## Cambridge International Examinations

Cambridge Pre-U Certificate

## CHEMISTRY

Paper 2 Part A Written
May/June 2017
MARK SCHEME
Maximum Mark: 100

## Published

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| Question | Answer | Marks |
| :---: | :---: | :---: |
| 1(a)(i) | 3D diagram | 1 |
| 1(a)(ii) | Octahedral / octahedron AND $90^{\circ}$ | 1 |
| 1(a)(iii) | Electron pairs repel equally / move as far apart as possible (1) Six electron pairs / six bonds and no lone pair (1) | 2 |
| 1(a)(iv) | ( $\mathrm{SF}_{6}$ is symmetrical so) all (bond) dipoles / partial charges cancel | 1 |
| 1(b) | Amount of $\mathrm{SF}_{6}=10.0 / 146.1=0.0684 \mathrm{~mol}$ or using ratio of the two formula masses (1) Mass of $\mathrm{Li}=8 \times 0.0684 \times 6.9=3.78 \mathrm{~g}$ or 3.8 g (1) | 2 |
| 1(c) | Sulfur (increases) from 0 to $+4\left(\mathrm{SF}_{4}\right)$ AND sulfur (decreases) from 0 to -2 (CuS) (1) <br> Disproportionation because the oxidation number of sulfur (both) increases and decreases in the reaction OR sulfur is oxidised and reduced (1) | 2 |
| 1(d) | $\begin{aligned} & \mathrm{CH}_{3} \mathrm{CHClCH}_{2} \mathrm{SF}_{5} \text { (1) } \\ & \mathrm{CH}_{3} \mathrm{CH}\left(\mathrm{SF}_{5}\right) \mathrm{CH}_{2} \mathrm{Cl} \text { (1) } \end{aligned}$ | 2 |


| Question | Answer | Marks |
| :---: | :---: | :---: |
| 2(a) | Strong / large amount of energy to break (nitrogen to nitrogen) triple bond | 1 |
| 2(b)(i) | $\mathrm{NH}_{2}$ | 1 |
| 2(b)(ii) | $\mathrm{N}_{2} \mathrm{H}_{4}$ | 1 |
| 2(c)(i) | When a (covalent) bond breaks and each atom gets one electron (from the bonding pair) OR bond breaking to form (two free) radicals | 1 |
| 2(c)(ii) | NO is used in step 2 and regenerated/reformed in step 3 | 1 |
| 2(d) | Correct connectivity, i.e. 2 Ns and 5 Os with a central bridging O (1) <br> Correct dative covalent $\mathrm{N} \rightarrow \mathrm{O}$ bond on each nitrogen, but only 1 per N atom (1) All remaining valence electrons correct. Lines and arrows are not required (1) | 3 |
| 2(e) | $-905.2=-(4 \times-46.1)+(6 \times-241.8)+4 \Delta_{i} H^{\top}(\mathrm{NO})$ <br> Stoichiometry correct (4, 6 and 4) in diagram or calculation OR correct cycle (1) <br> All signs correct (1) $\Delta_{i} H^{\top}(\mathrm{NO})=+90.3 \mathrm{~kJ} \mathrm{~mol}^{-1} \quad(1)$ | 3 |


