1: Respiration (Cellular and External)

1. What are some of the uses of energy in the human body? Can you name at least 4?

Synthesis: new substances for growth, development and repair

Active Transport: transport materials across cell membrane

Movement: contraction of muscles

Electrochemical activity: Generation of nerve impulses

Heat production: maintain constant body temperature in warm blooded animals

2 (a) What is aerobic respiration?

Breakdown of food substances in the presence of oxygen to release lots of energy.

2 (b) Where does it take place?

Mitochondria of cells

2 (c) What is the chemical word equation for aerobic respiration?

Glucose + Oxygen→ Carbon Dioxide + Water + Lots of energy

C6H12O6 + 6O2 → 6CO2 + 6H2O + Lots of energy

2 (d) What molecule is the energy produced stored as?

It is stored as an adenosine triphosphate (ATP) molecule. Energy stored in phosphate bonds. From ADP to ATP, it is called oxidative phosphorylation and it is an endergonic reaction. When ATP is converted to ADP, the process is de-phosphorylation or hydrolysis and it is an exergonic reaction.

2 (e) What are the 3 stages of aerobic respiration?

Glycolysis	Krebs Cycle	Electron Transport chain
Cytosol	Mitochondrion	
Glucose→ Pyruvate	Electrons	

3 (a) What is anaerobic respiration?

It is the breakdown of food substances in the absence of oxygen to release small amount of energy.

3 (b) What is the chemical and word equation for this in muscle and for yeast?

Fermentation: Glucose→ Carbon Dioxide + Ethanol + Small amount of energy

$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$ + Small amount of energy

Anaerobic Respiration in muscles: Glucose→Lactic Acid + Small amount of energy

$C_6H_{12}O_6 \rightarrow 2CH_3CHOHCOOH$ + Small amount of energy

3 (c) What are some of the uses of fermentation with yeast?

Wine making and bread making which require ethanol

3 (d) Where does it happen in the cell?

Cytosol

3 (e) What happens to muscles due to lactic acid accumulation?

Muscles become fatigued.

Acidosis occurs. The lowering of the pH causes severe pain.

Note: This is an important defense function the body developed in order to prevent a person from using his muscles too much until they die.

3 (f) What is the fate of lactic acid after a period of rest?

Lactic acid is transported to liver and oxidized to produce energy. This converts remaining lactic acid to glucose and transported to muscles (as glycogen) for storage or usage.

3 (g) Which is more efficient, aerobic and anaerobic respiration? Why?

Aerobic respiration. Larger amount of ATP is produced in anaerobic respiration, while waste products of lactic acid or ethanol contain much unused energy and are harmful if allowed to accumulate.

4. What are some differences between respiration and photosynthesis?

Respiration liberates energy while in photosynthesis; energy is stored in carbohydrate molecules. Respiration uses oxygen and releases CO2 and water. Photosynthesis uses CO2 and water to give off oxygen.

Respiration is catabolic (breakdown of glucose) while photosynthesis is anabolic (forms glucose). Respiration occurs all the time and results in loss of dry mass while photosynthesis occurs only in cells with chlorophyll and in presence of sunlight. Dry mass is gained.

5 (a) Why do multicellular organisms need a respiratory system but single celled organisms do not?

Unicellular organisms are small enough for oxygen to simply diffuse through and reach mitochondria for respiration, but multicellular organisms are larger and diffusion cannot happen effectively. Specialised systems for gaseous exchange are needed.

5 (b) Can you define breathing? Inspiration? Expiration?

Breathing	Rhythmic inspirations and expirations, 10-14 per min., automatic with control centers in brain
Inspiration	Process in which air is taken into body
Expiration	Process in which air is given out from body

5 (c) Where are the lungs located?

They are located in thoracic cavity.

6. Do you know how these structures relate to their function in the respiratory system?

(a) Nose and nasal hair? (also, what are the advantages of breathing through the nose?)

Dust and foreign particles trapped by hair in nostrils and mucus on mucous membrane.

Air is warmed and moistened before it enters the lungs.

Harmful chemicals detected by sensory cells in mucous membrane.

(b) Nasal mucosal gland?

It secretes mucus which helps to trap dust particles and bacteria. Mucus can be swept by mucus hair into stomach to kill bacteria.

(c) Larynx?

Voice box.

(d) Trachea and C shaped cartilage?

Trachea is always open to ensure smooth airflow. C shaped cartilage is sturdy but flexible to provide mechanical support in keeping trachea open. It withstands high pressure during sudden expansions.

(e) Ciliated cells and gland cells along the trachea?

Sweep dust particles up bronchi and trachea into pharynx, to be swallowed into oesophagus. This prevents obstruction of cartilage and kills bacteria automatically through the acidic conditions in stomach.

