

Q10 Describe the changes in inspired and alveolar oxygen partial pressure with increasing altitude. (20% of marks) Outline the respiratory physiological responses to altitude. (80% of marks) (Sept 2009)

Inspired PO₂ (PIO₂) = atmospheric pressure x FiO₂ (21% unless breathing supplemental oxygen)

Inspired air is humidified, hence need to consider the saturated water vapour pressure (SVP) of 47mmHg

PIO₂ = (atmospheric pressure – 47mmHg) x FiO₂ (0.21) = 159mmHg at sea level breathing room air. As altitude increases, atmospheric pressure will fall, however SVP will remain constant.

Alveolar oxygen partial pressure P_AO₂ = PIO₂ – (PCO₂ / R) + F, where R is the respiratory exchange ratio (usually 0.8) and F is a small correction factor, usually 2. Hence as altitude increases, alveolar PO₂ will fall.

PHYSIOLOGICAL RESPONSE TO ALTITUDE:

IMMEDIATE (minutes)

- Respiratory
 - Hyperventilation → most important response, governed by the response of peripheral chemoreceptors to hypoxia. Consider the climber on Mt Everest (PIO₂ = 43mmHg). If PCO₂ were 40 and RER 1, then P_AO₂ would be 3mmHg. By hyperventilating and reducing PCO₂ to 8, P_AO₂ rises to 35mmHg. The resulting low PCO₂ and alkalosis tend to inhibit the hyperventilation, but after 24 hours altered sensitivity of the chemoreceptors occurs along with movement of HCO₃ out of the ECF and renal excretion of HCO₃. This returns the blood pH to normal, and further hyperventilation can then occur.
- CNS
 - Impaired night vision, reduced mental acuity due to hypoxia

SLOWER ONSET (hours to days)

- Respiratory
 - Shift in the dissociation curve – at moderate altitudes, the increase in red cell 2,3 DPG due to hypoxia causes a rightward shift of the O₂/Hb dissociation curve. At higher altitudes the respiratory alkalosis shifts it to the left, increases the unloading of oxygen at the pulmonary capillaries.
 - Maximum breathing capacity increases – up to 200L/min
 - Pulmonary vasoconstriction – hypoxic pulmonary vasoconstriction occurs in response to alveolar hypoxia.
 - Altered peripheral chemoreceptor sensitivity occurs
- Haem
 - Polycythaemia – increase in RBC concentration increases the Hb and thus the oxygen carrying capacity of blood (negative effect of also causing hyperviscosity)
- CVS
 - Increase in the number of capillaries per unit volume
 - The increase in PVR in conjunction with the polycythaemia increases right heart work causing hypertrophy.
- Renal
 - Increase in HCO₃ excretion to compensate for respiratory alkalosis
- Metabolic
 - Alteration of activity of oxidative enzymes