GCE

Chemistry B

H433/02: Scientific literacy in chemistry

Advanced GCE

Mark Scheme for November 2020

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

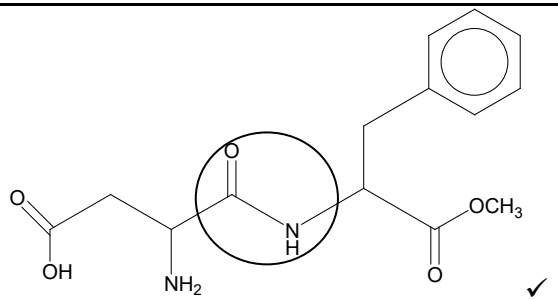
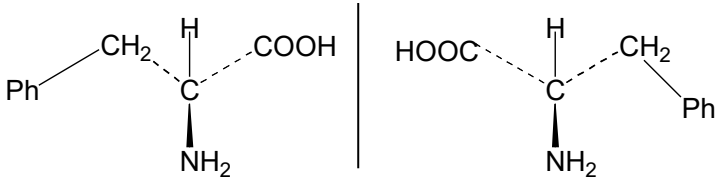
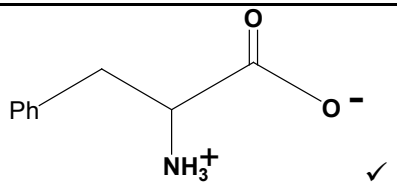
Mark schemes should be read in conjunction with the published question papers and the report on the examination.

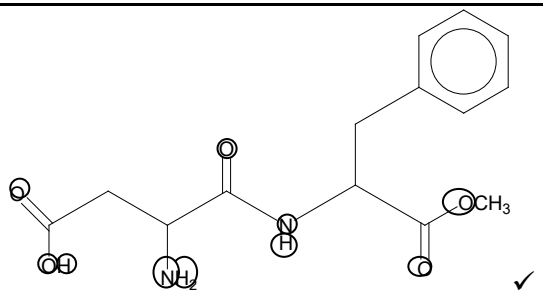
Annotations

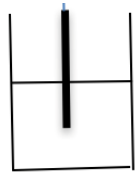
Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
BOD	Benefit of doubt given
CON	Contradiction
RE	Rounding error
SF	Error in number of significant figures
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
NBOD	Benefit of doubt not given
SEEN	Noted but no credit given
I	Ignore

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

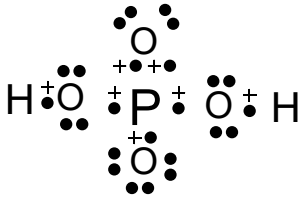
Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Question			Answer	Mark	AO element	Guidance
1	a		 ✓	1	1.1	**ALLOW** correct C–N bond circled
1	b	i	 Correct 3D structure around chiral centre ✓ correct mirror image ✓	2	2.1 x 2	**ALLOW** any object and correct mirror image scores 1 mark **ALLOW** dotted wedges instead of dotted lines. **ALLOW** wedges for bonds in front of the plane of the paper **ALLOW** two ordinary lines as long as they are **not** 180° to each other.
1	b	ii	 ✓	1	1.1	**DO NOT ALLOW** $NH^{3(+)}$ **IGNORE** extra correct details on skeletal structure
1	b	iii	$H_2NCH(COOH)CH_2COOH$ also formed ✓ also CH_3OH ✓ hydrolysis of ester ✓	3	3.2 x 3	**ALLOW** any unambiguous structures **ALLOW** NH_3^+ in formula of amino acid
1	c			1	1.1	**ALLOW** circles round NH_2, NH and OH rather than the atoms separately **ALL** indicated atoms MUST be circled to score the mark

