OCR
Oxford Cambridge and RSA

GCE

Chemistry B (Salters)

Unit **H033/02:** Chemistry in depth

Advanced Subsidiary GCE

Mark Scheme for June 2016

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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.

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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

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	Separates marking points
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	Marks	Guidance
1	(a)		$C_4H_{10}(g/l) + 6½O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$ ✓ for balanced equation ✓ for state symbols	2	**NOT** multiples
	(b)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = Δ_cH = -1419 (kJ mol^{-1}) award 3 marks** Calculates energy transferred to water q = 50.00 x 4.18 x (74 - 19) = 11495 (J) ✓ Calculates number of moles of butane burned = 0.47 / 58.0 **or** 0.008(1) mol ✓ (Δ_cH = -[11495 / 0.008(1)] = -1419136 J mol^{-1}) Δ_cH = -1419 (kJ mol^{-1}) ✓	3	**Correct answer -1419 ±1 kJ mol^{-1} scores 3 marks** **ALLOW ECF** between steps **ALLOW** final answer to 2 or more sf (eg -1440kJ mol^{-1} if early rounding is evident) Final MP **must** include negative sign
	(c)	(i)	–2850 - –2950 (kJ mol^{-1}) ✓	1	**Must** have negative sign
		(ii)	*Any two from:* ✓ ✓ loss of fuel by evaporation / escape of unburned butane evaporation of water incomplete combustion / reaction non-standard conditions /states heat used to raise temp of calorimeter	2	Answers can be in any order Ignore 'not fully reacted' as this makes it unclear whether the candidate is talking about the vol of butane or the combustion reaction **Ignore** measurement errors
		(iii)	One from: ✓ use a (draught) shield because this will reduce heat lost (to the surroundings); burn the butane in oxygen / because this will ensure that the combustion is more complete; use bomb calorimeter ensures complete combustion / reduces heat loss; use cover over lighter during weighing to prevent evaporation; insulate can to reduce heat loss	1	Must have method **plus** explanation to score **Ignore** changes to vol of water / mass of fuel / length of time for combustion / move flame nearer to can / **ALLOW** 'put lid on can' **NOT** 'use a polystyrene cup'

Question	Answer	Marks	Guidance
(d)	*Any one from*: reacting carbon and hydrogen doesn't (necessarily) make butane ✓ Carbon and Hydrogen do not react together (under standard conditions) ✓	1	**ALLOW** reference to formation of a mixture of products or alternative product(s) / side reactions
(e)	 skeletal formula systematic name: (2-)methylpropane ✓	1	**IGNORE** dashes, commas and spaces in the name Needs **BOTH** skeletal formula **AND** name
(f)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = (+)486.6 / (+)487 (kJ mol–1) award 3 marks** energy absorbed in breaking bonds = 3(413) + (358) + x + 1½(498) = 2344 + x (kJ) **AND** energy evolved in making bonds = 2(805) + 4(x) = 1610 + 4x (kJ) ✓ Overall energy change (Bonds broken – bonds made = ΔH) = [2344 + x] – [1610 + 4x] = -726 kJ mol-1 **OR** 2344 - 1610 + 726 = 3x 1460 = 3x ✓ x = (+)486.6 / (+)487 (kJ mol–1) ✓	3	**Correct answer +486.6 / +487 kJ mol^{-1} scores 3 marks** **ALLOW** ECF between steps 2344 and 1610 in calculation scores 1 mark if no other mark scored **ALLOW** OH for x in calculation ALLOW –sign if evaluation of their expression for x is correct
	Total	14	

