



Mark Scheme (Results)

January 2022

Pearson Edexcel International Advanced
Subsidiary Level
In Chemistry (WCH12)
Paper 01: Energetics, Group Chemistry,
Halogenoalkanes and Alcohols

Section A

Question Number	Answer	Mark
1	The only correct answer is D (exothermic, neutralisation) <i>A is incorrect because the reaction is exothermic and is not formation</i> <i>B is incorrect because the reaction is exothermic</i> <i>C is incorrect because the equation does not show formation</i>	(1)

Question Number	Answer	Mark
2	The only correct answer is B ($\text{Cl}_2(\text{g}) \rightarrow 2\text{Cl}(\text{g})$) <i>A is incorrect because this is the standard enthalpy change of atomisation of magnesium</i> <i>C is incorrect because this is the standard enthalpy change of atomisation of oxygen</i> <i>D is incorrect because this is the standard enthalpy change of atomisation of mercury</i>	(1)

Question Number	Answer	Mark
3	The only correct answer is B ($-16.6 \text{ kJ mol}^{-1}$) <i>A is incorrect because this is the energy change divided by the M_r</i> <i>C is incorrect because this is the energy change divided by the M_r and multiplied by the mass</i> <i>D is incorrect because this is the energy change but has not been correctly converted into kilojoules</i>	(1)

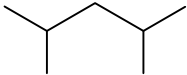
Question Number	Answer	Mark
4	The only correct answer is A (623 kJ mol⁻¹) <i>B is incorrect because this is the C=O bond in CO₂ added to an O–H bond minus 591</i> <i>C is incorrect because this is the value for C=O in CO₂</i> <i>D is incorrect because this is the value when only one of the two C-H bonds is taken into account</i>	(1)

Question Number	Answer	Mark
5	The only correct answer is D (CH₄ < Cl₂ < Br₂ < H₂O) <i>A is incorrect because the sequence is reversed</i> <i>B is incorrect because methane has the lowest boiling temperature</i> <i>C is incorrect because methane has the lowest boiling temperature</i>	(1)

Question Number	Answer	Mark
6	The only correct answer is C (the H–O–H bond angle is the same in ice and in water) <i>A is incorrect because ice does have a lower density than water</i> <i>B is incorrect because H₂O molecules are further apart in ice than in water</i> <i>D is incorrect because the molecules in ice are held together by hydrogen bonds</i>	(1)

Question Number	Answer	Mark
7	The only correct answer is D (hydrogen bonding, permanent dipole-permanent dipole forces and London forces) <i>A is incorrect because there are also permanent dipole-permanent dipole interactions</i> <i>B is incorrect because there are also London forces</i> <i>C is incorrect because there are also hydrogen bonds</i>	(1)

Question Number	Answer	Mark
8(a)	The only correct answer is B (hexane) <i>A is incorrect because this has a shorter chain length</i> <i>C is incorrect because this has a shorter chain length</i> <i>D is incorrect because this has a shorter chain length</i>	(1)

Question Number	Answer	Mark
8(b)	The only correct answer is A () <i>B is incorrect because this only has one branch</i> <i>C is incorrect because this only has one branch</i> <i>D is incorrect because this is unbranched</i>	(1)

Question Number	Answer	Mark
9	The only correct answer is C (hexane) <i>A is incorrect because butan-1-ol contains polar bonds</i> <i>B is incorrect because ethanoic acid contains polar bonds</i> <i>D is incorrect because water contains polar bonds</i>	(1)

Question Number	Answer	Mark
10	The only correct answer is C (concentrated phosphoric acid) <i>A is incorrect because this would oxidise the alcohol</i> <i>B is incorrect because this is a drying agent</i> <i>D is incorrect because this produces an alkene from a halogenoalkane</i>	(1)

Question Number	Answer	Mark
11	The only correct answer is C (sulfate(VI)) <i>A is incorrect because the oxidation number of sulfur is +6</i> <i>B is incorrect because the oxidation number of sulfur is +6</i> <i>D is incorrect because the oxidation number of sulfur is +6</i>	(1)

Question Number	Answer	Mark
12	The only correct answer is A ($\text{Ca}(\text{NO}_3)_2$) <i>B is incorrect because the oxidation number of nitrogen is -3</i> <i>C is incorrect because the oxidation number of nitrogen is +3</i> <i>D is incorrect because the oxidation number of nitrogen is +3</i>	(1)

