OCR
Oxford Cambridge and RSA

GCE

Chemistry B

Unit **H433A/01:** Fundamentals of chemistry

Advanced GCE

Mark Scheme for June 2017

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations available in RM Assessor

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
BP	Blank page

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

Subject-specific Marking Instructions

Treatment of chemical equations:

- Do not allow unnecessary brackets (eg 2(KCl))
- Do not allow wrong element symbols (eg CL)
- Do not allow superscripts for subscripts
- Allow one missing + or arrow if meaning is clear.

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

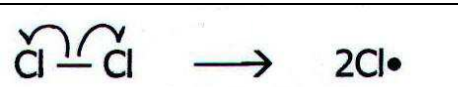
You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Section A

Q	Key		Mark	
1	C		1	
2	B		1	
3	D		1	
4	C		1	
5	A		1	
6	C		1	
7	B		1	
8	B		1	
9	D		1	
10	C		1	
11	C		1	
12	B		1	
13	A		1	
14	B		1	
15	A		1	
16	A		1	
17	B		1	
18	B		1	
19	D		1	
20	D		1	
21	C		1	
22	C		1	
23	A		1	
24	A		1	
25	B		1	
26	D		1	
27	B		1	
28	B		1	
29	A		1	
30	C		1	
		Total	30	

Question			Answer	Marks	Guidance
31	(a)		$2H_2O + 2e^- \rightarrow 2OH^- + H_2$ ✓ Oxidation state of hydrogen/ H has decreased/goes from +1 to zero. ✓	2	**ALLOW** $2H^+ + 2e^- \rightarrow H_2$ **ALLOW** $H_2O + e^- \rightarrow ½ H_2 + OH^-$ **ALLOW** Water/H^+ (ions)/ other species shown in (wrong) equation have gained electrons **NOT** just 'reduction is gain of electrons'
31	(b)		**FIRST CHECK ANSWER ON ANSWER LINE** If answer = 0.15 award 3 marks If sf incorrect, award 2 marks to anything rounding to 0.15. Moles of NaCl = $2.4 \times 10^5/58.5$ **OR** 4.1026×10^3 ✓ Moles of Cl_2 produced $0.5 \times 2.4 \times 10^5/58.5$ **OR** 2.0513×10^3 ✓ Mass Cl_2 = $\{0.5 \times 2.4 \times 10^5/58.5\} \times 71$ = 0.15 tonnes evaluated to 2sf ✓	3	**ALLOW** ecf 1. Calculation of moles NaCl 2. Use of ratio ÷ 2 or x 0.5 for a calculated no of moles 3. Moles Cl_2 to mass, unit conversion and 2 sf
31	(c)		Chlorine is toxic **AW** ✓	1	Incorrect refs to physical state/ flammability are **CON** **IGNORE** harmful
31	(d)	(i)	 ✓ Homolytic ✓	2	Single headed arrows are vital Dots on radicals not essential
31	(d)	(ii)	$Cl + C_2H_6 \rightarrow HCl + C_2H_5$ ✓ $C_2H_5 + Cl_2 \rightarrow C_2H_5Cl + Cl$ ✓	2	**ALLOW** $Cl + C_2H_6 \rightarrow C_2H_5Cl + H$ **AND** $H + Cl_2 \rightarrow HCl + Cl$ for 1 mark **DO NOT ALLOW** dots on molecules
31	(d)	(iii)	$Cl + O_3 \rightarrow ClO + O_2$ **AND** $ClO + O \rightarrow Cl + O_2$ ✓ (Homogeneous as) catalyst/it and reagent(s)/ozone are in same/gaseous phase/state ✓ Catalyst is re-generated/reformed/there at beginning and	3	**IGNORE** dots on radicals **IGNORE** other equations Third marking point must be related to the idea of the catalyst being recycled.

Question			Answer	Marks	Guidance
			end/recovered/recycled ✓		
31	(d)	(iv)	**FIRST CHECK ANSWER ON ANSWER LINE** If answer = 3.96 x 10^{-7}m (2 or more sf) award 2 marks Energy (per bond): 302000/6.02 x 10^{23} =(5.017 x 10^{-19} J) ✓ Use of E = hc/λ and calculation, λ = 3.96 x 10^{-7}m✓	2	**ALLOW** any number rounding to 4.0 x 10^{-7}m with 2 or more sf (to allow for early rounding) λ = 3 x 10^{8} x 6.63 x10^{-34} x 6.02 x 10^{23}/302000 **ALLOW** omission/error of one factor (1000, N_A, h or c) for 1 mark. (eg 3.96 x 10^{-4},6.59 x 10^{-31}, 5.98 x 10^{26}, 1.32 x 10^{-15}) **ALLOW** use of E = h λ (gives 7.57 x 10^{14}) for 1 mark
31	(e)		H_2SO_4 + KCl → $KHSO_4$ + HCl ✓	1	**ALLOW** H_2SO_4 + 2KCl → K_2SO_4 + 2HCl **ALLOW** elements in any order in $KHSO_4$ **IGNORE** state symbols
31	(f)		I, -1 and 0 ✓ S, +6 and -2 ✓ 8HI + H_2SO4 → $4I_2$ + H_2S + $4H_2O$ ✓	3	**NOT** signs after the numbers. **ALLOW** ecf on signs after numbers for second point. **ALLOW** '$8H^+$+ $8I^-$' for '8HI' **IGNORE** state symbols
			Total	19	

