Question Number	Answer	Acceptable answers	**Mark**
1 (a)	An explanation linking Marking point 1 – one from • forward and back reactions take place (at the same time) (1) • rate of the forward and back reactions is the same (1) Marking point 2 – one from • no (overall) change in the {amount/concentration/mass/ volume} of each {substance / reactant / product} (1) • no observable change (1)	assume 'both reactions' implies the forward and back reaction allow reversible reaction with the same rate (1) allow reversible reaction in a closed system (1) do not allow the forward reaction equals the reverse reaction allow overall effect is nil (1) allow reactants and products reach a balance (1) ignore forward reaction cancels out back reaction do not allow {amount / concentration /mass/volume} of reactants and products are equal	**(2)**

Question Number	Answer	Acceptable answers	Mark
1(b)(i)	An explanation linking two of • higher pressure favours forward reaction/equilibrium shifts to the right (1) • because decrease in {volume / number of molecules}/side with lower volume (1) • yield increases (1)	ignore answers related to rate/collisions maximum (1) if 3 statements given, but 1 is incorrect	**(2)**

Question Number	Answer	Acceptable answers	Mark
1(b)(ii)	An explanation linking any two of • lower temperature favours forward reaction/equilibrium shifts to the right (1) • because (forward) reaction is exothermic (1) • yield increases (1)	ignore answers related to rate/collisions if answer refers to increasing temperature, maximum (1) for (forward) reaction is exothermic / reverse reaction is endothermic maximum (1) if 3 statements given, but 1 is incorrect	**(2)**

Question Number	Answer	Acceptable answers	Mark
1(b)(iii)	catalyst	iron	**(1)**

Question Number	Answer	Acceptable answers	Mark
1(c)(i)	3 x 1000 (1) (= 3000)		**(1)**

Question Number	Answer	Acceptable answers	Mark
1(c)(ii)	marks are for the working Method 1 14 + (3 x 1) (1) g of NH_3 makes 14 + (4 x 1) + 14 + (3 x 16) (1) g NH_4NO_3 34 g of NH_3 makes $\frac{(14 + (4 \times 1) + 14 + (3 \times 16)) \times 34}{17}$ or $\frac{80 \times 34}{17}$ or 2(14 + (4 x 1) + 14 + (3 x 16)) g NH_4NO_3 (1) = 160 g Method 2 moles of NH_3 = $\frac{34}{17}$ (1) = 2 moles of NH_4NO_3 = moles of NH_3 or relative formula mass NH_4NO_3 = 80 (1) mass NH_4NO_3 = 2 x 80 (1) = 160 g	full marks awarded for an answer of 160 g with or without any working allow ecf on incorrect M_r s for either method allow ecf for incorrect moles eg if moles of NH_3 = 0.5 relative formula mass NH_4NO_3 = 80 (1) mass NH_4NO_3 = 0.5 x 80 (1) = 40 g	**(3)**

Question number	Answer	Mark
2(a)(i)	An explanation that combines identification – understanding (1 mark) and reasoning/justification – understanding (2 marks): • rate increased/time to reach equilibrium reduced (1) • because gas molecules closer/more concentrated (1) • so increased collision rate/more frequent collisions(1)	**(3)**

Question number	Answer	Mark
2(a)(ii)	A	**(1)**

Question number	Answer	Mark
2(b)	equilibrium position/usefulness of by-products	**(1)**

Question Number	Indicative content
2(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (6 marks)** The effect of the temperature rise on the rate of attainment of equilibrium and on the equilibrium yield are considered by: • higher temperature reaches equilibrium faster because molecules move faster • therefore there are more frequent collisions because molecules have more energy • therefore more collisions have required energy but yield will be lower • because higher temperature favours endothermic reaction and so equilibrium shifts to left hand side • which is decomposition of ammonia / ammonia reforms elements • catalyst causes reaction to reach equilibrium faster / catalyst increases rates (of both forward and back reactions) • lowers the activation energy (of both forward and back reactions) but does not affect yield • equilibrium position not affected.