(f) Bronchus and bronchiole?

Trachea divides into right and left bronchus, which further divides into three and two bronchia tubes respectively. Smallest tubes are bronchioles which each ends in alveoli.

(g) Alveoli? (Can you provide 4 adaptations of the alveoli and explain them?)

They are one cell thick for a high surface area to volume ratio. There is a thin layer of moisture on its surface to allow Oxygen to dissolve into bloodstream. Alveolus is surrounded by blood capillaries to ensure continuous flow of deoxygenated blood for diffusion of oxygen.

(h) Ribs?

Chest wall is supported by ribs, attached in front to sternum.

(i) Diaphragm?

The thorax (chest) is separated from the abdomen by the diaphragm- a thin sheet of tissue. Diaphragm muscles contract (downwards) or relax (upwards) to decrease or increase thoracic volume respectively, causing a pressure difference to force air in or out.

(j) Intercostal muscles?

External intercostal and internal intercostal muscles between ribs. Antagonistic muscles—when one contracts, the other relaxes to move ribs up and down hence changing volume of thoracic cavity.

7. Explain negative pressure breathing.

When the diaphragm contracts and flattens, thoracic cavity expands and this volume increase decreases the pressure inside the lungs to below atmospheric pressure. Air is forced in immediately due to this negative pressure.

External intercostal muscles contract, internal intercostal muscles relax. Ribs swing upwards and outwards, while sternum moved up and further from backbone.

8 (a) How is the diffusion gradient for gas exchange maintained between the alveolar space and the blood?

Movement of ribs and diaphragm forces inspiration of oxygen-rich air.

Continuous pumping of blood by heart in circulatory system.

8 (b) How does the blood carbon dioxide level affect breathing rate?

The higher the CO2 concentration, the higher the breathing rate. Impulses are sent to external intercostal muscles and diaphragm by the brain to increase their contraction rates.

8 (c) How is carbon dioxide transported in the blood and finally expired out in a gaseous form in the lungs? Can you provide the necessary chemical formula for these reactions and the locations of these reactions?

Carbon dioxide is transported in blood mainly as bicarbonate ions in the plasma (70-80%).

$H_20 + CO_2 \leftarrow\rightarrow H_2CO_3 \leftarrow\rightarrow H^+ + HCO_3^-$ (in alveoli, where CO_2 concentration Is low)

EXHALATION: CO2 diffuses out of blood into alveolar cavities. Water enters capillaries through osmosis and evaporates from alveoli walls. Heat also escapes from blood into alveolar air.

8 (d) How is oxygen transported from gaseous form in the alveolar space to the blood to the respiring cells?

During short pause between inspiration and expiration, oxygen dissolves in moisture lining alveolar walls which diffuses into blood. This combines with haemoglobin to form oxyhaemoglobin and enters bloodstream to be transported in circulatory system.

Pulmonary artery→Alveolus→Pulmonary vein

Note: Artery=from the heart Vein=to the heart

9. Can you explain how the breathing rate and heart rate of a person changes when doing rigorous exercise?

During rigorous exercise, more energy is required by body hence breathing rates and heart rates increase until their limit, to supply sufficient oxygen to muscles for aerobic respiration. More blood needs to be circulated to replace oxygen used up. However breathing rates increase until a peak, after which the muscles undergo anaerobic respiration.

10. Can you compare between inspired and expired air? (List 5 differences and 1 similarity)

Inspired Air	**Expired Air**
78% nitrogen	
21% Oxygen	16% oxygen
Water vapour variable	Saturated water vapour
Temperature variable	Temperature around 37C
Dust particles may be present	Little or no dust particles
0.03% Carbon dioxide	4% Carbon dioxide

11 (a) What is the respiratory medium and respiratory surface and in man? Fish?

	Man	**Fish**
Respiratory medium	Air	Water
Respiratory surface	Alveoli of Lungs	Gill filaments

11 (b) What is an advantage and disadvantage of having water as a respiratory medium?

Advantage: Oxygen is already dissolved in water for easy intake.

Disadvantage: There is much less oxygen in water than air.

12 (a) Can you define what is counter-current exchange system and compare it with the concurrent exchange system?

Water flows over gill filaments and in opposite direction to blood flow in capillaries. Hence, continuous diffusion of oxygen into blood takes place.

12 (b) Why is the counter-current exchange system more efficient?

In the counter current exchange system, blood and water flow in the opposite directions. As water flows over the gill surface, it encounters blood of lower oxygen concentration. Gas exchange occurs over the whole length of the gill filament, thereby increasing the amount of oxygen that diffuses into the blood. In the concurrent exchange system, only 50% of the oxygen is taken in as diffusion would stop in the middle once there is no more diffusion gradient.