Question			Answer	Marks	Guidance
32	(a)		They are in group 2/ same group/same no of outer electrons/ lose 2 electrons when they react ✓	1	
32	(b)		Magnesium (ions)... are smaller/ have a smaller radius/ have higher charge density **ORA** ✓ Distort (the charge on) the carbonate (ion)/ polarise the carbonate (ion) more **ORA** ✓	2	**NOT** magnesium carbonate/magnesium atoms have a higher charge density. Comparison is essential in both parts.
32	(c)		**FIRST CHECK ANSWER ON ANSWER LINE** If answer = 647 (2 or more sf) award 3 marks Moles CO_2 absorbed = 1000/40.3 (= 24.81)✓ Volume CO_2 absorbed = ans to 1st point x 8.31 x 298/95000 (= 0.647) ✓ Evaluation and conversion to dm^3 (x1000) = 647 dm^3✓	3	**ALLOW** ecf throughout **ALLOW** 2 or more sf 1. Moles of MgO calculated = moles CO_2 absorbed 2. Correct substitution into V = nRT/p 3. Evaluation and unit conversion

Question			Answer	Marks	Guidance
32	(d)*		*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Learners are able to explain the origin of colour, electron transitions that cause the lines and the application of the lines to identification of elements. They give most of the points in all 3 sections *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)** Learners clearly describe points from at least two of the sections or some coverage of all. *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)** Learners describe points from at least one of the sections or two points in total. *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 no response worthy of credit.	**6**	**Indicative scientific points may include:** **AO1.1 Origin of colour:** • Colour is related to certain visible frequencies/wavelengths of light. • $(\Delta)E = h\nu$ **AO1.1 Electron transitions:** • Excitation of electrons by absorbing energy (NOT em radiation) • Release of em radiation as electron drops down energy levels. • energy levels are quantised/discrete **AO2.1 Use in identification:** • Energy levels and hence gaps are unique to the element. • Comparison of spectrum showed it did not match any elements known at the time. (Comparison with barium alone only partially matches this criterion). **ALLOW** points made on a labelled diagram.

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>32</td><td>(e)</td><td></td><td>
<table>
<tr><td>Reagent solution</td><td>Ba^{2+}</td><td>Pb^{2+}</td><td>Fe^{2+}</td></tr>
<tr><td>(Dilute) sulfuric acid OR any named soluble sulfate</td><td>White ppt</td><td>White ppt</td><td>Green solution/ no reaction</td></tr>
<tr><td>Sodium/ potassium hydroxide/ ammonia</td><td>Colourless solution/ no reaction</td><td>White ppt</td><td>(Dirty) green ppt</td></tr>
<tr><td>Hydrochloric acid OR any named soluble chloride</td><td>Colourless solution/ no reaction</td><td>White ppt</td><td>Green solution/ no reaction</td></tr>
<tr><td>Any named soluble iodide</td><td>Colourless solution/ no reaction</td><td>Yellow ppt</td><td>Green solution/ no reaction</td></tr>
</table>
</td><td>3</td><td>ALLOW 1 mark for each correct row.

OR 1 mark for a column of correct observations, as long as 3 reagents used.

Cross incorrect boxes and tick remaining columns OR rows to give the higher score.

ALLOW anion name instead of full reagent.

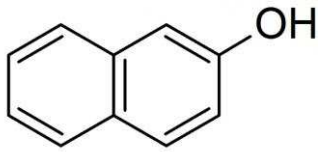
ALLOW a dash in a box as ‘no reaction’, but not an empty box.

