Higher Human Biology

Unit 2 - The Continuation of Life

Topic 4: Delivery of nutrients to Cells
1. The graph below shows the percentage saturation of a solution of haemoglobin plotted against the concentration of oxygen dissolved in the surrounding fluid at different temperatures.

![Graph showing the percentage saturation of a solution of haemoglobin plotted against the concentration of oxygen dissolved in the surrounding fluid at different temperatures.](image)

(a) (i) Describe a difference between the affinity of haemoglobin for oxygen at 10 °C and at 43 °C.

(ii) Calculate the difference in percentage saturation at 20 °C and at 38 °C when the concentration of oxygen is 40 units.

_Space for calculation_

Answer __________________________ (1)

_Marks_
2. The graph below shows oxygen-haemoglobin dissociation curves at 37°C and at 38°C.

(a) (i) Complete the table below to show the change in percentage oxygen saturation of haemoglobin at 37°C and 38°C when the partial pressure drops from 18 to 6 kPa.

<table>
<thead>
<tr>
<th>Partial pressure of oxygen (kPa)</th>
<th>Percentage oxygen saturation of haemoglobin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>37°C</td>
</tr>
<tr>
<td>18</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>change</td>
<td></td>
</tr>
</tbody>
</table>

(ii) Explain why this change in percentage oxygen saturation of haemoglobin improves the efficiency of working muscles.

(b) The partial pressure of oxygen in fresh air is 20 kPa. The partial pressure of oxygen in the alveoli is 16 kPa. Explain why there is a lower value for oxygen in the alveoli.
3. Oxygen consumption is often used to measure the intensity of exercise. 

\( V_O^{2\text{max}} \) is the maximum rate at which someone can take up and use oxygen.

Graph 1 shows the \( V_O^{2\text{max}} \) of office workers, and various professional sportsmen and sportswomen.

<table>
<thead>
<tr>
<th>Key</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>X</td>
</tr>
<tr>
<td>Male</td>
<td></td>
</tr>
</tbody>
</table>

**Marks**

(a) (i) What is the difference between the \( V_O^{2\text{max}} \) of a male cross-country skier and a male office worker?

*Space for calculation*

(ii) Cross-country skiing is a very energy demanding sport.

What is the advantage to a cross-country skier of having a high \( V_O^{2\text{max}} \)?

(b) Calculate the oxygen uptake, during a three minute race, of a female rower who weighs 85 kg. Assume that she has maximum oxygen uptake throughout the race.

*Space for calculation*

(c) The graph shows that, on average, men have higher maximum oxygen uptakes than women.

Suggest a reason for this difference.
Tests which determine the VO$_{2\text{max}}$ of individuals use the relationship between heart rate and oxygen uptake.

The maximum oxygen uptake occurs when an individual's heart is beating at its maximum rate.

Graph 2 shows measurements of heart rate and oxygen uptake for a professional sportsman and an office worker, who are both 24 years old. The measurements were taken as speed was gradually increased on a treadmill.

(d) (i) An individual's maximum heart rate can be calculated by subtracting their age from 220.

Calculate the maximum heart rate of the office worker.

*Space for calculation*

_________________ beats/min 1

(ii) **Use the graph** to predict the maximum oxygen uptake of the office worker.

_________________ litres/min 1

(iii) The sportsman weighed 60 kg.

Use the information in graphs 1 and 2 to determine his sport.

_________________ 1
4. An investigation was carried out to find out how the percentage concentration of carbon dioxide (CO₂) in inhaled air affects the volume of air breathed and the breathing rate. Ten subjects were chosen and tested at seven different concentrations of CO₂.

The graphs below show the results of this investigation.

Graph 1 Effect of CO₂ concentration on the volume of air inhaled

Graph 2 Effect of CO₂ concentration on the breathing rate

(a) From Graph 1, what is the volume of air inhaled in one minute when the CO₂ concentration is 3%?

(b) From Graph 2, describe the effect of increasing CO₂ concentration on breathing rate.

(c) (i) Complete the table below to show the mean volume of air inhaled in a single breath at each of the concentrations of CO₂ given.

<table>
<thead>
<tr>
<th>CO₂ concentration of inhaled air (%)</th>
<th>Volume of air inhaled per minute (dm³)</th>
<th>Breathing rate (breaths per minute)</th>
<th>Mean volume of one breath (dm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6</td>
<td>12</td>
<td>0.50</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. (c) (continued)

(ii) Draw a graph to show the relationship between the concentration of CO₂ in inhaled air and the mean volume of one breath.

(iii) What conclusion can be drawn from the graph? Quote data from your graph to illustrate your answer.

(d) (i) Before each reading was taken, each subject breathed the air samples for two minutes. Suggest a reason for this.

(ii) Suggest another variable, apart from time, which would have to be controlled between each reading.

(e) Suggest why ten subjects were chosen rather than just one.
5.  (a) The diagram below shows two views of a red blood cell.

(i) The diameter of the red blood cells is 7 μm (micrometres). By how many times has the cell shown above been magnified?

