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CO-ORDINATED SCIENCES **0654/42**

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)	guard cell ;	**1**	**I** stomata
1(b)	chlorophyll ;	**1**	**I** chloroplast
1(c)	**D** (many) air spaces ; for (efficient) diffusion of gases (to cells) ; **E** *idea of* tightly packed cells / many chloroplasts / lots of chlorophyll ; to absorb more light (for photosynthesis) ; **OR** (cells) positioned at / near, the surface of the leaf ; to receive more light (for photosynthesis) ;	**4**	**mark independently** **A** air gaps **I** empty space **A** for (efficient) gas exchange / description of gas exchange **A** cells densely packed **A** transfer light energy to chemical energy **I** store for absorb
1(d)(i)	(bubble gas through) limewater ;	**1**	**A** hydrogencarbonate indicator solution
1(d)(ii)	higher lower ; same higher ;	**2**	1 mark for 1st two correct 1 mark for 2nd two correct **A** high for higher and low for lower
1(e)	area = 0.159 (mm^2) ; (density =) (10 ÷ area) (0.159) = 63 ;	**2**	award 2 marks for correct answer on answer line **MP1 A** 0.16 **MP2** ecf from incorrect area **A** anything that rounds to 16 = 1 mark **A** 62.98 / 62.9 / 62.5 / anything that rounds to 63 = 2 marks

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Question	Answer	Marks	Guidance
2(a)	insulin ;	**1**	
2(b)	glycogen ; liver ;	**2**	
2(c)	pancreas ;	**1**	
2(d)	*any three from:* when blood glucose concentration is too high, insulin / hormone A, is released ; (causing) glucose to be converted to glycogen / blood glucose concentration to decrease (to a set point) ; when blood glucose concentration is too low glucagon released ; (causing) glycogen to be converted to glucose / blood glucose concentration to increase (to a set point) ;	**3**	**A** idea of returning to optimum / normal, for decrease or increase **A** when blood glucose concentration rises / falls for being too high or too low

Question	Answer	Marks	Guidance
3(a)	**B and D** ; *plus any three from:* *idea of* selection of chickens with, desirable features / AW ; breed / mate, the selected chickens ; select / breed, offspring with desirable features ; repeat for many generations ;	**4**	both needed for the mark **MP2 – 4** are independent marks **A** animals for chickens throughout **A** wanted features **I** selection of genes **R** different species breeding together **I** months / years / for a long time

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Question	Answer	Marks	Guidance
3(b)	antibiotics (only) kill / destroy, bacteria ; *idea that* unnecessary antibiotic use can lead to (the development of) antibiotic resistance (in bacteria) ;	**2**	**A** antibiotics cure / treat / 1work on / are effective against, bacterial, infection / disease **I** fight bacteria / only chicken Z has bacteria **R** antibiotics working against all pathogens / viruses **or** antibiotics releasing antibodies **A** using (antibiotics) when there is no infection leads to resistance **A** antibiotic use leads to resistant bacteria
3(c)(i)	bacterial cell structure — function cell wall — maintains shape of the cell plasmid — contains extra genes ribosome — site of protein synthesis ; ;	**2**	1 or 2 correct = 1 mark all 3 correct = 2 marks **R** additional lines
3(c)(ii)	decomposition ; (bacteria / decomposers / decomposition) , release carbon / carbon dioxide / nutrients / minerals / ions (trapped in dead matter) ; for photosynthesis (by producers to transfer through food chains) ;	**3**	**I** respiration **I** idea of releasing energy

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Question	Answer	Marks	Guidance
4(a)	nuclei ; zygote ; haploid ;	3	**A** nucleus **I** chromosomes **I** embryo
4(b)(i)	energy stores ; jelly coat that changes after fertilisation ; AVP ;	2	**A** nutrient store / (cytoplasm) contains nutrients / contains nutrients **I** food **A** jelly coat that only allows one sperm to enter **R** cell wall **I** cell membrane **A** haploid nucleus to maintain chromosome number **I** mitochondria for energy release
4(b)(ii)	female gametes are bigger / ORA ; more male gametes produced / ORA ; *max two from:* male gametes are motile / ORA ; male gametes contain X **or** Y chromosomes / female gametes contain X chromosome ; male gametes have acrosome ; male gametes have flagellum ; male gametes have lots of mitochondria ; female gametes have jelly coat ; female gametes have energy store ;	3	**A** egg for female gamete and sperm for male gamete throughout **I** data quotes copied from table **A** swim for motile **I** egg cells can't move **I** tail for flagella

