Entropy - Mark Scheme

Q**1**.

Question number	Answer		Additional guidance	Mark
(a)	• $2H_2O_2 \rightarrow 2H_2O + O_2$ • iodide ions act as a catalyst (as they don't appear in the overall equation)	(1) (1)	Ignore state symbols even if incorrect	2

Question number	Answer		Additional guidance	Mark
(b)			Example of calculation:	4
	• converts both temperatures from °C to K	(1)	22.0 °C = 295.0 K 47.0 °C = 320.0 K	
	• correct subtraction	(1)	$\ln\left(\frac{K_1}{K_2}\right) = -\frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$	
	• substitute numbers in equation correctly	(1)	$\ln\left(\frac{4.90\times10^{-4}}{1.07\times10^{-3}}\right) = -\frac{E_a}{8.31}\left(\frac{1}{295} - \frac{1}{320}\right)$	
	• correct value of E_a	(1)	(+)56.(0) (kJ mol^{-1}) Sign and final answer to 2 or 3 SF Incorrect units loses MP4 Correct answer with no working scores 4	

Question number	Answer		Additional guidance	Mark
(c)(i)	An explanation that makes reference to the following points:	(1)		3
	• (blue-black colour is) product of starch-iodine reaction			
	• the iodine produced reacts (rapidly) with the thiosulfate ions (to reform iodide ions)	(1)		
	• when all of the thiosulfate has reacted, the blue-black colour appears.	(1)		

Question number	Answer	Additional guidance	Mark
(c)(ii)	• the reaction (between thiosulfate and hydrogen peroxide) is slow	Allow reaction has high E_a	1

Q**2**.

Question number	Answer	Mark
	A ethane(g)	1

Q**3.**

Question number	Answer	Additional guidance	Mark
(a)	• use of $\Delta S_{system} = \Delta S_{products} - \Delta S_{reactants}$ (1) • correct value with sign and units (1)	Example of calculation: $\Delta S_{system} = (2 \times 240.0) - 304.2$ $= +175.8$ J K^{-1} mol^{-1} Correct answer with no working scores 2 Allow 3 SF	2

Question number	Answer	Additional guidance	Mark
(b)	• use of $\Delta_r H = 2 \times \Delta_f H(NO_2) - \Delta_f H(N_2O_4)$ (1) • correct value with sign and units (1)	Example of calculation: $\Delta_r H = (2 \times 33.2) - \Delta_f H(N_2O_4) = 57.2$ $\Delta_f H(N_2O_4) = +9.2$ kJ mol^{-1} Correct answer with no working scores 2	2

Question number	Answer	Additional guidance	Mark
(c)	• use of $\Delta S_{surroundings} = -\Delta H/T$ (1) • correct value (1) • answer to 3 SF with correct sign and correct units (1)	Example of calculation: $-(57.2 \times 1000/298)$ $= (-)191.(946)$ -192 J K^{-1} mol^{-1} Allow -0.192 kJ K^{-1} mol^{-1} for M2 and M3 Correct answer to 3 SF with no working scores 3	3

Question number	Answer	Additional guidance	Mark
(d)(i)	• $\Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings}$ • $\Delta S_{total} = +175.8 + (-191.9) = -16(.1)$ (J mol^{-1} K^{-1})	Allow TE from 23a and 23c Allow answers in kJ mol^{-1} K^{-1}	1

Question number	Answer	Additional guidance	Mark
(d)(ii)	• correct expression (1) • correct evaluation (1)	Example of expression and calculation: $\Delta H = T\Delta S_{system}$ or $T = \Delta H/\Delta S_{system}$ or $\Delta S_{system} = \Delta H/T$ or $\Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings} = 0$ $T = 57.2 \times 1000/175.8 = 325.37$ $= 325$ K/52 °C	2

Question number	Answer		Additional guidance	Mark
(e)(i)	• correct expression for K_p	(1)	$K_p = (p_{NO_2})^2 / p_{N_2O_4}$ Do not award any square brackets	2
	• units of pressure	(1)	atm	

Question number	Answer		Additional guidance	Mark
(e)(ii)			Example of calculation: (mol)N_2O_4 = 7.3, (mol)NO_2 = 5.4.	4
	• moles of N_2O_4 **and** NO_2 at eqm	(1)		
	• total number of moles **and** mole fractions calculated	(1)	Total moles = 12.7 Mole fraction N_2O_4 = 0.575 Mole fraction NO_2 = 0.425 Allow TE from M1	
	• converted to partial pressure	(1)	P N_2O_4 = 2.30 (answers to M2 × 4) NO_2 = 1.70 Allow TE from M2	
	• calculation of K_p	(1)	K_p = 1.26 (atm) Allow TE from M3 Ignore SF except 1 SF	

Question number	Answer	Additional guidance	Mark
(e)(iii)	• no effect on (the value of) K_p		1

Question number	Answer		Additional guidance	Mark
(e)(iv)	• double pressure (effect of squaring) increases numerator more than denominator	(1)		3
	• (but K_p must remain constant therefore) mole fraction of N_2O_4 must increase (relative to mole fraction of NO_2)	(1)		
	• (therefore) % dissociation of N_2O_4 decreases	(1)		

Q**4.**

Question number	Answer	Mark
	D monoclinic sulfur could change into rhombic sulfur but nothing can be deduced about the rate	1