Student Book Unit 4 Test 1 Mark scheme (Chapters 1.1 to 1.5)

1 a (i) Colorimeter / spectrophotometer (1); calibrate the colorimeter to correlate with the iodine concentration (1)
(ii) Titration (1); with sodium thiosulfate (1)
(iii) No need for quenching / ‘you can get the graph directly’ / difficulty of accurate timing (1) (5)

b (i) Constant (1)
(ii) Zero (1)
(iii) \( I_2 \) is not involved in it (1)
or reaction between propanone and \( H^+ \) is rate-determining step
(iv) Two (1) (4)

c (i) Iodoform / triiodomethane (1)
\[
\text{CH}_3\text{COCH}_3 + 3\text{I}_2 + 4\text{NaOH} \rightarrow \text{CH}_3\text{COONa} + \text{CHI}_3 + 3\text{NaI} + 3\text{H}_2\text{O} \quad (2)
\]
(allow 1 for correct organic products)
(ii) \[
\begin{array}{c}
\text{CH}_3
\
\text{O}
\
\text{CH}_3
\
\text{C}
\
\text{OH}
\end{array}
\quad (2)
\]
(iii) Potassium dichromate turns green with alcohol, not with ketone (1) (6)
any test that works is acceptable

(Total 15 marks)

2 a Halving \([\text{RX}]\) halves the rate, so first order w.r.t. \(\text{RX}\) (1)
Halving \([\text{OH}^-]\) halves the rate, so first order w.r.t. \(\text{OH}^-\) (1)
explanation of either statement (1)
So, rate = \(k[\text{RX}][\text{OH}^-]\) (1) (3)

b \[
k = \frac{\text{rate}}{[\text{RX}][\text{OH}^-]} = \frac{8 \times 10^{-6}}{0.01 \times 0.04} = 0.0215 \quad (1) \text{ dm}^3\text{ mol}^{-1}\text{ s}^{-1} \quad (1)
\]

(Total 5 marks)

3 a incompletely / partially / slightly dissociated (1)
or dissociation varies with concentration
allow poor proton donor or conjugate base strong

b (i) \[
\text{CH}_3\text{CH}_2\text{COOH} \rightleftharpoons \text{CH}_3\text{CH}_2\text{COO}^- + \text{H}^+
\]
or \[
\text{CH}_3\text{CH}_2\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{CH}_2\text{COO}^- + \text{H}_3\text{O}^+ \quad (1)
\]
\[
K_a = \frac{[\text{CH}_3\text{CH}_2\text{COO}^-][\text{H}^+]}{[\text{CH}_3\text{CH}_2\text{COOH}]} \quad \text{or} \quad \frac{[\text{CH}_3\text{CH}_2\text{COO}^-][\text{H}_3\text{O}^+]}{[\text{CH}_3\text{CH}_2\text{COOH}]} \quad (1)
\]
Mark consequentially for second mark if acid is incorrect but must have \(\text{H}^+\) or \(\text{H}_3\text{O}^+\) (2)

(ii) \[
[\text{H}^+] = \sqrt{K_a \times c} = \sqrt{1.30 \times 10^{-3} \times 0.01} = 3.6 \times 10^{-4} \quad (\text{mol} \text{ dm}^{-3}) \quad (1)
\]
pH = \(-\log [\text{H}^+]\) = \(-\log(3.6 \times 10^{-4})\) = 3.4 (1)
Any of:
• any rounding should be consistent
• assumes dissociation of acid is small / concentration of acid does not change (1) (3)

if made no assumptions i.e. solved quadratic and got correct answer (3)
penalise arithmetic errors once only
(iii) pH down means $[H^+]$ up (1)  
Dissociation endothermic (1)  
Equilibrium shifts in endothermic direction when temperature rises (1)  
mark consequentially

(Total 9 marks)

4 a (i) $pH = -\log [H^+]$ or $\log \frac{1}{[H^+]}$ (1)  
(ii) $K_w = [H^+] [OH^-]$ (1)  
accept $[H_2O^+]$ instead of $[H^+]$

b (i) $[H^+] = 0.200 \text{ mol dm}^{-3}$; $pH = 0.70$ (1)  
allow caveat or appropriate better chemistry, e.g. cannot be calculated because $K_a$ not given if calculated as a monobasic acid they must explain why

(ii) $[OH^-] = 0.0500 \text{ mol dm}^{-3}$; $[H^+] = \frac{1 \times 10^{-14}}{0.05} = 2 \times 10^{-13} \text{ (mol dm}^{-3})$ (1);  
$pH = 12.7$ (1)  
not 13  
allow calculation from $pOH = 1.3$, allow even if called $pH$  
penalise 4 or more significant figures  
mark consequentially if answer higher than 7 but less than 15

4 c (i) maintains pH nearly constant if small amounts of acid or base added (1)  
accept resists change to pH

(ii) $K_a = 1.8 \times 10^{-5} = \frac{[H^+] [CH_3COO^-]}{[CH_3COOH]} = \frac{[H^+]}{[\text{salt}]} \frac{[\text{salt}]}{[\text{acid}]}$ (1)  
$[H^+] = 1.8 \times 10^{-5} \times \frac{0.015}{0.055} = 4.91 \times 10^{-6} \text{ (mol dm}^{-3})$ (1)  
pH = $-\log 4.91 \times 10^{-6} = 5.3$ (1)  
Mark consequentially if salt and acid wrong way up  
Incorrect if used 0.015 twice but would get final mark consequentially

(Total 9 marks)

5 a Reacts in both directions (1); at equal rates (1)  
must mention rates for second mark

b 70–200 atm (1); high pressure moves equilibrium to right (1)  
350–550 °C (1); low temperature moves equilibrium to right (1)  
but rate too slow (1); (so use) iron or iron oxide catalyst (1)  
(max 5)  
if no other marks awarded high pressure and low temperature (1) if both given

c Makes it happen faster (1); no effect on equilibrium position (1)  
give mark if mentioned in part b

(Total 9 marks)
6 a  Correct expression for $K_p \ (1)$; no units or $\frac{\text{no}}{\text{atm}^2} \ (1)$  
   *no square brackets*  

b  (i)  Mole fraction HI = 0.78, H$_2$ = I$_2$ = 0.11 (1)  
   Partial pressure HI = 1.56 atm (1); H$_2$ = I$_2$ = 0.22 atm (1)  

   (ii) \[ K_p = \frac{1.56^2}{0.22^2} \ (1) \] (consequential on values in part b (i) and expression in part a)  
   = 50.28 or 50.3 or 50 (1)  

   (Total 13 marks)  

   c  (i) \[ 2\text{Na}_2\text{S}_2\text{O}_3 + \text{I}_2 \rightarrow \text{Na}_2\text{S}_4\text{O}_6 + 2\text{NaI} \] \ \text{species} \ (1); balanced (1)  
   balancing mark conditional on correct species  
   ionic equation acceptable  

   (ii) Starch (1); blue/black to colourless (1)  
   *not white or clear in place of colourless*  

   (iii) Ease of discernibility compared (1);  
   Actual colour change for iodine / thiosulfate – i.e. yellow → colourless (1)  

   (Total 13 marks)