Question			Answer	Marks	Guidance
2	(a)		8 - 11 ✓	1	Accept any value between 7.1 - 14
	(b)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 0.34 (mol) (2 sf) award 3 marks** mass of $Mg(OH)_2$ in 250 cm^3 = 8/100 x 250 (= 20) g ✓ M_r $Mg(OH)_2$ = 58.3 g mol^{-1} ✓ Moles $Mg(OH)_2$ = (20/58.3) = 0.34 (mol) (2 sf) ✓	3	Allow ecf throughout Final answer **MUST** be to 2sf
	(c)	(i)	(it is the) oxidation state/number of the sulfur ✓	1	incorrect number is CON **ALLOW** 6/+6/6+ **ALLOW** oxidisation/
	(c)	(ii)	$Mg(OH)_2$ is not (completely)soluble / forms a suspension (in water) ✓	1	**ALLOW** cloudiness of suspension obscures colour of indicator/ makes it difficult to identify end-point **ALLOW** medicine for $Mg(OH)_2$
	(d)	(i)	(it is the) mean/average of the concordant titres / repeats 1 and 3 ✓	1	**ALLOW** only used titres agreeing to within 0.1 cm^3 / repeat 2 not included as it is an anomalous result(outlier)
	(d)	(ii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 0.0166 (mol) award 2 marks** amount of NaOH (in titre) = (16.65/1000 x 1.99) = 0.0331 mol ✓ amount of H_2SO_4 in excess = (0.5 x 0.0331) = 0.0166 (mol) ✓	2	Allow ecf from incorrect titre used in calculation **Do not accept** 0.0165, incorrect rounding of 0.01655 Final answer to 2sf or more.

Question			Answer	Marks	Guidance
	(d)	(iii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 19.20 - 19.55 (g) award 3 marks** amount of H_2SO_4 initially = (25.0/1000 x 2.00) = 0.05 mol ✓ amount of H_2SO_4 used up = number of moles $Mg(OH)_2$ = (0.05 – 0.0166) = 0.0334 mol ✓ mass of $Mg(OH)_2$ in 250 cm^3 = (250/25 x 0.0334 x 58.3) = 19.47 / 19.5 (g) ✓	3	**ALLOW** ecf from incorrect value in d(ii) **ALLOW** ecf throughout **ALLOW** 3 or more sf throughout, but rounding must be correct
	(d)	(iv)	(0.06/25.0 x 100) = 0.2(%) ✓	1	Correct answer without working scores the mark
	(e)	(i)	$Mg \rightarrow Mg^{2+} + 2e^-$ / $Mg - 2e^- \rightarrow Mg^{2+}$ ✓	1	**Ignore** state symbols
	(e)	(ii)	(magnesium) loses (two) electrons ✓	1	**ACCEPT** the oxidation state (of the magnesium) increases (from 0 to +2) **ignore** species losing electrons unless incorrectly named
	(e)	(iii)	H^+/hydrogen (ion) ✓	1	**ACCEPT** hydrochloric acid/HCl **NOT** H / H_2
	(f)	(i)	$Mg^{2+}(aq) + 2OH^-(aq) \rightarrow Mg(OH)_2(s)$ ✓ for balanced ionic equation ✓ for state symbols	2	 **DO NOT ALLOW** spectator ions **ALLOW** state symbol mark if 'magnesium hydroxide' given as solid and all other species as aq
		(ii)	$Ba(OH)_2$ is <u>more</u> soluble (in water) ✓	1	ORA **ALLOW** $Ba(OH)_2$ will not precipitate
			Total	19	

