

2.4 TCA cycle and oxidative phosphorylation

Name: _____ Class: _____ Date: _____ **Total: 24 marks**

KEY WORDS ATP synthase ATP

Objective

Count reducing equivalents, protons and ATP through the TCA cycle and the chain.

1 Key knowledge and worked examples

■ **Per-acetyl yield**

3 NADH + 1 FADH₂ + 1 GTP per TCA turn. Chain: 10 H⁺/NADH, 6 H⁺/FADH₂, ~4 H⁺/ATP ⇒ 2.5 and 1.5.

■ **Worked example: the glucose total**

Counting every carrier: 2 + 5 (glyc NADH, malate) + 5 (PDH) + 2 GTP + 15 + 3 = **32 ATP** (malate) or **30** (glycerol-P) ✓.

2 Practice

2.1 How many protons does one FADH₂ pump, and why fewer than NADH? [3]

2.2 Compute ATP per acetyl-CoA through TCA + chain. [3]

2.3 Which complex does NOT pump protons? [3]

3 Exam-style questions

3.1 Compute the full aerobic ATP yield per glucose, showing every contribution.

List the NADH/FADH₂ sources with counts, convert with 2.5/1.5, and sum. Compare with the older 36–38 count and explain the difference. [8]

3.2 (Fictional) cyanide poisoning vignette.

State the inhibited complex and the immediate consequence for the proton gradient. Explain why venous blood is bright red and lactate rises. Give the mechanism-first rationale for one antidote approach. [7]

Solutions

2.1

- 6 H^+ (enters at complex II, skipping I: 4+2).

2.2

- $3 \times 2.5 + 1 \times 1.5 + 1 \times 1 = 10$ ATP-equivalents ✓.

2.3

- Complex II (succinate dehydrogenase / FADH_2 entry).

3.1

- Sources: glycolysis 2 ATP + 2 NADH; PDH 2 NADH; TCA 6 NADH + 2 FADH_2 + 2 GTP.
- Malate shuttle: $2 + 5 + 5 + 15 + 3 + 2 = \mathbf{32 \text{ ATP}}$ ✓; glycerol-P shuttle: $2 + 3 + 5 + 15 + 3 + 2 = \mathbf{30}$ ✓.
- The older 36–38 used P/O 3 and 2 – the ratio convention, not the bookkeeping, differs.

3.2

- Complex IV blocked: electrons stop, pumping stops, gradient collapses, ATP synthase stalls.
- Tissues cannot consume O_2 (venous blood red); ATP falls $\rightarrow$ glycolysis alone $\rightarrow$ lactate rises.
- Antidote rationale: hydroxocobalamin binds cyanide / nitrites shift Hb to a form that competes – mechanism-first.