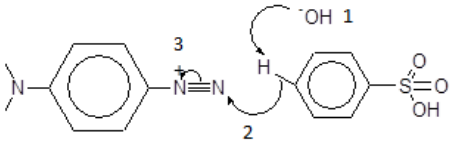
ALLOW white ppt for Ba^{2+} and NaOH

ALLOW formulae for names of reagents as long as correct.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>15</td><td></td></tr>
</table>

Question			Answer			Marks	Guidance
33	(a)			Increasing temp	Inc pressure	2	**ALLOW** 1 mark for a correct row if neither column correct. **ALLOW** up arrows (↑) for increase and down arrows for decrease.
			Effect on yield	Increases/more hydrogen	Decreases/less hydrogen		
			Effect on Kc	increases	No change		
				✓	✓		
	(b)		**FIRST CHECK ANSWER ON ANSWER LINE** If answer = 0.33 award 2 marks (mark units separately) Calculating eqm concs, CH_4= 1.66, H_2O = 0.66, CO = 0.34, H_2=1.02 ✓ Substitution into correct expression for K_c and calculating, $(1.02)^3$ x 0.34/1.66 x 0.66 = 0.33 ✓ Units: $mol^2\,dm^{-6}$ ✓		3	**ALLOW** ecf from concentrations **ALLOW** any number rounding to 0.33 1. Amounts at equilibrium 2. Substitution into K_c and evaluation 3. Units Incorrect concentrations substituted into correct K_c expression and correctly evaluated score second mark No ecf from wrong Kc for units.
	(c)	(i)	(Entropy increase because) more moles of products/ on right-hand side/more moles produced ✓			1	**ALLOW** particles/molecule as an alternative to moles **NOT** just ways of arrangement
	(c)	(ii)	**FIRST CHECK ANSWER ON ANSWER LINE** If answer = +130.6 or any number rounding to +131 award 2 $3S_{H2}$ = $\Delta_{sys}S$ + S_{H2O} + S_{CH4} – S_{CO} **OR:** $3S_{H2}$ = 214.5 + 186.3 + 188.7 – 197.7 ✓ Evaluation with sign = +130.6/131 ✓			2	No ecf from first point' 130.6/131 without sign scores 1 mark
	(d)		($\Delta_{total}S$ = +214.5 – 206000/1000) = (+)8.5 ✓ feasible (since positive)✓			2	**ALLOW** ecf from negative answer to first mpt and from wrong positive answer Second mark must be consistent with the (implied) sign of the answer to the first point

Question			Answer	Marks	Guidance
	(e)	(i)	6 x 100/ (16 + 18) = 17.6/17.65/18✓	1	**ALLOW** 2 or more sf
	(e)	(ii)	Co-product✓	1	**ALLOW** 'waste product' **DO NOT ALLOW** By-product
	(f)		Any 2 from:✓ ✓ • Stops the release of/ removes toxic/poisonous/dangerous/polluting CO **OR** no need to transport/remove CO **OR** uses up/re-uses CO • (Exothermic) reaction provides heat, saving fuel/ heating steam reforming/endothermic reaction • Higher yield of hydrogen/ more hydrogen/higher atom economy/less waste.	2	Any 2 from: 1. relating to utilisation of CO 2. energy considerations 3. yield of hydrogen/ atom economy/ waste **NOT** 'no waste'/100% atom economy as CO_2 is still a waste product. If more than 2 reasons are given, mark the first 2.
			Total	14	

Question			Answer	Marks	Guidance
34	(a)	(i)	*Bond angles:* Both have bond angle of 120^0 ✓ Both structures have three areas of electron density/ 3 groups (or regions or sets) of electrons/ 3 areas of negative charge (repelling) ✓ *Bond lengths:* Structure 1, all bond lengths the same. ✓ Structure 2, C=C shorter than C-C ✓	4	marks for bond angle and explanation. 2nd mark depends on the first 1 mark for bond lengths in each structure.
		(ii)	Structure 2 would be expected to have ΔH of 3 x cyclohexene/ (-)360 ($kJmol^{-1}$), ✓ benzene/structure 1 has delocalised (electrons) ✓	2	
	(b)	(i)	(Temp) below 55^OC **OR** 55^0C ✓ $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + 2HSO_4^- + H_3O^+$ ✓	2	**IGNORE** any reagents mentioned or conditions other than temperature for the first point **ALLOW** $HNO_3 + H_2SO_4 \rightarrow NO_2^+ + HSO_4^- + H_2O$ **ALLOW** $HNO_3 + H_2SO_4 \rightarrow H_2NO_3^+ + HSO_4^-$ then $H_2NO_3 \rightarrow NO_2^+ + H_2O$
		(ii)	$NaNO_2$/ Sodium nitrate(III)/ sodium nitrite **AND** HCl ✓ Temp below 5^oC ✓  ✓ Alkaline conditions **AW** ✓	4	**ALLOW** HNO_2/name **ALLOW** ice cold **ALLOW** H drawn on coupling carbon **ALLOW** third mark if appropriate conditions shown in middle box **IGNORE** any other reagents in bottom box unless **CON**
	(c)		(Sodium) Sulfonate	1	**IGNORE** any oxidation state given

