Problem Set #6 – Renal Physiology: Urine Concentration, Volume and Flow - Answer Key

1. Suppose you have a urine sample with a urea concentration of 6 g/L.
   How many grams of urea are contained in 200 mL of this urine?
   Concentration (C) and volume (V) are known; solve for grams of solute (S).
   \[ S = C \times V = (6 \text{ g/L}) \times (200 \text{ mL}) = (6 \text{ g/L}) \times (0.2 \text{ L}) = 1.2 \text{ g} \]
   (Note that you convert 200 mL to 0.2 L so that the volume units will cancel)

2. Suppose you perform a dilution by adding 100 mL of this urine to 200 mL of distilled water.
   a) What is the total volume of the diluted urine solution?
      Final volume \( V_2 \) = Initial Volume \( V_1 \) + Volume of dH\(_2\)O \( (V_2 - V_1) \)
      \[ V_2 = 100 \text{ mL} + 200 \text{ mL} = 300 \text{ mL} \]
   b) What is the concentration of urea in the diluted solution?
      \[ C_1V_1 = C_2V_2 \]. C\(_1\), V\(_1\) and V\(_2\) are known, solve for C\(_2\)
      \[ C_2 = \frac{C_1V_1}{V_2} = \frac{(6 \text{ g/L}) \times (100 \text{ mL})}{(300 \text{ mL})} = 2 \text{ g/L} \]

3. Suppose you add 0.9 grams of NaCl to the total volume of the diluted solution you prepared in question 2 above.
   What is the NaCl concentration of this solution in g/L?
   \[ C = \frac{S}{V} = \frac{(0.9 \text{ g})}{(300 \text{ mL})} = \frac{(0.9 \text{ g})}{(0.3 \text{ L})} = 3 \text{ g/L} \]

4. The renal clearance of a substance is defined as the volume of blood plasma that is totally cleared of the substance per unit time by excretion in the urine. It can be calculated by the formula:
   \[ \text{Clearance} = \frac{\text{Concentration in the urine} \times \text{Urine flow rate}}{\text{Concentration in the plasma}} \]
   The clearance of the polysaccharide inulin provides a useful measurement for analysis of renal function, because it is filtered into the renal tubules but is neither reabsorbed nor actively secreted.
   a) Calculate the clearance of inulin given the following values:
      Concentration of inulin in plasma (P) = 0.1 mg/L
      Concentration of inulin in urine (U) = 6 mg/L
      Urine flow rate (V) = 2 mL/min
      \[ \text{Clearance of inulin} = \frac{U \times V}{P} = \frac{(6 \text{ mg/L}) \times (2 \text{ mL/min})}{(0.1 \text{ mg/L})} = 120 \text{ mL/min} \]
   b) What physiological variable that pertains to renal function is approximately equal to the clearance of inulin? Glomerular filtration rate (GFR)
   c) Suppose that the clearance of inulin and its concentration in the plasma (P) stay the same as in (a) above, but the urine flow rate (V) decreases to 1 mL/min. Calculate the expected concentration of inulin (U) in the urine.
      \[ \text{Clearance and P are the same as above, V is 1 mL/min.} \]
      \[ \text{Concentration of inulin in urine (U)} = \frac{(120 \text{ mL/min}) \times (0.1 \text{ mg/L})}{(1 \text{ mL/min})} = 12 \text{ mg/L} \]