Question	Answer
4(a)	strontium nitrate **AND** because of larger cationic radius [1] NO_3^- / nitrate **ion** / anion is less distorted / polarised **OR** N–O or N=O bond less weakened / distorted [1]
4(b)	M1 magnesium oxide requires more water to dissolve **AND** because $Sr(OH)_2$ is more soluble [1] M2 lattice and hydration energies less for $Sr(OH)_2$ [1] M3 lattice energy is dominant factor / change in lattice energy is greater [1]
4(c)(i)	0.13 [1]
4(c)(ii)	26.7 cm^3 **must be 3SF** [1]

Question	Answer	Marks
3(a)(i)	1.3×10^{-5}	1
3(a)(ii)	**M1:** K_a expression used correctly **and** $K_a = 5.5(3) \times 10^{-10}$ **M2:** $pK_a = 9.26$ Award 2 marks for correct answer	2
3(b)(i)	$NH_3 + H^+ \rightarrow NH_4^+$	1
3(b)(ii)	$NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ **or** $H^+ + OH^- \rightarrow H_2O$ **and** reference to expression in Q shifting R	1
3(c)(i)	quotes $K_w = 1 \times 10^{-14}$ or 1×10^{-1} $[H^+][OH^-]$ $[H^+] = 1 \times 10^{-7}$	1
3(c)(ii)	**M1:** $[H^+] = 2.3 \times 10^{-7}$ (calculator value 2.290867×10^{-7}) **and** $K_w = [2.3 \times 10^{-7}]^2$ **M2:** $K_w = 5.2 \times 10^{-14}$ calculator 5.248074×10^{-14} Award 2 marks for correct answer	2

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>9(a)</td><td>
<table>
<tr><td>organic starting material</td><td>reagent and conditions</td><td></td></tr>
<tr><td>1-butyl halide, e.g.
$CH_3CH_2CH_2CH_2Br$</td><td>NH_3 under pressure or
heated in sealed tube</td><td>[1] + [1]</td></tr>
<tr><td>butanenitrile
$CH_3CH_2CH_2CN$</td><td>H_2 and Ni or Pt / $LiAlH_4$ /
Na + ethanol</td><td>[1] + [1]</td></tr>
<tr><td>butanamide
$CH_3CH_2CH_2CONH_2$</td><td>$LiAlH_4$ / Na + ethanol</td><td>[1] + [1]</td></tr>
</table>
</td><td>6</td></tr>
<tr><td>9(b)</td><td>M1 butylamine > ammonia > phenylamine [1]
M2 basicity related to ability of **lp** to accept proton / H^+ [1]
M3 butylamine is stronger because of positive inductive effect of **alkyl** group / C_4H_9 [1]
M4 phenylamine is weaker because **lp on N** is delocalised into ring [1]</td><td>4</td></tr>
</table>

Question	Answer	Marks
4(a)(i)	**M1** all five points plotted correctly **M2** best-fit straight line (ruler) with negative gradient drawn	2
4(a)(ii)	**M1** gradient correctly calculated **OR** gradient working seen **M2** gradient = $-\Delta S^{o}$ ΔS^{o} evaluated correctly ecf ΔS^{o} = (+)160 ± 10 ($J\,K^{-1}\,mol^{-1}$)	2
4(b)(i)	$2HCO_3^- \rightarrow CO_3^{2-} + CO_2 + H_2O$	1

Question	Answer	Marks
4(b)(ii)	**M1** ionic radius of M^+ / cationic radius increases **OR** charge density of ion / M^+ decreases down Group 1 **M2** less distortion / polarisation of the anion / HCO_3^- **OR** CO bond / C-O / C=O less weakened	2
4(c)(i)	**M1** solution which resists changes in pH when opposes / resists change in pH **M2** when small amount of acid / H^+ or alkali / base / OH^- is added	2
4(c)(ii)	**M1** (with acid) $HCO_3^- + H^+ \rightarrow H_2CO_3$ **OR** $HCO_3^- + H_3O^+ \rightarrow H_2CO_3 + H_2O$ **M2** (with alkali) $H_2CO_3 + OH^- \rightarrow HCO_3^- + H_2O$	
4(c)(iii)	**M1** $K_a = 10^{-6.35} = 4.47 \times 10^{-7}$ **M2** $[H^+] = 4.47 \times 10^{-7} / 14.1 = 3.17 \times 10^{-8}$ ecf **M3** pH = –log $[H^+]$ = 7.5 ecf from a calculated $[H^+]$ min 2sf	3

8/16

Question	Answer	Marks
2(a)	resists pH change when small amount of acid or alkali is added [1]	**1**
2(b)(i)	$C_6H_5COOH + NaOH \rightarrow C_6H_5COO^-Na^+ + H_2O$ [1]	**1**
2(b)(ii)	$C_6H_5COO^-Na^+ + HNO_3 \rightarrow C_6H_5COOH + NaNO_3$ [1]	**1**
2(c)	$[H^+] = 7.08 \times 10^{-5}$ [1] $[C_6H_5COOH] = 8.20 \times 10^{-3}$ [1] $[C_6H_5COO^-Na^+] = 7.31 \times 10^{-3}$ [1]	**3**

Question	Answer	Marks
2(d)	neutralisation is exothermic [1] All of the C_6H_5COOH has reacted **AND** excess KOH 1]	**2**
2(e)(i)	If $[X] = [Mg^{2+}] = [Mg(C_6H_5COO^-)_2]$ $4X^3 = 1.76 \times 10^{-7}$ so $X = 3.53 \times 10^{-3}$ [1] $0.940\ g\ dm^{-3}$ [1]	**2**
2(e)(ii)	lower than **AND** common ion effect [1]	**1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>3(a)</td><td><table>
<tr><th>energy change</th><th>always positive</th><th>always negative</th><th>can be either negative or positive</th></tr>
<tr><td>bond energy</td><td>✓</td><td></td><td></td></tr>
<tr><td>enthalpy change of atomisation</td><td>✓</td><td></td><td></td></tr>
<tr><td>enthalpy change of formation</td><td></td><td></td><td>✓</td></tr>
</table></td><td>1</td></tr>
<tr><td>3(b)</td><td>M1 (enthalpy change) when one mole of gaseous atoms is produced IGNORE energy released
M2 from its element(s) in its standard state / standard conditions / 298 K AND 1 atm</td><td>2</td></tr>
<tr><td>3(c)</td><td>M1 use of correct six numbers only –31 / 285 / 731 / –141 / 798 / 496

M2 2 × used correctly with Ag (2 × 285 (570) and 2 × 731 (1462)) AND 0.5 with O=O (496 (248))

M3 correct signs and evaluation
–31 = (2 × 285) + (2 × 731) + (–141) + (798) + x + (0.5 × 496)

x = –2968 kJ mol^{-1}</td><td>3</td></tr>
<tr><td>3(d)</td><td>• Ag_2Se Ag_2S Ag_2O OWTTE
<i>least exothermic</i> <i>most exothermic</i>

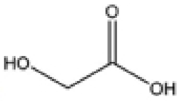
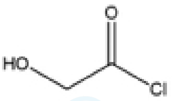
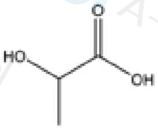
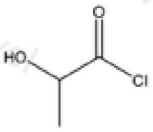
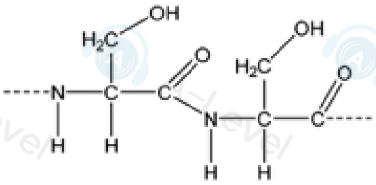
• charge density of anion decreases down the group ORA
/ radius/size of anion increases down the group
/ Se^{2-} largest radius / O^{2-} smallest radius / O has smallest ionic radius

• less attraction between the ions / ionic bond gets weaker (with Ag_2Se) ORA

Any two [1], all three [2]</td><td>2</td></tr>
<tr><td>3(e)(i)</td><td>(K_{sp} =) $[Ag^+]^2[SO_3^{2-}]$</td><td>1</td></tr>
</table>

Question	Answer	Marks
3(e)(ii)	x = $\sqrt[3]{1.5 \times 10^{-14} / 4}$ = 1.55×10^{-5} (mol dm^{-3}) $[Ag^+]$ = $1.55 \times 10^{-5} \times 2 = 3.11 \times 10^{-5}$ (mol dm^{-3}) min 2sf ecf (e)(i)	1
3(f)	• feasibility / it increases as temperature increases **ORA** • ΔS is positive / ΔS is >0 / entropy **change** is positive (and ΔH is positive) **OR** $-T\Delta S$ becomes more negative / $T\Delta S$ becomes more positive • as ΔG becomes / is negative / $\Delta G < 0$ Any two [1], all three [2]	2

Question	Answer	Marks
8(a)	**M1** chloroethanoic acid > ethanoic acid > phenol > ethanol **M2** correct link of acidity once can be implied from M1 weakens O—H / carboxylate anion stabilised **M3** / **M4** explanation linked to structure - ($ClCH_2CO_2H$ > ethanoic acid) due to electronegative / electron withdrawing / negative inductive effect of C*l* - (ethanoic acid > phenol) due to electronegative / electron withdrawing / negative inductive effect of COOH / C=O - (phenol > ethanol) due to lone pair of oxygen overlapping / delocalised into the ring - (ethanol weakest) alkyl group is electron donating / positive inductive effect two for one mark, four for two marks	4

Question	Answer	Marks
8(b)	- oxidation - (solution) decolourises **OR** purple → colourless / pale pink **OR** bubbles - $HOOCCOOH + [O] \rightarrow 2CO_2 + H_2O$ **OR** $5HOOCCOOH + 2MnO_4^- + 6H^+ \rightarrow 10CO_2 + 8H_2O + 2Mn^{2+}$ two for one mark, three for two marks	2
8(c)	**M1**  **OR**  **M2**  **OR** 	2
8(d)	 **M1** peptide linkage shown displayed with saturated C each side **M2** rest of structure correct **AND** continuation bonds	2

Question	Answer	Marks
8(e)	addition polymers do not hydrolyse **OR** condensation polymers can hydrolyse	

Question	Answer	Marks
3(a)(i)	**M1** pH = $-\log[H^+]$ **M2** $K_a = [H^+][A^-]/[HA]$	2
3(a)(ii)	**M1** $A^- + H^+ \rightarrow HA$ **OR** $NaA + H^+ \rightarrow HA + Na^+$ **M2** $HA + OH^- \rightarrow H_2O + A^-$	2
3(b)	remaining n(HC*l*O) = 0.17 – 0.03 = 0.14 mol (dm^{-3}) $[H^+] = 1.35 \times 10^{-7}$ mol dm^{-3} OR calculate pK_a (7.54) from K_a pH = $-\log(1.35 \times 10^{-7})$ = 6.87/ 6.9 OR pH = 7.54 + log(0.03/0.14) = 6.87	3