Mark Scheme (Results)

Summer 2019

Pearson International Advanced Subsidiary Level In Chemistry (WCH11) Paper 01 Structure, Bonding and Introduction to Organic Chemistry

Section A (multiple choice)

Question Number	Answer	Mark
1	**The only correct answer is C** (it has a molecular structure) **A** *is not correct because aqueous sodium chloride solution conducts electricity* **B** *is not correct because molten sodium chloride conducts electricity* **D** *is not correct because sodium chloride has a giant structure*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is B** (H–F) **A** *is not correct because the molecule is not polar* **C** *is not correct because chlorine is less electronegative than fluorine* **D** *is not correct because bromine is less electronegative than fluorine*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is D** (two nuclei and a shared pair of electrons) **A** *is not correct because this describes ionic bonding* **B** *is not correct because this describes metallic bonding* **C** *is not correct because electrons do not attract one another*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is C** (bonds are polar, molecule is non-polar) **A** *is not correct because the molecule is non-polar* **B** *is not correct because the C–F bonds are polar and the molecule is non-polar* **D** *is not correct because the C–F bonds are polar*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is C** (Mg^{2+} and O^{2-}) **A** *is not correct because these ions are singly charged* **B** *is not correct because these ions are singly charged* **D** *is not correct because these ions are larger*	**(1)**

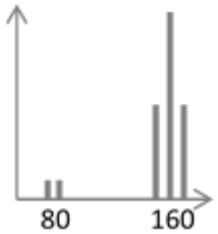
Question Number	Answer	Mark
6	**The only correct answer is B** ($TiCl_2$) **A** *is not correct because the mole ratio is 1:2 not 1:1* **C** *is not correct because the mole ratio is 1:2 not 1:3* **D** *is not correct because this is not an empirical formula*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is B** (^{12}C) **A** *is not correct because this has not been used since the beginning of the last century* **C** *is not correct because the isotope should be* ^{12}C **D** *is not correct because this has not been used since 1961*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is A** (atoms always contain the same number of protons and electrons) **B** *is not correct because many atoms have different numbers of protons and neutrons* **C** *is not correct because electrons do not have a relative mass of 1* **D** *is not correct because protons have a charge of +1*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is A** () **B** *is not correct because first ionisation energies decrease down Group 1* **C** *is not correct because first ionisation energies decrease more quickly at the start* **D** *is not correct because first ionisation energies decrease down Group 1, with no increases*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is D** (number of neutrons) **A** *is not correct because one atom would be in an excited state* **B** *is not correct because one would be an ion* **C** *is not correct because these would be different elements*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is D** () **A** *is not correct because this shows only one molecular ion peak* **B** *is not correct because this shows only one molecular ion peak* **C** *is not correct because this shows three molecular ion peaks in the wrong relative abundances*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is B** (28.2) **A** *is not correct because 28.0 is the mode of these values* **C** *is not correct because the relative abundance at 28 has not been properly taken into account* **D** *is not correct because 29.0 is the median of these values*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is B** ($A^{+}(g) \rightarrow A^{2+}(g) + e^{-}$) **A** *is not correct because this shows the first plus the second ionisation* **C** *is not correct because this shows the third ionisation* **D** *is not correct because this shows the third plus the fourth ionisation*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is A** (of giant covalent structures are the highest in Period 2 and Period 3) **B** *is not correct because the giant covalent structures have the highest melting temperatures* **C** *is not correct because there is not a regular pattern in each group* **D** *is not correct because melting temperatures increase then decrease within each Period*	**(1)**

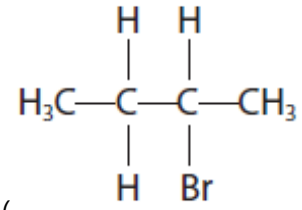
Question Number	Answer	Mark
15	**The only correct answer is A** ($1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$) **B** *is not correct because the wrong electron has been removed* **C** *is not correct because this is the electronic structure of the atom* **D** *is not correct because this is the electronic configuration of a* Sc^{3-} *ion*	**(1)**

