Chemical Equilibria - Mark Scheme

Q1.

Question number	Answer	Mark
(a)	C increase the temperature	1

Question number	Answer	Mark
(b)	A $[CO_2]$	1

Q2.

Question number	Answer	Mark
(a)	$K_c = \frac{[I_2(aq)]}{[I_2(\text{trichloromethane})]}$ D	1

Question number	Answer	Mark
(b)	C iodine molecules move from the water to the trichloromethane and from the trichloromethane to the water layer	1

Q3.

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: $\Delta S_{system} = (2 \times 240.0) - 304.2$ $= +175.8 \text{ J K}^{-1} \text{ mol}^{-1}$ 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: $\Delta_r H = (2 \times 33.2) - \Delta_f H(N_2O_4) = 57.2$ $\Delta_f H(N_2O_4) = +9.2 \text{ kJ mol}^{-1}$ 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 × 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)	• $\Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings}$ • ΔS_{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 × 1000/175.8 = 325.37 = 325 K/52 °C	2

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

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

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)		