18.1

**Summary questions**

1. **Dehydrogenation** – removal of hydrogen from triose phosphate molecules to form pyruvate **and** reduction of NAD / formation of reduced NAD (1); **phosphorylation** – addition of phosphate group to a glucose molecule forming hexose bisphtophate (1); (both) catalysed by enzymes (1).

2. NAD accepts hydrogen (atom) **and is reduced** (1) during the formation of pyruvate (1); supplies hydrogen to enzyme involved in later stage of respiration (1).

3. Addition of phosphate group (1); to ADP (1); **or** formation of ATP (using phosphate) from another molecule (1).

4. **Dehydrogenation** – hydrogen removed in breakdown of glucose (1); hydrogen required at a later stage (1). **Phosphorylation** – addition of phosphate groups destabilises (large) molecules/glucose (1); leads to breakdown of glucose (1); and synthesis of ATP (1).

18.2

**Summary questions**

1. Hydrogen is also removed (1); removal of hydrogen oxidises pyruvate (1).

2. Acetyl group (1); carbon dioxide (1)

3. Pyruvate (1); acetyl CoA (1); reduced NAD (1);

4. Enzymes required are in cytoplasm/ORA (1); glucose molecule too large to move into mitochondrion (1); no transport proteins for pyruvate (1); mitochondria not originally present in (eukaryotic) cells (1).

18.3

**Summary questions**

1. **ATP** – three phosphate groups (1); one ribose (1); one nitrogenous base (1); **NAD** – two phosphate groups (1); two riboses (1); two nitrogenous bases (1) (max 3 comparisons)

2. Idea that it is used to link reactions (1); idea that energy is released as a result of the activity of one enzyme and used by another enzyme (1).

3. Students answers may vary but must include: glucose to triose phosphate (1); triose phosphate to pyruvate (1); addition of two ATP (1); production of four ATP **and** two reduced NAD (1) (2 max).

4. One per turn (1) two in total (1).

5. Hydrogen needs to be removed for cycle to continue (1); hydrogen removed using NAD/FAD and reduced (1), then NAD/FAD are oxidised at electron transport chain (1); oxygen required for electron transport (1).

6. Enzymes are specific (1); active site complementary to substrate (1); different steps have different substrates (1); different steps require different enzymes (1); different enzymes (may) require different coenzymes (1); only one step in cycle has enzyme which requires FAD coenzyme (1).

18.4

**Summary questions**

1. Actively pumped to increase concentration gradient (1); energy required as moving from low to high concentration (1); membrane impermeable to ions so ions diffuse down concentration gradient (1); ATP synthase provides hydrophilic channel (1).

2. Reduced NAD releases electrons to carriers at the start of the ETC (1); reduced FAD releases electrons to carriers after the start of the ETC (1); with FAD electrons transported a shorter distance (1); so fewer protons are actively transported (1).

3. Stops flow of electrons (1); stops active transport of protons (1); proton gradient not formed (1); (less) ATP synthesised; so less energy available for (vital) metabolic processes (1).
4 ATP synthase is not actually part of the electron transport chain – agree (1); not an electron carrier (1).

Oxygen is required for the transfer of electrons along the electron transport chain – agree (1); oxygen is final electron acceptor, required for electron transport (1) Hydrogen ions return to the matrix by facilitated diffusion – agree (1); diffuse through hydrophilic channels (of ATP synthase) (1).

18.5

Investigation into respiration rates in yeast
1 Vacuum flask to control the temperature (1); paraffin prevents oxygen entering the solution (1); ensures respiration is anaerobic (1).
2 Tangent drawn a steepest part of curve (1); change in CO₂ ppm (y axis) divided by change in time s (x axis) (1); based on the following values (sensible answer but others accepted) 1500/250 = 6 ppm / s (1).
3 Respiratory substrate used up (1); accumulation of metabolic waste/alcohol (1); toxic to yeast (1)
4 Layer of liquid paraffin removed (1); (then) investigation carried out as for anaerobic respiration (1)

Small-scale and large-scale adaptations to low oxygen environments
1 Flexible rib cage; idea that lungs can collapse under high pressure (1); air compressed (1); maintaining concentration gradients (1); exhalation before inhalation (1); increase proportion of air exchanged (1); larger lungs would increase buoyancy (1); more energy would be used during dives (1).
2 Streamlined (1); heart rate slowed (1); reduced energy requirements (1); blowhole on top of the head (1); large breath (when surface) (1); larger red blood cells (1); more haemoglobin (1); more blood (1); faster oxygen transport (1); more myoglobin (1); increased oxygen storage (1).

