



Cambridge IGCSE™

COMBINED SCIENCE

0653/41

Paper 4 Theory (Extended)

October/November 2021

MARK SCHEME

Maximum Mark: 80

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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This document consists of **11** printed pages.

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GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors 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).

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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.

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5 'List rule' guidance

For questions that require ***n*** responses (e.g. State **two** reasons ...):

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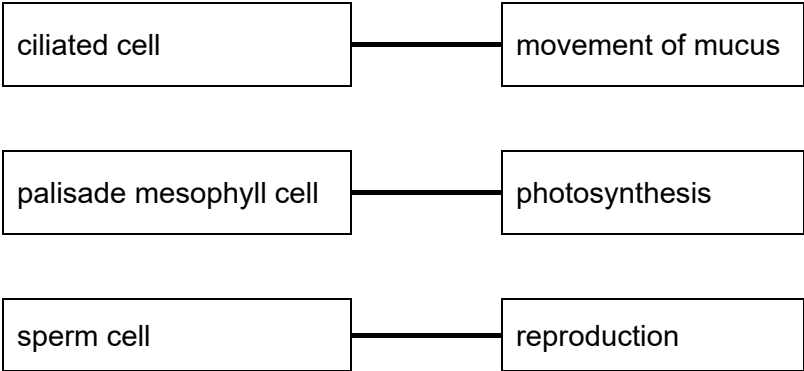
7 Guidance for chemical equations

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- underline actual word given must be used by candidate (grammatical variants accepted)
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Question	Answer	Marks
1(a)	 one correct line ; three lines correct ;	2
1(b)(i)	vacuole / cell wall ;	1
1(b)(ii)	root hair (cell) ;	1
1(b)(iii)	water moves by osmosis ; from high water potential to a low water potential / down a water potential gradient / (because) cell X has a lower water potential than cell Y OR A ; through a partially permeable membrane ;	3
1(c)	evaporation from (surface of) mesophyll cells ; diffusion (of water vapour) through stomata ;	2
1(d)	(magnesium deficiency causes) leaves (to) turn yellow ; (because magnesium) needed to make chlorophyll ;	2

Question	Answer	Marks
2(a)	A melting ; B condensation ; C freezing ;	3
2(b)	<i>energy</i> : particles have more (kinetic) energy at 120 °C ; <i>arrangement</i> : particles close / regular / lattice at –10 °C but random / spread out at 120 °C ; <i>movement</i> : particles (vibrate) in fixed positions at –10 °C but move around freely at 120 °C ;	3
2(c)	<i>any three from</i> : more (thermal) energy needed to break bonds (in sodium chloride) ; sodium chloride, contains ionic bonds / is ionic ; the bonds between ions are stronger than between (water) molecules ; attraction between ions is high due to opposite electrical charges / strong electrostatic attraction between ions ;	3

Question	Answer	Marks
3(a)	chemical (potential) ; thermal / heat ;	2
3(b)(i)	acceleration = change in speed ÷ time <i>in any form</i> / $17 \div 3.5$; $4.9 \text{ (m / s}^2\text{)}$;	2
3(b)(ii)	use of area under graph / $\frac{1}{2} \times 3.5 \times 17$; 30 (m) ;	2
3(b)(iii)	$KE = \frac{1}{2} m v^2$ <i>in any form</i> / $\frac{1}{2} \times 32 \times 17 \times 17$; 4600 (J) ;	2
3(b)(iv)	$P = E \div t$ <i>in any form</i> / $4600 \div 3.5$; 1300 ; watt(s) / W ;	3

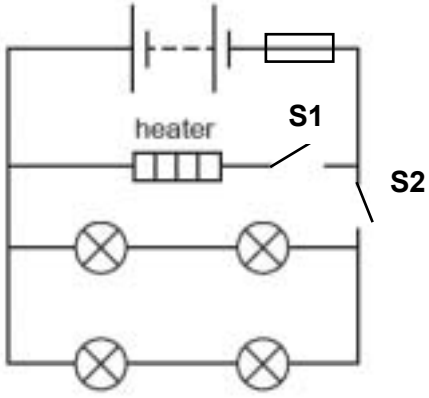
Question	Answer	Marks
4(a)	environment ; area ;	2
4(b)(i)	fish / blue whale ;	1
4(b)(ii)	transferred to fish when fish feeds on zooplankton ; transferred to bird when bird feeds on fish ;	2
4(c)	<i>(increased availability of nitrate ions causes)</i> (increased) growth of producers ; <i>(increased aerobic respiration by)</i> decomposers / bacteria ; <i>(death of fish due to)</i> lack of oxygen ;	3