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Question	Answer	Marks	Guidance
4(c)(i)	(a process that results in) genetically identical offspring ; from one parent ;	2	**I** meiosis / clone **A** doesn't need two parents **R** fusion of gametes for **MP2**
4(c)(ii)	no genetic variation so unable to adapt to a change in the environment ;	1	**A** examples of environmental change e.g. no genetic variation so a disease may cause, **extinction / all the population to be wiped out** **A** genetic diversity for genetic variation **I** all more susceptible to disease **A** different for change **A** less for no

Question	Answer	Marks	Guidance
5(a)	(arrangement) regular / lattice / close together ; (movement) vibrate ;	2	**I** fixed (position) **A** oscillate **I** fixed / don't move
5(b)	hydrogen has a smaller M_r (than nitrogen) / ORA ; (so) hydrogen molecules move fast**er** (than nitrogen molecules) / ORA ;	2	note: assume unqualified answer refers to hydrogen **I** hydrogen is lighter **A** hydrogen molecule **or** atom has less mass / hydrogen has a smaller atomic mass **A** particles for atoms or molecules **I** kinetic energy / diffuses faster
5(c)	21 (%) ;	1	
5(d)(i)	nitrogen and oxygen (from the air) reacts (in a car engine) because of high temperatures ;	1	**R** nitrogen and oxygen from the fuel

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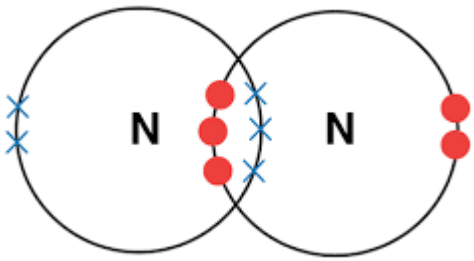
Question	Answer	Marks	Guidance
5(d)(ii)	(2CO +) 2NO → $2CO_2$ + N_2 ;	**2**	note: award 1 mark for formulae and 1 mark for balancing correct equation **A** correct equations involving other oxides of nitrogen
5(e)	 ; ;	**2**	note: award 1 mark for 3 shared pairs of electrons between nitrogen atoms award 1 mark for rest of structure correct **A** electrons to be all dots or all crosses **I** inner-shell electrons **A** any mixture of dots and crosses or other symbols

Question	Answer	Marks	Guidance
6(a)	copper has a lower melting point ☐ copper is softer ☐ copper is more dense ☑ ; copper is less reactive ☑ ; copper is less strong ☐	**2**	3 boxes ticked and 2 correct = 1 mark 3 boxes ticked and 1 correct = 0 marks 4 boxes ticked = 0 marks
6(b)	neon atoms have a full outer shell (of electrons) ; neon atoms do not need to, lose / gain / share electrons ;	**2**	**A** neon's electronic configuration is 2.8 / have 8 electrons in their outer shell **I** Neon is in group 8 / 0

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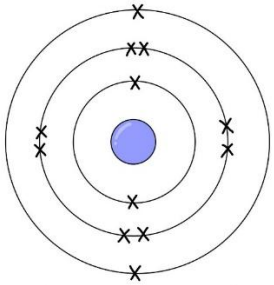
Question	Answer	Marks	Guidance
6(c)	A ☐ B ☐ C ☐ D ☑ ;	1	
6(d)	 ;	1	**A** electrons drawn as dots or crosses
6(e)	*idea that* layers (of ions in magnesium allow them to) slide (over each other easily) ;	1	**R** molecules **A** sheet / row for layer
6(f)(i)	ionic ;	1	**A** electrovalent
6(f)(ii)	*any three from:* magnesium atoms lose electrons ; oxygen atoms gain electrons ; idea that **two** electrons are, lost / gained ; oppositely charged ions attract / Mg^{2+} **and** O^{2-} formed ;	3	**A** correct dot-and-cross diagram **I** breaking bonds to form atoms

