



GCE

Chemistry A

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

Advanced Subsidiary 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.

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Subject-specific Marking Instructions

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.

Annotations

| 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 |

| Annotation | Meaning |
|---|--|
|  | Correct response |
|  | Incorrect response |
|  | Omission mark |
|  | Benefit of doubt given |
|  | Contradiction |
|  | Rounding error |
|  | Error in number of significant figures |
|  | Error carried forward |
|  | Level 1 |
|  | Level 2 |
|  | Level 3 |
|  | Benefit of doubt not given |
|  | Noted but no credit given |
|  | Ignore |

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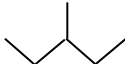

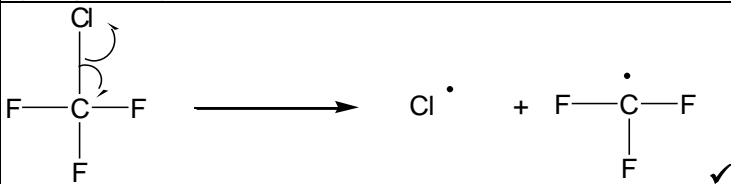
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| Question | | | Answer | Marks | Guidance |
|----------|-----|-------|---|-------|---|
| 1 | (a) | | <p><i>heterogeneous</i> (the catalyst is in) a different state/phase (of matter to the reactants and products) ✓</p> <p><i>catalyst</i> (a substance that) increases the rate of/speeds up a (chemical) reaction/provides a route of lower activation enthalpy AND does not get used up (in the process) ✓</p> | 2 | <p>for <i>catalyst</i> AND, IGNORE 'does not take part in the reaction' unless it is included along with 'does not get used up' in which case it is a CON ALLOW 'not chemically changed' IF qualified by 'at end of reaction'</p> <p>NOT simply provides an alternative route or lower the activation enthalpy (must have both)</p> |
| 1 | (b) | (i) | <p>the student is incorrect</p> <p>the student should use equal amounts/number of moles /number of particles ✓</p> | 1 | <p>there is no mark for 'incorrect' – the mark is awarded for the explanation</p> <p>IGNORE references to particle size as question states powdered compounds</p> |
| 1 | (b) | (ii) | <p>Any two from: ✓ (for both)</p> <ul style="list-style-type: none"> • concentration of hydrogen peroxide/solution • volume of solution • temperature (of solution) | 1 | NOT 'amount' instead of 'volume' |
| 1 | (c) | (i) | line of best fit drawn to exclude anomaly at (25, 55.0) ✓ | 1 | look for a best fit line that goes above the anomalous point and levels off at 63 |
| 1 | (c) | (ii) | <p>manganese(IV) oxide (is the most effective catalyst)</p> <p>it produces most oxygen/gas in the shortest time/a given/stated time/at the fastest rate/it has the steepest curve ✓</p> | 1 | explanation must include reference to rate or time |
| 1 | (c) | (iii) | <p>FIRST CHECK THE ANSWER ON THE ANSWER LINE</p> <p>If answer is 5.6×10^{-5} or 5.5×10^{-5} (2 or more sf) (mol s⁻¹) award 2 marks</p> <p>(volume of O₂ at 15 s = 20.0 cm³)</p> <p>amount of O₂ at RTP = $(20.0/24000) = 8.333 \times 10^{-4}$ mol ✓</p> <p>(average rate =) $(8.333 \times 10^{-4}/15.0) = 5.6 \times 10^{-5}$ (mol s⁻¹) ✓</p> | 2 | <p>Alternative method</p> <p>rate = $20/15 = 1.333 \text{ cm}^3 \text{ s}^{-1}$ ✓</p> <p>= $1.333/24000 = 5.6 \times 10^{-5} \text{ mol s}^{-1}$ ✓</p> <p>ALLOW 5.5×10^{-5} (mol s⁻¹) if amount is rounded to 2 sf</p> <p>ALLOW ECF on final answer if MP1 is correctly calculated, but for manganese(IV) oxide.</p> <p>Answer is 1.3×10^{-4} (again, allow 2 or more sf)</p> <p>DO NOT ALLOW calculation based on $pV=nRT$</p> |