Question Number	Answer	Mark
13	The only correct answer is A ($\text{Cu}^{2+} + 2\text{Ag} \rightarrow 2\text{Ag}^+ + \text{Cu}$) <i>B is incorrect because the oxidation number of the copper is unchanged</i> <i>C is incorrect because this is a reaction where copper is oxidised</i> <i>D is incorrect because this is a reaction where copper is oxidised</i>	(1)

Question Number	Answer	Mark
14	The only correct answer is C ($3\text{Cu} + 2\text{NO}_3^- + 8\text{H}^+ \rightarrow 3\text{Cu}^{2+} + 2\text{NO} + 4\text{H}_2\text{O}$) <i>A is incorrect because the charges have not been balanced</i> <i>B is incorrect because the charges have not been balanced</i> <i>D is incorrect because the charges have not been balanced</i>	(1)

Question Number	Answer	Mark
15	The only correct answer is B ($\pm 0.75\%$) <i>A is incorrect because only one of the readings has been taken into account</i> <i>C is incorrect because both the uncertainty and the number of readings have been doubled</i> <i>D is incorrect because the value has been multiplied by 1000 instead of 100</i>	(1)

Question Number	Answer	Mark
16	The only correct answer is A ($\text{Ba}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) + 2\text{H}^{+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s}) + 2\text{H}_2\text{O}(\text{l})$) <i>B is incorrect because it only shows the precipitation reaction</i> <i>C is incorrect because it only shows the neutralisation reaction</i> <i>D is incorrect because it shows the barium sulfate ions as separated</i>	(1)

Question Number	Answer	Mark
17	The only correct answer is D (3 and 4) <i>A is incorrect because a flame test will not positively identify ammonium ions and barium nitrate will not positively identify chloride ions</i> <i>B is incorrect because a flame test will not positively identify ammonium ions</i> <i>C is incorrect because barium nitrate will not positively identify chloride ions</i>	(1)

Question Number	Answer	Mark
18	The only correct answer is B (high temperature, low pressure) <i>A is incorrect because high pressure would favour the back reaction</i> <i>C is incorrect because both these conditions would favour the back reaction</i> <i>D is incorrect because low temperature would favour the back reaction</i>	(1)

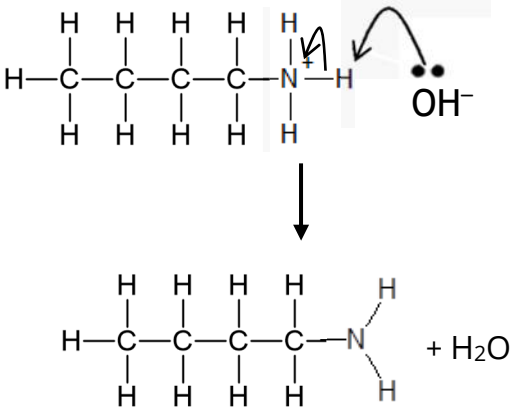
Question Number	Answer	Mark
19	The only correct answer is C (darker and then lighter) <i>A is incorrect because when the equilibrium is re-established the mixture becomes lighter</i> <i>B is incorrect because when the mixture is compressed it initially becomes darker</i> <i>D is incorrect because the colour change is reversed</i>	(1)

Total for Section A = 20 marks

Section B

Question Number	Answer	Additional Guidance	Mark
20(a)	An answer that makes reference to the following point: - nucleophilic (1) - substitution (1)		(2)

Question Number	Answer	Additional Guidance	Mark
20(b)(i)	An answer that makes reference to the following points: - lone pair on the nitrogen / N (1) - delta +/δ+/partial positive (charge) on the carbon (attached to the chlorine) (1)	The answers may be shown on the diagram Ignore “pairs” if only one lone pair shown on diagram Ignore “lone pair on the ammonia/NH₃” Do not award ammonium Ignore “positive dipole” alone Ignore any references to missing dipoles on ammonia molecule NOTE: The specific carbon does not need to be referenced but if annotated on diagram must be correct Use the list principle for extra comments	(2)

