



Cambridge IGCSE™

CO-ORDINATED SCIENCES

0654/04

Paper 4 Theory (Extended)

For examination from 2025

MARK SCHEME

Maximum Mark: 120

Specimen

This document has **14** pages. Any blank pages are indicated.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptions for the question
- the specific skills defined in the mark scheme or in the generic level descriptions for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct / valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptions.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however ; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptions in mind.

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	<p><u>'List rule' guidance</u></p> <p>For questions that require n responses (e.g. State two reasons ...):</p> <ul style="list-style-type: none"> • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked <i>ignore</i> 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.

6 Calculation specific guidance

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 Guidance for chemical equations

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.

mark scheme abbreviations

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

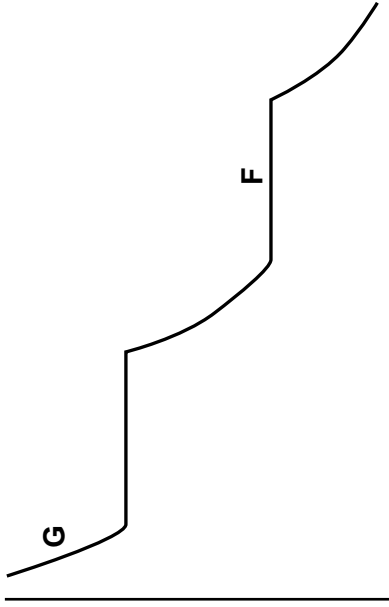
Question	Answer	Marks	Guidance
1(a)(i)	oxygen ;	1	
1(a)(ii)	the number of bubbles released / rate of photosynthesis, increases and decreases (with temperature) ; peak at, 45 °C / 71 bubbles per minute ;	2	
1(b)	any three from: enzymes denature at high temperature ; active site shape is changed ; substrate can no longer fit ; so rate of, reaction / photosynthesis decreases ;	3	
1(c)	sources release, sucrose / amino acids ; sinks, use OR store, sucrose / amino acids ;	2	
1(d)	starch ; glucose ; cellulose ;	3	

Question	Answer	Marks	Guidance
2(a)	pathogens ; lymphocytes ; memory ; increases / otuwe ; complementary ; phagocytes / phagocytosis ;	6	A virus I bacteria
2(b)	active ;	1	
2(c)	any two from: contaminated surfaces ; food ; air ; animals ;	2	R blood / body fluid

Question	Answer	Marks	Guidance
3(a)(i)	whooping crane ;	1	
3(a)(ii)	increase is $1415 - 210 = 1205$; percentage increase is $(1205 \div 210) \times 100$; 574 ;	3	1 mark for correct numbers from table and calculating increase 1 mark for correct percentage increase calculation 1 mark for correct rounding to a whole number 574 gains all 3 marks 573.8(095424) gains 2 marks
3(b)	any three from: global warming / climate change ; destruction, of habitat ; natural disasters ; hunting / collecting / poaching ; overharvesting ; (named) pollution ; introduced species / increased competition (for named resource) / otthwe ; food chain / web, disrupted OR over predation OR lack of food ; disease ;	3	
3(c)(i)	primary consumer ;	1	A trophic level 2
3(c)(ii)	energy is lost between the trophic levels ; named example of energy loss ; idea of fewer energy transfers to nene goose than to bald eagle ;	3	

Question	Answer	Marks	Guidance
4(a)(i)	$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$; ;	2	1 mark for $C_6H_{12}O_6 + 6O_2$ 1 mark for $6CO_2 + 6H_2O$ A reactants in either order A products in either order
4(a)(ii)	7 (minutes) ;	1	
4(b)(i)	blood ; muscles ;	2	A in either order

Question	Answer	Marks	Guidance
4(b)(ii)	(continuation) faster heart rate to transport lactic acid (in the blood) ; to the liver ; (continuation) deeper / faster, breathing to supply oxygen ; correct reference to using aerobic respiration (of lactic acid) ;	3	
4(c)	any one from: reduction in calories ; reduction in energy intake ; reduction in (saturated) fat consumed ; reduction in salt consumed ; ref. to maintaining a balanced diet ;	1	

Question	Answer	Marks	Guidance												
5(a)	<table border="1"> <tr> <td>particle separation</td> <td>particle arrangement</td> <td>particle motion</td> </tr> <tr> <td>solid</td> <td>close together ;</td> <td></td> </tr> <tr> <td>liquid</td> <td>random ;</td> <td></td> </tr> <tr> <td>gas</td> <td></td> <td>move fast in all directions ;</td> </tr> </table>	particle separation	particle arrangement	particle motion	solid	close together ;		liquid	random ;		gas		move fast in all directions ;	3	A random
particle separation	particle arrangement	particle motion													
solid	close together ;														
liquid	random ;														
gas		move fast in all directions ;													
5(b)(i)	G marked anywhere on top curve ;	1	R G on top of horizontal line 												
5(b)(ii)	F marked anywhere on lower horizontal line ;	1													