Question	Answer	Marks
5(a)	iron(III) oxide ; CuO ;	2
5(b)	carbon ; removes oxygen from the lead(II) oxide / reducing agents remove oxygen from another substance / it reduces lead(II) oxide / reduces lead <u>ions</u> ;	2
5(c)(i)	iron (<i>most</i>) lead copper (<i>least</i>) in correct order; the more reactive metal displaces the less reactive / AW ;	2
5(c)(ii)	(yes, because) zinc is more reactive (than iron) ;	1
5(d)	solution goes colourless / blue colour fades / decolourises ; lead has a brown / orange coating / dark brown / orange solid appears ;	2

Question	Answer	Marks
6(a)(i)	arrow showing one complete wavelength ;	1
6(a)(ii)	molecules clos(er) together in compressions / molecules further / (far) apart in rarefactions ;	1
6(b)(i)	<i>any two from:</i> bat / dog / horse ;	1
6(b)(ii)	bat AND canary bird ;	1
6(c)	$v = f\lambda$ in any form / $340 \div 170$; ($\lambda =$) 2 m ; (distance = $2 \times 60 =$) 120 (m) ;	3
6(d)	adaptation stated, e.g. large surface area ; correctly matched to method of energy transfer, e.g. radiation ;	2

Question	Answer	Marks
7(a)(i)	 bronchus labelled anywhere in shaded area ;	1
7(a)(ii)	<i>any two from:</i> large surface area ; good blood supply ; thin <u>walls</u> ; good ventilation ; AVP ;	2
7(b)(i)	person 1 has a higher increase in breathing rate ORA ;	1
7(b)(ii)	70 AND 130 AND 60 ; 86 ;	2
7(c)	<i>any two from:</i> increased respiration ; cause increase in carbon dioxide levels (in the blood) ; removes more carbon dioxide (from the blood) / removes carbon dioxide faster ; AVP ;	2

Question	Answer	Marks
8(a)	<i>any two from:</i> (sea) water / solutions, pass through filter ; insoluble materials / plastic / solids, do not pass through filter ; description of, filter / filter paper, as being, porous / having (small) holes ;	2
8(b)	distillation ; heat / boil / evaporate, (sea) water ; salt is left behind ; condense / cool, steam / water vapour (to obtain pure water);	4
8(c)	chlorine ; kills any bacteria in the water ;	2

Question	Answer	Marks
9(a)	total current = sum of branches / $8.5 + 1.5 + 1.5$; 11.5 (A) ;	2
9(b)	ammeter ;	1
9(c)	 correct symbols for fuse AND switch ; switch S1 in correct place for heater ; switch S2 in correct place for lamps ; fuse in correct place AND no short circuits, open circuits or additional components ;	4



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Question	Answer	Marks								
1(a)	 cervix labelled anywhere in shaded area ;	1								
1(b)(i)	respiration ;	1								
1(b)(ii)	amino acids come from mother's blood ; <i>plus any one from:</i> cross the placenta ; brought to fetus by umbilical cord ; via diffusion ;	2								
1(c)	idea that fetus needs some of the iron ; reference to any named iron deficiency symptom (in mother) / iron is needed for haemoglobin production ;	2								
1(d)	<table><tr><td>organ</td><td>function</td></tr><tr><td>mouth ;</td><td>(uses teeth to breakdown food into smaller pieces)</td></tr><tr><td>(large intestine)</td><td>absorbs water ;</td></tr><tr><td>anus ;</td><td>(egestion)</td></tr></table>	organ	function	mouth ;	(uses teeth to breakdown food into smaller pieces)	(large intestine)	absorbs water ;	anus ;	(egestion)	3
organ	function									
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(large intestine)	absorbs water ;									
anus ;	(egestion)									