Question Number	Answer	Additional Guidance	Mark
20(b)(ii)	A correctly drawn mechanism showing: - curly arrow from the lone pair on the oxygen going to the hydrogen (1) - curly arrow from the same N-H bond to N atom or + (1) - correct products (1)	An example of a mechanism:  Assume arrows drawn are curly Ignore spectator ions Penalise the use of ammonia once only i.e. M3 can be awarded for the correct products of reaction with further ammonia Covalent bonding in sodium hydroxide loses M1 Missing negative charge on OH⁻ loses M1 Allow structural formulae for M3	(3)

Question Number	Answer	Additional Guidance	Mark
20(c)	An answer that makes reference to the following points: - the rate of reaction will be slower for 1-chlorobutane (1) - C–Cl has a higher bond enthalpy (than C–Br) (1) 1-chlorobutane is a primary halogenoalkane (rather than a tertiary halogenoalkane) (1)	Allow reverse answers Allow less / decreased Allow reference to bond strength Allow C–Cl requires more energy to break Allow 1-chlorobutane is 1° / 2-bromo-2-methylpropane is 3° Allow reference to methyl stabilisation of (partial) positive charge(s) on carbon atom(s) Allow reference to stability of carbocations Do not award alcohol Do not award secondary / 2° M2 is dependent on M1 M3 is independent	(3)

(Total for Question 20 = 10 marks)

Question Number	Answer	Additional Guidance	Mark
21(a)(i)	mass change = 0.57(g) and temperature change = 45.8(°C)	Accept –0.57(g) Do not award –45.8 Ignore extra SF	(1)

Question Number	Answer	Additional Guidance	Mark
21(a)(ii)	An answer that makes reference to the following points: M_r calculated correctly for 2-methylpropan-2-ol - moles calculated correctly - correct use of $\Delta H = mc\Delta T$ - answer with units and minus sign	Example answer: $M_r = 74$ $0.57 \div 74 = 0.0077027 \text{ mol} / 7.7027 \times 10^{-3} \text{ mol}$ $\Delta H = 75 \times 4.18 \times 45.8 = 14358 \text{ (J)}$ $\Delta H = \frac{-(75 \times 4.18 \times 45.8)}{0.0077027} = \frac{-14358}{0.0077027}$ $\Delta H = -1\,864\,100 / -1.8641 \times 10^6 \text{ J mol}^{-1}$ OR $\Delta H = -1864.1 \text{ kJ mol}^{-1} / -1900 \text{ kJ mol}^{-1}$ Ignore extra M_r calculations Ignore SF except 1 SF TE throughout including from 21(a)(i) Correct answer with some working scores (4)	(4)

Question Number	Answer	Additional Guidance	Mark
21(b)(i)	oxygen is an element and in its standard state	Allow description of standard state of an element Allow oxygen is an element and gas in standard conditions Allow because ($\Delta_f H^\ominus$) value for an element is 0	(1)

Question Number	Answer	Additional Guidance	Mark
21(b)(ii)	An answer that makes reference to the following points: - balanced reactants and products - balanced elements with state symbols	An example of a completed cycle: Accept elements in any order Allow top heavy fractions throughout	(2)

Question Number	Answer	Additional Guidance	Mark
21(b)(iii)	An answer that makes reference to the following points: - expression for calculation of enthalpy change of combustion - answer and negative sign	<u>Example of calculation:</u> $\Delta H = - \Delta_f H \text{ reactants} + \Delta_f H \text{ products}$ OR $= - (-359) + (4 \times -394) + (5 \times -286)$ $= -2647 \text{ (kJ mol}^{-1}\text{)}$ Ignore SF except 1 SF Ignore units even if incorrect TE from balancing in 21(b)(ii)	(2)

Question Number	Answer	Additional Guidance	Mark
21(c)	An answer that makes reference to any two of the following points: • heat is lost (in the enthalpy experiment) OR - no account has been taken of the heat capacity of the beaker (1) - incomplete combustion (of alcohol) (1) - some alcohol evaporates (1)	Allow energy lost Allow heat transfer Ignore heat lost/transferred to the thermometer Ignore incomplete burning Do not award references to time Ignore evaporation of water / mass change Allow "no stirrer so temperature is not uniform" for 1 of the marks Ignore human error Ignore non-standard conditions	(2)

(Total for Question 21 = 12 marks)