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Question	Answer	Marks	Guidance
7(a)	(**s**) ;	**1**	
7(b)(i)	A ;	**1**	
7(b)(ii)	C ; longest time / slowest reaction ;	**2**	 **A** slow**est** time / takes long**est**
7(c)	(distilled water) contains fewer (chemical) impurities (than tap water) ;	**1**	assume answer refers to distilled water **A** distilled water is pure / has no impurities **A** tap water contains impurities **I** dirt / elements
7(d)(i)	any time less than 124 (s) ;	**1**	
7(d)(ii)	*any three from:* *(reaction is faster because) no mark* molecules have higher (average) kinetic energy ; more molecules with activation energy ; frequency of (effective) collisions (of molecules) is higher / more collisions per second ; more, successful / effective, collisions ;	**3**	 **A** particles for molecules **A** molecules are moving faster **I** 'faster collisions' **I** just more collisions **A** collision rate is higher / more likely to collide / increased chance of collision
7(e)	combustion ; sulfur ;	**2**	**A** oxidation / burning **I** sulfuric / sulfurous **A** sulphur

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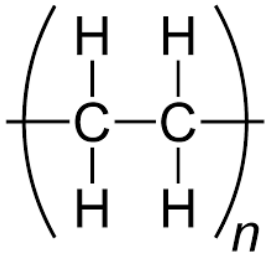
Question	Answer	Marks	Guidance
8(a)(i)	steam ;	1	**A** water vapour / water
8(a)(ii)	 ; ;	2	note: award 1 mark for **only** single bond between carbon atoms **R** presence of double bond award 1 mark for rest of structure correct **A** structure with **or** without the *n* **or** brackets **MP2** has to have continuation bonds **A** any number of carbons
8(a)(iii)	(orange to) colourless / decolourised ;	1	**I** goes clear / transparent
8(b)	$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$; ;	2	note: award 1 mark for formulae and 1 mark for balancing of the correct formula **A** correct multiples **A** $C_2H_6 + 3½O_2 \rightarrow 2CO_2 + 3H_2O$;
8(c)(i)	decreases ;	1	**A** smaller / shorter
8(c)(ii)	chemical feedstock ;	1	**A** solvent / cleaning fluid / dry-cleaning agent / to make chemicals or plastics / lighter fuel / making medicines **I** fuel unqualified or other types of fuel **I** chemical reactions

Question	Answer	Marks	Guidance
9(a)	speed has magnitude (only) / is a scalar ; velocity has magnitude and direction / is a vector ;	2	**A** speed is how fast something is moving **A** distance moved per unit time or per second **I** distance moved in s specific / certain time **A** velocity is the speed in a direction
9(b)(i)	non-constant acceleration ;	1	**I** increasing acceleration **A** decreasing / non-uniform, acceleration

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Question	Answer	Marks	Guidance
9(b)(ii)	$a = \frac{v-u}{t}$ **or** evidence of gradient e.g. (2.0 – 1.25) / (30 – 15) ; 0.050 (m/s²) ;	**2**	award 2 marks for correct answer on answer line
9(c)(i)	(resultant force =) ma or 5 × 1.2 ; (resultant force) = 6 (N) ; (resistive force) = 10.5 – 6 = 4.5 (N) ;	**3**	award 3 marks for correct answer on answer line
9(c)(ii)	E=0.5 mv² **or** 2.2 = 0.5 × 1.2 × v² ; v=1.9 (m / s) ;	**2**	$v^2 = \frac{2.2 \times 2}{1.2}$ award 2 marks for correct answer on answer line

Question	Answer	Marks	Guidance
10(a)(i)	detecting fake bank notes / AVP ;	**1**	**A** security marking / sterilisation / (sun) tanning / curing glue / kill bacteria or pathogens / fluorescent tubes ;
10(a)(ii)	damage to, (surface) cells / skin cells / eyes or skin cancer ;	**1**	**I** cancer / tumours unqualified **A** sunburn / tissue damage **A** damage skin
10(b)(i)	vibration ; parallel ;	**2**	**I** energy transfer **A** oscillations **I** compressions / rarefactions **A** same for parallel
10(b)(ii)	20 000 Hz / 20 kHz ;	**1**	**A** 20001 Hz – 21000 Hz **A** 21 kHz