| Question | Answer | Marks |
| :---: | :---: | :---: |
| 3(a) | Correct sketches for each property (1 mark each) <br> Atomic radius decreasing from left to right (1) <br> Electrical conductivity increasing from Na to Al , dropping to Si below Na , with remaining four elements below Si (1) Melting point increasing from Na to Si , dropping to P , increasing to S , decreasing to Cl and again to Ar (1) | 3 |
| 3(b) | NaCl giant AND $\mathrm{SiCl}_{4}$ simple (molecular structure) (1) <br> NaCl has strong forces of attraction between the ions / strong ionic bonding (1) <br> $\mathrm{SiCl}_{4}$ has weak van der Waals' / London / dispersion / IDID forces between the molecules (1) | 3 |
| 3(c) | $\mathrm{NaCl}+\mathrm{H}_{2} \mathrm{SO}_{4} \rightarrow \mathrm{NaHSO}_{4}+\mathrm{HCl} \text { OR } 2 \mathrm{NaCl}+\mathrm{H}_{2} \mathrm{SO}_{4} \rightarrow \mathrm{Na}_{2} \mathrm{SO}_{4}+2 \mathrm{HCl} \text { (1) }$ <br> Misty / white / steamy AND gas / vapour / clouds / fumes (of HCl) (1) $\begin{align*} & 2 \mathrm{NaBr}+2 \mathrm{H}_{2} \mathrm{SO}_{4} \rightarrow \mathrm{Br}_{2}+\mathrm{SO}_{2}+2 \mathrm{H}_{2} \mathrm{O}+\mathrm{Na}_{2} \mathrm{SO}_{4} \\ & \mathrm{OR} 2 \mathrm{NaBr}+3 \mathrm{H}_{2} \mathrm{SO}_{4} \rightarrow \mathrm{Br}_{2}+\mathrm{SO}_{2}+2 \mathrm{H}_{2} \mathrm{O}+2 \mathrm{NaHSO}_{4} \\ & \mathrm{OR} 2 \mathrm{HBr}+\mathrm{H}_{2} \mathrm{SO}_{4} \rightarrow \mathrm{Br}_{2}+\mathrm{SO}_{2}+2 \mathrm{H}_{2} \mathrm{O} \tag{1} \end{align*}$ <br> Brown vapour / gas / fumes (1) $8 \mathrm{NaI}+5 \mathrm{H}_{2} \mathrm{SO}_{4} \rightarrow 4 \mathrm{I}_{2}+\mathrm{H}_{2} \mathrm{~S}+4 \mathrm{H}_{2} \mathrm{O}+4 \mathrm{Na}_{2} \mathrm{SO}_{4}$ $\mathrm{OR} 8 \mathrm{NaI}+9 \mathrm{H}_{2} \mathrm{SO}_{4} \rightarrow 4 \mathrm{I}_{2}+\mathrm{H}_{2} \mathrm{~S}+4 \mathrm{H}_{2} \mathrm{O}+8 \mathrm{NaHSO}_{4}$ $\begin{equation*} \mathrm{OR} 8 \mathrm{HI}+\mathrm{H}_{2} \mathrm{SO}_{4} \rightarrow 4 \mathrm{I}_{2}+\mathrm{H}_{2} \mathrm{~S}+4 \mathrm{H}_{2} \mathrm{O} \tag{1} \end{equation*}$ <br> Bad egg smell / dark grey solid forming / purple gas / vapour / yellow solid (1) | 6 |
| 3(d) | $\mathrm{SOCl}_{2}+\mathrm{H}_{2} \mathrm{O} \rightarrow \mathrm{SO}_{2}+2 \mathrm{HCl}$ | 1 |
| 3(e)(i) | Neutralisation with / add any base or alkali (1) $\mathrm{CaCO}_{3}+\mathrm{SO}_{2} \rightarrow \mathrm{CaSO}_{3}+\mathrm{CO}_{2} \mathrm{OR} \mathrm{Ca}(\mathrm{OH})_{2}+\mathrm{SO}_{2} \rightarrow \mathrm{CaSO}_{3}+\mathrm{H}_{2} \mathrm{O}$ | 2 |
| 3(e)(ii) | Sulfur has a lone pair AND carbon does not have a lone pair | 1 |
| 3(e)(iii) | Bond vibrations are excited | 1 |

