

2.7 Nitrogen metabolism and the urea cycle

Name: _____ Class: _____ Date: _____

Total: 24 marks

KEY WORDS urea cycle

Objective

Trace nitrogen to urea, balance the daily ledger, and read a urea-cycle vignette.

1 Key knowledge and worked examples

■ The cycle

Transamination → glutamate → liver: $\text{NH}_3 + \text{CO}_2 + \text{aspartate} \rightarrow \text{urea (2 N)}$ at 3 ATP (4 bonds); glutamine and alanine are the taxis.

■ Worked example: the daily ledger

~70–100 g protein/day $\approx$ 11–16 g N; 30 g urea $\times$ 28/60 $\approx$ 14 g N ✓ – the urine matches the diet.

2 Practice

2.1 Which molecule carries nitrogen from brain to liver? [3]

2.2 How many nitrogens does one urea carry, and from which sources? [3]

2.3 Why is ammonia toxic at micromolar levels? [3]

3 Exam-style questions

3.1 A (fictional) patient eats 90 g protein/day.

Compute the nitrogen intake (assume 16 % N by mass). Compute the urea excreted if all N leaves as urea. Verify the ATP cost of that urea per day. [7]

3.2 (Fictional newborn) coma after first feeds; ammonia high, orotic acid in urine.

Localise the block to OTC deficiency. Explain the orotic acid. Explain why the brain, having no cycle, suffers first. State two management levers implied by the mechanism. [8]

Solutions

2.1

- Glutamine (the ammonia taxi).

2.2

- Two: one from free NH_3 (carbamoyl phosphate), one from aspartate.

2.3

- The brain lacks the urea cycle and ammonia drains into glutamate $\rightarrow$ glutamine, depleting intermediates and osmotic balance (astrocyte swelling).

3.1

- $90 \times 0.16 = 14.4 \text{ g N/day}$.
- Urea: $14.4 \div (28/60) = 30.9 \text{ g urea/day}$ ✓.
- Moles: $30.9/60 = 0.515 \text{ mol} \times 3 \text{ ATP} = 1.5 \text{ mol ATP/day} \approx$ ordinary liver expenditure.

3.2

- OTC: carbamoyl phosphate cannot enter the cycle; it spills to cytosolic pyrimidine synthesis $\rightarrow$ orotate.
- Brain has no urea cycle $\rightarrow$ ammonia accumulates locally, glutamine pools swell $\rightarrow$ oedema and encephalopathy.
- Levers: limit nitrogen intake; scavenge/alternatives (benzoate/ phenylbutyrate) and feed arginine/citrulline.