Question Number	Answer	Additional Guidance	Mark
22(a)	An answer that makes reference to the following points: (dark) grey / black and solid	Ignore shiny / metallic	(1)

Question Number	Answer	Additional Guidance	Mark
22(b)(i)	the ability of an atom to attract a bonding/shared pair of electrons (in a covalent bond)	Allow "ability of an atom to attract electrons in a covalent bond"	(1)

Question Number	Answer	Additional Guidance	Mark
22(b)(ii)	An explanation that makes reference to the following points: - elements become less electronegative (down the group) (1) - the outer electron(s)/shell is further away from the (positive) nucleus (so the bonding electrons are less strongly attracted) (1)	Allow decreases Allow descriptions using names of elements Allow increased repulsion (from inner electrons) Allow more shielding (by inner electrons) Allow more (inner) shells of electrons Allow effective nuclear charge is lower Ignore other comments about nuclear charge Ignore size/radius of atom increases Allow reverse argument Marks are independent	(2)

Question Number	Answer	Additional Guidance	Mark																				
22 (c)*	This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. <table><tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr><tr><td>6</td><td>4</td></tr><tr><td>5-4</td><td>3</td></tr><tr><td>3-2</td><td>2</td></tr><tr><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td></tr></table> The following table shows how the marks should be awarded for structure and lines of reasoning <table><tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr><tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr><tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr><tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr></table>	Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	6	4	5-4	3	3-2	2	1	1	0	0		Number of marks awarded for structure of answer and sustained lines of reasoning	Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkages between points and is unstructured	0	Guidance on how the mark scheme should be applied. The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages). In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning. If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s). Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning.	(6)
Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points																						
6	4																						
5-4	3																						
3-2	2																						
1	1																						
0	0																						
	Number of marks awarded for structure of answer and sustained lines of reasoning																						
Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2																						
Answer is partially structured with some linkages and lines of reasoning	1																						
Answer has no linkages between points and is unstructured	0																						

	Indicative content: IP1 all are disproportionation reactions (because chlorine is both oxidised and reduced) IP2 chlorine changes/is reduced from 0 to -1 (in Cl^- in all reactions) IP3 $\text{Cl}_2 + \text{H}_2\text{O} \rightleftharpoons \text{HCl} + \text{HOCl}$ IP4 $\text{Cl}_2 + 2\text{NaOH} \rightarrow \text{NaClO} + \text{NaCl} + \text{H}_2\text{O}$ IP5 $3\text{Cl}_2 + 6\text{NaOH} \rightarrow \text{NaClO}_3 + 5\text{NaCl} + 3\text{H}_2\text{O}$ IP6 chlorine oxidised to $+1$, $+1$ and $+5$ shown in the appropriate reaction	Allow for a description, including the name, of disproportionation if a reaction type is not given for all three equations Allow disproportional/disproportion reaction Allow $\text{Cl}_2 + \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{Cl}^- + \text{HOCl}$ Allow single arrow instead of equilibrium sign Allow HClO or ClOH Allow $\text{Cl}_2 + 2\text{OH}^- \rightarrow \text{ClO}^- + \text{Cl}^- + \text{H}_2\text{O}$ Allow $3\text{Cl}_2 + 6\text{OH}^- \rightarrow \text{ClO}_3^- + 5\text{Cl}^- + 3\text{H}_2\text{O}$ Allow oxidation numbers shown next to a combination of correct names and formulae even if the equations are not balanced Ignore state symbols even if incorrect	
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Total for Question 22 = 10 marks)

Question Number	Answer	Additional Guidance	Mark
23 (a)(i)	carbon monoxide / CO is (a) toxic (gas)	Allow explanations of toxicity in terms of reaction with haemoglobin Allow poisonous Ignore "fumes are toxic" Ignore harmful Ignore "it is toxic" Do not award corrosive	(1)

