Mark Scheme - 3.9 Acid-base Equilibria

(a) $K_w = [H^+][OH^-]$ (1)
Units = $mol^2\ dm^{-6}$ (1) [2]

(b) (i) In pure water $[H^+] = [OH^-]$ or $[H^+] = \sqrt{1.0 \times 10^{-14}}$ (1)
$pH = -\log 10^{-7} = 7$ (1) [2]

(ii) Final volume of solution is 1000 cm^3 so acid has been diluted by a factor of 100 so final concentration of acid is 0.001
or moles acid = $\frac{0.1 \times 10}{1000} = 0.001$ (1)
$pH = -\log 0.001 = 3$ (1) [2]

(c) $1.78 \times 10^{-5} = \frac{[H^+] \times 0.02}{0.01}$ (1)

$[H^+] = 8.90 \times 10^{-6}$ (1)

pH = 5.05 allow 5 or 5.1 (1) [3]

(d) The solution is a buffer (1)
Solution contains a large amount of CH_3COOH and CH_3COO^- ions
(Accept correct equations) (1)
When an acid is added, the CH_3COO^- ions react with the H^+ ions, removing them from solution and keeping the pH constant (1) [3]

Total [12]

(a) (dissociates to) release H^+ ions **[1]**

(b) 2.5-6.0 **[1]**

(a) an acid is a proton / H^+ donor **[1]**

(b) pH = -log[H^+] / negative log of hydrogen ion concentration **[1]**

(c) a low pH corresponds to a high concentration of H^+ (1)

a strong acid is totally dissociated whilst a weak acid is partially dissociated (1)

need to consider concentration (of acid solution) as well as strength of the acid (1)

a concentrated solution of a weak acid could have a lower pH than a dilute solution of a strong acid (1) **[4]**

QWC Accuracy of spelling, punctuation and grammar *QWC* **[1]**

(d) (i) $K_a = \frac{[HCOO^-][H^+]}{[HCOOH]}$ **[1]**

(ii) $1.75 \times 10^{-4} = \frac{x^2}{0.1}$ (1)

$x = 4.183 \times 10^{-3}$ (1)

pH = 2.38 (1) **[3]**

(e) (i) buffer **[1]**

(ii) $RCOOH \rightleftharpoons RCOO^- + H^+$ and $RCOONa \rightarrow RCOO^- + Na^+$ (1)

added H^+ removed by salt anion/ $A^- + H^+ \rightarrow HA$ (1)

added OH^- removed by acid/ $OH^- + HA \rightarrow A^- + H_2O$ (1) **[3]**

Total [15]

(a) Filtration [1]

(b) $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ [1]

(c) (i) Carbon O.S. at start = +3; Carbon O. S. at end = +4 [1]

(ii) $2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \rightarrow 2Mn^{2+} + 8H_2O + 10CO_2$ [1]

(d) Colour change of manganate(VII) is used to indicate the change [1]

(e) Volume of manganate(VII) = 27.92 cm^3 (1)

Moles manganate = $27.92 \times 0.020 / 1000 = 5.584 \times 10^{-4}$ mol (1)

Moles oxalate = $5.584 \times 10^{-4} \times 5/2 = 1.396 \times 10^{-3}$ mol (1)

Concentration = $1.396 \times 10^{-3} / 25 \times 10^{-3} = 0.0558$ mol dm^{-3} (1) [4]

(f) (i) $K_a = \frac{[H^+][HCOO^-]}{[HCOOH]}$ [1]

(ii) $[H^+]^2 = K_a \times [HCOOH] = 1.8 \times 10^{-4} \times 0.2 = 0.36 \times 10^{-4}$ (1)

$[H^+] = 6.0 \times 10^{-3}$ mol dm^{-3} (1)

pH = $-\log [H^+] = 2.22$ (1) [3]

(iii) A buffer keeps the pH almost constant when **small amounts** of acid or base are added (1)

$HCOOH \rightleftharpoons HCOO^- + H^+$ (1)

Adding acid shifts the equilibrium to the left which removes H^+ /
Adding base removes H^+ shifts equilibrium to right which replaces H^+ (1)
OR answer in terms of H^+ reacting with methanoate from sodium methanoate when acid added (1) and methanoic acid replacing H^+ when base removes H^+ (1)

MAX 3 [3]

QWC Selection of a form and style of writing appropriate to purpose and to complexity of subject matter [1]

(g) (i) Orange to green [1]

(ii) CrO_4^{2-} (1) Yellow (1) [2]

Total [20]

(a) (i) A helium (atom) nucleus / 2 protons and 2 neutrons / $^{4}He^{2+}$ [1]

(ii) b………22 (1) X……………Ne (1) [2]

(iii) (4 × 2.6) = 10.4 [1]

(b) The frequency of the green line at 569 nm is HIGHER. than the frequency of the yellow-orange line at 589 nm. Another line is seen at 424 nm, this is caused by an electronic transition of HIGHER. energy than the line at 569 nm. [1]

(c) (i) Na_2CO_3 → 106 + $NaHCO_3$ → 84 + $2H_2O$ → 36 (1) → 226 [1]

(or by other appropriate method – note mark is for the working)

(ii) Atom economy $= \frac{\text{'}M_r\text{' required product} \times 100}{\text{Total '}M_r\text{' of the reactants}}$ (1)

$= \frac{318 \times 100}{452}$ = 70.4 / 70.35 (%) (1) [2]

(iii) Carbon dioxide is produced (and released into the air) and this contributes to the greenhouse effect / increases acidity of sea (1)
It should be trapped / a use found for it. (1) [2]

(d) (i) Water is acting as a proton donor (1) and this combines with the carbonate ion / CO_3^{2-}, giving the hydrogencarbonate ion / HCO_3^- (1) [2]

(ii) The pH scale runs from 0-14 / measure of acidity / alkalinity (1)
pH <7 acid / >7 alkali (1)
acid stronger as pH value decreases / alkali stronger as pH value increases / 11.4 is strong alkali (1) [3]

Total [15]