Question Number	Answer	Mark
16	**The only correct answer is D** (1,2-dichloro-4-methylpentane) **A** *is not correct because the chlorine atoms are added to each end of the double bond* **B** *is not correct because the chlorine is numbered lower than the methyl group* **C** *is not correct because the chlorine atoms are added to each end of the double bon*d	**(1)**

Question Number	Answer	Mark
17	**The only correct answer is B** (heterolytic) **A** *is not correct because this is not a type of bond breaking* **C** *is not correct because this would form radicals* **D** *is not correct because the bond is covalent*	**(1)**

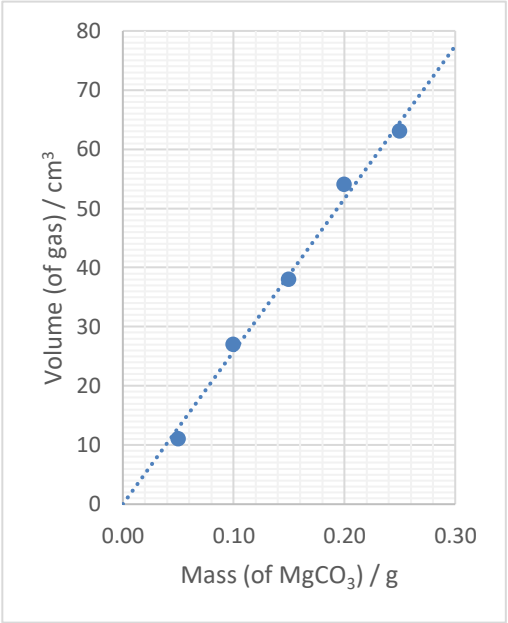
Question Number	Answer	Mark
18	**The only correct answer is C** (steam and acid catalyst) **A** *is not correct because this would produce a diol* **B** *is not correct because this would not react* **D** *is not correct because an acid catalyst is needed*	**(1)**

Question Number	Answer	Mark
19	**The only correct answer is B** (*cis* and *Z*) **A** *is not correct because E is incorrect* **C** *is not correct because trans and E are not correct* **D** *is not correct because trans is incorrect*	**(1)**

Question Number	Answer	Mark
20	**The only correct answer is A** () **B** *is not correct because this is the minor product* **C** *is not correct because this is a product with pent-2-ene* **D** *is not correct because this is a product with pent-2-ene*	**(1)**

Section B

Question Number	Answer	Additional guidance	Mark
21 (a)	• all correct state symbols	$MgCO_3$(**s**) + 2HCl(**aq**) → $MgCl_2$(**aq**) + H_2O(**l**) + CO_2(**g**) Allow capital letters Ignore extra brackets	**(1)**

Question Number	Answer	Additional guidance	Mark
21 (b)(i)	• suitable choice of scale so that the points cover at least 50% of the grid in both directions and correct choice of axes i.e. mass on x axis, suitably labelled including units **(1)** • all points plotted correctly (within ½ square) **(1)** • **straight** line of best fit (passes through the origin) **(1)**	Example of graph:  Allow no origin Allow units in brackets e.g. (g) instead of / g Any extrapolated line should pass within 2 squares of origin. Straight best fit lines that are not extrapolated are not penalised. If axes are the wrong way round, only MP1 is penalised.	**(3)**

Question Number	Answer	Additional guidance	Mark
21 (b)(ii)	• 46 (cm^3)	Allow 46.0(cm^3) Ignore units even if incorrect	**(1)**

Question Number	Answer	Additional guidance	Mark
21(b)(iii)	• 0.18 (g)	Accept answers from 0.17 (g) to 0.19 (g) Ignore SF TE on (b)(ii) and the graph, eg 54 (cm^3) gives 0.215 (g) Ignore units even if incorrect	**(1)**