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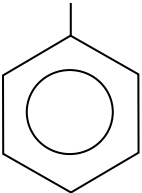
| Question | | | Answer | Marks | Guidance |
|----------|-----|------|--|-------|---|
| 1 | (d) | |   ✓ (for branched alkane, eg as shown) ✓ (for methylpropene) | 2 | ALLOW any branched alkane containing 6-carbon atoms |
| 1 | (e) | (i) | Stage 1 reactant(s) adsorbed/bond to surface of catalyst Stage 2 (reactant) bonds (weaken) and break Stage 3 (product) new bonds form Stage 4 product(s) desorbed from surface of catalyst ✓ (for Stages 1 and 4) ✓ (for Stages 2 and 3) | 2 | In Stage 1, 'absorbed' is a CON ALLOW '(reactant) forms <u>weak</u> bonds with catalyst' ALLOW reference to 'chemisorption' In Stage 4, ALLOW 'leaves/diffuses' for 'desorbed from' but DO NOT ALLOW 'dissociates from' |
| 1 | (e) | (ii) | (the poison) blocks the active sites/surface ✓ | 1 | |
| 1 | (f) | (i) |  | 1 | ALLOW both products without 'dot' but not one with, one without. ALLOW 'CF ₃ ' instead of full structural. |
| 1 | (f) | (ii) | FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer is 346 (nm) award 3 marks energy required to break a single C-Cl bond $= (346 / 6.02 \times 10^{23}) = 5.75 \times 10^{-22} \text{ (kJ)} \checkmark$ $E = h\nu$ $\therefore \nu = E/h$ (minimum) frequency of radiation required $= (5.75 \times 10^{-22} \times 1000 / 6.63 \times 10^{-34}) = 8.67 \times 10^{14} \text{ (Hz)} \checkmark$ $c = \nu\lambda$ $\therefore \lambda = c/\nu$ (maximum) wavelength of radiation required $= (3.00 \times 10^8 / 8.67 \times 10^{14}) = 3.46 \times 10^{-7} \text{ (m)}$ $= 346 \text{ (nm)} \text{ (3 sf)} \checkmark$ | 3 | The working for an incorrect answer MUST be checked in detail. Do be aware that candidates may well multiply/divide the numbers in a different order to that shown in the answer column so the numbers in this method of working may not necessarily be seen. However, candidates should be using $E = h\nu$, $c = \nu\lambda$ (or correct combination) and a conversion into nm. |

| | | | | | |
|---|-----|---|-----------|---|---|
| 1 | (g) | <p>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</p> <p>Level 3 (5 - 6 marks)</p> <p>Gives a detailed description (to include equations in parts 1 and 2) AND a comparison of relative effects.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3-4 marks)</p> <p>Less detailed description and comparison (equations may be included)</p> <p>OR</p> <p>Detailed description and no comparison ORA</p> <p><i>There is a line of reasoning presented with some structure. The information presented in the most part relevant and supported by some evidence.</i></p> <p>Level 1 (1-2 marks)</p> <p>Limited description and comparison</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks</p> <p>No response or no response worthy of credit</p> | 6 | <p>1.1 (x4)</p> <p>3.1 (x2)</p> | <p><i>Indicative Scientific points include:</i></p> <p>AO1.1 Description of and comparison of oxygen and chlorine atoms in the breakdown of ozone</p> <p>Role of oxygen:</p> <ul style="list-style-type: none"> atoms/radicals react with ozone (in the stratosphere) $O + O_3 \rightarrow 2O_2$ <p>Role of Cl in removing O_3</p> <ul style="list-style-type: none"> chlorine radicals react with ozone $Cl + O_3 \rightarrow ClO + O_2$ ClO react with oxygen atoms regenerating the chlorine radical $ClO + O \rightarrow Cl + O_2$ overall reaction is the removal of ozone $O + O_3 \rightarrow 2O_2$ <p>AO3.1 Make judgements: Comparison of relative effects</p> <ul style="list-style-type: none"> the chlorine radical is in a catalytic cycle AW one Cl atom can remove many ozone molecules one O atom can only remove one ozone molecule |
| | | Total | 23 | | |