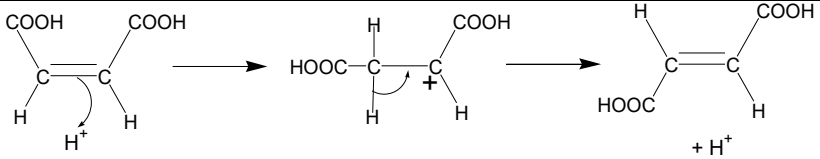
Question			Answer	Mark	AO element	Guidance
			 ✓			
1	d		Instantaneous (dipole)-induced dipole/id-id ✓	1	2.5	**ALLOW** Van der Waals or London
1	e	i	place in solvent and allow solvent to rise up paper ✓ solvent below level of spot ✓ (dry and) use ninhydrin/locating agent/UV (light) ✓ more than one spot indicates hydrolysis ✓	4	1.2 3.3 1.2 3.4	**ALLOW** labelled diagrams to score MP1, 2 & 4 **IGNORE** use of water as solvent **ALLOW** matching spots from individual amino acids
1	e	ii	enzyme would be denatured /tertiary structure broken down so no reaction (AW)✓	1	3.1	
1	e	iii	No difference to rate (AW)✓ Aspartame/substrate zero order (when in excess) ✓	2	3.1 x 2	**ALLOW** initially rate increases AND then becomes constant(AW) **ALLOW** all active sites occupied(AW) when aspartame in excess/at high concentration'

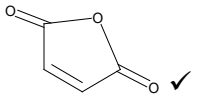
Question			Answer	Mark	AO element	Guidance
2	a	i	salt bridge ✓ filter paper **and** potassium nitrate (solution) ✓	2	3.4 x 2	**ALLOW** ion bridge **ALLOW** any Gr I /II nitrate solution
2	a	ii	298 K/ 25°C ✓ concentrations of solutions 1 mol dm^{-3} ✓	2	1.2 x 2	
2	b	i	silver ions / Ag^+ ✓	1	1.2	
2	b	ii	From Cu to Ag **AND** Cu electrode potential is more negative/less positive ✓	1	2.3	**ALLOW** Ag electrode is more positive/less negative **ALLOW** Cu is oxidised/loses electrons **ALLOW** Ag^+ ions are reduced/accept electrons
2	c		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 6.8 x 10^{-7} (mol dm^{-3}) award 4 marks** $E^\ominus$ = 0.46 ✓ Rearrange equation: 0.06 log[Ag^+] = $E - E^\ominus$ ✓ log [Ag^+] = –6.17 ✓ [Ag^+] = 6.8 x 10^{-7} (mol dm^{-3}) ✓	4	2.8 x 4	**ALLOW** 1 or more sf (0.06 in equation) **ALLOW** ecf throughout
2	d	(i)	Equation showing that IO_3^- reacts with Cu ✓ $2IO_3^- + 12H^+ + 5Cu \rightarrow I_2 + 6H_2O + 5Cu^{2+}$ ✓	2	2.8 x 2	Mark separately Second mark can be scored for reverse equation. **ALLOW** equilibrium sign **IGNORE** state symbols
2	d	(ii)		2	3.3 x 2	

Question			Answer	Mark	AO element	Guidance
			Pt/graphite electrode ✓ IO_3^- and I_2 **and** H^+ in solution ✓			
2	**d**	**(iii)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.4 (mol dm^{-3}) award 3 marks** $[I_2] = 0.04$ ✓ $\sqrt{0.04} = 0.2$ ✓ $[IO_3^-] = 0.4$ (mol dm^{-3}) ✓	3	2.8 x 3	0.28.... (omission of factors of 2) scores 1 mark 0.56 and 0.2 score 2 marks **ALLOW** ecf from any statement that begins "$[I_2]$ ="

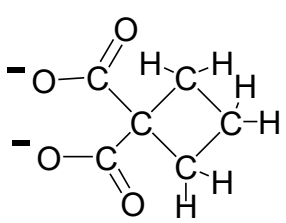
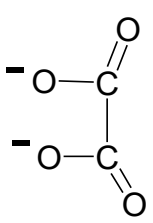
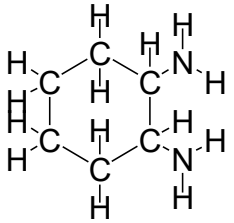
Question			Answer	Mark	AO element	Guidance
3	a		 ten electrons around P atom / eight electrons around P atom if clear that lone pair from P are used to form a dative covalent bond to one O atom ✓ rest correct ✓	2	2.5 x 2	**IGNORE** minus sign **ALLOW** 'extra' electron on single bonded O to be the same symbol or different from the rest of the electrons on that O. Must be clear that only five electrons are from P atom.
3	b		mol P = 52 x 2/142 = 0.73 **AND** mol K = 34 x 2/94.2 = 0.72 ✓ Ratio is about 1:1 as in KH_2PO_4 ✓	2	2.6 x 2	**ALLOW** 52/142 = 0.365 AND 34/94.2 = 0.36 for MP1
3	c	i	HPO_4^{2-} **AND** proton acceptor ✓	1	1.1	
3	c	ii	7.2..... ✓	1	1.2	
3	c	iii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 5.1.... award 2 marks** $[H^+]$ $(= \sqrt{(6.2 \times 10^{-8} \times 1.0 \times 10^{-3})}) = 7.87 \times 10^{-6}$ (mol dm^{-3}) ✓ pH = 5.1... ✓	2	2.2 x 2	**ALLOW** ecf provided '$[H^+]$ =' or 'H^+ =' is shown **AND** value is > 10^{-7} and < 10^{-4}
3	d		$NH_4^+ \rightleftharpoons NH_3 + H^+$ **OR** $NH_4^+ + H_2O \rightleftharpoons NH_3 + H_3O^+$ ✓ Acid/ H^+/ H_3O^+ (from KH_2PO_4) moves equilibrium (position) to left ✓	2	2.7 x 2	**ALLOW** equilbrium the other way round (and the corresponding 'right' in MP2)