Question Number	Answer	Additional guidance	Mark
21 (b)(iv)	• calculation of molar mass of magnesium carbonate **(1)** • calculation of moles of magnesium carbonate **(1)** • calculation of molar volume **(1)** • answer given to **2 or 3 SF and** units **(1)** M4 dependent on award of M3	Example of calculation: 84.3 OR expression used correctly: [24.3 + 12 + (3×16)] n= 0.18 ÷ 84.3 = 0.0021352 / 2.1352 x 10^{-3} (mol) 46 ÷ 0.0021352 = 21 543 / 2.1543 x 10^{4} (cm^3) = 22 dm^3 (mol^{-1}) / 22 000 cm^3 (mol^{-1}) Or 21.5 dm^3 (mol^{-1}) / 21 500 cm^3 (mol^{-1}) TE on any reasonable pair of values obtained from the candidates' graph or table provided eg 54cm^3 and 0.215(g) →2.5504 ×10^{-3} (mol) →21 200 cm^3 Correct answer scores 4 marks Final answer must not be given as a fraction to get MP4 Ignore units except for MP4	**(4)**

Question Number	Answer	Additional guidance	Mark
21 (b)(v)	• moles of magnesium carbonate and moles of acid in 30 cm^3 **(1)** • calculation of minimum concentration with units **(1)**	Example of calculation: n = 0.25 / 84.3 n = 0.0029655 or 0.00297 **and** 1:2 stoichiometry ∴0.00593 (moles acid) Accept 0.00594 from 0.00297 (0.00593 / 30) × 1000 = 0.198 mol dm^{-3} Accept answers from 0.198 to 0.200 mol dm^{-3} Allow TE throughout e.g. M_r from 21(b)(iv) Ignore SF Correct answer with no working scores 2	**(2)**

Question Number	Answer	Additional guidance	Mark
21 (c)	An answer that makes reference to any two of the following points: • loss of gas before the bung is inserted / other named reason **(1)** • some carbon dioxide dissolved in the water (**1**) • temperature of the lab was <u>lower</u> than standard temperature. **(1)**	Do not allow "loss of gas" unless a reason is given eg delivery tube not positioned correctly so not all goes into measuring cylinder, badly fitting bung Ignore leaks Allow gas for carbon dioxide Ignore higher pressure Do not award higher temperature / lower pressure / suck-back Ignore impurities in $MgCO_3$ Ignore incomplete reaction **Comment:** Apply the list principle ie • 1 correct answer and 1 do not award answer scores 1 • 2 correct answers and 1 do not award answer scores 1 • 2 correct answers and 2 do not award answers scores 0 • 2 correct answers and 1 ignore scores 2	**(2)**

(Total for Question 21 = 14 marks)

Question Number	Answer	Additional guidance	Mark
22 (a)(i)	An explanation that makes reference to the following points: • the carbon dioxide released when the fuel is used/burnt/combusted (is equal) **(1)** • (to the carbon dioxide that is) used/absorbed/taken in by the plant/during photosynthesis **(1)**	Ignore answers relating to fuel burnt on transport affecting carbon neutrality / energy spent on processing and drying MP1 do not award carbon for carbon dioxide Marks are independent Ignore sustainable resource **If no other marks awarded, for 1 mark:** Accept "no net CO_2 produced when using coffee grounds as a fuel" Accept "carbon intake = carbon release" Allow "renewable resource"	**(2)**

