16(a)	**The only correct answer is C** (0.123 m^3) ***A** is incorrect because this is the volume of O_2 produced* ***B** is incorrect because this is the volume of NO_2 produced* ***D** is incorrect because this is the volume of gas formed from 2 mols of magnesium nitrate*

Question Number	Answer
16(b)	**The only correct answer is D** (62.0 %) ***A** is incorrect because this is 25 divided by the mass of the nitrogen(IV) oxide* ***B** is incorrect because this is 25 divided by the mass of one mole of magnesium nitrate* ***C** is incorrect because this is 25 divided by the mass of 2MgO*

12(a)	**The only correct answer is D** (0.702 mol dm^{-3}) ***A** is incorrect because the stoichiometry has been used incorrectly* ***B** is incorrect because volumes have been used the wrong way around* ***C** is incorrect because the stoichiometry has not been used*

Question Number	Answer
12(b)	**The only correct answer is D** (0.68%) ***A** is incorrect because this is the error of a burette in cm^3 times two* ***B** is incorrect because this is the error if only one reading is taken* ***C** is incorrect because this is the error using the pipette value*

Question Number	Answer
8	**The only correct answer is D** (75%) ***A*** *is incorrect because 0.15 is the number of moles of carbon dioxide produced* ***B*** *is incorrect because 0.20 is the number of moles of calcium carbonate used* ***C*** *is incorrect because 25% is the percentage of the impurities*

Question Number	Answer
7	**The only correct answer is A** (20 cm^3 of 0.25 mol dm^{-3} sulfuric acid) **B** *is not correct because this contains twice as many moles of sulfuric acid for neutralisation* ***C*** *is not correct because this contains four times as many moles of sulfuric acid for neutralisation* ***D*** *is not correct because this contains twice as many moles of sulfuric acid for neutralisation*

Question Number	Answer
8	**The only correct answer is B** (9×10^{22}) ***A*** *is not correct because the number of moles has not been multiplied by 3* ***C*** *is not correct because the number of moles has been multiplied by 4* ***D*** *is not correct because the number of moles has been multiplied by 5*

Question Number	Answer
1(a)	**The only correct answer is D** $(-(55 \times 4.18 \times 6.5) \div 0.03)$ ***A*** *is incorrect because only the volume and moles of sodium hydroxide have been used* ***B*** *is incorrect because only the volume and moles of ethanoic acid have been used* ***C*** *is incorrect because the moles of sodium hydroxide have been used*

Question Number	Answer
1(b)	**The only correct answer is C** (15.4%) ***A*** *is incorrect because the measurement uncertainty for a single reading and this has been halved* ***B*** *is incorrect because that is the percentage uncertainty for a single reading* ***D*** *is incorrect because the percentage uncertainty has been doubled for each reading*

15	**The only correct answer is C** (0.683 mol dm^{-3}) ***A** is incorrect because this is the number of moles in the sample* ***B** is incorrect because this is double the number of moles in the sample* ***D** is incorrect because this is double the value of the concentration*

14	**The only correct answer is D** (1.012) ***A** is incorrect because this is the mass divided by the volume* ***B** is incorrect because this is the M_r divided by the volume in cm^3* ***C** is incorrect because this is the number of moles*

Number	Answer
8(a)	**The only correct answer is A** (4.5×10^{-5}) ***B** is incorrect because this is the rate at 100 seconds* ***C** is incorrect because this is the average rate* ***D** is incorrect because this is the rate at 385 seconds*

Question Number	Answer
8(b)	**The only correct answer is B** (mol dm^{-3} s^{-1}) ***A** is incorrect because this is not a change in concentration* ***C** is incorrect because the power of the volume should be negative* ***D** is incorrect because all the powers have the incorrect sign*

Question Number	Answer	Additional Guidance	Mark
18(a)	• conversion of temperature to K **and** conversion of kPa to Pa **(1)** • conversion of cm^3 to m^3 **(1)** • rearrangement of ideal gas equation **(1)** • calculation of n **(1)** • calculation of relative molecular mass **(1)**	Example of calculation: $95 + 273 = 368$ $99 \times 1000 = 99000$ (Pa) $81 \times 10^{-6} = 8.1 \times 10^{-5}$ (m^3) $n = \frac{pV}{RT}$ $\frac{99000 \times 8.1 \times 10^{-5}}{8.31 \times 368} = 2.6222 \times 10^{-3}$ (mol) $\frac{0.12}{2.6222 \times 10^{-3}} = 45.763$ (g mol^{-1}) TE throughout Ignore intermediate rounding Ignore SF except 1 Correct answer with some working scores 5	**(5)**

Question Number	Answer	Additional Guidance	Mark
18(b)	An answer that makes reference to the following point: • ethanol/ CH_3CH_2OH/C_2H_5OH/C_2H_6O	Accept methoxymethane/CH_3OCH_3 Allow dimethyl ether Allow TE from (a) provided it is a formula that could exist	**(1)**

(Total for Question 18 = 6 Marks)