Question			Answer	Mark	AO element	Guidance
3	e		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 69 (g) award 4 marks** Value of $[H^+]$: 3.16×10^{-7} ✓ Rearrangement of eqn: $[H_2PO_4^-] = [H^+][HPO_4^{2-}]/ Ka$ ✓ $[H_2PO_4^-] = 3.16 \times 10^{-7} \times 0.1 / 6.2 \times 10^{-8}$ OR 0.51 ✓ mass $KH_2PO_4 = (0.51 \times 136) = 69$ (g) ✓	4	2.8 x 4	**ALLOW** 2 or more sf **ALLOW** ecf throughout
3	f	i	Equilibrium will move to left (AW) ✓ $[H^+]$ only restored/unchanged (AW) if $[H_2PO_4^-]$ is large ✓	2	3.1 x 2	
3	f	ii	(Student is correct (AW) **AND**) HCl strong (acid) so all reacts/dissociates/ionises ✓	1	3.1	
	f	iii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.7 award 2 marks** $[H^+]$ $(= 0.05 \times 0.01/1000) = 5 \times 10^{-7}$ ✓ pH change = 7 – 6.3 = 0.7 ✓	2	2.8 x 2	**ALLOW** ecf

Question			Answer	Mark	AO element	Guidance
4	a	i	(C=C) decolorises bromine water ✓ (COOH/acid) will fizz with carbonate/appropriate colour with (named) indicator ✓	2	1.2 x 2	ALLOW gas produced turns limewater cloudy(AW) if carbonate test used
4	a	ii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 5 (cm^3) award 3 marks** conc maleic acid = (2.32/116) OR 0.02 (mol dm^{-3}) ✓ amt NaOH = 2 x 250 x 0.02/1000 OR 0.01 (mol) ✓ vol NaOH = 1000 x 0.01/2 = 5 ✓	3	2.4 x 3	2.5 scores 2 marks **ALLOW** ecf Allow wrong answers (after ecf) to 2 or more sig figs.
4	b	i	CHO ✓	1	1.2	**ALLOW** elements in any order
	b	ii	*Z* ✓ butenedioic acid ✓	2	1.1 x 2	**ALLOW** 'butendioic acid'
	c		Description of groups being spatially different across C=C ✓ Lack of free rotation of C=C /groups in a fixed position ✓	2	1.2 x 2	**ALLOW** they are stereoisomers.
	d		Loss of COOH/CO_2H **OR** $C_3H_3O_2^{(+)}$/CHCHCOOH✓	1	2.6	
	e	i	 one for each arrow ✓✓	2	2.5 x 2	One arrow must start) on the double bond and end pointing to H^+ (or to the bond being formed) The other arrow must start and end on the bonds shown. Other arrows are CON
	e	ii	(Electrophilic) Elimination	1	1.1	

Question			Answer	Mark	AO element	Guidance
	e	iii	No, either of the Hs on the left C (of carbocation) could leave ✓ some ^{2}H/D would be incorporated ✓	2	3.2 x 2	
	f		 ✓	1	2.1	
	g	i	Atom economies (98/170) = 58% **AND** (98/222) = 44% ✓ Identifies butane/reaction 1 should be used because it has the larger atom economy/produces less waste ✓	2	2.6 3.1	**ALLOW** 0.58 **AND** 0.44
	g	ii	Benzene toxic/ more expensive/butane more available from cracking /doesn't produce CO_2 (ORA for reaction 2)✓	1	3.1	**ALLOW** ecf from (g)(i) eg butane more flammable
	g	iii	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 61 (kg) award 2 marks** amt butane = 15000/24 = 625 mol ✓ mass maleic anh = 625 x 98/1000 = 61(kg) (2sf) ✓	2	2.8 x 2	61.3 or 61.2 score 1 Correct use of gas equation can score both marks