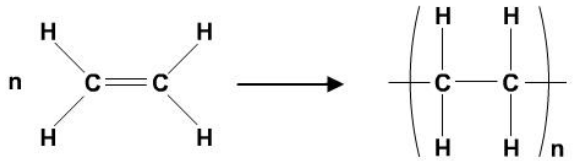
Question Number	Answer	Additional guidance	Mark
22 (a)(ii)	An explanation that makes reference to the following points: • fossil fuels release <u>carbon dioxide</u> (that has been locked up for millions of years) / carbon dioxide is a greenhouse gas **(1)** • increases the greenhouse effect / leads to global warming / causes temperature increase (and climate change) **(1)**	Ignore answers relating to the consequences of climate change Ignore an explanation of the greenhouse effect Ignore CO_2 is harmful Marks are independent Do not award answers relating to: • UV light • ozone • SO_2 • NO_x • methane as a product of burning • carbon monoxide • acid rain	**(2)**

Question Number	Answer	Additional guidance	Mark
22(b)(i)	• carbon monoxide	Allow CO Ignore unburnt hydrocarbons Do not award carbon Do not award nitrogen oxides	**(1)**

Question Number	Answer	Additional guidance	Mark
22 (b)(ii)	• formulae **(1)** • balancing **(1)**	$C_8H_{18} + 12½O_2 \rightarrow 8CO_2 + 9H_2O$ Accept 12.5 and 25/2 Allow multiples MP2 is dependent on MP1, but allow MP2 for correctly balanced equation for complete combustion of C_8H_{16} Ignore state symbols, even if incorrect Ignore references to energy on RHS eg *E* or *Q* or ΔH	**(2)**

Question Number	Answer	Additional guidance	Mark
22 (c)(i)	• cracking		**(1)**

Question Number	Answer	Additional guidance	Mark
22 (c)(ii)	• bromine water / bromine solution / $Br_2(aq)$ **(1)** • yellow / orange / (red-)brown to colourless **(1)**	MP2 is dependent on a correct reagent for MP1 Allow bromine / liquid bromine Ignore heat Do not award "in UV light" Do not award iodine Allow decolourises or "turns colourless" Accept: $KMnO_4$ **with acid / H^+** scores 1 mark purple to colourless scores 1 mark (allow decolourises) Allow $KMnO_4$ **with alkali / OH^-** scores 1 mark purple $\rightarrow$ green scores 1 mark	**(2)**

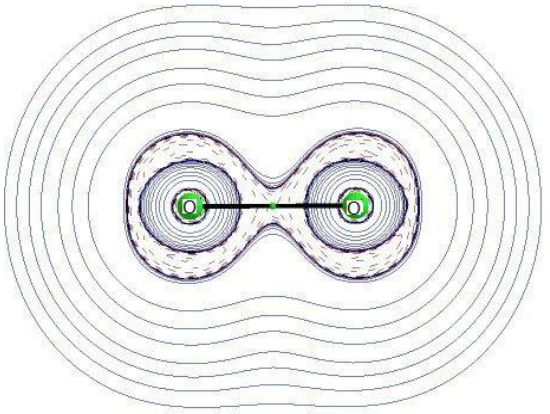
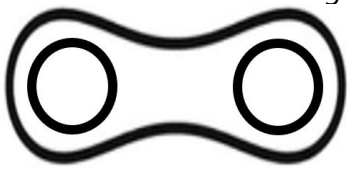
Question Number	Answer	Additional guidance	Mark
22 (d)(i)	• displayed equation for the polymerisation of ethene	 Accept 90° bond angles for the monomer Allow letters other than n if used on both sides Allow square brackets around the polymer Ignore brackets around the monomer Ignore any names even if incorrect Do not award answers where • the polymer does not have brackets • the polymer continuation bonds do not pass through the brackets	**(1)**