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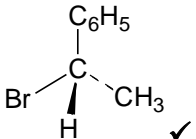
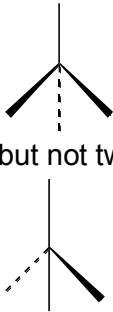
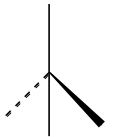
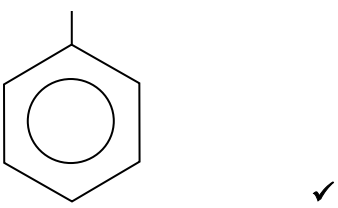
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| Question | | | Answer | Marks | Guidance |
|----------|-----|-------|--|-------|--|
| 2 | (a) | | <p>– CH – CH₂ –</p>  <p>✓ (for C – C single bond AND single bonds extending either side of each C-atom)</p> | 1 | <p>ALLOW C₆H₅ for phenyl group</p> <p>IGNORE brackets around repeating unit and use of 'n' to indicate a large number</p> |
| 2 | (b) | (i) | Bond A – pi/π(-bond) Bond B – sigma/σ(-bond) ✓ | 1 | |
| 2 | (b) | (ii) | <p>Bond angle C = 120(°) ✓</p> <p>Explanation there are 3 groups of electrons around the C-atom ✓ (which) repel so that they are as far apart as possible ✓</p> | 3 | <p>ALLOW 'areas of electron density' for 'groups of electrons'</p> <p>ALLOW arrange to minimise the repulsion between them DO NOT ALLOW 'repel as much as possible' unless qualified by the idea of 'minimising repulsion' DO NOT ALLOW 'three sets of bonding pairs' DO NOT ALLOW 'bonds repel' unless qualified by reference to 'electrons'</p> |
| 2 | (c) | (i) | yellow/orange/brown to colourless ✓ | 1 | <p>ALLOW any colour or combination of colours but no other colour DO NOT ALLOW 'decolorised' or 'loses its colour' IGNORE clear Any reference to 'red' is a CON</p> |
| 2 | (c) | (ii) | carbocation ✓ | 1 | <p>ALLOW carbonium ion DO NOT ALLOW 'carbon cation'</p> |
| 2 | (c) | (iii) | chloride ions/Cl ⁻ can attack/react with/bond with/combine with the carbocation/intermediate (in the second step of the mechanism) as well as bromide ions/Br ⁻ ✓ | 1 | Answer must refer to the carbocation/intermediate or if not, to the second step of the mechanism to get the mark |

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| | | | | | |
|---|-----|-------|--|-----------|---|
| 2 | (d) | | (there are) two different atoms/groups of atoms bonded/attached to the two carbon atoms of the double bond/C=C ✓ (and) there is no/limited (free) rotation about this bond/the C=C ✓ | 2 | DO NOT ALLOW 'movement' unless qualified by 'rotational' |
| 2 | (e) | (i) | HBr/hydrogen bromide ✓ | 1 | ALLOW BrH |
| 2 | (e) | (ii) |  <p>ALLOW just 'C' for C₆H₅ and/or CH₃ (it is the shape that is being examined)</p> | 1 | ALLOW other correct representations, eg  but not two 'lines' opposite each other, i.e  ALLOW 'dashed wedge' for 'dotted line' |
| 2 | (e) | (iii) | the hydroxyl group/OH/functional group is bonded to a carbon atom: with (only) one hydrogen atom OR attached to two carbon atoms ✓ | 1 | IGNORE any reference to hydroxide (ion)/OH ⁻ IGNORE 'it' for the OH group |
| 2 | (e) | (iv) | $\text{O} = \text{C} - \text{CH}_3$  | 1 | ALLOW any unambiguous structure |
| | | | Total | 14 | |