Question			Answer	Marks	Guidance
3	(a)	(i)	CH_3COOH ✓	1	**ALLOW** any unambiguous structure
		(ii)	ester ✓	1	
		(iii)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 75 (%) award 2 marks** Mr of aspirin = [(12.0 x 9) + (16.0 x 4) + (1.0 x 8)] = 180.0 ✓ % atom economy = 180.0 / (138.0 + 102.0) x 100 OR 180/(180 + 60) x 100 = 75 (%) ✓	2	**ALLOW** ecf from incorrect value for Mr of aspirin
	(b)		2-hydroxybenzoic acid ✓	1	**ALLOW** salicylic acid / phenol <u>group</u> (present) **IGNORE** dashes, commas and spaces **NOT** phenol on its own
	(c)		<u>dissolve</u> (crude) aspirin/solid in hot/warm ethanol/solvent ✓ use the minimum volume/amount of ethanol/solvent✓ (allow to) <u>cool/crystallise</u> ✓ <u>filter</u>, <u>wash</u> (with cold ethanol) and (allow to) <u>dry</u> ✓	4	'Dissolve in a minimum amount of hot ethanol' scores 2 marks (MP1 and MP2) **ALLOW** crystals to form
	(d)		the range (it) will be wider ✓	1	**ALLOW** (it will be) lower **ALLOW** recrystallized product will be higher/narrower range
	(e)		**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 45 - 46 (%) award 2 marks** (138.0 g 2-hydroxybenzoic acid → 180.0 g aspirin) 1.15 g 2-hydroxybenzoic acid → (1.15 / 138.0 x 180.0) = 1.50 g aspirin ✓ % yield = (0.68 / 1.50 x 100) = 45(.3) (%) ✓	2	Calculates number of moles as 1.15/138 = 0.00833 mol and 0.68/180 = 0.00378 mol (1) Allow ecf from incorrect value of Mr from 3a(iii) % yield = 0.00378/0.00833 x 100 = 45.3% **ALLOW** 2 or more sf

Question	Answer	Marks	Guidance
(f)	**LOR** *Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question* **Level 3 (5 - 6 marks)** Gives a detailed description (including some relevant fine detail) of **ALL** three phases *The descriptions are well-developed, clear and logically structured.* **Level 2 (3 - 4 marks)** Gives a basic description of all three phases of the process **OR** Describes two of the phases with one in some detail *The method and analysis/further action is clear with some structure. The running is workable and in an acceptable order.* **Level 1 (1 - 2 marks)** Gives a description of one of the phases *Response shows some structure.* **Level 0** Insufficient or irrelevant science.	6	**Indicative scientific points may include:** **Phase 1** Running the chromatography • place plate in beaker with solvent • Allow solvent to rise through spots • remove plate • dry plate **Phase 2** Analysis of chromatogram • crude product/CP contains (both aspirin and unreacted) 2-hydroxybenzoic acid • recrystallized/RP product contains some (unreacted) 2-hydroxybenzoic acid **Phase 3** Further action • further purification is required **At Level 3 the fine detail may include** • solvent below line of dots • cover beaker with a lid • produces a saturated atmosphere • (remove plate) when solvent front near top • transfer to fume cupboard to evaporate solvent • difference in intensity of spots linked to quantity of unreacted 2-hydroxybenzoic acid present • further recrystallisation is required • Repeat chromatography after further recrystallization

Question			Answer	Marks	Guidance
	(g)		No (observable) reaction with paracetamol ✓ Effervescence/fizzing/bubbling/gas with aspirin ✓ Aspirin contains a carboxyl/carboxylic acid functional group (ORA) ✓	3	**ALLOW** 'nothing happens' for 'no reaction' **ALLOW** 'dissolve' for aspirin and 'does not dissolve' for paracetamol **ALLOW** CO_2 **gas** but any other named gas is CON
			Total	21	

