النادي الطبي

GENITOURINARY SYSTEM

SUBJECT : MCQ(BRS)

LEC NO. : 1-7

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Review Test

1. Secretion of K^+ by the distal tubule will be decreased by

(A) metabolic alkalosis
(B) a high-K^+ diet
(C) hyperaldosteronism
(D) spironolactone administration
(E) thiazide diuretic administration

2. Jared and Adam both weigh 70 kg. Jared drinks 2 L of distilled water, and Adam drinks 2 L of isotonic NaCl. As a result of these ingestions, Adam will have a

(A) greater change in intracellular fluid (ICF) volume
(B) higher positive free-water clearance (C_{H_2O})
(C) greater change in plasma osmolarity
(D) higher urine osmolarity
(E) higher urine flow rate

QUESTIONS 3 AND 4

A 45-year-old woman develops severe diarrhea while on vacation. She has the following arterial blood values:

pH = 7.25
Pco_2 = 24 mm Hg
$[HCO_3^-]$ = 10 mEq/L
Venous blood samples show decreased blood $[K^+]$ and a normal anion gap.

3. The correct diagnosis for this patient is

(A) metabolic acidosis
(B) metabolic alkalosis
(C) respiratory acidosis
(D) respiratory alkalosis
(E) normal acid–base status

4. Which of the following statements about this patient is correct?

(A) She is hypoventilating
(B) The decreased arterial $[HCO_3^-]$ is a result of buffering of excess H^+ by HCO_3^-
(C) The decreased blood $[K^+]$ is a result of exchange of intracellular H^+ for extracellular K^+
(D) The decreased blood $[K^+]$ is a result of increased circulating levels of aldosterone
(E) The decreased blood $[K^+]$ is a result of decreased circulating levels of antidiuretic hormone (ADH)

5. Use the values below to answer the following question.

Glomerular capillary hydrostatic pressure = 47 mm Hg
Bowman space hydrostatic pressure = 10 mm Hg
Bowman space oncotic pressure = 0 mm Hg
At what value of glomerular capillary oncotic pressure would glomerular filtration stop?

(A) 57 mm Hg
(B) 47 mm Hg
(C) 37 mm Hg
(D) 10 mm Hg
(E) 0 mm Hg

6. The reabsorption of filtered HCO_3^-

(A) results in reabsorption of less than 50% of the filtered load when the plasma concentration of HCO_3^- is 24 mEq/L
(B) acidifies tubular fluid to a pH of 4.4
(C) is directly linked to excretion of H^+ as NH_4^+
(D) is inhibited by decreases in arterial Pco_2
(E) can proceed normally in the presence of a renal carbonic anhydrase inhibitor

7. The following information was obtained in a 20-year-old college student who was participating in a research study in the Clinical Research Unit:

Plasma	**Urine**
[Inulin] = 1 mg/mL	[Inulin] = 150 mg/mL
[X] = 2 mg/mL	[X] = 100 mg/mL
	Urine flow rate = 1 mL/min

Assuming that X is freely filtered, which of the following statements is most correct?

(A) There is net secretion of X
(B) There is net reabsorption of X
(C) There is both reabsorption and secretion of X
(D) The clearance of X could be used to measure the glomerular filtration rate (GFR)
(E) The clearance of X is greater than the clearance of inulin

8. To maintain normal H^+ balance, total daily excretion of H^+ should equal the daily

(A) fixed acid production plus fixed acid ingestion
(B) HCO_3^- excretion
(C) HCO_3^- filtered load
(D) titratable acid excretion
(E) filtered load of H^+

9. One gram of mannitol was injected into a woman. After equilibration, a plasma sample had a mannitol concentration of 0.08 g/L. During the equilibration period, 20% of the injected mannitol was excreted in the urine. The woman's

(A) extracellular fluid (ECF) volume is 1 L
(B) intracellular fluid (ICF) volume is 1 L
(C) ECF volume is 10 L
(D) ICF volume is 10 L
(E) interstitial volume is 12.5 L

10. A 58-year-old man is given a glucose tolerance test. In the test, the plasma glucose concentration is increased and glucose reabsorption and excretion are measured. When the plasma glucose concentration is higher than occurs at transport maximum (T_m), the

