CAMBRIDGE
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CO-ORDINATED SCIENCES **0654 / 41**

Paper 4 Theory (Extended) **May/June 2026**

MARK SCHEME

Maximum Mark: 120

Published

This mark scheme contains the instructions and marking guidance that our examiners used to mark candidate responses for this component.

Before they start marking, examiners complete a standardisation process. They review a range of candidate responses and discuss the mark scheme in detail to agree which answers can and cannot be accepted. Examiners award marks where it is clear that candidate responses have met the requirements of the mark scheme. These requirements may vary between different components or different versions of the same component, depending on the exact requirements of the question and the candidate responses seen during the standardisation process.

Sometimes, our mark schemes may allow marks to be awarded to responses which contain elements that are factually incorrect or for content not covered by the syllabus. We do this in response to the demands of a specific question to support candidates and make sure that our assessments are fair. However, these allowances should not be used as a guide for teaching and learning.

We cannot discuss the mark scheme with schools, and we recommend that schools read the mark scheme together with the assessment material and the Principal Examiner Report for Teachers.

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General marking principles

All examiners must apply these marking principles when marking candidate responses.

1	Examiners must award marks for each response in line with: • the specific **content** defined in the mark scheme • the specific **skills** defined in the mark scheme or in the level descriptions • the **standard of response** required as exemplified by the standardisation scripts.
2	Examiners must award **whole marks** (not half marks, or other fractions).
3	Examiners must award marks **positively**. This means that: • marks are not deducted for errors or omissions • marks are awarded for correct / valid answers as defined in the mark scheme and also for **other valid answers** which go beyond the scope of the syllabus and mark scheme referring to your team leader as appropriate • the quality of spelling, punctuation and grammar are judged **only** when the mark scheme indicates that these features are **specifically assessed** in the question. However, the meaning of all responses must be unambiguous.
4	Examiners must **consistently** apply the requirements of the mark scheme and any rules for what to do when candidates have not followed instructions correctly.
5	Examiners must use the **full range of marks** defined in the mark scheme, unless limited by the quality of the candidate responses seen.
6	Examiners must award marks according to the mark scheme and **must not** award marks with grade thresholds or grade descriptions in mind.

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Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>'List rule' guidance</u> For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

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6	<u>Calculation specific guidance</u> Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'. For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values. For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme. Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.
7	<u>Guidance for chemical equations</u> Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme. State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

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Annotations guidance for centres

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
✓	correct point or mark awarded
✗	incorrect point or mark not awarded
BOD	benefit of the doubt given
FT	follow through
NBOD	benefit of doubt was considered, but the response was decided to not be sufficiently close for benefit of doubt to be applied.
TV	response is too vague or there is insufficient detail in response
ECF	error carried forward applied
^	information missing or insufficient for credit
?	unclear response
I	incorrect or insufficient point ignored while marking the rest of the response

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Annotation	Meaning
R	incorrect point or mark not awarded
LNK	two statements are linked
SEEN	point has been noted, but no credit has been given or blank page seen
●	key point attempted / working towards marking point / incomplete answer / response seen but not credited / blank page seen
BP	blank page

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Mark Scheme Abbreviations

;	separates marking points
/	separates alternative responses for the same marking point
A	accept (a less-than-ideal answer which should be marked correct)
I	ignore (mark as if this material was not present)
R	reject the response
AND	indicates that two or more parts of a response are required for the mark
AVP	alternative valid point
AW	alternative wording (where responses vary more than usual)
NOT	indicates an incorrect response that would contradict another otherwise correct alternative
OR	alternative responses for the same marking point
owtte	or words to that effect
<u>underline</u>	actual word given must be used by candidate (grammatical variants excepted)
ecf	error carried forward
ORA	or reverse argument
( )	the word / phrase in brackets is not required but sets the context
max	indicates the maximum number of marks

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Question	Answer	Marks	Guidance
1(a)(i)	tassel ;	**1**	more than one circled – 0 marks accept any indication of answer including on diagram e.g. ticking or underlining but circling takes precedence
1(a)(ii)	**any one from:** (idea that) tassels / anther at top of plant (so exposed to wind) ; (idea that) tassels / anther hang out / down ; (idea that) styles / silks / stigma are sticky to catch pollen ; (idea that) styles / silks / stigma hang out / down ;	**1**	Answer must refer to a plant structure **I** references to pollen / male gametes on their own **A** tassels / anther are on the outside of the plant / exposed to the air **A** feathery stigma to catch pollen **A** styles / silks / stigma are on the outside of the plant / exposed to the air
1(a)(iii)	pair ; 20 ;	**2**	**A** two / 2 / two copies **R** Identical / duplicate
1(a)(iv)	meiosis ;	**1**	**R** mitosis
1(b)(i)	<table><tr><td></td><td>R</td><td>r</td></tr><tr><td>R</td><td>RR</td><td>Rr</td></tr><tr><td>r</td><td>Rr</td><td>rr</td></tr></table> one mark for correct gametes ; one mark for correct offspring genotypes ;	**2**	**A** alleles in either order **A** ECF for incorrect gametes
1(b)(ii)	25 ;	**1**	**A** any answer in the range 20 – 30 **A** ECF from an incorrect cross at 1bi allow ± 5 from expected cross outcome