Space for calculation

Number of times magnified  

(ii) The structure of a red blood cell is related to its function. State a feature shown in the diagram which aids the absorption and release of oxygen.

Feature  

(b) Name a vitamin essential for red blood cell production.
(c) Complete the blanks in the boxes in the following diagram which summarises information about the life history of red blood cells.

Site of production of red blood cells

Life span of red blood cells

Two organs where red blood cells are broken down
1. 
2. 

Breakdown products of red blood cells

A pigment present in bile

A mineral which is stored in the liver

(continued)
6. The diagram below shows stages in the life history of a red blood cell.

(a) Vitamin B$_{12}$ and iron are both used in the production of red blood cells.

(i) What substance is needed for the absorption of Vitamin B$_{12}$ from the gut?

__________________________

1

(ii) Which molecule requires iron for its production?

__________________________

1

(b) On average, how long do red blood cells remain in circulation?

__________________________

1

(c) At any given time there are 5.5 million red blood cells in 1 millilitre of human blood.

Calculate how many red blood cells will be in the circulation of an individual who has a total blood volume of 5 litres.

Space for calculation

__________________________

1
6. (continued)

(d) Explain how the structure of a red blood cell

(i) makes it very efficient at absorbing oxygen.

(ii) allows it to pass through capillaries.

(e) Apart from the liver, name a body site where red blood cells are broken down.

(f) One of the final products of the breakdown of red blood cells is bile.

(i) Where is bile stored in the body?

(ii) Explain the importance of bile salts in the digestion of lipids.

[Turn over]
(a) (i) Analysis of a blood sample yielded the following blood cell counts.

<table>
<thead>
<tr>
<th>Cell type</th>
<th>Number per mm$^3$ (x 1000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>8</td>
</tr>
<tr>
<td>Red</td>
<td>5600</td>
</tr>
</tbody>
</table>

Express as a simple ratio the number of white cells to red cells in this blood sample.

Space for calculation

\[ \text{White} : \text{Red} \]

1

(ii) Predict how the proportion of white cells to red cells would change if a person was suffering from influenza.

1

(b) Explain how the shape of the red blood cell is related to its function.

2

(c) Haemoglobin is found in red blood cells. Where in the body are red cells manufactured and destroyed?

2

[Turn over]
8. The diagram below shows the structure of a villus.

(a) (i) Name lymph vessel X.

(ii) Describe the role of lymph vessel X in the transport of nutrients.

(b) (i) Vitamin B_{12} is absorbed into the blood capillaries of the villus. Name the substance which must be present before vitamin B_{12} can be absorbed.

(ii) Which type of body cell requires vitamin B_{12} for its manufacture?

(c) Name the blood vessel which transports nutrient-rich blood away from the small intestine.
9. The flow diagram below summarises what happens in the body after a meal of fish and chips.

Digestion of fish and chips in the stomach and small intestine

Absorption of the products of digestion through the walls of the small intestine

Metabolism of some absorbed substances by the liver

Transport of some products of metabolism around the body in the bloodstream

(a) Explain how bile salts aid the digestion of the fish and chips.

(b) The products of fat digestion are fatty acids and glycerol. Describe the route taken by these products as they move from the small intestine to the bloodstream.
10. The three Figures below show data relating to the ageing process.

**Figure 1**
Changes in body tissue composition with age

![Figures showing body tissue composition with age]

**Figure 2**
Changes in protein requirement with age

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Average daily protein required (g/kg body mass)</th>
<th>Average body mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>1.5</td>
<td>28</td>
</tr>
<tr>
<td>20</td>
<td>0.8</td>
<td>75</td>
</tr>
<tr>
<td>70</td>
<td>0.6</td>
<td>70</td>
</tr>
</tbody>
</table>

**Figure 3**
Changes in bone density with age
10. (continued)

(a) With reference to Figures 1 and 2, calculate the total bone mass of an average twenty-year-old person and an average seventy-year-old person.

Space for calculation

Twenty-year-old _________ Seventy-year-old _________ (1)

(b) Calculate the average yearly loss of bone mass from the age of 20 to the age of 70.

Space for calculation

__________ g/year (1)

(c) What information provided in Figure 3 would suggest that it is misleading to calculate the average yearly loss of bone mass between the ages of 20 and 70?

__________________________________________________________________________________________ (1)
Unit 2: The Continuation of Life

Topic 4: Delivery of Nutrients to Cells

Essay Questions

1. *Give an account of how the structure of a red blood cell relates to its function* (10)

2. *Give an account of the life history of a red blood cell* (10)

3. *Describe the functions of the liver under the following headings:*
   
i) *Production of Urea* (2)
   
   ii) *Metabolism of carbohydrates* (5)

   iii) *Breakdown of red blood cells* (3)

   (10)

4. *Describe the functions of the liver under the following headings:*
   
i) *Carbohydrate metabolism* (4)

   ii) *Protein metabolism* (6)

   (10)