Periodicity & Trends

Mark Scheme 2

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	The Core Principles of Chemistry
Sub Topic	Periodicity & Trends
Booklet	Mark Scheme 2

Time Allowed: **72 minutes**

Score: **/60**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	$Mg^{+}(g) \rightarrow Mg^{2+}(g) + e^{(-)}$ OR $Mg^{+}(g) - e^{(-)} \rightarrow Mg^{2+}(g)$ OR $Mg^{+}(g) + e^{(-)} \rightarrow Mg^{2+}(g) + 2e^{(-)}$ **1st mark** Correct species for reactants **and** products **(1)** **2nd mark** Correct state symbols **This mark can only be awarded if first mark has already been awarded.** **(1)** **NOTE** Award state symbols mark if '$X^{+}(g)$' OR 'MG' used instead of 'Mg' $Mg(g) \rightarrow Mg^{2+}(g) + 2e^{(-)}$ **scores (0)**	"MG" for first mark	**2**

Question Number	Acceptable Answers	Reject	Mark
1(a)*(ii)	Any **TWO** from: Electron (in Mg^+) is being removed from a positive ion **(1)** Electron being removed is closer to the nucleus (in Mg^+) / Mg^+ is smaller (than Mg) **(1)** Proton: electron ratio greater (in Mg^+) / remaining e^- more tightly held (in Mg^+) **(1)** Greater (force of) attraction between nucleus and (outermost) electron (in Mg^+) **(1)** Electron repulsion is less in Mg^+ (than Mg) **(1)** **IGNORE** References to "effective nuclear charge (ENC)" / high charge-density in Mg^+ / references to shielding	"Mg^+ has more protons than Mg" scores **(0)** overall Electron is being removed from a new shell/different shell / 2nd shell scores **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
1(a)(iii)	Any value in range 5000 to 9000 (kJ mol^{-1}) **NOTE** Actual value is 7730 (kJ mol^{-1})		**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	(Phosphorus) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ ALLOW p_x, p_y, p_z notation / upper case **(1)** (Sulfur) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$ ALLOW p_x, p_y, p_z notation / upper case **(1)** ALLOW Noble gas core: [Ne] for $1s^2\ 2s^2\ 2p^6$		**2**

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	**1st mark – idea of paired e^- in S** In sulfur, spin-pairing has occurred / two electrons in the same orbital / paired e^- Note: **Just** $3p^4$ stated for S does not gain this mark. **ALLOW** an 'electrons-in-box' diagram, showing two electrons in the same orbital **(1)** **2nd mark – idea of repulsion** (resultant increase in) **repulsion** **(1)** **ALLOW** **Just** phosphorus has a half-filled sub-shell which is more stable (max **(1)**)		**2**

(Total for Question 1 = 9 marks)

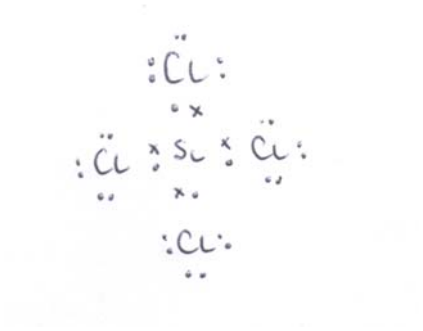
Question Number	Acceptable Answers	Reject	Mark
2(a)(i)	14p,14e,15n All correct		**1**

Question Number	Acceptable Answers	Reject	Mark
2(a)(ii)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ Fully correct ALLOW Subscripts rather than superscripts SPD in capitals $2p_x^2\ 2p_y^2\ 2p_z^2$ and $3p_x^1\ 3p_y^1$ for 2p and 3p IGNORE $1s^2$ written again before $2s^2$		**1**

Question Number	Acceptable Answers	Reject	Mark
***2(b)(i)**	**First mark: Structure of silicon** • Silicon is **giant** covalent / **giant** atomic / **giant** molecular / macromolecular / **giant** structure / **giant** lattice **(1)** IGNORE **JUST** 'GIANT' OR **JUST** 'LATTICE' **Second mark: Structure of phosphorus** • Small molecules / simple molecules / P_4 molecules / molecular covalent / simple covalent / molecular **(1)** IGNORE **JUST** 'SIMPLE' /'SIMPLE STRUCTURE' **Third mark: Interactions overcome on melting** **BOTH** • (Breaking strong) **covalent bonds** in silicon **AND** • Between phosphorus molecules: weak forces / (weak) intermolecular forces / (weak) London forces / (weak) van der Waals' forces / (weak) dispersion forces / (weak) induced-dipole forces **(1)** [ALLOW "weak bonds" **IF** implies between phosphorus **molecules**]	Silicon "giant ionic" / silicon "giant metallic" Intermolecular forces broken in silicon Covalent bonds broken in phosphorus / weak bonds between phosphorus **atoms** / weak **covalent** bonds	**3**