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Question	Answer	Marks	Guidance
2(a)	makes small(er) / soluble **molecules** ; (that can be) absorbed ;	**2**	**R** breaks down **soluble** molecules
2(b)	glycerol ;	**1**	
2(c)(i)	**any three from:** (only) lipase digests fats / protease **and** amylase cannot digest fats ; lipase is specific to fats / lipids ; correct reference to complementary active site ; (only) lipase forms enzyme-substrate complex with fats ;	**3**	**A** (only) lipase breaks down fats / protease **and** amylase cannot break down fats **A** protease and amylase active site is not complementary (on fats) **A** ESC
2(c)(ii)	(secreted) salivary glands ; (acts) mouth ; **or** (secreted) pancreas ; (acts) small intestine ;	**2**	2nd mark dependent on 1st **A** oesophagus **I** stomach if linked to salivary glands **A**(secreted) small intestine / duodenum A duodenum / ileum
2(d)	bile ;	**1**	
2(e)	to kill (harmful) microorganisms in food ; to provide (an acidic) pH which is optimum for protease activity ;	**2**	**A** bacteria / microbes / pathogens for microorganisms **I** germs **I** ideas of breaking down food **A** enzyme / pepsin for protease

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Question	Answer	Marks	Guidance
3(a)	carnivore consumer 3rd trophic level 4th trophic level ; ;	**2**	2 or 3 correct = 1 mark 4 correct = 2 marks 5 or 6 ticks: four correct = 1 mark five or six ticks: three or less correct = 0 more than six ticks = 0
3(b)(i)	green algae → water flea / amphipod → sculpin → perch → trout ;	**1**	
3(b)(ii)	energy lost from one trophic level to the next / only 10% / small percentage of (total) energy is passed from one level to the next / energy is lost at each trophic level ; one example of energy lost ; (idea that) loss of energy limits length (of food chain) ;	**3**	**R 10%** of energy is lost / **90%** of energy is passed on **A** energy decreases as it moves up trophic levels **A** examples: heat / metabolic processes, movement, egestion, death without consumption / uneaten material, undigested material, waste / urine / faeces / excretion **A** not enough / insufficient energy for more (than 5) levels **I** just 'less energy'
3(c)(i)	cell wall / vacuole ;	**1**	**I** chloroplasts / chlorophyll **R** <u>temporary</u> vacuole
3(c)(ii)	(left) 6 CO_2 + 6 H_2O ; (right) $C_6H_{12}O_6$ + 6 O_2 ;	**2**	1 mark for each side correct

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Question	Answer	Marks	Guidance
4(a)	transmissible ;	1	accept any indication of correct answer e.g. ticking, underlining but circling takes precedence more than one circle = 0 marks
4(b)	genetic ; protein ;	2	**A** RNA / DNA
4(c)	brain / spinal cord ;	1	**I** spine **R** nerves
4(d)(i)	immune lymphocytes complementary memory ; ; ;	3	All four correct – 3 marks three correct – 2 marks one or two correct – 1 mark **A** Immunity **A** B cells / B lymphocytes **I** white blood cells **I** specific
4(d)(ii)	**any three from:** cases (rapidly) decreased after 1955 / since vaccine was produced / first used ; if enough people are vaccinated it stops the spread (of polio) ; (because) infected people less likely to be in contact with unvaccinated people ; vaccine levels were high enough to eliminate polio ; no / very few, cases from 1965 / after 10 years ;	3	**A** disease for polio throughout **R** cases **slowly** decrease **A** decrease from mid 1950s **A** (population has) <u>herd immunity</u> ; **A** mid 1960s
4(d)(iii)	3.668×10^6 (births in 2022) ; 1.47×10^7 (doses of vaccine) ;	2	**note**: award 2 marks if answer is 1.47×10^7 / 14 700 000 / 14 672 000 / 1.4672×10^7 / 1.5×10^7 to any correct rounding on the answer line regardless of working out. **A** 3 670 000 / 3 668 000 / 3.7×10^6 **A** ecf from incorrect births × 4 if working shown

