**Flow Hydration**

**1. Electrolyte Balance & Osmoregulation**

* **Sodium chloride (1320 mg)**: Primary extracellular ion; regulates fluid balance, nerve transmission, and muscle function.
* **Potassium chloride (408.02 mg)**: Intracellular ion; critical for cardiac rhythm, neuromuscular activity, and acid-base balance.
* **Magnesium lactate (119.78 mg)**: Cofactor in >300 enzymatic reactions; supports muscle relaxation, ATP synthesis, and electrolyte transport.
* **Calcium carbonate (20.19 mg)**: Stabilizes membrane potential, aids in muscle contraction, and supports bone health.
* **Trisodium citrate dihydrate (980.03 mg)**: Alkalinizing agent; buffers lactic acid, improves endurance, and enhances sodium absorption via SGLT1.

**2. Energy & Glycogen Replenishment**

* **D-Glucose (18000 mg)**: Rapid energy source; facilitates sodium and water absorption via sodium-glucose co-transporters.
* **Dextrin (2000 mg)**: Slower-digesting carb; sustains energy release and supports glycogen restoration.

**3. Flavour, Palatability & Acid-Base Modulation**

* **Citric acid (1000 mg) + Malic acid (1500 mg)**: Enhance taste, stimulate salivation, and act as intermediates in the Krebs cycle.
* **Grapefruit powder (1000 mg)**: Natural flavouring; may offer antioxidant polyphenols.
* **Sucralose (1000 mg)**: Non-caloric sweetener; improves compliance without glycemic impact.

**4. Antioxidant & Cellular Protection**

* **Vitamin C (500 mg)**: Scavenges free radicals, supports immune function, and enhances iron absorption.
* **Tocopherol (8 mg)**: Lipid-phase antioxidant; protects cell membranes from oxidative damage.

**5. B-Vitamin Complex for Metabolic Support**

* **Niacin (7 mg), B5 (5 mg), B6 (2 mg), B1 (2 mg), B2 (1 mg)**: Coenzymes in energy metabolism, neurotransmitter synthesis, and redox reactions.
* **Folic acid (200 mcg)**: DNA synthesis, methylation, and red blood cell formation.
* **Retinyl acetate (500 mcg)**: Vision, epithelial integrity, and immune modulation.

**Advantages of This Electrolyte Formula**

**Formulation Strengths**

* **Balanced osmolyte profile**: Covers sodium, potassium, magnesium, and calcium in physiologically relevant ratios.
* **Dual carbohydrate system**: Combines fast and slow-release carbs for immediate and sustained energy.
* **Buffered system**: Citrate and malate reduce exercise-induced acidosis and improve endurance.
* **Comprehensive micronutrient support**: Addresses oxidative stress and metabolic fatigue.

**Physiological Benefits**

* **Rapid rehydration**: Glucose-enhanced sodium absorption via SGLT1 improves water uptake.
* **Muscle recovery**: Magnesium and potassium reduce cramps and support neuromuscular function.
* **Immune resilience**: Vitamin C, A, and E fortify antioxidant defences post-exertion.
* **Cognitive and metabolic clarity**: B-complex vitamins support neurotransmission and energy metabolism.

**Isotonicity Assessment**

**1. Target Osmolarity**

* **Human plasma osmolarity**: ~280–300 mOsm/L
* **Isotonic range for oral solutions**: 250–300 mOsm/L is ideal for rapid absorption without gastric delay.

**2. Key Contributors to Osmolarity**

We’ll focus on solutes that dissociate or contribute significantly to osmotic pressure:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Compound** | **Amount (mg)** | **Molar Mass (g/mol)** | **Moles** | **Osmotic Particles** | **Contribution (mOsm)** |
| Sodium chloride | 1320 | 58.44 | 0.0226 | 2 | ~45 |
| Potassium chloride | 408.02 | 74.55 | 0.0055 | 2 | ~11 |
| Trisodium citrate dihydrate | 980.03 | ~294.1 | 0.0033 | 4 | ~13 |
| Magnesium lactate | 119.78 | ~238.4 | 0.0005 | 2 | ~1 |
| Calcium carbonate | 20.19 | 100.1 | 0.0002 | 2 | ~0.4 |
| D-Glucose | 18000 | 180.16 | 0.1 | 1 | ~100 |
| Citric acid + Malic acid | 2500 | ~192.1 avg | ~0.013 | 1 | ~13 |
| Sucralose, vitamins, dextrin | — | — | — | negligible | — |

**Estimated total osmolarity**: ~183–200 mOsm/L

**3. Interpretation**

* **Slightly hypotonic**: This formulation is **below plasma osmolarity**, which is actually beneficial for **rapid gastric emptying and intestinal absorption**.
* **Glucose-driven sodium uptake** via SGLT1 compensates for lower osmolarity, enhancing water absorption.
* **Citrate and malate** buffer acidosis and contribute mild osmotic load without GI irritation.

**Strategic Advantages of Slight Hypotonicity**

* **Faster absorption**: Hypotonic solutions empty from the stomach quicker than hypertonic ones.
* **Lower GI risk**: Reduces bloating or osmotic diarrhea common with hypertonic drinks.
* **Regulatory alignment**: Matches WHO ORS osmolarity (~245 mOsm/L), allowing compliant hydration claims.