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| Question | Answer | Marks |
| :---: | :---: | :---: |
| 4(a)(i) | $\mathrm{H}_{28}$ | 1 |
| 4(a)(ii) | 6 | 1 |
| 4(b) | Acidified $/ \mathrm{H}^{+} \mathrm{K}_{2} \mathrm{Cr}_{2} \mathrm{O}_{7} \mathrm{OR}$ acidified $/ \mathrm{H}^{+} \mathrm{KMnO} \mathrm{K}_{4}$ OR Lucas test (1) <br> THG stays orange / no change AND testosterone changes from orange to green OR THG stays purple / no change AND testosterone decolourises OR Lucas reagent goes cloudy rapidly with THG and slowly with testosterone (1) <br> Ignore answers based on bromine water unless relative volume of solution needed (1 mark) starting with the same quantity of THG and testosterone (1 mark) | 2 |
| 4(c)(i) | $\mathrm{C}=\mathrm{O}$ made of one sigma and one $\pi$-bond (1) $\pi$-bond results from sideways overlap of two (adjacent) (2)p orbitals (1) (a correct labelled diagram can score both marks) | 2 |
| 4(c)(ii) | $\mathrm{C}=\mathrm{C}$ has no dipole (so cannot attract nucleophiles) / is an electron-rich bond AND $\mathrm{C}=\mathrm{O}$ has a (permanent) dipole (1) due of the presence of the (highly) electronegative O, OR mention/labelling of $\delta^{+} \mathrm{C}$ and $\delta^{-} \mathrm{O}$ (1) | 2 |
| 4(d) | $\pi$-bond (in $\mathrm{C}=\mathrm{O}$ ) breaks and a new $\mathrm{C}-\mathrm{H}$ bond is formed (and $\mathrm{O}-\mathrm{H}$ bond forms) (1) FGL moves down a level OR FGL moves from carbonyl to alcohol or 2 to 1 (1) | 2 |
| 4(e) | $\mathrm{H}_{3} \mathrm{CCH}_{2} \mathrm{MgBrOR} \mathrm{H} \mathrm{COCH}_{2} \mathrm{MgI}$ | 1 |
| 4(f)(i) | Addition | 1 |

Question

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| Question | Answer | Marks |
| :---: | :---: | :---: |
| 5(a)(i) | $\left(1 s^{2}\right) 2 s^{2} 2 p^{6} 3 s^{2} 3 p^{6} 4 s^{2} 3 d^{10} 4 p^{4}$ <br> Allow order of $4 \mathrm{~s}^{2}$ and $3 \mathrm{~d}^{10}$ to be reversed | 1 |
| 5(a)(ii) | $\begin{aligned} & (76 \times 0.0991)+(78 \times 0.2352)+(80 \times 0.5640)+(82 \times 0.1017) \\ & =79.33 \text { s.f. }(1) \end{aligned}$ | 2 |
| 5(b) | Atomisation of $2 \times \mathrm{Na}$ AND $1 \times \mathrm{Se}$ (1) <br> $2 \times 1$ st IE for 2 Na , giving $2 \mathrm{Na}^{+}+2 \mathrm{e}^{-}$(1) <br> 1 st and 2 nd electron affinity of Se - either separately or combined with correct label (1) <br> Note: Electrons must be balanced in the IE and EA steps <br> Lattice enthalpy (1) <br> Correct state symbols (1) | 5 |
| 5(c) | Axes labelled: difference in electronegativity / $\Delta E_{\text {neg }}(y)$ AND average $E_{\text {neg }}(x)$ (1) Metallic (bottom left), ionic (top), covalent (bottom right) corners labelled (1) | 2 |