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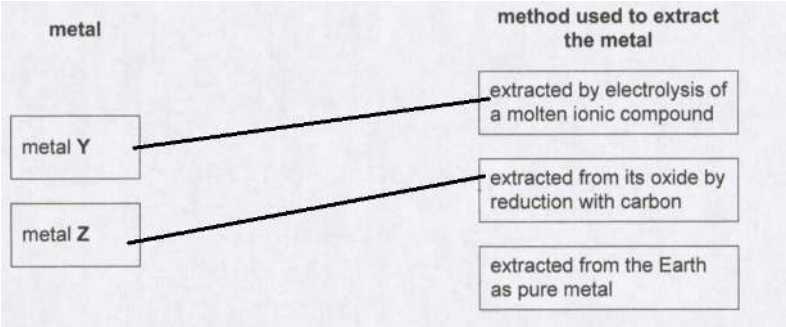
Question	Answer	Marks	Guidance
5(a)(i)	13 ;	**1**	
5(a)(ii)	27 ;	**1**	
5(a)(iii)	(element X has) 3 occupied electron shells ;	**1**	**A** three shells of electrons
5(b)	(element X) has delocalised electrons ; (electrons) which can move through / along (the metal) ;	**2**	**A** (element X) has a sea of electrons / free electrons / mobile electrons **R** ions **A** (electrons) can flow / drift through / along (the metal)
5(c)	 ; ;	**2**	
5(d)	hydrogen (gas) ;	**1**	**A** H_2 **I** 2 H / H / H^2 / H^+

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Question	Answer	Marks	Guidance
5(e)	(3×24) 72 g Mg $\rightarrow$ (2×56) 112 g Fe ; 0.6 g Mg $\rightarrow$ $\frac{112 \times 0.6}{72}$ g Fe; = 0.93 / 0.9 (g) ; **OR** moles of Mg = 0.6 ÷ 24 = 0.025 ; moles of Fe = $\frac{2}{3} \times 0.025 = 0.0167$; mass of Fe = $0.0167 \times 56 = 0.9352$ / 0.94 / 0.9 (g) ;	**3**	**note:** award 3 marks if answer is 0.93 / 0.9 (g) regardless of working out **note:** award 3 marks if answer is 0.93 / 0.94 / 0.9 (g) regardless of working out **A ecf** from incorrect moles of Mg **note**; if no other mark awarded allow 72 and 112 anywhere in the answer for 1 mark

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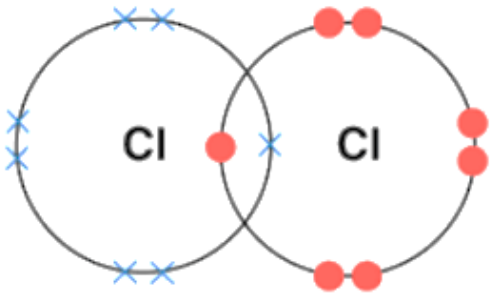
Question	Answer	Marks	Guidance
6(a)	minimum (amount of) energy ; (colliding) particles must have to react ;	**2**	**A** for a reaction to happen / occur
6(b)	→ 2 NaC*l* + I_2 ; ;	**2**	**note**: award 1 mark for formulae and 1 mark for balancing a **correct** equation **R** I / I^2 / I^+
6(c)	 ;;	**2**	**note:** award 1 mark for shared pair of electrons between chlorine atoms award 1 mark for rest of structure correct **A** electrons shown as all dots or all crosses or any mix note: ignore inner-shell electrons if drawn
6(d)	chlorine has intermolecular forces / forces between <u>molecules</u> ; sodium iodide has electrostatic forces / attractive forces between <u>oppositely charged ions</u> ; (the attractive) forces in chlorine / covalent molecules are weaker so need <u>less</u> <u>energy</u> to overcome (so the melting point is lower) ; Or (the attractive) forces in sodium iodide / ionic compounds are stronger so need <u>more</u> <u>energy</u> to overcome (so the melting point is lower) ;	**3**	**A** covalent molecules have intermolecular forces **R** ionic / atoms **A** ionic compounds has electrostatic forces / attractive forces between <u>oppositely charged ions</u> **R** covalent (bonds) / molecules **R** intermolecular forces