Question	Answer	Marks									
2(a)(i)	does not react (with the solution) ;	1									
2(a)(ii)	<table border="1"> <thead> <tr> <th>(solution)</th><th>(name of gas formed at positive electrode)</th><th>(name of gas formed at negative electrode)</th></tr> </thead> <tbody> <tr> <td>(dilute aqueous sodium chloride)</td><td>oxygen</td><td>hydrogen</td></tr> <tr> <td>(concentrated aqueous sodium chloride)</td><td>chlorine</td><td>hydrogen</td></tr> </tbody> </table> oxygen ; chlorine ; hydrogen AND hydrogen ;	(solution)	(name of gas formed at positive electrode)	(name of gas formed at negative electrode)	(dilute aqueous sodium chloride)	oxygen	hydrogen	(concentrated aqueous sodium chloride)	chlorine	hydrogen	3
(solution)	(name of gas formed at positive electrode)	(name of gas formed at negative electrode)									
(dilute aqueous sodium chloride)	oxygen	hydrogen									
(concentrated aqueous sodium chloride)	chlorine	hydrogen									
2(a)(iii)	<i>positive</i> : anode AND <i>negative</i> : cathode ;	1									
2(b)	sodium ions are positive ; attracted to the, negative electrode / cathode ; where they gain, electrons / one electron each (to form sodium) ;	3									
2(c)	only sodium cations are present in molten sodium chloride / molten sodium chloride does not contain any hydrogen (ions) / hydrogen (ions) also present in aqueous sodium chloride ; sodium is more reactive than hydrogen / hydrogen ions (in aqueous solution) more easily discharged / AW ;	2									

Question	Answer	Marks
3(a)(i)	3 ;	1
3(a)(ii)	double-headed arrow between equilibrium position (mid-point) and any peak or trough ;	1
3(b)(i)	frequency = number of waves per second / 6 ÷ 40 ; 0.15 ; Hz ;	3
3(b)(ii)	$v = f\lambda$ in any form / 0.15×18 ; 2.7 (m / s) ;	2
3(c)	0.055 s AND sound travels faster through, water / liquids (than in, air / gases) ORA ;	1

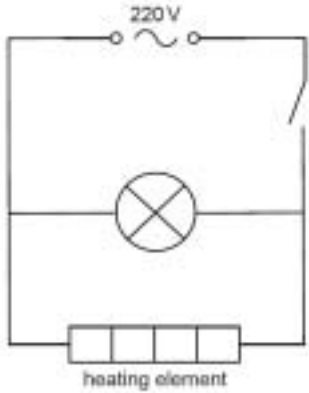
Question	Answer	Marks
4(a)(i)	diaphragm ;	1
4(a)(ii)	larynx labelled ;	1
4(b)	<i>difference</i> : more carbon dioxide in expired air ; <i>explanation</i> : because produced in respiration ;	2
4(c)	<i>any three from</i> : cilia are, damaged / shorter ; (goblet cells make) more mucus ; pathogens / particles, trapped in the mucus ; idea that it is harder (for cilia) to move the mucus ; idea that, pathogens / particles, are not removed (easily) from the airways ;	3

Question	Answer	Marks
5(a)	use universal indicator ; observe the colour ;	2
5(b)(i)	iron(III) chloride AND has the lowest pH ;	1
5(b)(ii)	copper(II) sulfate AND iron(III) chloride ;	1
5(c)	experiment 4 ; more particles, have / collide with, the (minimum) activation energy ; <i>plus any two from:</i> higher temperature means higher, kinetic energy / speed ; small pieces have larger surface area ; reference to more frequent collisions ;	4

Question	Answer	Marks
6(a)(i)	force due to Earth's gravitational field accelerates meteorite / energy is transferred from GPE store to KE store ;	1
6(a)(ii)	$KE = \frac{1}{2}mv^2$ in any form / $\frac{1}{2} \times 45\,000 \times (1.7 \times 10^4)^2$; 6.5×10^{12} (J) ;	2
6(b)(i)	(resultant opposing force of) air resistance / friction ;	1
6(b)(ii)	(opposing) force increases / atmosphere becomes denser ;	1
6(c)(i)	(volume = $3480 - 2500 =$) $980 \text{ (cm}^3\text{)}$;	1
6(c)(ii)	unit conversion / $980 \times 10^{-6} \text{ (m}^3\text{)}$; density = $m \div V$ in any form / $4.52 \div 980 \times 10^{-6}$; $4610 \text{ (kg / m}^3\text{)}$; so must be stony-iron meteorite / identification of type of meteorite matched with density calculation ;	4