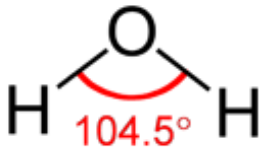
Question Number	Answer		Additional guidance	Mark
22 (d)(ii)	• one advantage	**(1)**	eg bananas are a renewable resource / more bananas can be grown / crude oil is running out / limited supply of crude oil Ignore references to: eco-friendly / carbon neutral / does not pollute / clean environment / idea of ethene produced by bananas does not pollute / banana skin being biodegradable / sustainable Do not award "no shortage of bananas"	**(2)**
	• one disadvantage	**(1)**	eg many bananas would be needed to produce a small amount of plastic / bananas only produce a small quantities of ethene / it would take a long time / loss of food source / less land available for growing food / not economically viable / only grow in certain climates / bananas would need to be transported long distances / banana transport would burn fossil fuels / inefficient process Ignore references to cost and biopolymers Do not award • polythene is non-biodegradable • impure ethene is produced	

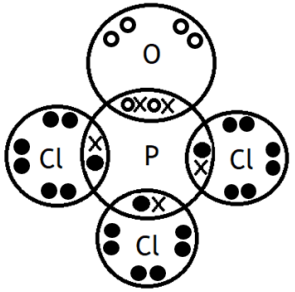
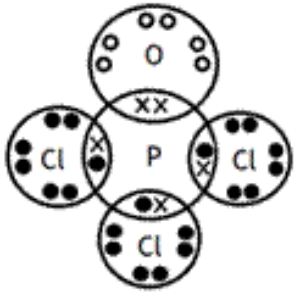
Question Number	Answer	Additional guidance	Mark
22 (e)(i)	• (HCl is) toxic / corrosive	Allow poisonous Allow irritant Ignore acidic Ignore harmful Ignore damage Do not award: • acid rain • ozone depletion • global warming • greenhouse gas • chlorine is toxic • flammable	**(1)**

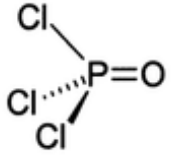
Question Number	Answer	Additional guidance	Mark
22 (e)(ii)	• use of basic/alkaline (scrubbers) / form a ppt/salt/solid or injection of powdered activated carbon (to the flue) or pass through water / dissolve the HCl in water	Allow named examples of basic/alkaline chemicals e.g. NH_3, NaOH, $CaCO_3$ etc Scrubbers alone is insufficient Accept adsorption in granular activated carbon or coke beds Allow dissolve in steam Ignore fractional distillation of gases Do not award general descriptions of recycling	**(1)**

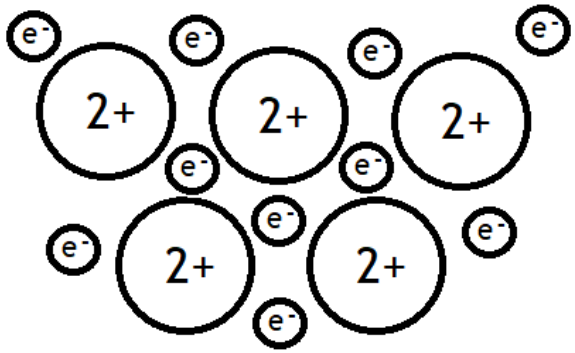
(Total for Question 22 = 15 marks)

Question Number	Answer	Additional guidance	Mark
23 (a)	A sketch showing: • two atoms with high electron density and a symmetrical cloud around both	e.g.  At least one separate circle around each atom **and** at least one contour line with an indentation above and below the axis **and** circling both atoms ie  is the minimum Allow nuclei shown as + signs Allow dashed contour lines	**(1)**

Question Number	Answer	Additional guidance	Mark
23 (b)	A diagram that includes: • shape of H_2O **(1)** • bond angle **(1)**	CHECK THE ANSWER LINE ON BOTTOM RIGHT CORNER! (as well as angles on diagram)  Allow dot-cross diagrams if in the correct shape Allow 3D representations showing lone pairs Ignore the presence of lone/bonding pairs of electrons Ignore charges or partial charges even if incorrect Do not award double bonds Accept bond angle from 104° to 105 ° Allow bond angle labelled <u>correctly</u> on diagram Do not award M2 if one correct and one incorrect bond angle stated	**(2)**