(A) clearance of glucose is zero
(B) excretion rate of glucose equals the filtration rate of glucose
(C) reabsorption rate of glucose equals the filtration rate of glucose
(D) excretion rate of glucose increases with increasing plasma glucose concentrations
(E) renal vein glucose concentration equals the renal artery glucose concentration

11. A negative free-water clearance $(-C_{H_2O})$ will occur in a person who

(A) drinks 2 L of distilled water in 30 minutes
(B) begins excreting large volumes of urine with an osmolarity of 100 mOsm/L after a severe head injury
(C) is receiving lithium treatment for depression and has polyuria that is unresponsive to the administration of antidiuretic hormone (ADH)
(D) has an oat cell carcinoma of the lung, and excretes urine with an osmolarity of 1,000 mOsm/L

12. A buffer pair (HA/A^-) has a pK of 5.4. At a blood pH of 7.4, the concentration of HA is

(A) 1/100 that of A^-
(B) 1/10 that of A^-
(C) equal to that of A^-
(D) 10 times that of A^-
(E) 100 times that of A^-

13. Which of the following would produce an increase in the reabsorption of isosmotic fluid in the proximal tubule?

(A) Increased filtration fraction
(B) Extracellular fluid (ECF) volume expansion
(C) Decreased peritubular capillary protein concentration
(D) Increased peritubular capillary hydrostatic pressure
(E) Oxygen deprivation

14. Which of the following substances or combinations of substances could be used to measure interstitial fluid volume?

(A) Mannitol
(B) D_2O alone
(C) Evans blue
(D) Inulin and D_2O
(E) Inulin and radioactive albumin

15. At plasma para-aminohippuric acid (PAH) concentrations below the transport maximum (T_m), PAH

(A) reabsorption is not saturated
(B) clearance equals inulin clearance
(C) secretion rate equals PAH excretion rate
(D) concentration in the renal vein is close to zero
(E) concentration in the renal vein equals PAH concentration in the renal artery

16. Compared with a person who ingests 2 L of distilled water, a person with water deprivation will have a

(A) higher free-water clearance (C_{H_2O})
(B) lower plasma osmolarity
(C) lower circulating level of antidiuretic hormone (ADH)
(D) higher tubular fluid/plasma (TF/P) osmolarity in the proximal tubule
(E) higher rate of H_2O reabsorption in the collecting ducts

17. Which of the following would cause an increase in both glomerular filtration rate (GFR) and renal plasma flow (RPF)?

(A) Hyperproteinemia
(B) A ureteral stone

(C) Dilation of the afferent arteriole
(D) Dilation of the efferent arteriole
(E) Constriction of the efferent arteriole

18. A patient has the following arterial blood values:

pH = 7.52
Pco_2 = 20 mm Hg
$[HCO_3^-]$ = 16 mEq/L

Which of the following statements about this patient is most likely to be correct?

(A) He is hypoventilating
(B) He has decreased ionized $[Ca^{2+}]$ in blood
(C) He has almost complete respiratory compensation
(D) He has an acid–base disorder caused by overproduction of fixed acid
(E) Appropriate renal compensation would cause his arterial $[HCO_3^-]$ to increase

19. Which of the following would best distinguish an otherwise healthy person with severe water deprivation from a person with the syndrome of inappropriate antidiuretic hormone (SIADH)?

(A) Free-water clearance (C_{H_2O})
(B) Urine osmolarity
(C) Plasma osmolarity
(D) Circulating levels of antidiuretic hormone (ADH)
(E) Corticopapillary osmotic gradient

20. Which of the following causes a decrease in renal Ca^{2+} clearance?

(A) Hypoparathyroidism
(B) Treatment with chlorothiazide
(C) Treatment with furosemide
(D) Extracellular fluid (ECF) volume expansion
(E) Hypermagnesemia

21. A patient arrives at the emergency room with low arterial pressure, reduced tissue turgor, and the following arterial blood values:

pH = 7.69
$[HCO_3^-]$ = 57 mEq/L
Pco_2 = 48 mm Hg

Which of the following responses would also be expected to occur in this patient?