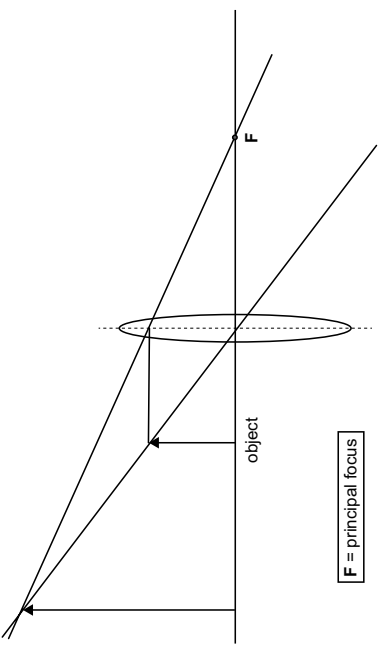
Question	Answer	Marks	Guidance
5(b)(iii)	horizontal line(s) on the graph shows water is pure because it does not melt/boil over a range of temperatures / horizontal line(s) on the graph shows water is pure because it has a precise melting and / or boiling point / otfwe ; there is a horizontal line on the graph / owtte ;	1	
5(b)(iv)	any two from: the energy of the particles decrease / the particles move more slowly ; the intermolecular forces increase between the particles pulling the particles closer together ; energy is transferred to the surroundings ;	2	
5(c)	(water has) weak intermolecular forces / weak attractions between (water) molecules ; these forces do not require a large amount of energy to break / owtte ;	2	R references to covalent / ionic bond

Question	Answer	Marks	Guidance
6(a)	any one from: resistance to corrosion / does not react ; malleable (aluminium has a) low density / light in weight / lightweight ;	1	I does not rust A not toxic
6(b)	salt ; hydrogen ;	2	A in either order
6(c)	(oxidation because) aluminium atoms lose electrons / oxidation number of aluminium increases (from 0 to +3) ;	1	award mark for explanation no mark for oxidation
6(d)(i)	(basic because) copper is a metal ;	1	
6(d)(ii)	$\text{CuO} + \text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{H}_2\text{O}$;	1	
6(e)(i)	(exothermic because) (thermal) energy is transferred to the surroundings / energy is given out / products have less energy than the reactants ;	1	award mark for explanation no mark for exothermic R references to endothermic
6(e)(ii)	minimum amount of energy ; that colliding particles must have to react ;	2	


Question	Answer	Marks	Guidance
7(a)	water / H ₂ O ;	1	
7(b)	(carbon dioxide) absorbs thermal energy radiated from the Earth ; (carbon dioxide) then emits thermal energy (in all directions) ; this reduces thermal energy loss to space / owtte ;	3	A thermal energy is emitted back down to Earth causing temperatures to increase
7(c)	any one from: (advantage) idea that the water waste product is not harmful or may be reused / fuel cell produces electricity as long as hydrogen is supplied / idea of no moving parts so energy is not lost through friction / electricity is generated directly from the reaction (so no turbines or generators) / idea that because there are not many stages there are fewer places for energy to be lost as heat / any one from: (disadvantage) there are very few hydrogen filling stations or the car may not have a long range / expensive to manufacture / hydrogen (is a gas so) takes up lots of space to store / idea that production of hydrogen for fuel cells involves (non-renewable) fossil fuels ;	2	I hydrogen is explosive / flammable (an equal if not greater hazard)
7(d)(i)	alkane ;	1	
7(d)(ii)	Mr of C ₇ H ₁₆ = 100 ; moles of C ₇ H ₁₆ = 2.5 ÷ 100 = 0.025 ; moles of CO ₂ = 7 × 0.025 = 0.175 ; volume of CO ₂ = 0.175 × 24 = 4.2 dm ³ ;	4	award 4 marks if answer is 1.2 dm ³ , regardless of working out A ecf from incorrect Mr A ecf , i.e. 7 × moles of C ₇ H ₁₆ A ecf from incorrect moles of CO ₂