Question Number	Answer	Additional guidance	Mark
23 (c)(i)	A diagram that includes: • phosphorus singly covalently bonded to three chlorine atoms and three lone pairs on each chlorine **(1)** • phosphorus doubly bonded to an oxygen atom and two lone pairs on the oxygen or a dative covalent bond from the phosphorus and three lone pairs on the oxygen **(1)**	 OR  Penalise absence of lone pairs once only Allow lone pairs to appear as separate electrons Allow any representation of electrons **but** electrons in a dative covalent bond must appear to be the same	**(2)**

Question Number	Answer		Additional guidance	Mark
23 (c)(ii)	An answer that makes reference to the following points:			**(3)**
	• (based on) tetrahedron / tetrahedral (arrangement)	**(1)**	MP1 can be given for a 3-D diagram 	
	• four regions of bonding electrons	**(1)**	Accept 5 bonding pairs, where two (in double bond) behave as one. Allow 4 bonding pairs Allow phosphorous bonds to 4 other atoms	
	• adopt the positions of minimum repulsion	**(1)**	Accept repel to maximum separation Allow maximise the distance between the bonding pairs Allow to achieve lowest (potential) energy state Ignore to become most stable Do not award maximum repulsion Ignore bond angles throughout Ignore lone pairs throughout	

Question Number	Answer	Additional guidance	Mark
23 (d)(i)	A diagram that includes: • <u>positive</u> (2+) ions / cations **(1)** • surrounded by randomly arranged delocalised electrons with approximately equal positive and negative charges **(1)**	The diagram must include at least four ions in two rows  Accept 1+ ions Accept close packed ions Allow +1/+2 (oxidation state instead of charge) Accept reference to "sea of electrons" Allow "e" or "–" to represent electrons Ignore "electron cloud"	**(2)**

Question Number	Answer	Additional guidance	Mark
23 (d)(ii)	An explanation that makes reference to the following points: Electrical conductivity: • the <u>electrons</u> can flow (under a potential difference) **(1)** High melting temperature: • <u>strong</u> force of attraction between the (positive) ions and electrons **(1)** Malleability: • the ions can <u>slide</u> past each other (while still being held together by the electrons) **(1)**	Accept "move" Accept "carry charge/current" Allow "mobile" "Delocalised electrons" alone is insufficient Allow bond strength instead of force of attraction Allow metallic bonds are <u>strong</u> Do not award protons instead of cations Do not award negative ions instead of electrons Do not award strong intermolecular bonds Accept ions can <u>move over</u> each other Allow atoms/layers slide over each other Ignore "mobile ions"	**(3)**

Question Number	Answer	Additional guidance	Mark
23 (e)(i)	An explanation that makes reference to the following points: • diamond is hard **and** graphite is soft **(1)** • because diamond has a rigid lattice / weak forces between the layers in graphite (allow the layers to slide over one another) **(1)** • graphite conducts (electricity) **and** diamond does not **(1)** • because graphite has delocalised electrons (which are free to move) / diamond does not **(1)**	Ignore strong in place of hard Accept "diamond has covalent bonds in a 3D structure" Ignore diamond has a tetrahedral structure Accept that electrons are free to move in graphite Allow free electrons Marks are independent. I.e. Comments on properties without comparison score 2 for MP2 and MP4. Ignore additional properties e.g. melting temperature	**(4)**

Question Number	Answer	Additional guidance	Mark
23 (e)(ii)	• single layer / monolayer	Accept "one atom thick layer" Allow "graphene is one layer of graphite" or "individual layer of graphite" Ignore references to the structures and bonding of graphite and graphene Do not award "thin sheet of graphite" NB Assume "it" refers to graphene	**(1)**