(A) Hyperventilation
(B) Decreased K^+ secretion by the distal tubules
(C) Increased ratio of $H_2PO_4^-$ to HPO_4^{-2} in urine
(D) Exchange of intracellular H^+ for extracellular K^+

22. A woman has a plasma osmolarity of 300 mOsm/L and a urine osmolarity of 1200 mOsm/L. The correct diagnosis is

(A) syndrome of inappropriate antidiuretic hormone (SIADH)
(B) water deprivation
(C) central diabetes insipidus
(D) nephrogenic diabetes insipidus
(E) drinking large volumes of distilled water

23. A patient is infused with para-aminohippuric acid (PAH) to measure renal blood flow (RBF). She has a urine flow rate of 1 mL/min, a plasma [PAH] of 1 mg/mL, a urine [PAH] of 600 mg/mL, and a hematocrit of 45%. What is her "effective" RBF?

(A) 600 mL/min
(B) 660 mL/min
(C) 1,091 mL/min
(D) 1,333 mL/min

24. Which of the following substances has the highest renal clearance?

(A) Para-aminohippuric acid (PAH)
(B) Inulin
(C) Glucose
(D) Na^+
(E) Cl^-

25. A woman runs a marathon in 90°F weather and replaces all volume lost in sweat by drinking distilled water. After the marathon, she will have

(A) decreased total body water (TBW)
(B) decreased hematocrit
(C) decreased intracellular fluid (ICF) volume
(D) decreased plasma osmolarity
(E) increased intracellular osmolarity

26. Which of the following causes hyperkalemia?

(A) Exercise
(B) Alkalosis
(C) Insulin injection
(D) Decreased serum osmolarity
(E) Treatment with β-agonists

27. Which of the following is a cause of metabolic alkalosis?

(A) Diarrhea
(B) Chronic renal failure
(C) Ethylene glycol ingestion
(D) Treatment with acetazolamide
(E) Hyperaldosteronism
(F) Salicylate poisoning

28. Which of the following is an action of parathyroid hormone (PTH) on the renal tubule?

(A) Stimulation of adenylate cyclase
(B) Inhibition of distal tubule K^+ secretion
(C) Inhibition of distal tubule Ca^{2+} reabsorption
(D) Stimulation of proximal tubule phosphate reabsorption
(E) Inhibition of production of 1,25-dihydroxycholecalciferol

29. A man presents with hypertension and hypokalemia. Measurement of his arterial blood gases reveals a pH of 7.5 and a calculated HCO_3– of 32 mEq/L. His serum cortisol and urinary vanillylmandelic acid (VMA) are normal, his serum aldosterone is increased, and his plasma renin activity is decreased. Which of the following is the most likely cause of his hypertension?

(A) Cushing syndrome
(B) Cushing disease
(C) Conn syndrome
(D) Renal artery stenosis
(E) Pheochromocytoma

30. Which set of arterial blood values describes a heavy smoker with a history of emphysema and chronic bronchitis who is becoming increasingly somnolent?

	pH	HCO_3^- (mEq/L)	P_{CO_2} (mm Hg)
(A)	7.65	48	45
(B)	7.50	15	20
(C)	7.40	24	40
(D)	7.32	30	60
(E)	7.31	16	33

31. Which set of arterial blood values describes a patient with partially compensated respiratory alkalosis after 1 month on a mechanical ventilator?

	pH	HCO_3^- (mEq/L)	P_{CO_2} (mm Hg)
(A)	7.65	48	45
(B)	7.50	15	20
(C)	7.40	24	40
(D)	7.32	30	60
(E)	7.31	16	33

32. Which set of arterial blood values describes a patient with chronic renal failure (eating a normal protein diet) and decreased urinary excretion of NH_4^+?

	pH	HCO_3^- (mEq/L)	P_{CO_2} (mm Hg)
(A)	7.65	48	45
(B)	7.50	15	20
(C)	7.40	24	40
(D)	7.32	30	60
(E)	7.31	16	33