Question	Answer	Marks
7(a)(i)	0.2 ÷ 180 ; 0.001 (cm / s) ;	2
7(a)(ii)	as light intensity increases, the rate of photosynthesis increases ; idea that rate levels off (below 20 cm) ;	2
7(b)	<i>any three from:</i> 0 to 30 °C rate increases as enzymes gain more kinetic energy ; 0 to 30 °C rate increases as there are more (effective) collisions ; above 30 °C enzymes denature / shape of active site changes ; above 30 °C substrate no longer fits into active site ;	3
7(c)	phloem ; starch ;	2
7(d)(i)	phototropism ;	1
7(d)(ii)	auxin ;	1

Question	Answer	Marks
8(a)(i)	respiration / AVP ;	1
8(a)(ii)	combustion of fossil fuels / AVP ;	1
8(b)	causes <u>enhanced</u> greenhouse effect / global warming ; leads to, climate change / named harmful effect of climate change e.g. sea level rise ;	2
8(c)(i)	<i>solvent</i> : water ; <i>solute</i> : salts / gases ; <i>solution</i> : carbonic acid / sea (water) ;	3
8(c)(ii)	seas are becoming more acidic / acidification / named harmful effect ;	1

Question	Answer	Marks
9(a)	100 °C ;	1
9(b)	reference to (thermal) expansion (of metal) ; brass expands more (than steel causing the switch to bend / open) ;	2
9(c)(i)	conversion of kW to W / 2400 ; $P = IV$ in any form / $2400 \div 220$; 11 (A) ;	3
9(c)(ii)	 correct symbols for lamp AND switch ; lamp in parallel with heating element ; switch controls both lamp and heater AND no short circuits, open circuits or additional components ;	3



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1(a)(ii)	encloses fetus / holds or produces amniotic fluid ;	1															
1(a)(iii)	<i>any three from:</i> via umbilical cord ; to the placenta ; passes into mother's blood ; correct reference to diffusion ;	3															
1(b)	<i>any two from:</i> contraction ; of ventricles / muscle ; AVP ;	2															
1(c)	<table border="1"> <thead> <tr> <th></th><th>male gametes</th><th>female gametes</th></tr> </thead> <tbody> <tr> <td>name</td><td>sperm(s) ;</td><td>(eggs)</td></tr> <tr> <td>where they are made</td><td>testes ;</td><td>(ovaries)</td></tr> <tr> <td>number released at any one time</td><td>(over 40 million)</td><td>one ;</td></tr> <tr> <td>adaptive feature</td><td>flagellum / enzymes ;</td><td>(jelly coating)</td></tr> </tbody> </table>		male gametes	female gametes	name	sperm(s) ;	(eggs)	where they are made	testes ;	(ovaries)	number released at any one time	(over 40 million)	one ;	adaptive feature	flagellum / enzymes ;	(jelly coating)	4
	male gametes	female gametes															
name	sperm(s) ;	(eggs)															
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number released at any one time	(over 40 million)	one ;															
adaptive feature	flagellum / enzymes ;	(jelly coating)															

Question	Answer	Marks
2(a)	ammonium nitrate AND sodium chloride ; an upwards arrow shows, energy change is positive / energy has been taken in / energy of the products is greater than the energy of the reactants ;	2
2(b)(i)	thermometer / temperature probe ; stop-watch;	2
2(b)(ii)	increases then decreases ; (increases because) energy given out / exothermic reaction ; (decreases because) reaction is finished (and so it cools) ;	3
2(b)(iii)	$(34.5 - 22.0 =) 12.5$ (°C) ;	1

Question	Answer							Marks							
3(a)(i)	<table border="1"><tr><td>(gamma radiation)</td><td></td><td></td><td>visible light ;</td><td>infrared ;</td><td>(microwaves)</td><td></td></tr></table>							(gamma radiation)			visible light ;	infrared ;	(microwaves)		2
(gamma radiation)			visible light ;	infrared ;	(microwaves)										
3(a)(ii)	3×10^8 (m / s) AND all <u>electromagnetic</u> waves travel with same speed ;							1							
3(b)	$v = f\lambda$ in <i>any form</i> / $3 \times 10^8 \div 635 \times 10^{-9}$; 4.72×10^{14} ; Hz ;							3							
3(c)(i)	thermal ;							1							
3(c)(ii)	dull black surfaces are good absorbers (of radiation) ;							1							
3(d)	molecular vibration ; transfer by electrons ;							2							

