M1. (a) (i) **B**   1

               C

                                                                         1

               A

                                                                           1

       (ii) cresolphthalein or thymolphthalein

                                                                        1

   (b) $pH = -\log[H^+]$

                                                                        1

$$K_a = \frac{[H^+]^2}{[CH_3COOH]} \quad \text{or} \quad [H^+] = [A^-]$$

                                                                        1

       $[H^+] = \sqrt{1.74 \times 10^{-5} \times 0.15}$ (or 1.62×10^{-3})

                                                                         1

       pH = 2.79 (penalise 1 dp or more than 2dp once in the qu)

                                                                        1

                                                                                  [8]

M2. (a) $-\log[H^+]$

                      ecf if [ ] wrong and already penalised

                                                                        1

      4.57×10^{-3}

                      allow 4.6×10^{-3}

                      ignore units

                                                                            1

   (b) (i) $K_a = \dfrac{[H^+][X^-]}{[HX]}$ allow HA etc

PhysicsAndMathsTutor.com

not $\dfrac{[H^+]^2}{[HX]}$ *but mark on*

If expression wrong allow conseq units in (ii)
but no other marks in (ii)

1

(ii) $\dfrac{[H^+]^2}{[HX]}=\dfrac{(4{\cdot}57\times10^{-3})^2}{[0{\cdot}150]}$

If use 4.6×10^{-3}

1

$K_a = 1.4(1) \times 10^{-4}$ *and pKa = 3.85*

$= 1.39 \times 10^{-4}$

allow $1.39 - 1.41 \times 10^{-4}\,mol\,dm^{-3}$

1

(iii) $pK_a = 3.86$

Penalise dp of final answer < or > 2 in pH once in paper

1

(c) (i) $\dfrac{30}{1000} \times 0.480 = 0.0144$ or $1.4(4) \times 10^{-2}$

Mark is for answer (M1)

1

(ii) $\dfrac{18}{1000} \times 0.350 = 0.0063$ or 6.3×10^{-3}

Mark is for answer (M2)

1

(iii) $0.0144 - 2(0.0063) = 1.80 \times 10^{-3}$

M3 is for (i) – 2(ii)
If x 2 missed, CE i.e. lose M3 and the next mark gained

1

(iv) $1.80 \times 10^{-3} \times \dfrac{1000}{48} = 0.0375\ (0.038)$

M4 is for answer

If vol is not 48×10^{-3} (unless AE) lose M4 and next mark gained
If multiply by 48 - this is AE - i.e. lose only M4
If multiply by 48×10^{-3} this is AE - i.e. lose only M4

1

(v) 10^{-14} / 0.0375   (10^{-14} / 0.038)

          M5 for K_w/[OH$^-$]

1

      (= 2.66×10^{-13})   (= 2.63×10^{-13})

          or pOH

    or pOH = 1.426   (or pOH = 1.420)

          If no attempt to use K_w or pOH lose both M5 and M6

1

    pH = 12.57   (12.58)   M6

          Allow M6 conseq on AE in M5 if method OK

1

[13]

M3.   (a) $K_a = \dfrac{[H^+][A^-]}{[HA]}$

          (All three sets of square brackets needed, penalise missing brackets or missing charge once in the question)
          (Don't penalise extra $[H^+]^2$/[HA])

1

    (b) $K_a = \dfrac{[H^+]^2}{[HA]}$ or [H$^+$] = [A$^-$]

    [H$^+$]   = $\sqrt{(1.45 \times 10^{-4}) \times 0.25}$

        = 6.02×10^{-3}pH = 2.22

          (must be to 2dp)
          (allow 4th mark consequential on their [H$^+$])

1

    (c)   (i)   pH (almost) unchanged

          (Must be correct to score explanation)

1

H+ removed by A– forming HA
or acid reacts with salt
or more HA formed

1

(ii) $[H^+]$ $= 10^{-3.59} = 2.57 \times 10^{-4}$ or 2.6×10^{-4}

1

$$[A^-] = \frac{K_a[HA]}{[H^+]}$$

1

$$= \frac{(1.45 \times 10^{-4}) \times 0.25}{2.57 \times 10^{-4}}$$

1

     = 0.141 (mol dm $^{-3}$)
     (Allow 0.139 to 0.141 and allow 0.14)
     (If not used 3.59, to find $[H^+]$ can only score M2 for working)
     (If 3.59 used but $[H^+]$ is wrong, can score M2 for correct method and conseq M4)
     If wrong method and wrong expression, can only score M1)

1

(ii)   *Alternative scheme for first three marks of part (c)(ii)*

$$pH = pK_a - \log\frac{[HA]}{[A^-]}$$

1

$pK_a = 3.84$

1

$$3.59 = 3.84 - \log\frac{0.250}{[A^-]}$$

1

[11]

M4.   (a)   (i)   B;

1

Page 5

C;

1

A;

1

(ii)   cresolphthalein

OR

thymolphthalein;

1

(b)   (i) $-\log[H^+]$;

1

(ii) $[H^+] = 1.259 \times 10^{-12}$ (or 1.26 or 1.3)

OR

OH = 14 – pH;

1

$$[OH^-] = \frac{10^{-14}}{1.258 \times 10^{-12}}$$

OR

= 2.10;

1

$= 7.9(4) \times 10^{-3}$;
        (if [H⁺] is wrong allow 1 for [OH] = $K_w/[H^+]$ or as numbers)

1

(c)   (i) $K_a = [H^+]^2/[CH_3CH_2COOH]$

OR

$[H^+]^2/[HA]$

OR

$[H^+] = [A^-]$ etc;

1

$[H^+]$ $= \sqrt{1.35 \times 10^{-5} \times 0.117}$ or expression without numbers;

1

= 1.257×10^{-3}

PhysicsAndMathsTutor.com

pH   = 2.9<u>0</u>;

1

(iii) $K_a = [H^+]$

OR

pK_a = pH;

1

pH = 4.8<u>7</u>;
       (penalise 1dp once)

1

[13]

M5.   (a)   Concentration of acid: $m_1v_1 = m_2v_2$ hence $25 \times m_1 = 18.2 \times 0.150$

OR

moles NaOH = 2.73×10^{-3};

1

$m_1 = 18.2 \times 0.150/25 = 0.109$;

1

(b)   (i) $K_a = [H^+][A^-]/[HA]$ *not* $K_a = [H^+]^2 / [HA]$;

1

(ii)   p$K_a = -\log K_a$;

1

(iii) $[A^-] = [HA]$;

1

hence $K_a = [H^+] [A^-] / [HA] = [H^+]$

and $-\log K_a = -\log[H^+]$;

1

(c)   ratio $[A^-]$: $[HA]$ remains constant;

1

hence as $[H^+] = K_a [HA] / [A^-]$; $[H^+]$ remains constant;

1

(d) (i)   pH of 0.250 mol dm^{-3} HCl   = 0.60
and pH of 0.150 mol dm^{-3} HCl   = 0.82;

1

pH change = 0.22;

1

(ii) moles HCl = 30 × 0.250 × 10^{-3} = v × 0.150 × 10^{-3} = 7.50 × 10^{-3}

OR

v = 30 × 0.250 × 10^{-3}/ 0.150 × 10^{-3} =50;

1

water added = 50 – 30 = 20 cm^3;

1

[12]