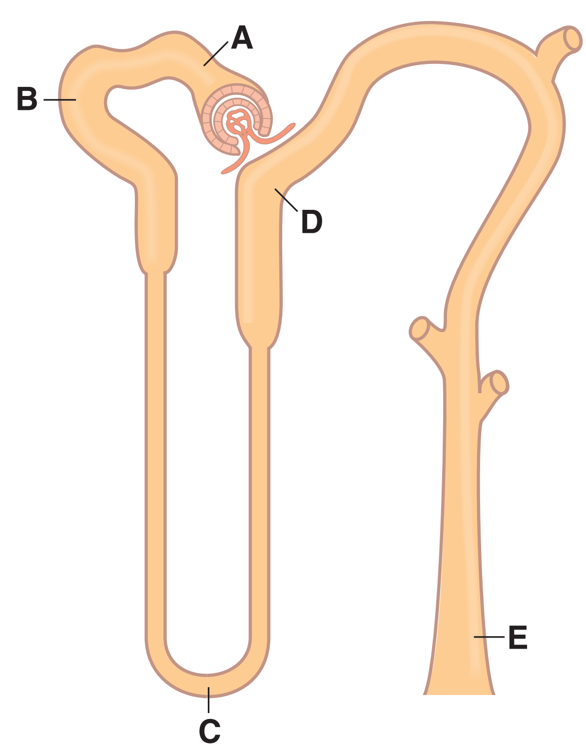
33. Which set of arterial blood values describes a patient with untreated diabetes mellitus and increased urinary excretion of NH_4^+?

	pH	HCO_3^- (mEq/L)	P_{CO_2} (mm Hg)
(A)	7.65	48	45
(B)	7.50	15	20
(C)	7.40	24	40
(D)	7.32	30	60
(E)	7.31	16	33

34. Which set of arterial blood values describes a patient with a 5-day history of vomiting?

	pH	HCO_3^- (mEq/L)	P_{CO_2} (mm Hg)
(A)	7.65	48	45
(B)	7.50	15	20
(C)	7.40	24	40
(D)	7.32	30	60
(E)	7.31	16	33

The following figure applies to Questions 35–39.



35. At which nephron site does the amount of K^+ in tubular fluid exceed the amount of filtered K^+ in a person on a high-K^+ diet?

(A) Site A
(B) Site B
(C) Site C
(D) Site D
(E) Site E

36. At which nephron site is the tubular fluid/plasma (TF/P) osmolarity lowest in a person who has been deprived of water?

(A) Site A
(B) Site B
(C) Site C
(D) Site D
(E) Site E

37. At which nephron site is the tubular fluid inulin concentration highest during antidiuresis?

(A) Site A
(B) Site B
(C) Site C
(D) Site D
(E) Site E

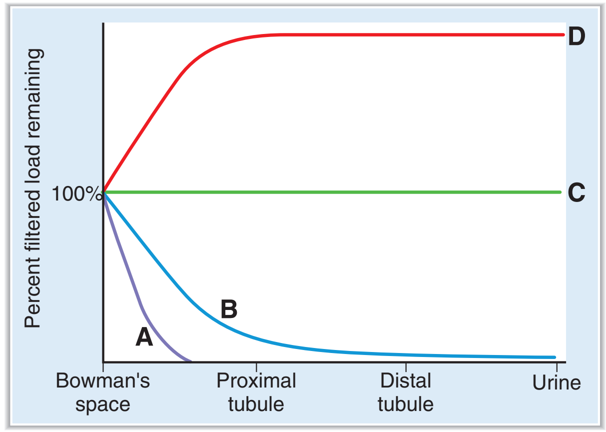
38. At which nephron site is the tubular fluid inulin concentration lowest?

(A) Site A
(B) Site B
(C) Site C
(D) Site D
(E) Site E

39. At which nephron site is the tubular fluid glucose concentration highest?

(A) Site A
(B) Site B
(C) Site C
(D) Site D
(E) Site E

The following graph applies to Questions 40–42. The curves show the percentage of the filtered load remaining in the tubular fluid at various sites along the nephron.



40. Which curve describes the inulin profile along the nephron?

(A) Curve A
(B) Curve B
(C) Curve C
(D) Curve D

41. Which curve describes the alanine profile along the nephron?

(A) Curve A
(B) Curve B
(C) Curve C
(D) Curve D

42. Which curve describes the para-aminohippuric acid (PAH) profile along the nephron?

(A) Curve A
(B) Curve B
(C) Curve C
(D) Curve D

43. A 5-year-old boy swallows a bottle of aspirin (salicylic acid) and is treated in the emergency room. The treatment produces a change in urine pH that increases the excretion of salicylic acid. What was the change in urine pH, and what is the mechanism of increased salicylic acid excretion?