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| Question | | | Answer | Marks | Guidance |
|----------|-----|-------|--|-------|--|
| 3 | (a) | (i) | $[M_r \text{ of NaOH} = 40 \text{ g mol}^{-1}$ $0.5 \text{ tonne} = 5 \times 10^5 \text{ g}]$ amount of NaOH = $(5 \times 10^5 / 40) = 12500 \text{ (mol)}$ ✓ | 1 | Answer only (to 2 or more sf) (not the working) scores the mark |
| 3 | (a) | (ii) | [amount of Cl_2 formed in same time as 0.5 mol NaOH = $(\frac{1}{2} \times 12500) = 6250 \text{ (mol)}$ M of $\text{Cl}_2 = 71]$ mass of $\text{Cl}_2 = [(6250 \times 71) = 443750 \text{ g} =]$ 0.44 (tonnes) ✓ ALLOW ECF from (a)(i) | 1 | Answer only (to 2 or more sf) (not the working) scores the mark |
| 3 | (a) | (iii) | volume [= $(6250 \times 24) = 150\,000 \text{ dm}^3]$ = 150 m^3 ✓ ALLOW ECF from (a)(i) and/or (ii) | 1 | Answer only (to 2 or more sf) (not the working) scores the mark |
| 3 | (b) | | similarity: chlorine is still produced (at the anode/positive electrode) difference: sodium is produced/hydrogen/hydroxide ion is not produced (at the cathode/negative electrode) ✓ | 1 | |
| 3 | (c) | | (i) anode (+): yellow/orange/brown (colour in solution) (ii) cathode (-): gas (evolved)/bubbles/effervescence /fizzing ✓ (for both i and ii) | 1 | ALLOW any of these colour or combination of them but no other colour at (i) IGNORE iodine at (i) and hydrogen at (ii) |
| 3 | (d) | | (i) anode (+): $2\text{Br}^- \rightarrow \text{Br}_2 + 2\text{e}^-$ ✓ (ii) cathode (-): $2\text{H}_2\text{O} + 2\text{e}^- \rightarrow 2\text{OH}^- + \text{H}_2$ ✓ | 2 | ALLOW multiples or halves of equations ALLOW $2\text{Br}^- - 2\text{e}^- \rightarrow \text{Br}_2$ ALLOW $2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2$ ALLOW 'e' for 'e ⁻ ' IGNORE state symbols |
| 3 | (e) | (i) | Brown/orange/yellow ✓ | 1 | ALLOW any of these colours (or combination of them) but no other colour IGNORE colourless |
| 3 | (e) | (ii) | $\text{Br}_2 + 2\text{I}^- \rightarrow \text{I}_2 + 2\text{Br}^-$ ✓ | 1 | IGNORE state symbols |
| 3 | (f) | (i) | $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$ ✓ | 1 | ALLOW $\text{I}^- \rightarrow \frac{1}{2}\text{I}_2 + \text{e}^-$ ALLOW 'e' for 'e ⁻ ' ALLOW $2\text{I}^- - 2\text{e}^- \rightarrow \text{I}_2$ |

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| | | | | | |
|---|-----|------|---|-----------|--|
| 3 | (f) | (ii) | chlorine/ Cl_2 ✓ | 1 | IGNORE Cl |
| 3 | (g) | | <p>halogens/they increase in atomic radius/size/get bigger/the outer shell is further from the nucleus/core/shielding (by completed inner shells) from top to bottom of/going down the Group ✓</p> <p>the (electrostatic) attraction between the nucleus/core and the outer electrons decreases from top to bottom of/going down the Group ✓</p> <p>halogens/they gain an extra electron less readily/easily from top to bottom of/going down the Group ✓</p> | 3 | ALLOW any reference to halogen as either atom or molecule |
| | | | Total | 14 | |

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| Question | | | Answer | Marks | Guidance |
|----------|-----|------|--|-------|--|
| 4 | (a) | (i) | <p>(statement 1): equations should have (g) for both state symbols ✓</p> <p>(statement 2): is correct ✓</p> <p>(statement 3): the outer (shell) electrons in barium are further from/more well shielded from the nucleus (than in calcium) ✓ (the electrostatic) attraction between the nucleus/core and the outer electrons in barium is less (than in calcium) ✓</p> | 4 | <p>MP1, 3 and 4 are awarded for correcting the incorrect chemistry and not for simply stating 'incorrect'</p> <p>DO NOT ALLOW 'force' for 'attraction'</p> |
| 4 | (a) | (ii) | <p>FIRST CHECK ANSWER ON ANSWER LINE if answer = 754 (cm³) award 2 marks (must be 3sf)</p> <p>amount of Ca = $(1.26/40.1) = 3.14 \times 10^{-2}$ (mol) amount of H₂ = 3.14×10^{-2} (mol) volume of hydrogen = $(3.14 \times 10^{-2} \times 24000) = 754$ (cm³) ✓ answer to 3sf ✓</p> | 2 | <p>ALLOW ECF on sf from a correct seen calculation</p> <p>Note that if A_r of Ca is used as 40, answer is 756</p> <p>DO NOT ALLOW an answer from calculation based on $pV=nRT$ BUT the sf mark can still be awarded</p> |