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Question	Answer	Marks	Guidance
7(a)	(test): use limewater ; result: (carbon dioxide) turns cloudy / milky ;	**2**	**A** white precipitate
7(b)	correctly drawn tangent at 0.95 g ; correct value for x-step **and** y-step from tangent ; rate = $\frac{\text{value for y-step}}{\text{value for x-step}}$; = value between 0.0025 and 0.003 inclusive ;	**4**	**note:** award 3 marks (MP2 / 3 / 4) for calculation if answer is (or rounds correctly to be) between 0.0025 and 0.003 inclusive **A ecf** from incorrect tangent e.g. 130 s **and** (1.10 – 0.62) = 0.48 g **A ecf** from incorrect x-step and / or y-step calculation e.g. 0.48 ÷ 130 **A ecf** incorrect final answer= 0.0037 g / s **note**: If only axis intercept correctly read (± ½ square) and used award **one mark max** for correct answer derived from their readings 0.95 and 81 = 0.011 0.95 and 82 = 0.011 0.95 and 83 = 0.0114457 0.95 and 84= 0.011309 0.95 and 85 = 0.011176 (to any correct rounding) for MP4 only;
7(c)	graph would be less steep / AW ; but would still level off 1.00 (g) ;	**2**	
7(d)	moles of CO_2 = mass ÷ Mr = 1 ÷ 44 = 0.0227 ; volume of CO_2 = mol × 24 = 0.0227 × 24 ; = 0.5454 dm^3 / 0.5 dm^3 ;	**3**	**note**: award 3 marks if answer is 0.5 / 0.545 / 0.54 / 0.55 / 0.6 dm^3 regardless of working out **A ecf** from incorrect moles **A** 0.48 if moles rounded to 0.02 at MP1

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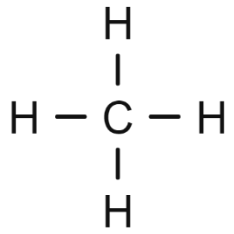
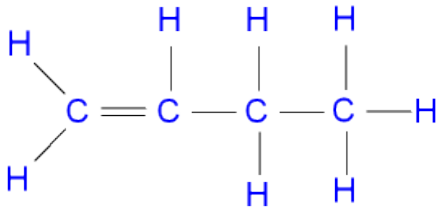
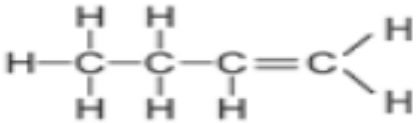
Question	Answer	Marks	Guidance
8(a)	coal / petroleum ;	**1**	**A** crude oil / diesel / petrol **I** just 'oil'
8(b)	 ;	**1**	
8(c)(i)	$C_{10}H_{22}$;	**1**	**R** C10H22 / $C^{10}H^{22}$
8(c)(ii)	 ; ; **Or** 	**2**	**note**: award 1 mark for one double bond between carbons 1 and 2 **or** 3 and 4 award 1 mark for rest of structure correct relative to where the double bonds are MP2 is dependent on MP1 being correct
8(c)(iii)	covalent ;	**1**	**A** correct answer ticked, circled or underlined in list. Answer line takes precedence.

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Question	Answer	Marks	Guidance
8(d)	combustion of carbon containing fuels ☐ reaction of an alkene with steam ☐ reaction of an alkene with hydrogen ☐ waste gases from digestion in animals ☑ ;	1	more than one box ticked – 0 marks
8(e)	*any two from*: planting trees ; reduction in livestock farming ; decreasing use of fossil fuels ; increasing use of hydrogen or renewable energy ; AVP ;	2	**A** afforestation **A** stop deforestation **/** less deforestation **A** (idea of) decrease meat consumption / switch to vegetarian diet **I** just 'decrease CO_2 emissions' **A** switch to using renewables **A** increase use of / switch to a specific example of renewable energy. e.g. wind, solar, tidal **I** use electric cars / vehicles **AVP** examples; air conditioning / flood control / develop drought resistant or high temperature tolerant crops

Question	Answer	Marks	Guidance
9(a)(i)	stopwatch / stopclock / timer ;	1	**A** Light gates **I** chronometer
9(a)(ii)	v = s / t or v = d / t or v = 2.4 / 4.4 ; 0.55 (m / s) ;	2	**note:** award 2 marks if answer is 0.55 (m / s) regardless of working out **A** 0.545 / 0.54 / 0.5
9(a)(iii)	a = Δv / Δt or a = v – u / t or Δv = 0.85 × 2 ; 1.7 (m / s) ;	2	**note**: award 2 marks if answer is 1.7 (m / s) regardless of working out
9(a)(iv)	straight line with constant non-zero gradient through origin ;	1	

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Question	Answer	Marks	Guidance
9(b)(i)	9.8 (m / s²) ;	1	**I** units
9(b)(ii)	E=mgh or E=0.5 mv² ; equating and cancelling m / gh=0.5v² / 9.8 × 0.75 = 0.5 × v² ; 3.8 (m / s) ;	3	**note:** award 3 marks if answer is 3.834 to any correct d.p. (m / s) regardless of working out **note** : award 3 marks if answer is 3.87298 to any correct d.p. if 10 used as value for gravity.

