force needed for orbital / circular motion [1] (idea that) centripetal force needs to be bigger at lower altitude/ORA [1] (idea of) gravity provides this centripetal force [1]	3	**Ignore** unqualified references to gravity. Eg gravity is stronger [0]
	Total	**7**	

Question			Answer	Marks	Guidance
4			**Level 3** A clear description and reason why it is unusual for asteroids to be NEOs **AND** a clear description of the possible actions that could be taken to reduce the threat of this asteroid. **Quality of written communication does not impede communication of the science at this level.** **(5–6 marks)** **Level 2** A general description about why it is unusual for asteroids to be NEOs **AND** a limited description of the possible actions that could be taken to reduce the threat of this asteroid. **Quality of written communication partly impedes communication of the science at this level.** **(3–4 marks)** **Level 1** A general description about why it is unusual for asteroids to be NEOs **OR** a general description of the possible actions that could be taken to reduce the threat of this asteroid. **Quality of written communication impedes communication of the science at this level.** **(1–2 marks)** **Level 0** Insufficient or irrelevant science. Answer not worthy of credit. **(0 marks)**	6	**This question is targeted up to grade A** **Indicative scientific points may include:** **why is it unusual for asteroids to be a threat** • unusual for predicted trajectory to be with the Earth as Earth is so small compared with space/probability idea • most asteroids orbit between Mars and Jupiter • (idea that) most small asteroids 'burn up' in the Earth's atmosphere before they reach the Earth • unusual for asteroids to be near the Earth **possible actions that could be taken to manage the threat of this asteroid** • predict the trajectory • constant surveys by telescope • constant monitoring (by satellites / scientists) • could be deflected by explosions • (idea that) explosion need to be distant to the Earth so the explosion does not damage the Earth • if going to use an explosion need to do so soon as 2019 is not that far away • difficult to deflect 2002 NT7 because of large size or mass • easier to deflect away from collision further away from Earth. Use L1, L2, L3 annotations in scoris; do not use ticks.
			Total	**6**	

Question			Answer	Marks	Guidance
5			**any 2 from:** must be robust (to withstand take off) / AW (1) must be reliable / if it breaks in space it cannot be easily repaired / AW (1) must be able to operate without overheating / cooling system or heat sinks needed (during manufacture) (1) must be able to withstand large variations in temperature (in space) (1) must be clean /dust free (1) difficult to make connection to small objects / difficult to see faults (1) (idea that it is) difficult to obtain very pure silicon (1) (idea that) specialised manufacturing equipment or expertise is required (1)	2	**allow** very expensive to repair (in space) **allow** need to be made in a clean room / must be made in a dust free environment **allow** difficulty to hold small objects / difficult to hold small objects still eg. fiddly **allow** need to use specific equipment e.g. must use microscopes
			Total	**2**	

Question			Answer	Marks	Guidance
6	(a)	(i)	(improved) astronomical observation (of planets) (1) mathematical explanation or physical model used (1) reviewing previous theories or made use of previous observations / AW (1)	1	Ignore telescopes
		(ii)	(He) used a (better) telescope (1) (He) invented / developed a telescope / AW (1) (He) observed moons around Jupiter (1) (He) observed that not all bodies orbited Earth (1)	1	
		(iii)	contradicted religious views / AW (1)	1	
	(b)		galaxies move away / show red-shift / AW (1) Distant galaxies move faster (than closer galaxies) (1) BUT distant galaxies move away quicker / AW (2)	2	**ignore** background microwave radiation **ignore** planets / merely stars moving away **ignore** universe expanding
	(c)		Only current evidence explained (1) Further research done / new evidence may be found in future (1) Technological advances (1)	1	eg new data (will be found) (1)
			Total	**6**	

