Answers to examination-style questions

Answers	Marks	Examiner's tips
1 a) i) $K_w = [H^+][OH^-]$ $pH = -\log [H^+]$	**2**	Two nice easy marks so learn these equations.
ii) $[H^+] = [OH^-]$	**1**	This is a deduction from part **i)**.
iii) $(2.0 \times 10^{-3}) \times 0.5 = 1.0 \times 10^{-3}$ mol	**1**	This was covered in chapter 1 and is needed throughout the course.
iv) $[H^+] = \dfrac{4.02 \times 10^{-14}}{1.0 \times 10^{-3}}$ $pH = 10.40$	**2**	2 dp needed.
b) i) $K_a = \dfrac{[H^+][CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$ $= \dfrac{[H^+]}{[CH_3CH_2COOH]}$ $[H^+] = \sqrt{1.35 \times 10^{-5}} \times 0.125$ $pH = 2.89$	**4**	2 dp needed.
c) i) $(50.0 \times 10^{-3}) \times 0.125$ $= 6.25 \times 10^{-3}$ mol	**1**	2 dp needed.
ii) $(6.25 \times 10^{-3}) - (1.0 \times 10^{-3})$ $= 5.25 \times 10^{-3}$ mol	**1**	2 dp needed.
iii) mol salt formed $= 1.0 \times 10^{-3}$ $(H^+) = K_a \times \dfrac{[CH_3CH_2COOH]}{[CH_3CH_2COO^-]}$ $= (1.35 \times 10^{-5}) \times \dfrac{\left(\frac{5.25 \times 10^{-3}}{V}\right)}{\left(\frac{1.0 \times 10^{-3}}{V}\right)}$ $= 7.088 \times 10^{-5}$ $pH = 4.15$	**4**	Remember [ ] are showing moles per dm^3. The volume is this case cancels out so that is why it was not given in the question.

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2 a) $K_a = \dfrac{[H^+]^2}{[CH_3CH_2COOH]}$	**3**	Round brackets will be penalised. Square brackets are showing concentration.
$[H^+] = \sqrt{1.35 \times 10^{-5} \times 0.169}$		1 mark is allowed for correct pH from candidates with wrong $[H^+]$ value.
$= 1.51 \times 10^{-3}$		
pH = 2.82		
b) i) $CH_3CH_2COOH + NaOH \rightarrow CH_3CH_2COONa + H_2O$	**1**	Can show a molecular or ionic equation since the question does not specifically ask for either.
or $CH_3CH_2COOH + OH^- \rightarrow CH_3CH_2COO^- + H_2O$		
ii) mol propanoic acid = 0.250 – 0.015 = 0.235 mol	**2**	
mol propanoate ions = 0.190 + 0.015 = 0.205 mol		
iii) $[H^+] = \dfrac{K_a \times [CH_3CH_2COOH]}{[CH_3CH_2COO^-]}$	**3**	$\dfrac{K_a \times [HA]}{[A^-]}$ would be allowed.
$= \dfrac{(1.35 \times 10^{-5})(0.235)}{0.205}$		1 mark allowed for correct pH from wrong $[H^+]$ value.
$= 1.548 \times 10^{-5}$		
pH = 4.81		
3 a) i) $K_w = [H^+][OH^-]$	**1**	
ii) 2.34×10^{-7} mol dm^{-3}	**1**	2 dp needed.
iii) 2.34×10^{-7} mol dm^{-3}	**1**	This mark is consequential on part **ii).**
iv) answers in the range of 5.48×10^{-14} to 5.50×10^{-14}	**1**	This is consequential as well, i.e. = **ii)** × **iii)**.
b) $[H^+] = \dfrac{10^{-14}}{0.136} = 7.35 \times 10^{-14}$	**2**	2 dp needed.
pH = 13.13		

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4 a) i) $pH = -\log[H^+]$	**1**	Allow: $\log\frac{1}{[H^+]}$
ii) 0.437 or 0.44 mol dm^{-3}	**1**	Need at least 2 dp.
b) i) Before A: $CO_3^{2-} + H^+ \rightarrow HCO_3^-$ Between A and B: $HCO_3^- + H^+ \rightarrow H_2O + CO_2$ or $HCO_3^- + H^+ \rightarrow H_2CO_3$	**2**	Any spectator ions will be ignored in the equation.
ii) A: metacresol purple B: bromophenol blue	**2**	
iii) $\frac{40}{10^3} \times 0.150 = 6.0 \times 10^{-3}$ mol	**1**	
iv) Number of moles of HCl $= 12.0 \times 10^{-3}$ mol conc = $\frac{12.0 \times 10^{-3}}{50.0 \times 10^{-3}}$ $= 0.24$ mol dm^{-3}	**2**	
5 a) $K_a = \frac{[H^+]^2}{[CH_3CH_2COOH]}$ $[H^+] = \sqrt{(1.35 \times 10^{-5} \times 0.55)} = 2.72 \times 10^{-3}$ pH = 2.56 or 2.57	**3**	Don't forget to take the square root of H^+.

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b)	**i)**	$30.0 \times 10^{-3} \times 0.55 = 1.65 \times 10^{-2}$ mol	**1**	Will accept 0.017 mol.
	ii)	$10.0 \times 10^{-3} \times 0.23 = 2.30 \times 10^{-3}$ mol	**1**	Will accept 0.0023 mol.
	iii)	$(1.65 \times 10^{-2}) - (2.30 \times 10^{-3})$ $= 1.42 \times 10^{-2}$ mol	**1**	
	iv)	Number of moles of $CH_3CH_2COONa = 2.30 \times 10^{-3}$ mol $[H^+] = \frac{K_a \times [CH_3CH_2COOH]}{[CH_3CH_2COO^-]}$ $= \frac{(1.35 \times 10^{-5})\left(\frac{1.42 \times 10^{-2}}{V}\right)}{\frac{2.3 \times 10^{-3}}{V}}$ $= 8.33 \times 10^{-5}$ pH = 4.08	**3**	2 dp needed.
6 **a)**		$-\log [H^+] = 4.57 \times 10^{-3}$	**2**	4.6×10^{-3} is allowed. Units are ignored.
b)	**i)**	$K_a = \frac{[H^+][X^-]}{[HX]}$	**1**	
	ii)	$\frac{[H^+]^2}{[HX]} = \frac{(4.57 \times 10^{-3})^2}{[0.150]}$ $= 1.39 \times 10^{-4}$ mol dm^{-3}	**3**	A range of between 1.39×10^{-4} and 1.41×10^{-4} is allowed.
	iii)	$pK_a = 3.86$	**1**	2 dp needed.
c)	**i)**	$\frac{30}{1000} \times 0.480 = 0.0144$ mol	**1**	Will accept 1.44×10^{-2}
	ii)	$\frac{18}{1000} \times 0.350 = 0.0063$ mol	**1**	Will accept 6.3×10^{-3}

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iii) $0.0144 - 2(0.0063)$ $= 1.80 \times 10^{-3}$ mol	**1**	This answer is consequential and is from candidates' answer **i) – ii)**. If × 2 missed, this is a chemical error so lose a mark.
iv) $1.80 \times 10^{-3} \times \frac{1000}{48}$ $= 0.0375$ mol dm^{-3}	**1**	0.038 also allowed here since 3 significant figs.
v) $\frac{10^{-14}}{0.0375}\left(\frac{10^{-14}}{0.038}\right)$ $= 2.66 \times 10^{-13}$ pH = 12.57	**2**	Allow this mark consequentially if arithmetic error in previous questions.