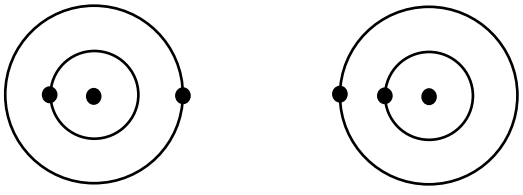
Question number	Answer	Notes	Marks
1 (a)	D – the Sun		1
(b) (i)	Substitution; Calculation; speed = $\frac{2 \times \pi \times 250\,000\,000}{690}$ = 2 300 000 (km/day) (correct to 2SF)	If answer given to more than 2SF, then allow range of 2 275 000 → 2 280 000 max 1 for POT error in bald answer	2
(ii)	Any two of 1. Idea of different speeds; 2. idea of different orbits /radii; 3. Idea of variable relative motion, e.g. both on the same side of the Sun and then on opposite sides of the Sun; 4. Appropriate calculation e.g. difference or sum of radii, attempt to calculate speed of Earth; e.g. Diagram showing understanding of MP2 and MP3  Earth Sun Mars Mars Earth Sun	Accept appropriate labelled diagrams Allow for one mark: elliptical if no other mark scored e,g, orbit of Mars is more elliptical than Earth's ignore Mars labelled inside Earth's orbit	2

Question number	Answer	Notes	Marks
1 (c) (i)	Working;; e. 300 000 = $\frac{170\ 000\ 000}{t}$ 1 working mark (sub ONLY) t = $\frac{170\ 000\ 000}{300\ 000}$ both working marks (sub AND rearrange) Calculation; e. = 570 (566.7) (s) 1 mark (ans to > 1 SF)	'show that' question, working must be shown for full marks REVERSE CALCS: maximum mark =2 (correct calc plus a comparison statement e.g. 283 333 ≡ 300 000 180 000 000 ≡ 170 000 000) Allow (without the subject of the equation) for 2 marks, $\frac{170\ 000\ 000}{300\ 000}$	3

Question number	Answer	Notes	Marks
1 (c) (ii)	Any two of 1. IDEA of HOW THE LOW SPEED AFFECTS DRIVING; low speed reduces stopping distance low speed helps to avoid obstacle 2. IDEA of THE EFFECT OF LOW SPEED ON COLLISION; momentum /low speed / low (kinetic) energy reduces damage if in collision 3. IDEA of WHAT THE TIME DELAY DOES; time delay affecting reaction time / stopping distance / steering 4. IDEA of WHAT THE TIME (DELAY) IS; it takes a long time to get the signal (the communication delay is) ≈ 1200 (s) (we see images which are) 600s delayed light and radio waves travel at the same speed in a vacuum	Allow idea that rover could travel up to 48 m between commands RA ignore better photos/detail of the planet /eq	2
		Total	**10**

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>2 (a) (i)</td><td>
<table>
<tr><th>Isotope</th><th>Proton number</th><th>Neutron number</th></tr>
<tr><td>Uranium-234</td><td>2</td><td>142</td></tr>
<tr><td>Uranium-235</td><td>92</td><td>143</td></tr>
<tr><td>Uranium-238</td><td>2</td><td>146</td></tr>
</table>
92 as shown;
146 as show;</td><td>Reject for the relevant mark</td><td>2</td></tr>
<tr><td>(ii)</td><td>Time taken;

and either of
• For half of (radioactive) nuclei / atoms /isotope to decay;
For (radio)activity to halve;</td><td>‘half the time’
particles
molecules
‘break down’
‘reactivity’
nucleus
halve in mass
to completely/fully decay

Allow
how long it takes</td><td>2</td></tr>
<tr><td>(iii)</td><td>any one from:

• Other isotopes have decayed more quickly;
• It has the longest half-life;</td><td>Allow
• reverse arguments
• comparative e.g. longer rather than longest
Ignore
• number of neutrons
purity /concentration</td><td>1</td></tr>
</table>