Question			Answer	Marks	Guidance
7	(a)		<table><tr><td>**large star**</td></tr><tr><td>red supergiant</td></tr><tr><td>supernova</td></tr><tr><td>black hole</td></tr></table> (1)	1	**all three in correct order needed**
	(b)		**any two from these three different areas:** teams of scientists look at different theories / views / ideas / opinions (1) teams bring different equipment / resources / technology / skills (1) different teams can take / check different measurements / data (1)	2	 eg other people can develop the work further (1) eg 'More scientists do more research in less time' (1) eg 'More information can be found' (1) eg 'More people means work done faster' (1) eg compare / check results or evidence (1) eg share data (1) eg check reliability (1) **not** merely 'repeat results' **but** 'repeat results to check data / reliability' (1)
			Total	**3**	

Question			Answer	Marks	Guidance
8	(a)		particles hit rocket walls / AW (1) causing force / thrust / AW (1)	2	But particles colliding **with each other** (0) Allow particles collide with each other and walls (1) **ignore** pressure / upthrust Reward higher level answers in terms of action and reaction: eg particles move downwards to produce an equal and opposite force on the rocket' (2)
	(b)		more force and acceleration because of: • more frequent collisions / more energetic collisions / twice as many collisions (1) or • faster particles / more particles / more energy / more momentum (1)	1	**but** more frequent collisions between gas particles scores (0) **allow** more frequent collisions between gas particles and walls (1) **allow** higher level answers in terms of kinetic theory (1) **ignore** pressure **ignore** more gas **allow** force applied for longer giving greater acceleration (1)

<table>
<tr><th colspan="3">Question</th><th>answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td>(c)</td><td></td><td>[Level 3]
Answers must give a comparison and an explanation of at least two ideas with reference to gravitational / centripetal force. (See summary chart)
Quality of written communication does not impede communication of the science at this level.
(5–6 marks)

[Level 2]
Answers must give a comparison and a description of at least two ideas.
Quality of written communication partly impedes communication of the science at this level.
(3–4 marks)

[Level 1]
Answers are limited to one simple description OR a description of an appropriate use of a satellite.
Quality of written communication impedes communication of the science at this level.
(1–2 marks)

[Level 0]
Insufficient or irrelevant science. Answer not worthy of credit.
(0 marks)</td><td>6</td><td>This question is targeted at grades up to A*.
allow reverse arguments for geostationary orbits throughout.
Indicative scientific points may include at level 3:
• higher gravitational force and lower altitude for polar orbit
• higher gravitational force and higher speed or acceleration for polar orbit.
• higher gravitational force and shorter period for polar orbit

Indicative scientific points may include at level 2:
• lower altitudes for polar orbit
• higher speeds for polar orbit.
• shorter period for polar orbit
• polar orbit over poles and geostationary orbit over equator

Indicative scientific points may include at level 1:
• short(er) time period for polar orbit
• geostationary orbits around equator.
• Correct use for a relevant satellite (eg polar – military, mapping, navigation, weather, etc. Geostationary – navigation, communication, weather etc.)

Use the L1, L2, L3 annotations in Scoris; do not use ticks.
<table><tr><td>ideas</td><td>geostat y</td><td>polar</td></tr><tr><td>orbit description</td><td>equator</td><td>Go over poles</td></tr><tr><td>period</td><td></td><td>shorter</td></tr><tr><td>speed</td><td>lower</td><td>higher</td></tr><tr><td>gravitational force</td><td>lower</td><td>higher</td></tr></table>At level 3 accept higher level answer in terms of acceleration</td></tr>
</table>

Question			Answer	Marks	Guidance
	(d)	(i)	703 (N) scores (2) **but if answer is incorrect** 185 x 3.8 scores (1)	2	
		(ii)	**any two from:** weight of Rover on Earth is 1850 (N) / AW (1) too heavy (on Earth) (1) weight too near to safe limits / more likely to break (1)	2	 **allow** Rover is 50 (N) more than it can take (2) **allow** heavier / weighs too much (1) eg. Legs / wheels not able to support (1) incorrect statement about mass scores a maximum of (1)
			Total	**13**	