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)**
$CH_3COCH_3 + 3I_2 + 4NaOH \rightarrow CH_3COONa + CHI_3 + 3NaI + 3H_2O$ **(2)**
(allow (1) for correct organic products)

(ii)  **(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 [RX] halves the rate, so first order w.r.t. RX **(1)**
Halving $[OH^-]$ halves the rate, so first order w.r.t. OH^- **(1)**
explanation of either statement (1)
So, rate = $k[RX][OH^-]$ **(1)** **(3)**

b $k = \dfrac{\text{rate}}{[RX][OH^-]} = \dfrac{8 \times 10^{-6}}{0.01 \times 0.04} = 0.0215$ **(1)** $\text{dm}^3\,\text{mol}^{-1}\,\text{s}^{-1}$ **(1)** **(2)**

(Total 5 marks)

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

b (i) $CH_3CH_2COOH \rightleftharpoons CH_3CH_2COO^- + H^+$
or $CH_3CH_2COOH + H_2O \rightleftharpoons CH_3CH_2COO^- + H_3O^+$ **(1)**
$K_a = \dfrac{[CH_3CH_2COO^-]\,[H^+]}{[CH_3CH_2COOH}$ or $\dfrac{[CH_3CH_2COO^-]\,[H_3O^+]}{[CH_3CH_2COOH]}$ **(1)**
Mark consequentially for second mark if acid is incorrect but *must* have H^+ or H_3O^+ **(2)**

(ii) $[H^+] = \sqrt{K_a \times c} = \sqrt{1.30 \times 10^{-5} \times 0.01} = 3.6 \times 10^{-4}$ (mol dm^{-3}) **(1)**
$\text{pH} = -\log[H^+] = -\log(3.6 \times 10^{-4}) = 3.4$ **(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

Student Book Unit 4 Test 1 Mark scheme (cont.)

(iii) pH down means $[H^+]$ up **(1)**
Dissociation endothermic **(1)**
Equilibrium shifts in endothermic direction when temperature rises **(1)** **(3)**
mark consequentially

(Total 9 marks)

4 a (i) $pH = -\log [H^+]$ or $\log \frac{1}{[H^+]}$ **(1)**

(ii) $K_w = [H^+]\,[OH^-]$ **(1)** **(2)**
accept $[H_3O^+]$ 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)** **(3)**
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

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

(ii) $K_a = 1.8 \times 10^{-5} = \frac{[H^+]\,[CH_3COO^-]}{[CH_3COOH]} = \frac{[H^+]\,[\text{salt}]}{[\text{acid}]}$ **(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)** **(4)**
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)** **(2)**
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)** **(2)**
*give mark if mentioned in part **b***

(Total 9 marks)

Student Book Unit 4 Test 1 Mark scheme (cont.)

6 a Correct expression for K_p **(1)**; no units or $\frac{atm^2}{atm^2}$ **(1)** **(2)**
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)** **(3)**

(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)** **(2)**

c (i) $2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$; species **(1)**; balanced **(1)** **(2)**
balancing mark conditional on correct species
ionic equation acceptable

(ii) Starch **(1)**; blue/black to colourless **(1)** **(2)**
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)** **(2)**

(Total 13 marks)