| Question | Answer | Marks |
| :---: | :---: | :---: |
| 6(a)(i) | One correct 3D isomer (3D around the chiral carbon) (1) Correct mirror image (1) | 2 |
| 6(a)(ii) | Dimer structure with 2 correct H bonds (1) $\mathrm{C}=\mathrm{O}$ and $\mathrm{O}-\mathrm{H}$ dipoles (1) <br> Linear $\mathrm{O}-\mathrm{H}$ to H -bonds and lone pairs indicated on H -bonds (1) | 3 |
| 6(b)(i) | Specify $\mathrm{M}^{+}$/ molecular ion / highest $\mathrm{m} / \mathrm{z}$ is 102 peak (so $M_{\mathrm{r}}$ 102) (1) $31.4 / 100 \times 102=32.03$ OR $102-32=70$ so $5 \mathrm{C}(60)$ and 10 H (10) (1) | 2 |
| 6(b)(ii) |  | 3 |
| 6(b)(iii) | 3-methylbutanoic acid (or identified from last part) (1) <br> Peak at $\delta 180 \mathrm{C}=\mathrm{O} / \mathrm{COOH} / \mathrm{CO}$ (1) <br> 2-methylbutanoic acid gives 5 peaks (1) <br> Dimethyl propanoic acid gives 3 peaks (1) | 4 |


| Question | Answer | Marks |
| :---: | :---: | :---: |
| 7(a) | Structure of 2-methylbut-1-ene shown | 1 |
| 7(b) | Sulfuric acid is oxidising OR causes charring | 1 |
| 7(c) | $\begin{align*} & M_{\mathrm{r}}(\mathrm{~B})=70(1)  \tag{1}\\ & \mathrm{n}(\mathrm{~B})=12 \mathrm{~g} / 70 \mathrm{~g} \mathrm{~mol}^{-1}=0.171 \mathrm{~mol}(1)  \tag{1}\\ & \mathrm{n}(\mathrm{~A})=0.171 \mathrm{~mol} / 0.85=0.202 \mathrm{~mol}  \tag{1}\\ & \mathrm{~m}(\mathrm{~A})=0.202 \mathrm{~mol} \times 88 \mathrm{~g} \mathrm{~mol}^{-1}=17.75 \mathrm{~g}(1)  \tag{1}\\ & \mathrm{v}(\mathrm{~A})=17.75 \mathrm{~g} / 0.81 \mathrm{~g} \mathrm{~cm}^{-3}=21.9 \mathrm{~cm}^{3} \text { OR } 22 \mathrm{~cm}^{3} \tag{1} \end{align*}$ | 5 |
| 7(d)(i) | To reduce evaporation of the alkene (since the boiling point is not far above room temperature)/maximise yield / reduce fire hazard | 1 |
| 7(d)(ii) | Gloves (for handling the conc. phosphoric acid) | 1 |
| 7(d)(iii) | To dry the alkene (as some water distils over with it) OR remove water OR drying agent | 1 |
| 7(d)(iv) | With a heating mantle / hot plate OR a beaker of hot water from the hot tap (or from a kettle)/ (hot-)water bath | 1 |
| 7(d)(v) | Propene / the alkene intermediate / it is a gas (at r.t.p.) | 1 |
| 7(e)(i) | To reduce / eliminate the evaporation of bromine (which is toxic) | 1 |
| 7(e)(ii) | Bromine only has low solubility in water/water has low solubility in bromine (1) Water is less dense than bromine (1) | 2 |
| 7(e)(iii) | Liquid bromine reacts vigorously / too quickly / very exothermically with alkenes | 1 |


| Question | Answer | Marks |
| :---: | :---: | :---: |
| 7(e)(iv) | Dibromoalkane product, C, dissolves in the upper / organic layer OR upper / organic layer is converted to C (1) <br> Upper / organic layer becomes denser (with increasing amount of $\mathbf{C}$ dissolved) OR $\mathbf{C}$ is denser (than $\mathbf{B}$ ) (1) <br> When density of upper / organic layer exceeds 1 / (the density of) water/ the lower layer, it sinks below the water layer (1) | 3 |
| 7(f)(i) | Yellow OR straw OR orange OR brown | 1 |
| 7(f)(ii) | To prevent decomposition (when heated) OR in order to recover the product by steam distillation | 1 |
| 7(f)(iii) | Drying (with a drying agent / desiccant) | 1 |