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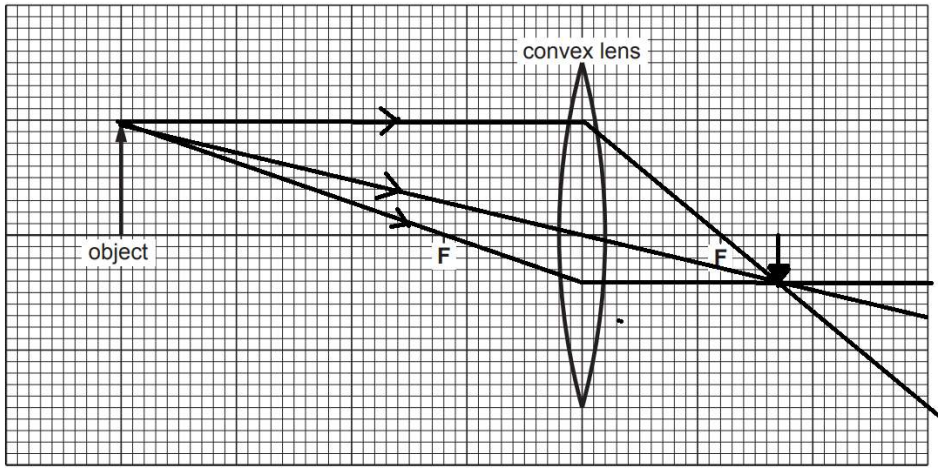
Question	Answer	Marks	Guidance
10(b)(iii)	at compressions pressure is greater ; due to particles being closer together ; OR at rarefactions pressure is lower ; due to particles being further apart ;	**2**	**A** at compression pressure is high **A** particles being close together **A** at rarefactions pressure is low **A** particles being far apart **A** molecules for particles **I** waves for particles **I** particles being denser **A** particle density
10(c)	any one correct complete light ray from object to image ; any second correct complete light ray from object to image ; image marked with an inverted arrow between principal axis and point where rays cross ;  	**3**	**I** arrows on the light rays Allow ecf for MP3

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Question	Answer	Marks	Guidance
11(a)(i)	doubles ;	1	**I** increases
11(a)(ii)	6.3 (Ω) ;	1	**I** half
11(b)(i)	recall of formula for resistors in series or parallel ; 10 (Ω) is combined resistance of two 20 W resistors ; (10 + 40 =) 50 (Ω) ;	3	$R_T = R_1+R_2$ or $1 / R_T = 1 / R_1+1 / R_2$ or $R_T = R_1R_2 / R_1+R_2$ or numerical substitution award 3 marks for correct answer on answer line
11(b)(ii)	I=V ÷ R **or** 3.6 ÷ 50 = 0.072 (A) ; (0.072 ÷ 2 =) 0.036 (A) ;	2	**ecf on their 11(b)(i)** award 2 marks for correct answer on answer line
11(c)	evidence of E=VIt **or** 3.6 × 0.18 × 60 ; 39 (J) ;	2	**A** 38.88 award 2 marks for correct answer on answer line

Question	Answer	Marks	Guidance
12(a)(i)	92 **and** 143 ;	1	this order only
12(a)(ii)	(+)92 ;	1	**A** ecf from **12(a)(i)** incorrect proton number
12(a)(iii)	splitting up of a <u>nucleus</u> ;	1	**A** breaking up / dividing / separating
12(b)	cosmic rays / Sun / exploding stars ;	1	**I** sunlight
12(c)	(nuclear) fusion ; hydrogen into helium ;	2	**R** nuclear fission

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Question	Answer	Marks	Guidance
12(d)	v=2π r / T **or** v = d / t ; 1030 = 2π r / (27 × 60 × 60 × 24) **or** r = 382 thousand km ; 3 820 000 / 3 × 10^8 = 1.27 (s) ;	**3**	$r = \frac{1030 \times 2.3 \times 10^6}{6.2} = 3.8 \times 10^8$ m $t = \frac{d}{v} = \frac{3.8 \times 10^8}{3 \times 10^8} = 1.27\ (1.3)$ s
12(e)	*any two from:* the Universe expanded from a (single) point of high, density / temperature ; the Universe is still expanding ; the Universe is approximately 13.8 billion years old ;	**2**	**I** pressure **A** values of 13–14 billion

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