(A) Acidification, which converts salicylic acid to its HA form
(B) Alkalinization, which converts salicylic acid to its A^- form
(C) Acidification, which converts salicylic acid to its A^- form
(D) Alkalinization, which converts salicylic acid to its HA form

Answers and Explanations

1. **The answer is D** [V B 4 b]. Distal K^+ secretion is decreased by factors that decrease the driving force for passive diffusion of K^+ across the luminal membrane. Because spironolactone is an aldosterone antagonist, it reduces K^+ secretion. Alkalosis, a diet high in K^+, and hyperaldosteronism all increase [K^+] in the distal cells and thereby increase K^+ secretion. Thiazide diuretics increase flow through the distal tubule and dilute the luminal [K^+] so that the driving force for K^+ secretion is increased.

2. **The answer is D** [I C 2 a; VII C; Figure 5.15; Table 5.6]. After drinking distilled water, Jared will have an increase in intracellular fluid (ICF) and extracellular fluid (ECF) volumes, a decrease in plasma osmolarity, a suppression of antidiuretic hormone (ADH) secretion, and a positive free-water clearance (C_{H_2O}), and will produce *dilute* urine with a high flow rate. Adam, after drinking the same volume of isotonic NaCl, will have an increase in ECF volume only and no change in plasma osmolarity. Because Adam's ADH will not be suppressed, he will have a higher urine osmolarity, a lower urine flow rate, and a lower C_{H_2O} than Jared.

3. **The answer is A** [IX D 1 a–c; Tables 5.8 and 5.9]. An acid pH, together with decreased HCO_3^- and decreased Pco_2, is consistent with metabolic acidosis with respiratory compensation (hyperventilation). Diarrhea causes gastrointestinal (GI) loss of HCO_3^-, creating a metabolic acidosis.

4. **The answer is D** [IX D 1 a–c; Tables 5.8 and 5.9]. The decreased arterial [HCO_3^-] is caused by gastrointestinal (GI) loss of HCO_3^- from diarrhea, not by buffering of excess H^+ by HCO_3^-. The woman is hyperventilating as respiratory compensation for metabolic acidosis. Her hypokalemia cannot be the result of the exchange of intracellular H^+ for extracellular K^+, because she has an increase in extracellular H^+, which would drive the exchange in the other direction. Her circulating levels of aldosterone would be increased as a result of extracellular fluid (ECF) volume contraction, which leads to increased K^+ secretion by the distal tubule and hypokalemia.

5. **The answer is C** [II C 4, 5]. Glomerular filtration will stop when the net ultrafiltration pressure across the glomerular capillary is zero; that is, when the force that favors filtration (47 mm Hg) exactly equals the forces that oppose filtration (10 mm Hg + 37 mm Hg).

6. **The answer is D** [IX C 1 a, b]. Decreases in arterial Pco_2 cause a decrease in the reabsorption of filtered HCO_3^- by diminishing the supply of H^+ in the cell for secretion into the lumen. Reabsorption of filtered HCO_3^- is nearly 100% of the filtered load and requires carbonic anhydrase in the brush border to convert filtered HCO_3^- to CO_2 to proceed normally. This process causes little acidification of the urine and is not linked to net excretion of H^+ as titratable acid or NH_4^+.

7. **The answer is B** [II C 1]. To answer this question, calculate the glomerular filtration rate (GFR) and C_X. GFR = 150 mg/mL × 1 mL/min ÷ 1 mg/mL = 150 mL/min. C_X = 100 mg/mL × 1 mL/min ÷ 2 mg/mL = 50 mL/min. Because the clearance of X is less than the clearance of inulin (or GFR), *net reabsorption of X* must have occurred. Clearance data alone cannot determine whether there has also been secretion of X. Because GFR cannot be measured with a substance that is reabsorbed, X would not be suitable.

8. **The answer is A** [IX C 2]. Total daily production of fixed H^+ from catabolism of proteins and phospholipids (plus any additional fixed H^+ that is ingested) must be matched by the sum of excretion of H^+ as titratable acid plus NH_4^+ to maintain acid–base balance.

9. The answer is C [I B 1 a]. Mannitol is a marker substance for the extracellular fluid (ECF) volume. ECF volume = amount of mannitol/concentration of mannitol = 1 g – 0.2 g/0.08 g/L = 10 L.

