

2.3 Bioenergetics and glycolysis

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

KEY WORDS glycolysis

Objective

Track carbons, ATP and control through glycolysis, and reason about a blocked gate.

1 Key knowledge and worked examples

■ **The ledger**

Glucose → 2 pyruvate: invest 2 ATP, return 4 ATP + 2 NADH – net 2 ATP + 2 NADH. Gates: hexokinase –16.7, PFK-1 –14.2 (committed), pyruvate kinase –23.0 kJ/mol.

■ **Worked example: the anaerobic ceiling**

Without O₂ the 2 NADH are spent on lactate: yield exactly 2 ATP per glucose ✓. PFK-1 reads AMP (on), ATP/citrate (off), F-2,6-BP (strongly on).

2 Practice

2.1 Where does the carbon of glucose end up anaerobically? [3]

2.2 Name the enzyme of the payoff phase that MAKES ATP directly. [3]

2.3 Why is hexokinase NOT the committed step? [3]

3 Exam-style questions

3.1 A cell has 1 glucose and no oxygen.

Trace the fate of all six carbons. Count net ATP and the NAD⁺/NADH turnover. Explain why the process must stop if NAD⁺ is not regenerated. State the enzyme that performs regeneration. [8]

3.2 (Fictional) PFK-1 deficiency, exertional cramps, no lactate rise on sprint testing.

Localise the block precisely and explain the absent lactate. State which glycolytic intermediates accumulate. Predict the effect of an infusion of fructose-1,6-bisphosphate bypass candidates and why this does not fully rescue muscle. [7]

Solutions

2.1

- Two lactate molecules (3 C each): pyruvate reduced by NADH.

2.2

- Phosphoglycerate kinase and pyruvate kinase (both substrate-level).

2.3

- Other sugars (fructose, galactose) also enter via hexokinase-type phosphorylation – the step is not unique to glycolysis; PFK-1 is.

3.1

- $6 \text{ C} \rightarrow 2 \times \text{pyruvate (3 C each)} \rightarrow 2 \times \text{lactate}$.
- Net 2 ATP (invest 2, return 4); 2 NADH made in payoff, consumed by lactate dehydrogenase.
- Without NAD^+ regeneration, G3P dehydrogenase halts and the payoff phase stops.
- Regeneration: lactate dehydrogenase.

3.2

- Block: after F-6-P, before F-1,6-BP – the committed gate.
- Lactate absent because glycolytic flux never reaches pyruvate.
- Accumulate: glucose-6-P, fructose-6-P (and glucose uptake slows by feedback).
- Downstream intermediates cannot cross the membrane efficiently nor restore the full pathway's regulation in intact muscle.