Question	Answer	Marks	Guidance
10(a)(i)	ρ = m / V or 1.4 / 900 ; 0.0016 (g / cm³) ;	2	**note**: award 2 marks if answer is 0.00155 (g / cm³) regardless of working out **A** 0.00155 / 0.00156 / 0.002 / 0.0015 or any other correct rounding **A** 1.6 / 1.56 / 1.5 × 10^{-3}
10(a)(ii)	particles collide with walls of container ; (they) exert a force (on the walls) ; pressure is force per unit area / refer to p=F / A with terms defined ;	3	**A** gas particles transfer their momentum (when they collide with the walls)
10(b)(i)	P=IV or 2.5 × 12 ; 30 (W) ;	2	
10(b)(ii)	boiling occurs throughout liquid / evaporation occurs **only** at surface ; boiling occurs **only** at boiling point / evaporation occurs below boiling point ;	2	**A** Boiling occurs at one specific / set / fixed / certain temperature **A** evaporation happens at any temperature **I** ideas about bubbles / speed
10(b)(iii)	straight line with constant non-zero gradient through origin ;	1	

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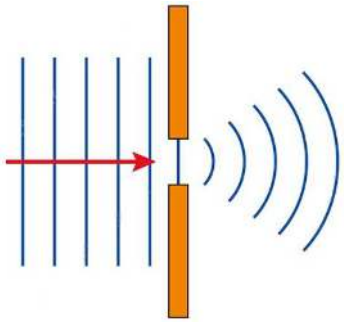
Question	Answer	Marks	Guidance
11(a)(i)	vibration / oscillation ; parallel / same direction to direction of energy transfer / travel / propagation ;	**2**	**A** energy transfer / travel / propagation is parallel to direction of vibration / oscillation = 2 marks
11(a)(ii)	sound ; seismic P waves ;	**2**	**A** ultrasound / infrasound **I** just 'seismic waves' **R** seismic S waves **I** just 'slinky' / spring **I** water waves
11(b)	 three curved wavefronts ; constant spacing of wavefronts throughout the diagram ;	**2**	**I** arrows
11(c)	n = sin i / sin r **or** 1.52 = sin 50 / sin r ; r = $\sin^{-1}$ (sin 50 / 1.52) ; r = 30° ; (90 – 30 =) 60° ;	**4**	**note**: award 4 marks if answer is 60° / 59.7° regardless of working out **note**: award 3 marks if r= 30° / 30.26° regardless of working out **A** ecf their r (90 – r) calculated correctly

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Question	Answer	Marks	Guidance
12(a)(i)	gravitational attraction ;	1	**A** gravitational force / force due to gravity gravitational pull / gravity
12(a)(ii)	decreases ;	1	**A** weakens / becomes weaker / lessens / AW
12(a)(iii)	nuclear fusion ; of hydrogen into helium ;	2	**A fusion of nuclei** **R** solar power
12(a)(iv)	conversion of T = 27 days to seconds **or** $27 \times 24 \times 60 \times 60$ **or** 2 332 800 ; $v = \frac{2\pi r}{T}$ ÷ **or** $v = \frac{2\pi \times 380\,000\,000 \text{ (converted to metres)}}{27 \times 24 \times 60 \times 60 \text{ or } 2\,332\,800}$; v = 1023 m / s ;	3	**note:** award 3 marks if answer is a 1023 regardless of working out. **A** any correct rounding of 1023.495 / 1023 / 1020 / 1000 (m / s)
12(b)	28,500 / 5,700 = 5 (half-lives) ; $307 \div 2^5$; = 9.59 counts / minute ;	3	**note**: award 3 marks if answer is 9.59 / 9.6 (counts / minute) regardless of working out **A** 10 (counts per minute) **A** alternative method Evidence of 5 half lives ; Correct calculation ; Correct final answer 1st H / L 307 ÷ 2 = 153.5 2nd H / L 153.5 ÷ 2 = 76.75 3rd H / L 76.75 ÷ 2 = 38.375 4th H / L 38.375 ÷ 2 = 19.1875 5th H / L 19.1875 ÷ 2 = 9.59(375) **A** ECF from incorrect number of half lives at MP1

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