Question	Answer	Marks	Guidance
8(a)(i)	$MgCl_2$;	1	R $MgCl^2 / MgCl_2$
8(a)(ii)	(good conductor when aqueous) ions are free to move so charge can flow / owtte ; (does not conduct when solid because) ions are held in fixed positions and cannot move / owtte ;	2	
8(b)	$Mg^{2+} + 2e^- \rightarrow Mg$ formulas ; balancing ;	2	
8(c)	(as the temperature increases) the rate of reaction increases / for every 10 °C increase, the rate of reaction doubles ; any three from: molecules have higher (average) energy / molecules are moving faster ; more molecules with activation energy ; frequency of collision (of molecules) is higher / more collisions per second ; more successful collisions ;	4	A particles for molecules I quicker or faster collisions A collisions more often / collisions more likely / greater chance of collision I just more collisions
8(d)	(catalyst) decreases the activation energy / E_a (of the reaction) ;	1	A decreases the minimum amount of energy that colliding particles must have to react

Question	Answer	Marks	Guidance
9(a)(i)	change in velocity per unit time ;	1	
9(a)(ii)	straight line from the origin ; finishing at (3.0, 30.0) ;	2	
9(a)(iii)	($F =$) <i>ma</i> OR 1750×10 ; ($F =$) 17 500 (N) ;	2	
9(b)(i)	a quantity with magnitude and direction ;	1	

Question	Answer	Marks	Guidance
9(b)(ii)	gravitational field strength ; velocity ;	2	do not credit more than two ticks
9(c)	$(R =) \frac{V}{I} \text{ OR } \frac{12}{0.3}$; $(R =) 40$; Ω / Ohms ;	3	A $\frac{12}{0.6}$
9(d)	at least two real rays correctly drawn ; at least two virtual rays correctly drawn ; correct position of image ;	3	

Question	Answer	Marks	Guidance
10(a)(i)	arrow drawn from Saturn pointing towards the Sun ;	1	
10(a)(ii)	gravitational (force / attraction) ;	1	
10(a)(iii)	(11 000 Earth days =) 9.50×10^9 (s) ; $(v =) \frac{2\pi r}{T} = 2\pi \times 1.43 \times 10^{12} / 9.50 \times 10^8$; $(v =) 9500$ (m / s) ;	3	A 9458 (m / s)
10(b)	any two from: protostar ; (interstellar) clouds of dust and gas ; gravitational attraction ;	2	A nebula
10(c)	(the Universe expanded) from a point ; of very high temperature and density ;	2	

Question	Answer	Marks	Guidance																					
11(a)(i)	<table border="1"> <thead> <tr> <th></th> <th>red LED</th> <th>amber LED</th> </tr> </thead> <tbody> <tr> <td></td> <td>4.62 × 10¹⁴</td> <td></td> </tr> <tr> <td>frequency / Hz</td> <td>4.92 × 10¹⁴</td> <td>✓</td> </tr> <tr> <td></td> <td>5.66 × 10¹⁴</td> <td></td> </tr> <tr> <td></td> <td>5.30 × 10⁻⁷</td> <td></td> </tr> <tr> <td>wavelength / m</td> <td>6.10 × 10⁻⁷</td> <td>✓</td> </tr> <tr> <td></td> <td>6.50 × 10⁻⁷</td> <td>✓</td> </tr> </tbody> </table>		red LED	amber LED		4.62 × 10 ¹⁴		frequency / Hz	4.92 × 10 ¹⁴	✓		5.66 × 10 ¹⁴			5.30 × 10 ⁻⁷		wavelength / m	6.10 × 10 ⁻⁷	✓		6.50 × 10 ⁻⁷	✓	1	
	red LED	amber LED																						
	4.62 × 10 ¹⁴																							
frequency / Hz	4.92 × 10 ¹⁴	✓																						
	5.66 × 10 ¹⁴																							
	5.30 × 10 ⁻⁷																							
wavelength / m	6.10 × 10 ⁻⁷	✓																						
	6.50 × 10 ⁻⁷	✓																						
11(a)(ii)	$4.92 \times 10^{14} \times 6.10 \times 10^{-7} = 3.001 \times 10^8$	1																						
11(b)(i)	(P =) 3.6 × 0.025 ; (P =) 0.09 (W) ;	2																						
11(b)(ii)	0.09 × 0.4 ; 0.036 (W) ;	2	ecf from (b)(i)																					
11(c)		1																						

Question	Answer	Marks	Guidance
12(a)(i)	splitting of (large) nuclei (to release energy) ;	1	
12(a)(ii)	(steam) particles collide with walls of container / boiler ; (exerting) a force (per unit area) on walls of container / boiler ;	2	walls of container may be implied from M1
12(a)(iii)	kinetic ;	1	A KE I thermal
12(b)(i)	region in which a magnetic pole experiences a force ;	1	
12(b)(ii)	increase strength of magnetic field ; more turns on the coil ;	2	
12(b)(iii)	sinusoidal shape ; larger amplitude ; shorter time period ;	3	

BLANK PAGE