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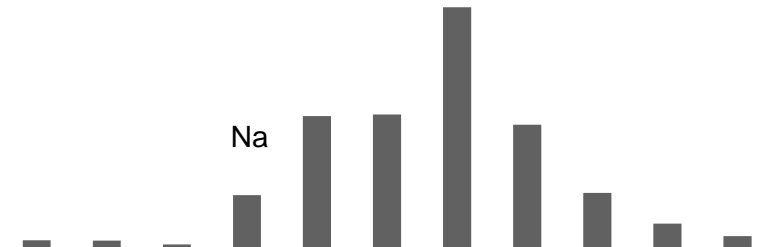
| Question | | Answer | Marks | Guidance |
|----------|-----|---|-------|---|
| 4 | (b) | <p><i>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</i></p> <p>Level 3 (5-6 marks)</p> <p>Detailed description of an experiment that would work with reason(s) AND detailed suggested expected results</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3-4 marks)</p> <p>Outline description of an experiment either with reason(s) or suggested expected results</p> <p>OR</p> <p>Detailed description of the experiment without reason(s) or suggested expected results</p> <p><i>There is a line of reasoning presented with some structure. The information presented in the most part relevant and supported by some evidence.</i></p> <p>Level 1 (1-2 marks)</p> <p>Outline description of an experiment</p> <p>OR</p> <p>Outline of suggestions for expected results</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks</p> | 6 | <p><i>Indicative scientific points include</i></p> <p>A03.3 Develop practical techniques and procedures - Description of experiment</p> <p>Description:</p> <ul style="list-style-type: none"> • heating carbonate and bubbling gas into limewater / measuring volume of gas / measuring mass loss • equal amounts/number of moles of each carbonate heated • using the same Bunsen flame AW • the first to go cloudy has the lower thermal stability (or alternative methods based on amounts of cloudiness in certain time etc) <p>Reasons: not just 'fair test'</p> <ul style="list-style-type: none"> • comparing same number of particles • delivering the same energy / heat <p>A03.4 Interpretation - Suggested expected results</p> <ul style="list-style-type: none"> • $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$ (or equation for strontium) or described in words • CO_2 given off shown by limewater going cloudy / gas collected / loss of mass • calcium carbonate decomposes quicker than strontium carbonate AW |

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| Question | | | Answer | Marks | Guidance |
|----------|-----|-------|---|-------|---|
| | | | <i>No response or no response worthy of credit</i> | | |
| 4 | (c) | (i) | it is the mean of 20.80 (cm ³) and 20.90 (cm ³) which are concordant/within 0.1(0) cm ³ OR 21.55 (cm ³) is a trial/rough titre/overshot the end-point/is an anomaly/outlier/not concordant/within 0.1(0) cm ³ ✓ | 1 | |
| 4 | (c) | (ii) | (% error) = $([2 \times 0.05]/20.80) = 0.5 \text{ (\%)} \checkmark$ | 1 | ALLOW 0.48 (%) ALLOW $\pm 0.5/0.48 \text{ (\%)}$ |
| 4 | (c) | (iii) | FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer is 1.54 (g dm ⁻³) (to 2 or more sf) award 3 marks (calculation of amount Ca(OH) ₂ in titre): amount of HCl = $(20.85/1000 \times 0.050) = 1.0425 \times 10^{-3} \text{ (mol)}$ amount of Ca(OH) ₂ in 25 cm ³ = $(\frac{1}{2} \times 1.0425 \times 10^{-3})$ = $5.2125 \times 10^{-4} \text{ (mol)} \checkmark$ (calculation of amount Ca(OH) ₂ per dm ³): [Ca(OH) ₂] = $(5.2125 \times 10^{-4} \times 1000/25.0)$ = $2.085 \times 10^{-2} \text{ (mol dm}^{-3}\text{)} \checkmark$ (calculation of mass Ca(OH) ₂ per dm ³): M of Ca(OH) ₂ = $40.1 + 2(16.0 + 1.0) = 74.1 \text{ (g mol}^{-1}\text{)}$ concentration of Ca(OH) ₂ = $(2.085 \times 10^{-2} \times 74.1)$ = $1.54 \text{ (g dm}^{-3}\text{)} \checkmark$ | 3 | ALLOW ecf ALLOW 2 or more sf. |
| 4 | (d) | | the number of protons in the nucleus/atom ✓ | 1 | NOT just 'element' |

| Question | | | Answer | Marks | Guidance |
|----------|-----|--|--|-------|----------|
| 4 | (e) | | <div><p>correct position of Na ✓</p></div> | 1 | |
| | | | Total | 19 | |

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