Question			Answer	Marks	Guidance
4	(a)	(i)	Reagents ..... acidified (potassium) dichromate(VI) **AND** Conditions ..... reflux ✓	1	**ALLOW** (potassium) dichromate in (sulfuric) acid (VI) in 'dichromate(VI)' is not required but must be correct if included **ACCEPT** $H^+/Cr_2O_7^{2-}$
	(a)	(ii)	$C_2H_5OH + 2[O] \rightarrow CH_3COOH + H_2O$ ✓	1	**ALLOW** CH_3CH_2OH for ethanol / 2[O] over the arrow **DO NOT ALLOW** C_2H_6O for ethanol or $C_2H_4O_2$ for ethanoic acid as question asks for structural formulae Displayed or skeletal formulae are also both acceptable
	(b)		$C_2H_5OH + 2O_2 \rightarrow 2CO + 3H_2O$ ✓	1	**ALLOW** either CH_3CH_2OH or C_2H_6O for ethanol **ALLOW** $C_2H_5OH + O_2 \rightarrow 2C + 3H_2O$ **OR** $C_2H_5OH + 2.5O_2 \rightarrow CO_2 + CO + 3H_2O$ (or doubled) **OR** any other balanced equation that includes C and/or CO as a product I**gnore** state symbols
	(c)		ethanol and ethanoic acid – both hydrogen-bonds ✓ ethanoic acid has **stronger/more** H-bonds / id – id ✓ H-bonds stronger than pd-pd / H-bonds are the strongest **and** stronger bonds take more energy to break (ORA) ✓ Ethanal – permanent dipole - permanent dipole/pd - pd ✓	4	 **ALLOW** pd : pd / Van der Waal forces as an alternative to id : id **ALLOW** Permanent dipole – dipole / dipole – permanent dipole / permanent – permanent dipole
	(d)	(i)	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 750 (cm^3) award 2 marks** moles of CH_3CHO = (0.55/44) = 0.0125 mol 0.0125 mol CH_3CHO requires (2½ x 0.0125) = 0.03125 mol O_2 ✓ volume of O_2 = (0.03125 x 24000) = 750 (cm^3) ✓	2	 **ALLOW** 2 or more sf. Throughout Allow ecf **ALLOW** vol of O_2 = 300 (cm^3) from correct calculation of Moles CH_3CHO x 24000 ie 0.0125 x 24000 for 1 mark
	(d)	(ii)	Mr CO_2 / (Mr CO_2 + Mr H_2O) x 100 44 / (44 + 18) x 100 = 71% ✓	1	**Correct** answer = 71% without working scores Allow 2 or more sf

Question	Answer	Marks	Guidance
(e)	*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question* **Level 3 (5 - 6 marks)** **Calculates** both the empirical formula from the % composition and the molecular formula using MS. **AND** Uses IR spectrum to identify C=O bond and one other bond (or lack of bond) present in the structure. **AND** Draws correct detailed conclusion for ester formula/structure from above and MS fragment data *The conclusion relates to the evidence and is clear and logically structured.* **Level 2 (3 - 4 marks)** **Concludes** A is an ester supported by evidence from molecular formula/Mr and some IR data **OR** **Concludes** it is ethanal supported by empirical formula **and** appropriate evidence using IR / MS data *The conclusion relates to the limited evidence and is clear and logically structured.* **Level 1 (1 - 2 marks)** States empirical formula or Mr of Compound A using evidence from MS / % composition **OR** suggests it is an ester/aldehyde from IR evidence alone *Pieces of evidence given are related in some way* **Level 0** Insufficient or irrelevant science	**6**	**Indicative scientific points may include:** **Formula/Mass Spec evidence** • empirical formula C_2H_4O with calculation from % data, C = (54.5/12.0) = 4.54, H = (9.1/1.0) = 9.1, O = (36.4/16.0) = 2.275, C = 2(1.99), H = 4, O = 1) • Mr = 88 identified from molecular ion peak in mass spectrum • molecular formula = empirical formula (mass) x 2 = $C_4H_8O_2$ **Infra-red evidence** • C=O bond in ester (aldehyde/ester) present, absorption is 1740 OR in range 1720-1740 (cm-1) • O-H bond in carboxylic acid not present, no (broad) absorption in range 2500-3300 (cm-1) • C-O bond present as absorption in range 1250 – 1300 (cm^{-1}) **Conclusion** • ester • $CH_3COOC_2H_5$ (structure or name, ethyl ethanoate) • because of fragment(s) identified in mass spectrum
	Total	**16**	

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