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Buffer Capacity and pKa During Weak-Acid Titration

Experiment 15 - Practical Notes

Name: _____ Roll no.: _____ Date: _____

Aim

To determine local buffer capacity and estimate pKa for a suitable weak-acid/strong-base system.

Principle

A weak acid and its conjugate base resist pH change most effectively around comparable concentrations. Buffer capacity is the amount of added strong acid/base per solution volume per pH change. For an ideal monoprotic weak acid, pH at half-equivalence approximates pKa.

Requirements

- Assigned weak-acid solution, standardised strong base and water control.
- Burette, calibrated pH meter, stirrer, volumetric glassware and temperature record.

Procedure

1. Calibrate

Calibrate the pH meter with appropriate buffers at the working temperature. Record acid identity, volume and concentration.

2. Titrate

Add measured base increments, allow mixing/equilibration and record pH and cumulative volume. Use smaller increments near important transitions.

3. Find equivalence

Determine equivalence from the titration curve using the assigned method rather than merely assuming an indicator colour.

4. Estimate pKa

Read pH at half the measured equivalence volume for a suitable monoprotic system. State limitations for concentrated, mixed or polyprotic systems.

5. Capacity

For small intervals calculate $\beta \approx \Delta n_{base}/(V_{average}\,\Delta pH)$, using actual interval solution volume in litres. Compare early, half-equivalence and later stages.

6. Compare

Plot capacity against titration stage/pH and compare with the water control. Large intervals only give average capacity and can mask local behaviour.

Observations and Record

Cumulative base (mL)	pH / total solution volume	Interval β and units
_____	_____	_____
_____	_____	_____
_____	_____	_____

Worked Example

The numbers below are illustrative; enter your own observations in the record.

- If Δnbase = 0.000200 mol, average solution volume = 0.102 L and ΔpH = 0.200, β ≈ 0.00980 mol/L per pH unit.
- For 20.0 mL of 0.100 mol/L monoprotic acid titrated with 0.100 mol/L base, theoretical equivalence is 20.0 mL; half-equivalence is 10.0 mL.
- An illustrative half-equivalence pH of 4.76 gives pKa ≈ 4.76 under the stated approximation.

Result

Record the observed outcome and calculated value, with units. State whether the stated laboratory specification was met; do not copy the worked example as your result.

Precautions

- Use the instructor's assigned material and apparatus; record actual temperature and units with every measured property.
- Check instrument calibration and use repeat readings rather than a single convenient result.
- Compare a marketed teaching formulation only under the same method and conditions; its excipients can change the property.
- Use actual titrant standardisation and account for added volume; rinse the electrode without wiping its sensitive surface harshly.

Viva Questions and Answers

1. Where is a simple buffer usually strongest?

Near pH = pKa when acid and conjugate-base concentrations are comparable.

2. Why include solution volume in capacity?

Capacity is expressed per litre, and titrant addition changes that volume.

3. Is half-equivalence pH always a precise thermodynamic pKa?

No. Activity, concentration and the chemical system affect the approximation.

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