Question			Answer	Marks	Guidance
	(d)		✓ ✓ ✓ 1 for each arrow 	3	**ALLOW** arrows that, if continued in the same direction, would start and finish in the correct places, (anywhere on appropriate atom or bond). **ALLOW** arrow from H into the ring **AND** an arrow from the ring to the right-hand N as alternative for arrow 2
	(g) (e)		**FIRST CHECK ANSWER ON ANSWER LINE** If answer = 0.8(0) award 2 marks $[H^+] = 10^{-3.7}$ evaluated = 2.0×10^{-4} ✓ $K_a / [H^+] = [In^-]/[HIn]$ evaluated = 0.80 ✓	2	Must have 'H^+ =' to score the first point **ALLOW** 1: 1.25, 4: 5 etc **NOT** 1: 0.8
			Total	18	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>35</td><td>(a) *</td><td></td><td>

Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.

Level 3 (5–6 marks)

Gives a clear account with at least 1 fine detail point in all 3 sections.

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)

Gives a point from each of the 3 sections.
OR Gives an account of 2 areas, both including a fine detail point.

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)

Makes at least 2 relevant points.

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 no response worthy of credit.

</td><td>6</td><td>

Indicative scientific points might include:
AO3.2 Make judgements – Interpret practical procedure

1 Use of ppt
- Weigh ppt

Fine detail:
- Filter to collect ppt
- Rinse ppt with distilled/deionised water
- Dry precipitate. This may be in the remedies for inaccuracy

2 Use of mass of ppt to find x
- Find moles of $MgCO_3$

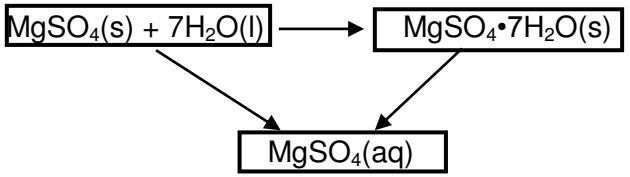
Fine detail:
- Appreciation that mass ppt related to moles $MgSO_4$
- Subtract mass of $MgSO_4$ from original mass of crystals to find mass of water
  - calculate no. moles water and find the ratio.

3 AO3.4 Develop and refine
At least one point from:

<table>
<tr><th>Inaccuracy</th><th>Remedy (fine detail)</th></tr>
<tr><td>Not enough sodium carbonate added to precipitate all the magnesium ions or not all $MgSO_4$ dissolved</td><td>Add excess sodium carbonate

Add more water</td></tr>
<tr><td>Mass of ppt inaccurate due to water</td><td>dry ppt IGNORE means of drying</td></tr>
<tr><td>Losses of substances when filtering/pouring etc</td><td>Rinse all containers with distilled water and add to the filter.</td></tr>
</table>

</td></tr>
</table>

Question	Answer	Marks	Guidance
(b)	**FIRST CHECK ANSWER ON ANSWER LINE** If answer = -99.9 or -100 award 4 marks (+) 99.9 or -68.1 scores 3 (1 of the last 2) 1. Use of Q=mcΔT: 50 x 3.0 x 4.18 (= 627 J or 0.627 kJ) ✓ 2. moles $MgSO_4•7H_2O$ = 9.7/ 246.4 = 0.0394 **AND** Scale up for 1 mole: ΔH = 0.627/ 0.0394 =(+)15.9 kJ mol^{-1} ✓ 3. ΔH = (-84.0 – (+15.9)) ✓ **OR** Cycle (or enthalpy level diagram) labelled with species✓  4. Evaluated with sign = -99.9 kJ mol^{-1} ✓		**ALLOW** ecf throughout. **IGNORE** sign for first point. A common mistake is to take the mass as 59.7. **NOT** -15.9 as temp of water falls. **IGNORE** (7)H_2O in bottom box.
(c)	Top box: Mg^{2+} (g) **AND** SO_4^{2-} (g) ✓ $\Delta_{LE}H$ (= -1922 -1099 +84) = –2937 ✓	**2**	
(d)	Strontium (ions) are larger/have a lower charge density ✓ so forces between water and strontium/ion-dipole forces less strong **OR** fewer water molecules surround it **OR** Not enough energy released in making ion-dipole bonds **OR** $\Delta_{hyd}H$ is less exothermic/releases less energy✓	**2**	1 Charge density/radius. 2 Correct statement on the interactions between strontium ions and water. **IGNORE** smaller/larger in relation to $\Delta_{hyd}H$. **ORA** throughout
	Total	**14**	

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