Question Number	Answer	Additional Guidance	Mark
23 (a)(ii)	An answer that makes reference to the following points: M_r of MgC_2O_4 and MgCO_3 - mass of MgC_2O_4 that reacts - mass of MgCO_3 that is formed - mass of MgC_2O_4 remaining and total solid	Example calculation: (1) $M_r \text{MgC}_2\text{O}_4 = 112.3$ and $M_r \text{MgCO}_3 = 84.3$ (1) $6.0 \times 0.7 = 4.2 \text{ (g)}$ OR $6.0 \times 0.3 = 1.8 \text{ (g)}$ (1) $(4.2 \div 112.3) \times 84.3 = 3.15 \text{ (g)}$ (1) $(6.0 - 4.2 = 1.8 \text{ (g)})$ $3.15 + 1.8 = 4.95 \text{ (g)}$ Alternative method: (moles oxalate calculated) $6 \div 112.3 = 0.05343$ (moles carbon monoxide calculated) $0.7 \times 0.05343 = 0.03740$ (mass carbon monoxide calculated) $0.03740 \times 28 = 1.0472 \text{ (g)}$ mass of solid remaining $6.0 - 1.0472 = 4.95(28) \text{ (g)}$ Ignore SF except 1SF Allow use of Magnesium as 24 to get 4.96 (g) Correct answer with some working scores (4)	(4)

Question Number	Answer	Additional Guidance	Mark
23 (b)	An answer that makes reference to the following points: - the temperature of decomposition of carbonates / thermal stability increases (down the group) - the size of the cation increases (but has the same charge) (so) polarises the anion / carbonate (ion) less	(1) Ignore references to rate Ignore "decomposition decreases down the group" Allow amount of heat energy needed to decompose increases down the group (1) Accept reference to the metal ion size/radius Allow charge density of (cat)ion decreases Ignore "ion size decreases" Do not award atomic radius (1) Allow polarises electron cloud less Allow weakens the carbon oxygen bond	(3)

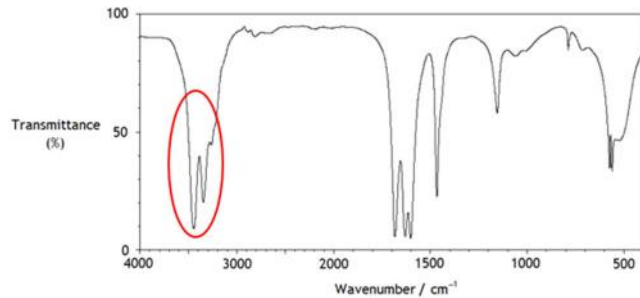
(Total for Question 23 = 8 marks)

Section C

Question Number	Answer	Additional Guidance	Mark
24(a)	An answer that makes reference to the following points: • urea forms hydrogen bonds (1) • urea forms (permanent) dipole-dipole forces (1) • these forces are stronger than London forces (1)	Ignore references to number of hydrogen bonds Allow a correct diagram Allow hydrogen bonds are the strongest intermolecular forces Allow dispersion forces/van der Waals for London forces Do not award M3 if breaking covalent bonds is referenced	(3)

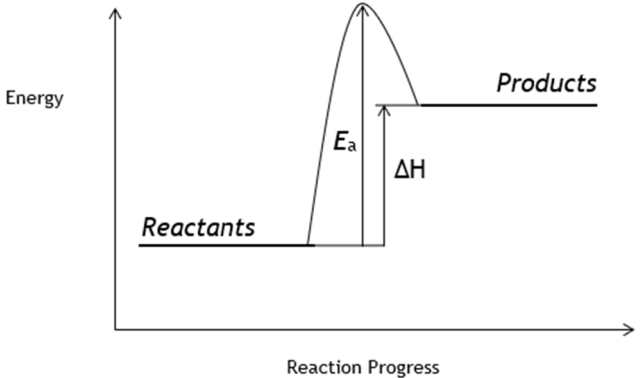
Question Number	Answer	Additional Guidance	Mark
24(b)	An answer that makes reference to the following points: • M_r of urea (1) OR • moles of urea • mass of urea required (1)	$M_r = 60$ $(9.07 \div 1000) \times 150 = 1.36(05)$ $(9.07 \div 1000) \times 150 \times 60 = 81.63 \text{ (g)} / 81.6 \text{ (g)}$ Ignore SF except 1 SF Correct answer scores (2) No M2 if units other than grams are used	(2)

Question Number	Answer	Additional Guidance	Mark
24(c)	An answer that makes reference to the following point: (oxides of nitrogen lead to the formation of) acid rain	Allow formation of photochemical smog Allow "NO can react with ozone" Allow descriptions of acid rain formation e.g. forms HNO_3 Do not award greenhouse effect / global warming Do not award depletes the ozone layer without reference to nitrogen(II) oxide/NO	(1)