Question Number	Answer	Additional guidance	Mark
23 (e)(iii)	• potential use **(1)** • (use linked to) at least one property **(1)** **See notes on next page**	Examples: • flexible electronics • as only one atom thick or conducts electricity or • transparent electrodes scores • as only one atom thick or conducts electricity or • oxidation resistant layer • as is unreactive or • data storage • as is lightweight or conducts electricity or is durable Marks are independent but to score 2, the property must have a plausible link to the named application Ignore lubricant Ignore used as electric wires Do not award reference to: • pencils as a use • making carbon brushes as a use • electrodes as a use (without a small size reference) • layers as a property	**(2)**

Example uses of Graphene (non-exhaustive!)
• added to other materials e.g. drill tips, roads, bullet proof clothing, body armour • heat sinks e.g. thermal foils for mobile phones • coatings on spacecraft • microelectronics • (small) batteries • supercapacitors • enhancing fuel cells • non-stick coatings e.g. do not allow just "frying pan" • anti-corrosion coatings or paints e.g. for self-healing pipes, NB do not allow "aeroplanes" or "industrial equipment" without qualification • efficient and precise sensors • faster electronics • micro electrodes • flexible displays • touchscreens / mobile (phone) screen • solar panels / photo(voltaic) cells • making nanotubes • composites • microtubules or microfibres in drug delivery / medicine • low friction coatings • used to make electric wires

Properties of graphene
• thin • flexible • transparent • oxidation resistant • reduces friction between surfaces • low density • high melting point • durable • strong • thermal conductor • electrical conductor • can be made into nanotubes

(Total for Question 23 = 20 marks)

Question Number	Answer	Additional guidance	Mark
24(a)	• correct equation	$2NaN_3 \rightarrow 2Na + 3N_2$ Accept $NaN_3 \rightarrow Na + 1.5N_2$ Accept $NaN_3 \rightarrow Na + 3/2\ N_2$ Allow multiples Ignore state symbols even if incorrect Do not award Na_2	**(1)**

Question Number	Answer	Additional guidance	Mark
24(b)	• conversion of volume m^3 **(1)** • conversion of temperature to K **(1)** • correct substitution into the equation / rearrangement of the equation **(1)** • calculation of n for N_2 **(1)** • calculation of n for NaN_3 (2:3) **(1)** • calculation of mass to **2 or 3 SF** **(1)**	V = 0.12 m^3 T = 298 K Accept 298.15K 101000 × 0.12 = n × 8.31 × 298 n = 101000 × 0.12 / 8.31 × 298 or $n = PV/RT$ n = 4.89(424) n = 4.89 × 2/3 = 3.2628 M_r (NaN_3) = 65 m = 3.26 × 65 = 212.08 (g) = 212 (g) (210 to 2SF) Correct answer scores 6 Do not award incorrect units for MP6 TE throughout 318 (g) or 320 (g) scores 5 317.8(5) (g) scores 4 0.32 (g) scores 4	**(6)**

Question Number	Answer	Additional guidance	Mark
24(c)(i)	• quoting or using atom economy formula **(1)** • calculation of total molar masses of reactants or products **(1)** • calculation of atom economy to **2 or 3 SF** **(1)**	Example of calculation: $\frac{\text{molar mass desired product}}{\text{sum of all product molar masses}} \times 100\%$ OR $\frac{28}{[(39.1 \times 2)+16] + [5\times(23\times2)+16] + [14\times2]} \times 100\%$ 432.2 Allow 432 TE on incorrect numerical atom economy expression **if** 39.1, 16, 23 and 14 are in the denominator and correctly used (28.0 ÷ 432.2) × 100 = 6.4785 = 6.5 / 6.48(%) TE on incorrect quoted molar masses Correct answer scores 3 Correct answer to <2 or >3 SF scores 2 Penalise omission of 100% once only	**(3)**

Question Number	Answer	Additional guidance	Mark
24(c)(ii)	• neutralisation	Allow acid-base	**(1)**

(Total for Question 24 = 11 marks)

Total for Section B = 60 MARKS