Question Number	Acceptable Answers	Reject	Mark
***2(b)(ii)**	**LLOW** reverse arguments in each case **PENALISE** Omission of 'atoms' or 'ions' / mis-use of 'atom' or 'ion' ONCE only where relevant **ANY TWO FROM:** • Magnesium atoms / magnesium ions are smaller (than sodium atoms/ions) **(1)** **NOTE:** Allow symbols (e.g. Mg or Mg^{2+}) • Magnesium ions are Mg^{2+} whereas sodium ions are Na^{+} **OR** Mg^{2+} /magnesium **ions** have a higher charge (density) than Na^{+}/sodium ions **(1)** **IGNORE** References to (effective) nuclear charge • Magnesium has more delocalised electrons (than sodium) /magnesium has more electrons (than sodium) in its sea of electrons **(1)** • Attraction between positive ions and (delocalised) electrons is stronger in magnesium (than in sodium) **(1)** **IGNORE** References to **JUST** 'more energy needed' (to break bonds in magnesium)	Attraction "between **nucleus** and (delocalised) electrons" Mention of "intermolecular forces" or "molecules" scores **(0)** overall for this question	**2**

Question Number	Acceptable Answers	Reject	Mark
2(c)	**st mark:** More protons / increasing nuclear charge / increasing effective nuclear charge **(1)** **IGNORE** 'increasing atomic number' **2nd mark:** Same shielding (of outermost electrons) / same number of (occupied) shells **OR** (Outermost) electrons in same shell **OR** Greater attraction between nucleus and (outermost) electrons **(1)**	'Increasing charge densities' (Outermost) electrons in same **sub-shell**	**2**

Question Number	Acceptable Answers	Reject	Mark
2(d)	 Outer shell of Si with total of 8 electrons **(1)** Each Si electron sharing with one electron from an outer shell of 7 in chlorine **(1)** Comment Do not penalise if dots and crosses are reversed **MAX 1** if all dots or all crosses		**2**

Question Number	Acceptable Answers	Reject	Mark
2(e)(i)	**I:** level of cross between Na and Mg (actual value 578) **Si:** level of cross anywhere above Al and Mg (actual value 789) Both needed for the mark		**1**

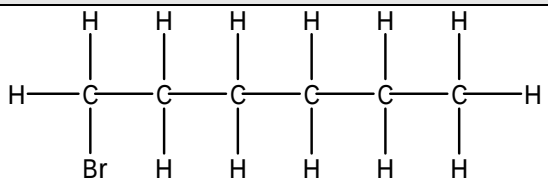
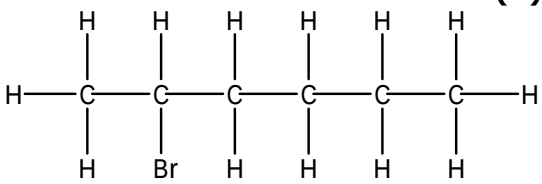
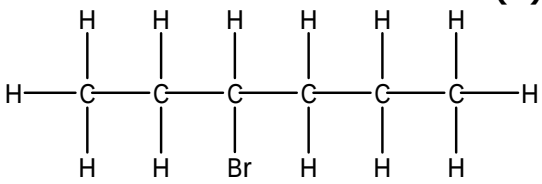
Question Number	Acceptable Answers	Reject	Mark
2(e)(ii)	**:** (3p) **electron/e^-** (lost is) from higher energy (level) / (more) shielded (by 3s electrons) / further from nucleus / from p orbital / from $3p_x$ **(1)** **Si:** more protons / extra proton / greater nuclear charge (compared to Al) **(1)**	If e^- lost from a **2p** orbital / if states that Al has **higher** ionization energy than Mg	**2**

Total for Question 2 = 14 marks

Question Number	Acceptable Answers	Reject	Mark
3 (a)(i)	Penalise use of chlorine once only in Q21(a)(i), (ii) and (iii) IGNORE lone pairs of electrons, even if incorrect in Q21(a)(i), (ii) and (iii) ALLOW one slip in the formula of the element if it is correctly given elsewhere in the answer e.g B for Br $Br_2 \rightarrow Br\bullet + Br\bullet$ / $Br_2 \rightarrow 2Br\bullet$ Ignore position of dot Ignore state symbols and curly arrows even if incorrect	Br	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(ii)	$Br_2 \rightarrow Br^+ + Br^-$ Ignore state symbols and curly arrows even if incorrect	$\boldsymbol{\delta^+}$ / $\boldsymbol{\delta^-}$ for the + or −	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(iii)	(free radical) $Br\bullet$ NOTE: No TE, except $Cl\bullet$ **(1)** Penalise omission of the dot only once in (a)(i) and (a)(iii) (electrophile) $\boldsymbol{Br^+}$ NOTE: No TE, except Cl^+ **(1)**	Br	**2**

