7. Equilibria

7.1 Chemical equilibria- reversible reactions, dynamic equilibrium

Paper 2

Marking Scheme

Q1.

3(a)	**M1** (if a change in conditions occurs) the equilibrium shifts **M2** to minimise the change in conditions	**2**
3(b)	**M1** change in appearance paler red / more yellow / less orange **M2** change in relative concentration of $FeSCN^{2+}(aq)$ lower **M3** change in value of the equilibrium constant, K_c lower	**3**
3(c)(i)	**M1** *deduce the concentration of SCN^- present in initial mixture* $[SCN^-$ eq'm$]$ = $[Fe^{3+}$ eq'm$]$ = [original SCN^-] – [$FeSCN^{2+}$ produced] $1.30 \times 10^{-3} + 0.300 \times 10^{-3} = 1.60 \times 10^{-3}$ mol dm^{-3} **M2** *find initial amount of Fe^{3+} initially* M1 × 25 / 1000 = amount of Fe^{3+} added initially = 4.00×10^{-5} (mol)	**2**
3(c)(ii)	**M1** value for K_c = 178 **M2** units = mol^{-1} dm^3	**2**

Q2.

3(a)	**M1** rates of forward and reverse / backward reactions are equal **M2** no change in measurable properties **OR** concentration of reactants **AND** products remain constant	**2**
3(b)(i)	**M1** change to appearance of the mixture: (goes) darker red / more red **M2** change to relative concentration of $Fe^{3+}(aq)$: decreases **M3** change to the value of equilibrium constant, K_c: constant / none	**3**

3(b)(ii)	Method 1 **M1** conc of initial conc of Fe^{3+} and SCN^- = 0.0020 (mol dm^{-3}) **M2** at equilibrium the conc of Fe^{3+} and SCN^- are (M1 – 0.000423) **M3** use 0.000423 ÷ (**M1** – 0.000423)^2 to calculate K_c = 170(.089) **M4** units = mol^{-1} dm^3 **OR** dm^3 mol^{-1} Method 2 **M1** no mol $FeSCN^{2+}$ = $4.23 \times 10^{-4} \times 25 / 1000 = 1.0575 \times 10^{-5}$ **M2** no mol Fe^{3+} and SCN^- are (5×10^{-5} – **M1**) = 3.9425×10^{-5} **M3** 0.000423 ÷ (**M2** × 1000 / 25)^2 = 170(.089) **M4** units = mol^{-1} dm^3 **OR** dm^3 mol^{-1}	**4**

Q3.

4(b)	**M1** amount ethanol increases **M2** equilibrium moves to right **AND** to produce fewer moles gas OR smaller amount of gas (to reduce the pressure)	**2**

Q4.

2(c)	NO NO$_2$ N$_2$O$_3$ mole fraction $\frac{0.605}{1.60}$ (= 0.378125) $\frac{0.605}{1.60}$ = (= 0.378125) $\frac{0.390}{1.60}$ (= 0.24375)	**1**
	(partial pressure / kPa 38.19 38.19 24.62) K_p = 24.62 ÷ 38.19^2 = 0.0169	**1**
	kPa^{-1}	**1**

2(b)	equilibrium position would / it moves to left / reactants	**1**
	forward reaction is exothermic (so disfavoured by increase in T)	**1**

Q5.

3(a)(i)	**M1** rate(s) of forward and reverse / backward reactions are equal / are the same **M2** no change in measurable properties **OR** concentration of reactants and products remain constant	**2**
3(a)(ii)	(colourless gas) becomes purple (gas)	**1**
3(a)(iii)	$K_p = \frac{(pH^2)(pI^2)}{(pHI)^2}$	**1**
3(a)(iv)	**M1** *use correct expression for finding amount of HI used up in reaction* 86.4 = 100 × (0.025 – x) / 0.025 – x + x / 2 + x / 2) where x = *HI mol used up* OR 86.4 = 100 × (0.025 – 2x) / (0.025 – 2x + x + x) where 2x = *HI mol used up* **M2** *correct calculation to find amount of HI(mol) at equilibrium based on* *HI(mol) at eq'm = 0.025 – HI(mol) used* = 0.025 – 0.0034 = 0.0216 **OR** 0.022 (mol) **alternative method** **M1** *use the pp H$_2$ and pp I$_2$ at equilibrium (= 13.6) to calculate no mol H$_2$ & I$_2$ at equilibrium* (either 0.0034 in total **OR** 0.0017 each) **M2** *use value for no mol H$_2$ + I$_2$ in expression to find no mol HI* 0.025 – (no mol H$_2$ + I$_2$) = 0.0216	**2**

3(c)	none / no change	**1**

Q6.

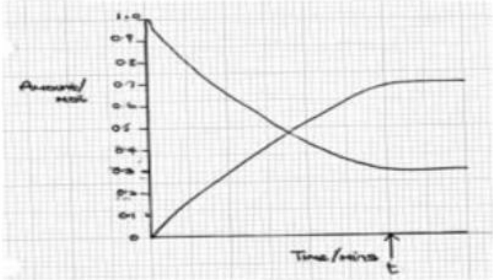
1(c)(i)	$K_p = \frac{pHI^2}{pH_2\ p\,I_2}$	**1**
1(c)(ii)	28.76 **OR** 28.8 **OR** 29	**1**
1(c)(iii)	**EITHER** **option 1** which assumes $\Delta H_{reaction}$ *is (still) endothermic (using the value shown in (b)).* **M1** (K_p) decreases **AND** endothermic / $\Delta H_{(f)}$ = + / positive **M2** reaction favours formation of reactants / hydrogen and iodine OR (product) yield / partial pressure of HI decreases / equilibrium shifts to the left **OR** **option 2** which realises that $\Delta H_{reaction}$ *is in fact exothermic (using bond energy data in Data Booklet)* **M1** (K_p) increases **AND** exothermic / $\Delta H_{(f)}$ = + / negative **M2** reaction favours formation of products / hydrogen iodide yield increases / partial pressure of HI increases / equilibrium shifts to the right	**2**

Q7.

2(d)(iii)	***(at 1000 K and 100 kPa)*** **M1:** (yield) **decreases**	**4**
	M2: reaction is exothermic **AND** equilibrium moves **left**	
	(at 500 K and 500 kPa) **M3:** (yield) **increases**	
	M4: fewer moles (of gas) on right-hand side **AND** equilibrium moves right	

Q8.

1(b)	(forward reaction is) exothermic reaction	**1**
	the proportion of methylpropane / product decreases OR the proportion of butane / reactant increases	**1**

1(c)(i)	*t* shown on graph which corresponds to start of the horizontal part of both curves. 	**1**
1(c)(ii)	concentration of butane = 0.3 mol dm^{-3} AND concentration of methylpropane = 0.7 mol dm^{-3}	**1**
1(c)(iii)	[methylpropane] / [butane] OR $[(CH_3)_2CHCH_3] / [CH_3(CH_2)_2CH_3]$	**1**

1(c)(iv)	**M1** *value for* K_c $K_c = \frac{\text{value of methylpropane in } \textbf{(ii)}}{\text{value of butane in } \textbf{(ii)}}$ = 0.7 / 0.3 = 2.3 (3)	**1**
	M2 *units consistent with expression used in* M1 no units / dimensionless / none	**1**

Q9.

1(d)(i)	**M1:** no effect / none **M2:** equal mol(es) (*of gas*) on both sides (of equilibrium / equation) owtte	**2**
1(d)(ii)	**M1:** (forward reaction is) endothermic **M2:** Any temperature higher than 300 K	**2**