

| Question |     | Answer  | Marks | AO element         | Guidance  |
|----------|-----|---|-------|--------------------|---|
| 17       | (a) | <p>High pressure <b>AND</b> low temperature ✓</p> <p>Right-hand side has fewer (gaseous) moles/molecules<br/><b>OR</b><br/>left-hand side has more (gaseous) moles/molecules ✓</p> <p>(Forward) reaction is exothermic/gives out heat<br/><b>OR</b> reverse reaction is endothermic/takes in heat ✓</p> | 3     | 1.2×1<br><br>1.1×2 | <p>Marks are independent</p> <p><b>ORA</b> throughout</p> <p><b>ALLOW</b> RHS<br/><b>ALLOW</b> suitable alternatives for RHS<br/>e.g. product side</p>  |
|          | (b) | <p>(Reaction can be carried out at) lower temperatures / lower energy demand ✓</p> <p>Less (fossil) fuels burnt / less CO<sub>2</sub> emissions ✓</p>   | 2     | 1.1×2              | <p><b>ALLOW</b> lower pressures as alternative to lower temperature</p> <p><b>ALLOW</b> reduced carbon footprint as alternative to less fuels burnt</p> <p><b>ALLOW</b> different reactions can be used with greater atom economy / less waste</p> <p><b>ALLOW</b> can reduce use of toxic substances</p> |



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|----------|-----|--|-----------|---------------------------|--|
|          | (d) | <p><b>FIRST CHECK THE ANSWER ON ANSWER LINE</b><br/> <b>If answer = <math>2.22 \times 10^4</math> award first 2 marks</b></p> <p>-----</p> $\ln K_p = -\Delta G/RT = \frac{2.48 \times 10^4}{8.314 \times 298} = 10.01 \checkmark$ $K_p = 2.22 \times 10^4 \text{ (3SF required)} \checkmark$ <p>Units = <math>\text{atm}^{-2} \checkmark</math></p> | 3         | <p>3.1×2</p> <p>1.2×1</p> | <p><b>ALLOW ECF</b> for transcription errors in first sum</p> <p><b>ALLOW</b> 10 up to calculator value of 10.00979992</p> <p><b>ALLOW</b> 22200</p> <p><b>ALLOW</b> <math>2.20 \times 10^4</math> <b>OR</b> 22000 (use of 10)</p> <p><b>ALLOW</b> alternatives (k)Pa<sup>-2</sup> <b>OR</b> N<sup>-2</sup> m<sup>4</sup> <b>OR</b> mmHg<sup>-2</sup> <b>OR</b> PSI<sup>-2</sup> <b>OR</b> bar<sup>-2</sup></p> <p><b>Common errors for 1 mark:</b><br/> 22400 (use of 8.31)<br/> <math>4.50 \times 10^{-5}</math> (use of -10.01)</p> |
|          |     | <b>Total</b>   | <b>14</b> |                           |  |