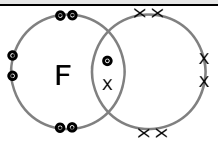
Question Number	Acceptable Answers	Reject	Mark
3 (b)(i)	 **(1)**  **(1)**  **(1)** Isomers can be in any order ALLOW skeletal or structural formulae	Any branched-chain isomers	**3**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(ii)	Corrosive / toxic / poisonous Allow correct symbols for corrosive or toxic / poisonous   IGNORE harmful / dangerous / irritant / acidic / volatile / any references to state of HBr IGNORE Any precautions taken, EXCEPT those related to flammability	Flammable / 'naked flames'	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(iii)	**First mark** Calculation of the $C_6H_{13}Br$ M_r value and the total of the product Mr EXPECTED 164.9 **AND** 245.8 ALLOW 165 **AND** 246 **(1)** **Second mark** EXPECTED $\frac{164.9}{245.8}$ (x 100%) = 67.08706265(%) **= 67.1(%) to 3 s.f.** ALLOW $\frac{165}{246}$ (x 100%) = 67.07317073 (%) = **67.1(%) to 3 s.f.** ALLOW TE from any incorrect M_r value(s) provided answer is not greater than 100% **(1)** Answer **MUST** be rounded correctly to 3 s.f. for the second mark Correct answer with no working **(2)**		**2**

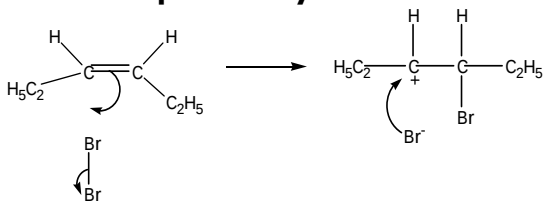
Question Number	Acceptable Answers	Reject	Mark
3 (c)(i)	$CH_4 + F_2 \rightarrow CH_3F + HF$ IGNORE state symbols, even if incorrect	Cl_2 "Fl" if used more than once	**1**

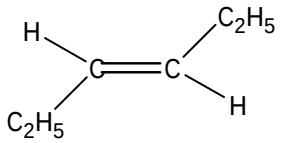
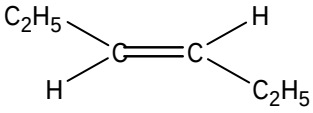
Question Number	Acceptable Answers	Reject	Mark
3 (c)(ii)	NOTE Allow reverse argument throughout **1st Mark** Fluorine / F (atom is) **smaller** (than a Cl atom) **(1)** **2nd Mark** Any ONE of:- (so expect) F—F **bond** to be shorter (than the Cl—Cl bond) OR F—F **bonding** electrons / **bond** pair / / **shared** pair closer to (both) nuclei OR (so) attraction between nuclei and **bonding** electrons / **bond** pair / **shared** pair expected to be stronger **(1)** IGNORE Any references to the strengths of the F-F and/or Cl-Cl bonds Any references to the 'repulsion between nuclei' Any references to 'shielding' / 'Charge density' / 'Electronegativity' / outer electrons	F_2 / 'fluorine **molecule**' Mention of 'Intermolecular forces' (no **2nd** mark)	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(iii)	 Shared pair of electrons shown **(1)** The remaining six electrons on each F atom **(1)** NOTE Can be dots or crosses – only total number of electrons matters Circles not required IGNORE Two inner-shell electrons ALLOW 'Fl' or F symbol missing		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(iv)	'**Repulsion** between electrons' scores (1) BUT '**Repulsion** between lone pairs (of electrons)' scores (2) ALLOW 'Non-bonding electrons' for lone pairs	Just repulsion between bonding / shared electrons	**2**