Question number	Answer	Notes	Marks
2 (b)	any three from 1. Neutrons; 2. (product) nuclei/a named nucleus; 3. Appropriate qualification of either term above(DOP); 4. gamma (radiation)/thermal energy e.g. of MP3 neutrons - 2, 3, fast, high energy nuclei – daughter, lighter, e.g. for M allowed nuclei include : krypton, barium, xenon,	 Allow two correct named nuclei as MP2 & MP3 Ignore extra as a qualifier for neutrons helium alpha beta atoms daughter atoms/cells	3
(c) (i)	Any one of to slow down neutrons/eq; to increase rate of fission; to increase absorption of neutrons by uranium/fuel;	allow reduce the (kinetic) energy of neutrons	1
(ii)	Any two of 1. rate of reaction increases; 2. fewer neutrons absorbed by control rod OR more neutrons collide with uranium; 3. temperature <u>increases</u>;	allow rate of fission increases control rods absorb neutrons <u>more</u> heat released (need for comparative) ignore risk of explosion	2

Question number	Answer	Notes	Marks
2 (d)	Any five of the following ideas facts about radioactivity 1. idea of harmful nature of radiation / danger to life; 2. high (activity) levels; 3. long half-life / half-lives; consequences 4. difficulties for (emergency) workers to access the area, e.g. short safe working times / need for protective clothing; 5. (requirement for) special handling equipment OR difficulty in removing material; 6. idea of extensive time OR distance (exclusion/hazardous) zone; environmental effects local and distant 7. idea of radioactive material mixing with the local environment e.g. soil, plants, water, air; idea of further /more distant spreading of material e.g. by fire, wind, water;	Ignore repeat of the stem, i.e. radioactive material has been spread into the surrounding area can't be seen allow MP1 toxic, can kill, causes mutation, ionises cells MP5 a lot of (contaminated) material to deal with MP6 still radioactive after a long time takes a long time to go away	5
		Total	**16**

Question number	Answer	Notes	Marks
3 (a)	C the Solar System;		(1)
(b)	small circle centred on Q;		(1)
(c)	correct shape; correct orbit, star is clearly not at the centre of the orbit;	accept • 'open' ellipse /eq • oval • hyperbola it is not necessary that perihelion < orbital radius of S	(2)
(d) (i)	Any one comparison from: MP1. smaller {orbital path/ distance travelled} for close planets; MP2. larger speed for close planets;	Allow reverse arguments accept smaller orbital radius ignore lack of gravity all refs to time	(1)
(ii)	C planet S makes more orbits than P;		(1)
(e) (i)	250 (million km);		(1)
(ii)	150 (million km);		(1)

Total for Question 3 = 8 marks

Question number	Answer	Notes	Marks
4 (a)	(speed = 2πr/T is given) use of equation; final value; matching unit; e. Speed = (2 x π x 58 000 000) / (88 x 24 x 60 x 60) Speed = (2 x π x 58 000 000) / (88 x 24 x 60 x 60) = 47.9 km/s	alternatives - 88 days, 2112 hours, 126720 minutes, 7603200 seconds 47930 m/s, 172439596 m/hr, 172548.596 km/hr, 4138560 km/day	3
(b) (i)	Gravitational;	ALLOW 'gravity'	1
(ii)	Ellipse added to diagram with Sun nearer one focus of the ellipse;	DO NOT ALLOW symmetrical ellipse with Sun at the centre ALLOW incomplete ellipse (i.e. path around the Sun shown with orbit extending beyond the diagram space)	1
(iii)	Point closest Sun labelled X / ecf from the ellipse drawn	Should ideally extend from outside Mercury orbit to inside Mercury orbit ALLOW a tolerance on the position of X in line with the drawing skill	1
(iv)	Close / closest / closer to Sun; Gravitational force strongest;	ALLOW '(force of) gravity greater' ALLOW Answer based on gpe/ke	1 1
		Total	**8**

Question number	Answer	Notes	Marks
5 (a)	gravity		1
(b) (i)	6960 (km)		1
(ii)	equation quoted (NO MARK) conversion of km OR min; v = (2 x π x 6 960 000) / (96 x 60); 7600;	 ECF on (i) Allow for rounding errors	3
(c)	EITHER grav pe reduces when closer; (so) ke increases; because total energy conserved; OR gravitational attraction / field strength increases when closer; mass remains constant; so accelerates;	 Grav force increases so ke increases = 1 (mixing arguments) REJECT 'gravity higher' 'gravity stronger' ACCEPT 'pull of gravity' 'force of gravity'	3
(d) (i)	electromagnetic (spectrum)	Accept transverse (waves)	1
(ii)	Any two from X-rays have shorter wavelength; ORA X-rays have higher frequency; ORA X-rays have higher energy; ORA X-rays have greater penetration range; ORA X-rays have greater effects on living tissue; ORA	Idea of comparison must be there REJECT 'visible light can be seen' / eq	2