Summary questions
1 Yeast cells normally respire aerobically (1); can respire anaerobically when required (1)
2 Electron transport chains present in some types of anaerobic respiration (1); aerobic respiration always includes presence of electron transport chains (1); no electron transport chains present in lactate fermentation (1).
3 Increase in lactic acid leads to decrease in pH (1), muscle contraction depends on protein (1) e.g., enzymes, contractile proteins (1); decreasing pH denatures protein (1); protein no longer functional (1).
4 Red blood cells adapted to carry oxygen (1); lack of mitochondria means more space for haemoglobin (1); increased oxygen transport (1); lactic acid not produced in cardiac muscle (1); enzymes not denatured, no fatigue (1); blood flow to rest of organism not interrupted (1).

18.6

Calculating the respiratory quotient
1 At rest 10/10.5 = 0.95 (1); in flight 113.6/160 = 0.71 (1).
2 Respiratory substrate changes (1); (from) mainly carbohydrate to carbohydrate and lipid (1)

Low carbohydrate diets
1 Statement is accurate triglycerides are hydrolysed to fatty acids (and glycerol) (1); fatty acids, broken down/oxidised, to acetyl groups / acetyl-coA (1); acetyl group transferred to, oxaloacetate / Krebs cycle (1); carbohydrates / pyruvate, maintain oxaloacetate level / keep Krebs cycle going (1); statement is inaccurate not all fats are triglycerides (1).
2 Benefits weight loss (1); (relatively) fast (1); diabetes risk reduced (1); drawbacks intake of, healthy foods/fruit/vegetables, reduced (1); increased, gluconeogenesis / described (1); increased lipid metabolism (1), risk of ketosis (1); increased protein metabolism (1); risk of, liver/kidney, damage (1); muscle wastage/described (1).
Practical investigations into the factors affecting rate of respiration using respirometers

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Respirometer</th>
<th>Reading at start (cm³)</th>
<th>Reading after 20 minutes (cm³)</th>
<th>Difference (cm³)</th>
<th>Corrected difference (cm³)</th>
<th>Rate of oxygen uptake (cm³ min⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>A</td>
<td>0.93</td>
<td>0.74</td>
<td>0.19</td>
<td>0.16</td>
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<td>0.04</td>
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</tr>
</tbody>
</table>

C rows are beads only, used to get the corrected differences.

2 To make the volume of contents / peas, the same (1); volume of peas in A is greater than volume of peas in B (1); peas in A have absorbed more water (1); without beads there would be more, air/oxygen (1).

3 Find difference in volume between soaked peas and dry peas (1); difference represents the volume of glass beads required (1); calculate volume of one bead to determine number of beads required (1).

4 Increased kinetic energy (1); of enzymes / named, involved (1).

5 Reactions, require aqueous medium, take place in water (1); so enzymes and substrates can collide (1); soaked seeds need more energy (1); ORA for named process e.g., protein synthesis (1).

Summary questions

1 Triglyceride is broken down into fatty acids and glycerol (1); fatty acids undergo beta oxidation forming acetyl groups (1); acetyl groups are taken into Krebs cycle by coenzyme A (1); glycerol is converted to pyruvate, which undergoes oxidative phosphorylation (1).

2 Both measure oxygen uptake/carbon dioxide release (1); so rate of respiration (1); respirometer is modified spirometer/(usually) used for smaller organisms (1).

3 A – carbohydrate/C₆H₁₂O₆ = 12/24 = 50% (1)
   B – amino acid/C₂NO₂H₅ = 5/10 = 50% (1)
   C – fatty acid/C₁₈O₂H₃₆ = 36/56 = 64% (1)

Highest proportion of hydrogen in fatty acid because it has more C–H bonds (1); lipids have highest energy value (1); equal proportion of hydrogen in carbohydrate and amino acid so carbohydrate and protein energy values are (almost) the same (1).