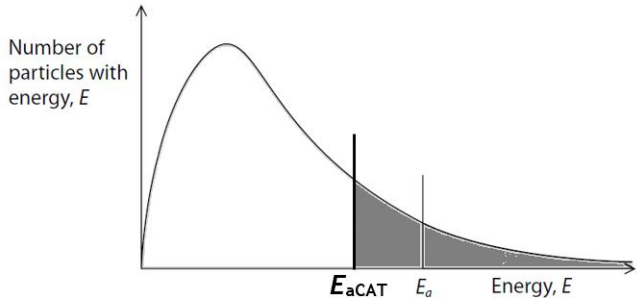
Question Number	Answer	Additional Guidance	Mark
24(d)(i)	An answer that makes reference to the following point correct peak circled	Example of completed spectra:  Allow any number of the three peaks in the region to be circled individually Extra circles negate the mark	(1)

Question Number	Answer	Additional Guidance	Mark
24(d)(ii)	An answer that makes reference to the following point C=O		(1)

Question Number	Answer	Additional Guidance	Mark
24(e)(i)	An answer that makes reference to the following points products and reversible arrow	Example of balanced equation: $\rightleftharpoons 2\text{NH}_3 + \text{CO}_2$ Accept products in any order Allow multiples if equation is balanced Allow 2 full headed arrows, one in either direction	(1)

Question Number	Answer	Additional Guidance	Mark
24(e)(ii)	An answer that makes reference to the following points: - line labelled products higher than line labelled reactants and to the right ΔH labelled correctly E_a labelled correctly	 Accept actual reactants and products labelled on diagram (even if slightly incorrect names or formulae are used) Ignore state symbols even if incorrect Allow ΔH given as +133 Double-headed arrows penalised once only Arrows in wrong direction or missing heads penalised each time M2 and M3 can be given as a TE on exothermic reaction if arrows are consistent	(3)

Question Number	Answer	Additional Guidance	Mark
24(f)(i)	An explanation that makes reference to the following points: the urea is a reactant and forms a new product (that leaves the catalytic converter)	Allow "catalysts are not used up in the reaction" Allow "urea is used up in the reaction" Allow "the amount/mass of urea changed" Allow "urea is not reformed" Allow "the catalyst is a metal oxide" Ignore references to activation energy / rate / reusable Do not award "catalysts do not react"	(1)

Question Number	Answer	Additional Guidance	Mark
24(f)(ii)	An explanation that makes reference to the following points: - catalyst decreases the activation energy required - more particles have the energy required for the reaction to take place - increases the number of successful collisions per unit time / frequency of successful collisions	Example of a completed diagram  Accept M1 shown on the diagram Allow "E_a moves to the left" Allow area under the curve above E_a increases for M2 NOTE: Shading is not required, but incorrect shading would negate M2	(3)

Question Number	Answer	Additional Guidance	Mark
24(g)(i)	hot gases from the engine warm up the catalytic converter	Allow uses the (heat) energy from the engine Allow energy from combustion of fuel Allow the reactions that occur in the catalytic converter are exothermic	(1)

Question Number	Answer	Additional Guidance	Mark
24(g)(ii)	- conversion of m³ to dm³ - moles of nitrogen - number of molecules of nitrogen	<u>An example of a calculation:</u> (1) $89.3 \times 1000 = 89300 \text{ dm}^3$ (1) $89300 \div 51.1 = 1747.6 / 1748 \text{ mol}$ (1) $1748 \times 6.02 \times 10^{23} = 1.052 \times 10^{27} / 1.05 \times 10^{27} / 1.1 \times 10^{27}$ Allow TE throughout Ignore SF except 1SF Ignore units even if incorrect $1.052 \times 10^{24} / 1.05 \times 10^{24} / 1.1 \times 10^{24}$ scores 2 $1.052 \times 10^{21} / 1.05 \times 10^{21} / 1.1 \times 10^{21}$ scores 2 $2.747 \times 10^{30} / 2.75 \times 10^{30} / 2.8 \times 10^{30}$ scores 2 Correct answer with some working scores (3)	(3)

(Total for Question 24 = 20 marks)

TOTAL SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS