Question 1: Long Answer — 10 points

(a) For the correct calculated value: **1 point**

$$0.300\text{ g } C_8H_8O_3 \times \frac{1\text{ mol } C_8H_8O_3}{152.15\text{ g}} \times \frac{1\text{ mol } HC_7H_5O_3}{1\text{ mol } C_8H_8O_3} \times \frac{138.12\text{ g}}{1\text{ mol } HC_7H_5O_3} = 0.272\text{ g } HC_7H_5O_3$$

(b) For the correct answer and a valid justification: **1 point**

Yes (consistent). Because the acid is soluble in water, some crystals may dissolve during rinsing, causing the mass of the collected precipitate to be lower than expected. This would lead to a percent yield less than 100%.

(c) For the correct calculated value of either q: **1 point**

Accept one of the following:

- $q_{heat} = mc\Delta T = (0.105\text{ g})(1.17\text{ J/(g} \cdot \text{°C)})(159\text{°C} - 25\text{°C}) = 16.5\text{ J}$
- $q_{melt} = 0.105\text{ g} \times \frac{1\text{ mol}}{138.12\text{ g}} \times \frac{27{,}100\text{ J}}{1\text{ mol}} = 20.6\text{ J}$

For the correct calculated value of the other q and the total heat: **1 point**

$q_{total} = q_{heat} + q_{melt} = 16.5\text{ J} + 20.6\text{ J} = 37.1\text{ J}$

Total for part (c) **2 points**

(d) For a correct explanation: **1 point**

Molecules of salicylic acid have more hydrogen bonding sites than molecules of methyl salicylate have, which leads to stronger intermolecular forces and a higher melting point for salicylic acid.

(e) For the correct answer: **1 point**

The pK_a *is approximately 3.*

(f) For the correct answer and a valid justification, consistent with part (e): **1 point**

Accept one of the following:

- *The conjugate base,* $C_7H_5O_3^-$. *When* $pH = 4$, *the titration is beyond the half-equivalence point, where* $[HC_7H_5O_3] = [C_7H_5O_3^-]$. *Thus,* $[C_7H_5O_3^-]$ *must be greater than* $[HC_7H_5O_3]$.
- *The conjugate base,* $C_7H_5O_3^-$. *Because the* pH *of the solution is greater than the* pK_a *of the acid, the majority of the molecules will be deprotonated.*

(g) For the correct calculated value: **1 point**

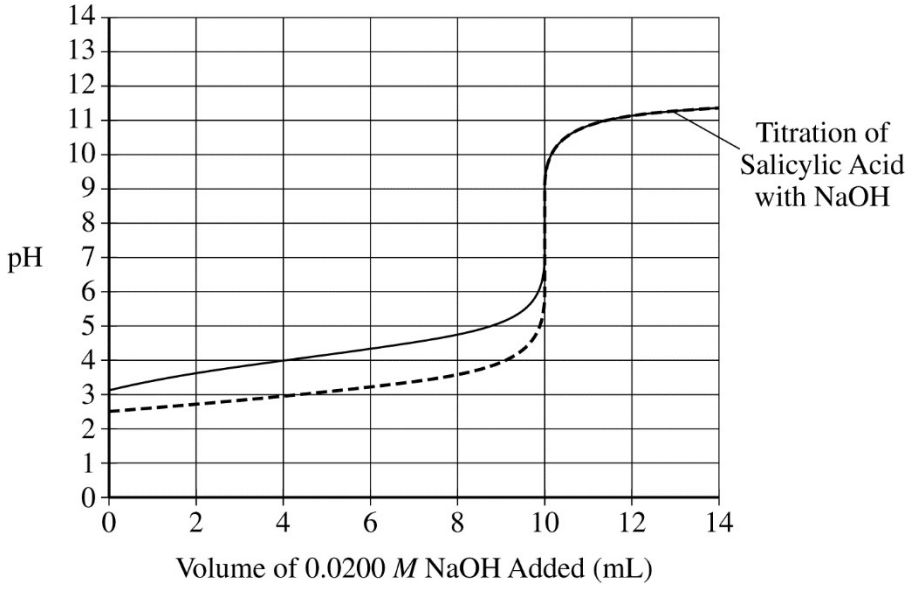
$pK_a = -\log(6.3 \times 10^{-5}) = 4.20$

(h) For a curve that shows a correct starting and half-equivalence point, consistent with part (g): **1 point**

The curve starts at pH ≈ 3.11 *and passes through the* pK_a *calculated in part (g) at* 5 *mL*.
See example response below.

For a curve that shows the correct equivalence point: **1 point**

The curve inflects vertically at 10 *mL showing the same volume of base needed to reach the equivalence point.*



Total for part (h) 2 points

Total for question 1 10 points