<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*6(a)</td>
<td>This question assesses a 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 and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent and 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>
</td>
<td>Guidance on how the mark scheme should be applied:

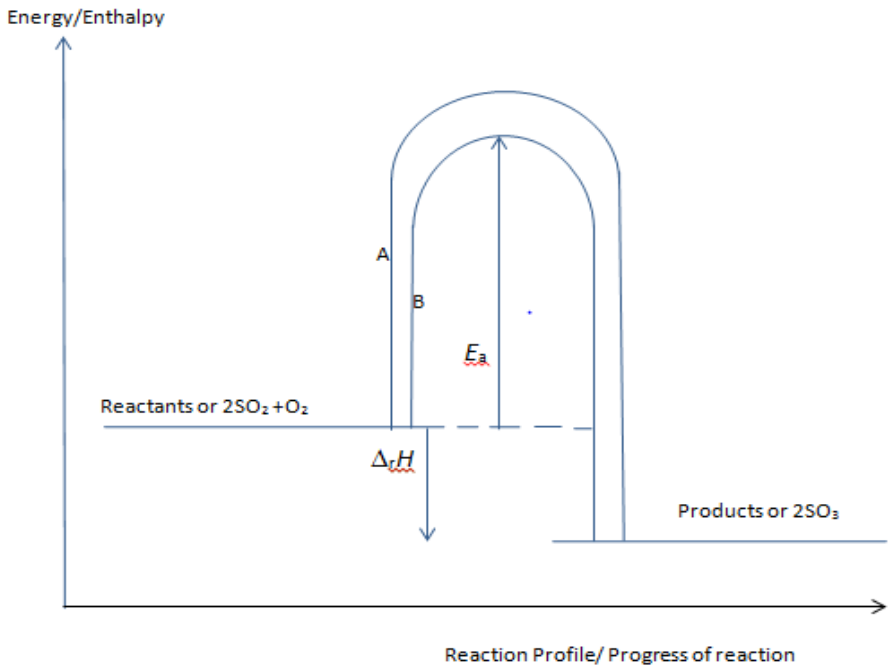
The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning, scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

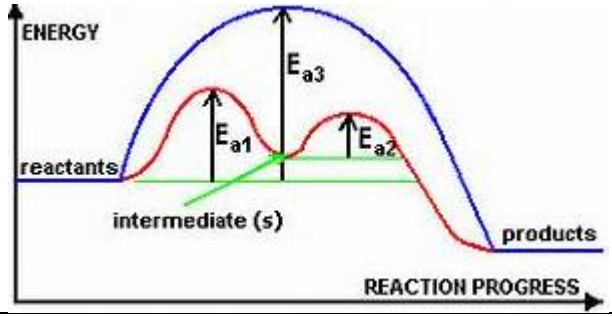
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

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.</td>
<td>(6)</td>
</tr>
</table>

***6(a)**	**Indicative content:** • IP1 increase in temperature will increase rate • IP2 (but) increase in temperature will decrease yield/move the equilibrium to the LHS/ produce less SO_3 **because** it is an exothermic reaction (in the forward direction) • IP3 increase in temperature increases **energy** costs • IP4 increase in pressure has no effect on rate (because all the active sites are already occupied on a heterogeneous catalyst). **OR** increase in pressure will increase rate (of reaction) • IP5 increase in pressure will move position of eqm to RHS/increase yield **because** there are less moles/molecules (of gas) on the RHS • IP6 but increased pressure increases (construction and running) costs/reduces economic viability	Decreased yield with no reference to exothermic reaction does not get IP2. Allow increases yield of reactants/SO_2 **and** O_2 (with reference to exothermic reaction) Increased yield with no reference to number of moles does not get IP5. Award one mark for IP2 and IP5 if correct references to yield in both but reasons not given Allow IP3 and IP6 if increased costs of higher temperature and pressure are mentioned together **provided** that the temperature costs are linked to energy costs. Otherwise only IP6 can be awarded. Ignore any reference to catalyst	

Question Number	Acceptable Answer	Additional Guidance	Mark
6(b)(i)	• vertical axis labelled: H/enthalpy/energy/E **(1)** • level of reactants / $2SO_2 + O_2$ above level of products / $2SO_3$ **(1)**	 Do not award ΔH Ignore horizontal axis label Ignore units if given ignore state symbols even if incorrect	**(3)**

	• correct profile for uncatalysed reaction labelled A **and** peak lower for catalysed reaction labelled B **(1)**	allow vertical lines for catalysed and uncatalysed reactions to run together allow double hump profile  	

Question Number	Acceptable Answer	Additional Guidance	Mark
6(b)(ii)	enthalpy change, $\Delta_r H / \Delta H /$ (-)197(kJ mol^{-1}), shown correctly **(1)** activation energy, E_a, shown correctly (upper diagram) **(1)**	Ignore presence/absence of arrowheads Allow a degree of imprecision in the start/finish points of the lines for ΔH and E_a Ea shown on double hump profile - shown in this diagram as Ea_1 Ignore Ea2 if also shown	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
6(c)(i)	$(K_c =) \quad \frac{[SO_3]^2}{[O_2][SO_2]^2}$	Do not award just K or K_p. must be square brackets do not accept partial pressures ignore units or lack of units ignore state symbols Allow x sign in the denominator but not +	**(1)**

Question Number	Answer	Mark
6(c)(ii)	**6(c)(ii). The only correct answer is B** ***A*** *is not correct because it refers to the inverted expression for* K_c ***C*** *is not correct because units do not cancel for concentration*^{2}*/concentration*^{3} ***D*** *is not correct because it refers to concentration*^{3}*/concentration or similar ratio of powers*	**(1)**

(Total for Question 6 = 13 marks)