Q3 Outline the anatomy and physiology of humidification during normal breathing (50% of marks). Describe the mechanisms of humidification used within Intensive Care practice (50% of marks) (Sept 2012)

Humidification of air in the respiratory tract:

- Water vapour pressure at atmospheric pressure: 47mmHg
- At the carina: absolute humidity 44g/m3, relative humidity normally 100%
- Optimal function requires: an absolute humidity > 33g/m3 or relative humidity of > 75%
- Typical room air at 22 degrees Celsius with an absolute humidity of 10gH2O/m3 will have a moisture deficit compared to alveolar air.
- Inspired air must be warmed and moistened to prevent structural damage and failure of the mucociliary elevator
- INSPIRED AIR
    - During nose breathing, air flows in a turbulent manner over the nasal epithelium, whose surface area is greatly increased by the nasal turbinates. Air is warmed by the radiant heat from nasal blood supply. As it is warmed, moisture evaporates from the epithelia to increase the relative humidity of the inspired air to ~90%
    - As inspired gas reaches the lungs, it reaches the isothermic saturation boundary where it achieves BTPS (body temperature and pressure, saturated with water vapour) conditions. This usually occurs at the second generation of bronchi.

- EXPIRED AIR
    - During exhalation, expired gas transfers heat back to the cooler trachea and nasal mucosa. As this saturated gas cools, it can hold less water vapour (its saturated water vapour pressure falls) and condensation occurs on the mucosal surfaces, where the liquid water is reabsorbed. Reabsorption reduces potential airway water losses from 300ml/day to ~150ml/day

Mechanisms of humidification used in ICU:

- Heat and Moisture Exchanger (HME) → acts by condensing some of the water vapour in the expired gas via a hygroscopic membrane, which in inspiration evaporates to humidify the inspired gas
- Active humidifiers → use an external heat source to vapourise water in the circuit. Three main types:
    - Bubble humidifiers → inspired gas passes through water in a humidification chamber, providing a large gas/liquid surface for evaporation
    - Pass over humidifiers → contain an element which heats water in a vapourising chamber, raising the temperature and humidity of fresh gas as it passes through the inspiratory limb of the circuit
    - Porous chambers → with a porous surface to humidify gas
    - Nebulisers → produce water droplets with a diameter of ~1micrometer for ease of evaporation in conjunction with a heated element to saturate inspired gas