Chapter 5

Question 5.5

Minimum volume of urine (L) required to excrete the Na^+ absorbed by the gut after drinking 500 mL (= 0.5 L) of seawater

$$= \frac{Na^{+}\text{obtained by absorption from the gut (mmol)}}{\text{maximum } Na^{+}\text{concentration of urine }(\text{mmol L}^{-1})}$$

$$= \frac{Na^{+}\text{concentration of seawater }(\text{mmol L}^{-1}) \times \text{volume of seawater drunk (L)}}{\text{maximum } Na^{+}\text{concentration of urine }(\text{mmol L}^{-1})}$$

$$= \frac{468\ (\text{mmol L}^{-1}) \times 0.5\ (\text{L})}{330\ (\text{mmol L}^{-1})}$$

= 0.709 L

= 709 mL

The seal would be in negative balance as the volume excreted (709 mL) is larger than the intake volume of seawater (500 mL)

The net volume of seawater lost = 709 − 500 mL = 209 mL

Question 5.8

(i) Theoretical concentration of Ca^{2+} in rectal fluid = 10 (mmol L^{-1}) × (100/(100-80))
= 50 mmol L^{-1}

Theoretical concentration of Mg^{2+} in rectal fluid = 53 (mmol L^{-1}) × (100/100-80))
= 265 mmol L^{-1}

(ii)

Percentage removal of Ca^{2+} from solution by gastrointestinal processing

$$= \frac{\text{(theoretical } Ca^{2+}\text{concentration in rectal fluid - measured } Ca^{2+}\text{concentration in rectal fluid)}}{\text{theoretical } Ca^{2+}\text{concentration in rectal fluid}} \times 100$$

From answer (i), theoretical concentration of Ca^{2+} in rectal fluid based on the volume of fluid absorbed = 50 mmol L^{-1}

Measured concentration of Ca^{2+} in rectal fluid given in question = 2 mmol L^{-1}

Therefore:
Percentage removal of Ca^{2+} from solution by gastrointestinal processing = [(50-2) ÷ 50] x 100

Percentage removal of Ca^{2+} from solution by gastrointestinal processing = 96 %

Percentage removal of Mg^{2+} from solution by gastrointestinal processing

$$= \frac{\left(\text{theoretical } Mg^{2+} \text{concentration in rectal fluid - measured } Mg^{2+} \text{concentration in rectal fluid}\right)}{\text{theoretical } Mg^{2+} \text{concentration in rectal fluid}} \times 100$$

From answer (i), theoretical concentration Mg^{2+} in rectal fluid based on volume of fluid absorbed = 265 mmol L^{-1}
Measured concentration Mg^{2+} in rectal fluid given in question = 160 mmol L^{-1}

Therefore:
Percentage removal of Mg^{2+} in solution by gastrointestinal processing = [(265 − 160) ÷ 265] × 100

Percentage removal of Mg^{2+} from solution by gastrointestinal processing = 39.6 %

(iii) The estimated reduction in overall osmolality of intestinal fluids

= (theoretical osmolality) − (osmolality based on measured concentrations of ions) (Equation 1)

Theoretical osmolality based on theoretical total molarity:
Theoretical total molarity = 265 (Mg^{2+}) + 50 (Ca^{2+}) = 315 mmol L^{-1}
Therefore, theoretical osmolality (assuming approximation of 1 mol = 1 osmol) = 315 mOsm kg^{-1}

Osmolality based on measured concentrations of ions:
Measured total molarity due to Mg^{2+} (160), Ca^{2+} (2), and bicarbonate (110) = 160 + 2 + 110 = 272 mmol L^{-1}
Therefore, osmolality from measured values (assuming approximation of 1 mol = 1 osmol) = 272 mOsm kg^{-1}

Substituting the calculated values into Equation 1:

The estimated reduction in overall osmolality of intestinal fluids
= (theoretical osmolality) − (osmolality based on measured concentrations of ions)

= 315 − 272 = **43 mOsm kg^{-1}**

The reduction in osmolality of the intestinal fluids by 43 mOsm kg^{-1} allows additional water absorption, by osmosis, as we discuss in Box 5.1 (available online) and in Section 5.1.3.