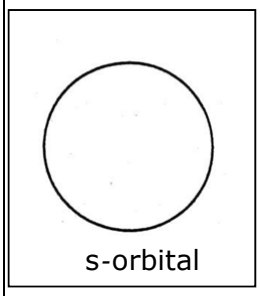
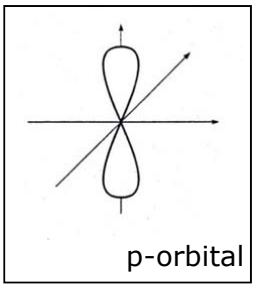
Question Number	Acceptable Answers	Reject	Mark
3 (c)(v)	UV (light) / (sun) light / heat / energy required to break Cl—Cl bond OR UV (light) / (sun) light / heat / energy required to form Cl• OR F—F requires less energy to break OR F—F requires less energy to form F• IGNORE **Just** F_2 more reactive (than Cl_2) **Just** F—F bond is weaker (than Cl—Cl) **Just** F—F bond energy is lower (than Cl—Cl)		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (d)	**Mark independently**  **First mark:** For **both arrows** in initial step Allow upper arrow as in diagram or directly to Br atom **(1)** **Second mark:** Carbocation intermediate **(1)** **Third mark:** Arrow from anywhere on the bromide ion to the C or to the + sign on the intermediate **(1)** Lone pair(s) on Br^- not required	**Half-arrow(s)** **Incorrect polarities** **Full**-charges on Br_2 **Half-arrow(s)** **δ**$^-$ instead of the full **–** sign on the Br^-	**3**

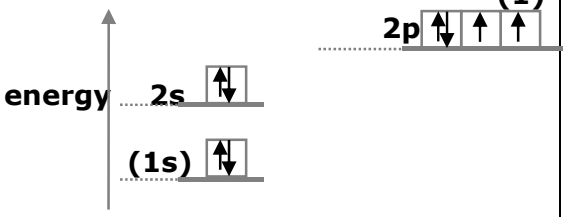
Question Number	Acceptable Answers	Reject	Mark
3(e)(i)	 OR  Diagram **clearly shows** that H atoms are diagonal to each other in the *E*-isomer/correct relative positions of hydrogen atoms and ethyl groups ALLOW Skeletal or displayed formula		**1**

Question Number	Acceptable Answers	Reject	Mark
3(e)(ii)	EITHER **Rotation** around C—C bond (in product molecule) OR Double bond is broken so **rotation** (is now possible) ALLOW Same carbocation / intermediate formed (so product is the same) IGNORE Comments about optical isomerism		**1**

(Total for Question 3 = 23 marks)

Question Number	Acceptable Answers	Reject	Mark
4(a)	 s-orbital  p-orbital **(s-orbital)** Circle drawn ALLOW Concentric circles drawn **(1)** **(p-orbital)** Figure of '8' / 'dumb-bell' drawn NOTE: p-orbital can be drawn along any axis (axis does not have to be shown) **(1)** ALLOW If one, two or three p-orbitals of correct shapes are shown If **overlapping** orbitals are shown of correct shape in both cases, award **(1)** mark		**2**

Question Number	Acceptable Answers	Reject	Mark
4(b)	**(region)** **(no. of electrons)** (a d-orbital) **2** **(1)** (a p sub-shell) **6** **(1)** (the third shell) **18** **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
4(c)	**First mark: BOTH** 2s and 2p labelled ALLOW $2s^2$ and $2p^4$ **(1)** **Second mark: ALL** eight e^- shown correctly **(1)**  ALLOW Half-arrows or full arrows for each electron Paired arrows in any one of the 2p orbitals NOTE Single arrows must be orientated in same direction Paired arrows must have opposite spins	$2p^6$	**2**

Question Number	Acceptable Answers	Reject	Mark
4(d)(i)	**First mark:** Makes mention of energy/enthalpy/(heat) energy/heat (change/required) AND to remove an electron **(1)** **Second mark:** one mole/1 mol **(1)** **Third mark:** Makes mention of **gaseous atom(s)** **(1)** **ALTERNATIVE ANSWER** Energy change per mole / kJ mol^{-1} for **(1)** $X(\mathbf{g}) \rightarrow X^{+}(\mathbf{g}) + e^{(-)}$ **(2)** One mark for species One mark for correct state symbols Mark independently IGNORE any references to standard conditions	"Energy **given out**…" for first mark **Just** 'gaseous element'/ 'gaseous substance'	**3**

Question Number	Acceptable Answers	Reject	Mark
4(d)(ii)	$O^{2+}(g) - e^{-} \rightarrow O^{3+}(g)$ OR $O^{2+}(g) \rightarrow O^{3+}(g) + e^{-}$ All species and balancing correct **(1)** State symbols correct **(1)** 2nd mark is dependent on 1st mark ALLOW 'e' for 'e^{-}' IGNORE (g) the e^{-}	Reverse equation scores **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
4(d)(iii)	**First mark:** **Big** 'jump' / **large** increase **(1)** **Second mark:** between **6th** and **7th** (IE) OR after the **6th** OR to the **7th** OR from 13327 to 71337 OR of 58010 **IGNORE** Additional jump identified between **4th** and **5th** (IE) if justified in terms of a change of **sub-shell** OR Additional jump identified between **4th** and **5th** (IE) if justified in terms of NOT being a change of shell **(1)**	Any other ionization jumps mentioned	**2**

(Total for Question 4 = 14 marks)