Question			Answer	Mark	AO element	Guidance
	h*		*Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.* **Level 3 (5 – 6 marks)** Correct structure/identity deduced and **detailed** evidence related to the structure is provided from **each** spectrum. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3 – 4 marks)** Correct structure/identity deduced with **detailed** evidence from at least one spectrum. **OR** Structure/identity attempted with some correct evidence from a minimum of two spectra. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1 – 2 marks)** Correct structure/identity deduced with no relevant evidence. **OR** Structure/identity not given or incorrect, but some correct evidence from at least one spectrum. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or nothing of value	**6**	**3.1 x 4** **3.2 x 2**	**Indicative scientific points may include:** **AO3.1 Analysis:** **IR:** • C=O at 1700 • Broad OH 2500-3300 • COOH **HNMR:** • Three H environments • 1.2: Hs on C connected to C-H • 2.3: H on C connected to Cs with many Hs • 11.8 H in COOH **CNMR:** • Three C environments • two Cs in same environment • one C=O (at 183ish) • two C-C **AO3.2 Evaluation:** Compound A identified as 2-methylpropanoic acid Structure $CH_3CH(CH_3)COOH$ presented in any unambiguous way

Question			Answer	Mark	AO element	Guidance
5	a	i	Two C*l*s/chlorines/two Cl^-/ chloride ligands are each -1 ✓	1	1.1	
5	a	ii	$5d^8$ ✓	1	1.1	
5	a	iii	Yes, it has an ion with an incomplete d subshell (in a compound) ✓	1	1.1	
5	b		 **OR**  **OR**  correct identification ✓ full structural (with O^- for first two)✓	2	1.1 x 2	
5	c	i	guanine✓	1	1.1	
5	c	ii	hydrogen (bond)✓	1	2.1	
5	c	iii	(dative) covalent/ co-ordinate (bond) ✓ (lone) pair on nitrogen donated to Pt ✓	2	2.1 x 2	
5	d	i	octahedral ✓	1	2.1	
		ii	6 ✓	1	2.1	

Question			Answer	Mark	AO element	Guidance
5	d	iii	Satraplatin also has ethanoate/ester/C=O groups/(4) O atoms (in addition to NH_3 groups that cisplatin also has) ✓ (These form more) H-bonds with water(ORA for cisplatin) ✓ and (more than) compensate for 'insoluble' (AW) ring **OR** H-bonds broken in water ✓	3	3.1 x 3	Oxygen MOLECULES is CON
5	e*		*Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.* **Level 3 (5 – 6 marks)** Considers disadvantages of cisplatin, with most examples of both toxicity **and** cell resistance. **AND** Identifies most examples of how new drugs attempt to overcome the disadvantages of cisplatin. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3 – 4 marks)** Considers disadvantages of cisplatin, with some examples of both toxicity and cell resistance. **OR** Gives a detailed treatment of either toxicity OR cell resistance **AND** Attempts to provide examples of the ways new drugs attempt to overcome the disadvantages of cisplatin. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.*	6	3.1 x 3 3.2x 3	**Indicative scientific points include:** **Disadvantages:** **toxicity** • damaging to the kidneys/ gastrointestinal tract / nervous system. • targets all cells • difficulty of administration **cell resistance** • influx slower/method of entry slowed/prevented • efflux faster/method of exit accelerated • removed before it can act on DNA • improved cell repair mechanism • cancer cells evolve • improved methods of DNA repair **New Drugs attempting to overcome disadvantages** • carboplatin less toxic • satraplatin/picoplatin different structure and overcame resistance • formulae of some of above • bulky group in picoplatin helps overcome resistance • satraplatin soluble/ administered orally

Question			Answer	Mark	AO element	Guidance
			Level 1 (1 – 2 marks) Considers disadvantages of cisplatin, with examples of toxicity OR cell resistance. **OR** Attempts to provide examples of the ways new drugs attempt to overcome the disadvantages of cisplatin *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant and correct.* **0 marks** No response or nothing of value			

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