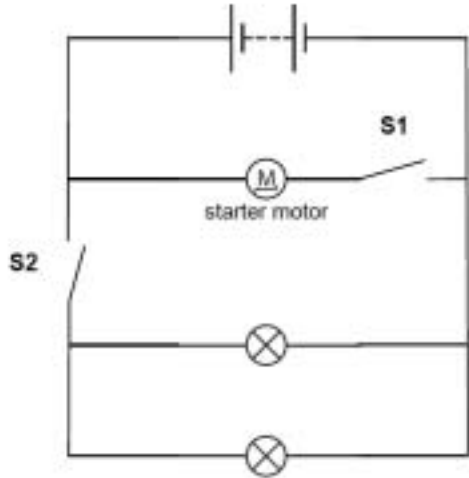
Question	Answer	Marks
4(a)(i)	arrow drawn pointing from grasshopper to eagle ;	1
4(a)(ii)	grasshopper / squirrel ;	1
4(a)(iii)	<i>any two from:</i> energy is lost between trophic levels ; named example of energy loss ; the longer the chain the less energy is available ;	2
4(b)	soil has a higher water potential / water moves from area of high water potential to low water potential ; reference to osmosis ; across a partially permeable membrane ;	3

Question	Answer	Marks
5(a)	<i>iron:</i> $\leq 2500\text{ }^{\circ}\text{C}$ AND <i>aluminium oxide:</i> $> 2500\text{ }^{\circ}\text{C}$; at $2500\text{ }^{\circ}\text{C}$, iron is a liquid and aluminium oxide is a solid ;	2
5(b)	aluminium displaces iron / aluminium removes oxygen from iron ; because aluminium is more reactive than iron ;	2
5(c)	iron(III) oxide / Fe^{3+} ; causes aluminium to gain oxygen ;	2
5(d)	charge on, iron(II) is $2+$ AND iron(III) is $3+$; total positive charge needs to match total negative charge ;	2

Question	Answer	Marks
6(a)	(total surface area = $2 \times 0.28 =$) $0.56 \text{ (m}^2\text{)}$; pressure = force $\div$ area <i>in any form</i> / $8000 \times 10 \div 0.56$; $1.4 \times 10^5 \text{ (Pa)}$;	3
6(b)(i)	acceleration = change in speed $\div$ time / $4 \div 8$; $0.5 \text{ (m / s}^2\text{)}$;	2
6(b)(ii)	deceleration ; not constant ;	2
6(b)(iii)	maximum speed identified as 4 m / s ; $KE = \frac{1}{2}mv^2$ <i>in any form</i> / $\frac{1}{2} \times 8000 \times 4^2$; $64\,000 \text{ (J)}$;	3

Question	Answer	Marks
7(a)(i)	as temperature increases so does the rate ; rate decreases above 35°C ;	2
7(a)(ii)	enzymes denature / shape of active site changes ; substrate no longer fits into active site ;	2
7(b)(i)	any palisade cell labelled ;	1
7(b)(ii)	gas exchange ;	1
7(b)(iii)	<i>any three from:</i> magnesium ions needed to make chlorophyll ; (deficiency means) less chlorophyll will be made ; (less chlorophyll means) less light energy transferred to chemical energy ; idea that the chemical energy is in the form of carbohydrates (so less are made) ;	3

Question	Answer	Marks
8(a)(i)	<i>bromine</i> : (dark) orange / brown ; <i>iodine</i> : solid ;	2
8(a)(ii)	all contain the same number of electrons (seven electrons) in the outer shell ;	1
8(b)(i)	single bond between atoms shown as two shared electrons ; (dependent mark) rest of molecule correct ;	2
8(b)(ii)	molecules have only two atoms ; of the same type ;	2
8(c)(i)	rubidium ; outer electron (is furthest from nucleus and so) more easily lost / rubidium is further down Group I ;	2
8(c)(ii)	KCl ;	1

Question	Answer	Marks
9(a)	if one (head)lamp breaks, the other still works / still a complete circuit ;	1
9(b)	correct time conversion / $5 \times 60 \times 60 / 18\,000$; $Q = It$ in <i>any form</i> / $5 \times 18\,000 / 5 \times 5 \times 60 \times 60$; 90 000 (C) ;	3
9(c)	 switch S1 for starter motor in correct position ; switch S2 for headlamps in correct position ; switch symbols correct AND no short circuits, open circuits or additional components ;	3