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	• Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Question Number	Answer	Acceptable answers	Mark
3(a)	**B** 200 cm^3		**(1)**

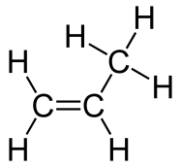
Question Number	Answer	Acceptable answers	Mark
3(b)	65.0 g Zn produces 24 dm^3 H_2 (1) 13.0 g Zn produces $\frac{13.0}{65.0}$ x 24 (1) (= 4.8 dm^3 H_2)	$\frac{13.0}{65.0}$ mol Zn produces $\frac{13.0}{65.0}$ mol H_2 Vol of H_2 = $\frac{13.0}{65.0}$ x 24 (2) (= 4.8dm^3) 4.8 dm^3 (2) without working allow 65/13 x 24 (1) = 120dm^3 13/65 (1) x (1/24) = 0.00833 dm^3 0.2 anywhere 1 mark x 24 anywhere 1 mark	**(2)**

Question Number	Answer	Acceptable answers	Mark
3(c)(i)	natural gas		**(1)**

Question Number	Answer	Acceptable answers	Mark
3(c)(ii)	An explanation linking forward and back reactions take place / reversible / dynamic (1) at the same rate / equilibrium (1)	dynamic equilibrium = 2 marks	**(2)**

Question Number		Indicative Content	Mark
QWC	***3(d)**	A description including some of the following points Higher pressure: • higher pressure gives increased yield • equilibrium shifts to right hand side • because decrease in number of molecules going from left to right • therefore decrease in volume • favoured by increase in pressure • reaches equilibrium faster • because molecules closer together • so get more frequent collisions Higher temperature • higher temperature reaches equilibrium faster • because molecules move faster • therefore more frequent collisions • molecules have more energy • therefore more collisions have required energy • but yield will be lower • because higher temperature favours endothermic reaction • equilibrium shifts to left hand side • which is decomposition of ammonia / ammonia reforms elements Use of catalyst • catalyst causes reaction to reach equilibrium faster / catalyst increases rates (of both forward and back reactions) • *lowers the activation energy (of both forward and back reactions)* • *reaction follows a new pathway* • does not affect yield • equilibrium position not affected	**(6)**

Level		No rewardable content
1	**1 - 2**	• a limited description e.g. one valid effect of change OR general comment indicating improved yield or faster rate • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	**3 - 4**	• a simple description e.g. at least two valid effects of change with one point of explanation OR at least three valid effects of change • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	**5 - 6**	• a detailed description e.g. at least three valid effects of change with two points of explanation OR at least two valid effects with three points of explanation (in total) • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Question Number	Answer	Mark
4(a)	 any 3 carbon molecule **and** <u>one</u> C=C (1) fully correct molecule with <u>all bonds</u> (2)	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(b)(i)	**A** 333 dm^3		**(1)**

Question Number	Answer	Acceptable answers	Mark
4(b)(ii)	An explanation linking • <u>all / three</u> gases present/ <u>nitrogen, hydrogen and ammonia</u> (1) • ammonia decomposes/ ammonia turns back to reactants/ reaction goes both ways / reversible (1)	reject ammonium ignore incomplete reaction assume that "both reactions" refer to forward and backward reaction allow **<u>dynamic</u>** equilibrium	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(b)(iii)	An explanation linking • increased / high**er** {yield / amount of ammonia} (1) • because fewer (gas) molecules/ moles on RHS/ 4 mole(cule)s on left and 2 on right/ decreased volume on RHS/equilibrium shifts to RHS/ equilibrium shifts in forward direction (1)	mark independently ignore "high yield" reject answers referring to exothermic or endothermic ignore any references to rate	**(2)**

Question Number	Answer	Acceptable answers	Mark
4(b)(iv)	An explanation to include • **rate** increased/ time to reach equilibrium reduced (1) • because gas molecules closer / more concentrated (1) • so increased **collision** rate / more **collisions** in a given time / more frequent **collisions**(1)	mark independently ignore any refs to equilibrium ignore 'time is faster'/ allow 'quicker' allow atoms/ particles instead of molecules; allow more molecules present (in same container) do not allow 'more collisions'	**(3)**