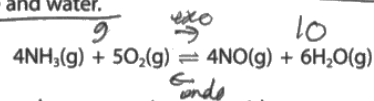


## Chemistry Paper 1 Higher Tier: Extended Open Response question 10(c)

\* (c) In another stage in the production of nitric acid, ammonia is reacted with oxygen to form nitrogen oxide and water.



The conditions chosen for the reaction are

- excess air, rather than just the right amount
- a pressure of 10 atm, rather than atmospheric pressure
- a temperature of 900°C, rather than room temperature.

Explain the effect of the conditions chosen on the equilibrium yield of nitrogen oxide and on the rate of attainment of equilibrium.

(6)

High pressure (10 atm)  
~~Pressure~~ Causes the equilibrium to move to the ~~left~~ <sup>right</sup> side with fewest moles. The left side has 9 moles whilst the right side has 10 moles. This means that the yield of nitrogen oxide would decrease as the equilibrium shifts to the left. ~~This de~~  
Increasing pressure also increases the rate of attainment because the ~~per~~ gas molecules are closer together, and therefore <sup>have</sup> a higher frequency of collisions, so therefore have a higher rate of reaction.

High temperature (900°C) causes the equilibrium to shift to the endothermic side in order to ~~reduce~~ <sup>absorb</sup> the heat produced. Since "heat energy is given out when ammonia reacts with oxygen", the equilibrium ~~is~~ equilibrium would shift to the left, ~~as~~ as it is endothermic, and ~~therefore~~ therefore decrease the

yield of <sup>nitrogen</sup> ~~nitrous~~ oxide.  
Increasing temperature increases the rate of attainment because the gas particles collide with greater kinetic energy and as a result the chance of successful collisions with ~~the~~ <sup>enough</sup> activation energy ~~lower~~ increases, therefore increasing the rate of reaction.

Question number	Indicative content	Mark
*10(c)	<p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlines in the generic mark scheme.</p> <p>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.</p> <p><b>AO1 &amp; AO2 (6 marks)</b></p> <p><b>EXCESS AIR</b></p> <ul style="list-style-type: none"> <li>• increases oxygen concentration</li> <li>• so excess air favours right hand side</li> <li>• and gives higher yield</li> <li>• excess air increases concentration of oxygen</li> <li>• equilibrium reached faster</li> </ul> <p><b>PRESSURE</b></p> <ul style="list-style-type: none"> <li>• 9 molecules on left and 10 on right</li> <li>• so higher pressure favours left hand side</li> <li>• and gives lower yield</li> <li>• higher pressure increases concentration of gases</li> <li>• more frequent collisions</li> <li>• equilibrium reached faster</li> </ul> <p><b>TEMPERATURE</b></p> <ul style="list-style-type: none"> <li>• heat energy given out in forward reaction</li> <li>• higher temperature favours reaction that takes in heat energy</li> <li>• so higher temperature favours left hand side</li> <li>• hence lower yield</li> <li>• molecules move faster at higher temperature</li> </ul>	(6)
	<ul style="list-style-type: none"> <li>• more frequent collisions</li> <li>• therefore more reactions in given time</li> <li>• equilibrium reached faster</li> </ul>	

Level	Mark	Descriptor
	0	<ul style="list-style-type: none"> <li>No awardable content</li> </ul>
Level 1	1-2	<ul style="list-style-type: none"> <li>Demonstrates elements of chemical understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1)</li> <li>The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)</li> </ul>
Level 2	3-4	<ul style="list-style-type: none"> <li>Demonstrates chemical understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1)</li> <li>The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)</li> </ul>
Level 3	5-6	<ul style="list-style-type: none"> <li>Demonstrates accurate and relevant chemical understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1)</li> <li>The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)</li> </ul>

Level	Mark	Descriptor	Additional guidance
	0	No rewardable material.	Read whole answer and ignore all incorrect material/ discard any contradictory material then:
Level 1	1–2	<p><u>Additional guidance</u> One factor is discussed with a statement of effect on yield and/or rate (1)</p> <p>One factor is discussed with explanation of yield and/or rate (2)</p> <p>Two or three factors are discussed with statement of effect on yield and/or rate (2)</p>	<p><u>Possible candidate responses</u> A higher pressure gives a lower yield because there are more gas molecules on the right hand side. Factor and reason – 2 marks</p>
Level 2	3–4	<p><u>Additional guidance</u> One factor is fully discussed with explanation of yield and rate. (3)</p> <p>Two factors are discussed with explanation of yield and/or rate in one case and just statement of yield and/or rate in one case(3)</p> <p>Two factors are discussed with explanation of yield and/or rate in each case (4)</p> <p>Three factors are discussed with statement of effect on yield and/or rate with explanation for at least one (4)</p>	<p><u>Possible candidate responses</u> A higher pressure gives a lower yield because there are more gas molecules on the right hand side. A higher temperature gives a lower yield because the forward reaction is exothermic. 2 factors both with reasons – 4 marks</p>
Level 3	5–6	<p><u>Additional guidance</u> All three factors are discussed, with explanation of yield and/or rate in each case (6)</p> <p>All three factors are discussed, with explanation of yield and/or rate in two cases (5)</p>	<p><u>Possible candidate responses</u> Excess air gives a higher yield. A higher pressure gives a higher rate because the gas molecules are closer and collide more frequently. A higher temperature gives a higher rate because more molecules have the activation energy. 3 factors, 2 have reasons, 1 statement (air) – 5 marks</p>