Section C

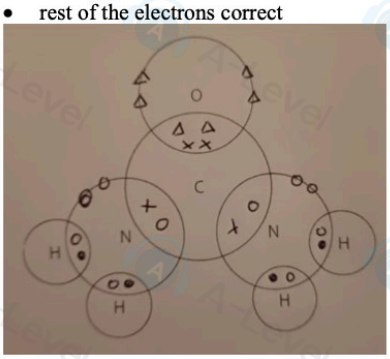
Question Number	Answer		Additional Guidance	Mark
22(a)	An explanation that makes reference to the following points:		Allow reverse arguments for all points	(3)
	• method 2 is more sustainable because it does not use methane/fossil fuels	(1)	Allow method 2 is more sustainable as method 1 uses methane/fossil fuels Ignore it produces oxygen	
	• methane/fossil fuels are a finite resource / solar power is renewable	(1)	Allow methane is a finite energy (resource) Allow water is renewable if related to method 2 Ignore clean energy from solar power Ignore solar is a sustainable resource	
	• because it does not produce CO_2 / does not produce greenhouse gases / contribute to global warming	(1)	Ignore good for the environment Ignore any reference to atom economy etc Ignore any reference to intermolecular forces etc Penalise wrong chemistry only once	

Question Number	Answer	Additional Guidance	Mark
22(b)(i)	• calculation of % N	Example of calculation: $28 \div 80 \times 100 = 35\%$ Correct answer with no working scores 1	(1)

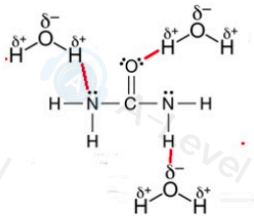
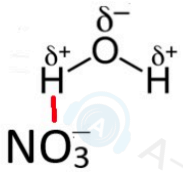
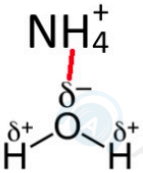
Question Number	Answer		Additional Guidance	Mark
22(b)(ii)	An answer that makes reference to the following points:			(2)
	• advantage: ammonia has a high % N	(1)	Allow just contains more N	
	• disadvantage: ammonia is a gas (so hard to apply)	(1)	Allow ammonia (as it is a gas) will escape Allow ammonia is a base/alkali/will increase the pH Allow it is toxic Allow it is corrosive Allow it will evaporate Allow (as it is a gas) it is harder to transport/store Ignore it has a bad smell Ignore it is a greenhouse gas Ignore any reference to cost/atom economy	

Question Number	Answer	Additional Guidance	Mark
22(c)(i)	• $HNO_3 + NH_3 \longrightarrow NH_4NO_3$ Or $HNO_3 + NH_4OH \longrightarrow NH_4NO_3 + H_2O$	Allow NH_4^+ and NO_3^- Ignore state symbols even if incorrect	(1)

Question Number	Answer	Additional Guidance	Mark
22(c)(ii)	An answer that makes reference to the following points: • neutralisation (reaction)/neutralization (reaction)	Allow acid/base (reaction)	(1)

Question Number	Answer	Additional Guidance	Mark
22(d)	An answer that makes reference to the following points: • correct electrons round C ie a double bond to the O and 2 singles to the Ns **(1)** • rest of the electrons correct **(1)** 	Allow all dots or crosses or any combination of any symbols	**(2)**

Question Number	Answer	Additional guidance	Mark
*22(e)	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. 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 The following table shows how the marks should be awarded for structure and lines of reasoning. 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 3 or 4 indicative points would get **1** reasoning mark 0, 1 or 2 indicative points would get **0** reasoning marks. 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 exp**

Question Number	Answer	Additional Guidance
*22(e)	**Indicative points**	
	IP1 hydrogen bonds are formed between water and urea	Allow H bonds Allow both water and urea have hydrogen bonds
	IP2 urea is soluble in water as the hydrogen bonds formed are stronger/ similar in magnitude to the intermolecular forces between the individual molecules	Allow a comparison with any intermolecular force/ London forces/dipole-dipole forces/hydrogen bonds
	IP3 diagram showing **one** hydrogen bond between urea and water Note ignore lack of lone pairs, dipoles and bond angles, including the hydrogen bond If the hydrogen bond is labelled this will score IP1 and IP3	 Ignore if multiple water molecules and hydrogen bonds are shown.
	IP4 ammonium nitrate is soluble in water as the water **hydrates** the ions (and the bonds formed are stronger/ similar in magnitude to the ionic bonds)	Allow ion- dipole interaction
	IP5 diagram showing the interaction between nitrate ions and water Ignore lack of diploes	 The H must be adjacent to the nitrate ion
	IP6 diagram showing the interaction between ammonium ions and water	The hydration attraction does not need to be shown Ignore if both Hs of a water molecule are attracted to the same ion Ignore multiple water molecules attracted to a single ion  The O must be must be adjacent to the ammonium ion The hydration attraction does not need to be shown Ignore multiple water molecules attracted to a single ion **IP3**, **5** and **6** must be scored via diagrams. **IP1** and **4** may be scored by annotated diagrams.

Question Number	Answer	Additional Guidance	Mark
22(f)	• calculation of the number of hectares **(1)** • calculation of the mass of N required **(1)** • calculation of the mass of urea required **(1)** • answer in tonnes to 2 or 3 SF **(1)**	Example of calculation (500 × 640) ÷ 10000 = 32 ha 32 × 160 × 1000 = 5120000 g / 5120 kg/ 5.12×10^6 (g) 5120000 (g) × 100/46.7 = 10963597 g / 1.0963597×10^7 g / 10964 kg/ 10.964 tonnes 11 (tonnes)/11.0 (tonnes) TE throughout Correct answer with no working scores 4	**(4)**

(Total for Section C = 20 marks)
TOTAL FOR PAPER = 80 MARKS