10. The answer is D [III B; Figure 5.5]. At concentrations greater than at the transport maximum (T_m) for glucose, the carriers are saturated so that the reabsorption rate no longer matches the filtration rate. The difference is excreted in the urine. As the plasma glucose concentration increases, the excretion of glucose increases. When it is greater than the T_m, the renal vein glucose concentration will be less than the renal artery concentration because some glucose is being excreted in urine and therefore is not returned to the blood. The clearance of glucose is zero at concentrations lower than at T_m (or lower than threshold) when all of the filtered glucose is reabsorbed but is greater than zero at concentrations greater than T_m.

11. The answer is D [VII D; Table 5.6]. A person who produces hyperosmotic urine (1,000 mOsm/L) will have a negative free-water clearance ($-C_{H_2O}$) [$C_{H_2O} = V - C_{osm}$]. All of the others will have a positive C_{H_2O} because they are producing hyposmotic urine as a result of the suppression of antidiuretic hormone (ADH) by water drinking, central diabetes insipidus, or nephrogenic diabetes insipidus.

12. The answer is A [IX B 3]. The Henderson-Hasselbalch equation can be used to calculate the ratio of HA/A⁻:

$$\begin{aligned} pH &= pK + \log A^-/HA \\ 7.4 &= 5.4 + \log A^-/HA \\ 2.0 &= \log A^-/HA \\ 100 &= A^-/HA \text{ or } HA/A^- \text{ is } 1/100 \end{aligned}$$

13. The answer is A [II C 3; IV C 1 d (2)]. Increasing filtration fraction means that a larger portion of the renal plasma flow (RPF) is filtered across the glomerular capillaries. This increased flow causes an increase in the protein concentration and oncotic pressure of the blood leaving the glomerular capillaries. This blood becomes the peritubular capillary blood supply. The increased oncotic pressure in the peritubular capillary blood is a driving force *favoring reabsorption* in the proximal tubule. Extracellular fluid (ECF) volume expansion, decreased peritubular capillary protein concentration, and increased peritubular capillary hydrostatic pressure all inhibit proximal reabsorption. Oxygen deprivation would also inhibit reabsorption by stopping the Na^+–K^+ pump in the basolateral membranes.

14. The answer is E [I B 2 b–d]. Interstitial fluid volume is measured indirectly by determining the difference between extracellular fluid (ECF) volume and plasma volume. Inulin, a large fructose polymer that is restricted to the extracellular space, is a marker for ECF volume. Radioactive albumin is a marker for plasma volume.

15. The answer is D [III C; Figure 5.6]. At plasma concentrations that are lower than at the transport maximum (T_m) for para-aminohippuric acid (PAH) secretion, PAH concentration in the renal vein is nearly zero because the sum of filtration plus secretion removes virtually all PAH from the renal plasma. Thus, the PAH concentration in the renal vein is less than that in the renal artery because most of the PAH entering the kidney is excreted in urine. PAH clearance is greater than inulin clearance because PAH is filtered and secreted; inulin is only filtered.

16. The answer is E [VII D; Figures 5.14 and 5.15]. The person with water deprivation will have a higher plasma osmolarity and higher circulating levels of antidiuretic hormone (ADH). These effects will increase the rate of H_2O reabsorption in the collecting ducts and create a *negative* free-water clearance ($-C_{H_2O}$). Tubular fluid/plasma (TF/P) osmolarity in the proximal tubule is not affected by ADH.

17. The answer is C [II C 4; Table 5.3]. Dilation of the afferent arteriole will increase both renal plasma flow (RPF) (because renal vascular resistance is decreased) and glomerular filtration rate (GFR) (because glomerular capillary hydrostatic pressure is increased). Dilation of the efferent arteriole will increase RPF but decrease GFR. Constriction of the efferent arteriole will decrease RPF (due to increased renal vascular resistance) and increase GFR. Both hyperproteinemia (↑ π in the glomerular capillaries) and a ureteral stone (↑ hydrostatic pressure in Bowman space) will oppose filtration and decrease GFR.

18. The answer is B [IX D 4; Table 5.8]. First, the acid–base disorder must be diagnosed. Alkaline pH, low Pco_2, and low HCO_3^- are consistent with respiratory alkalosis. In *respiratory alkalosis*, the $[H^+]$ is decreased and less H^+ is bound to negatively charged sites on plasma proteins. As a result, more Ca^{2+} is bound to proteins and, therefore, the *ionized* $[Ca^{2+}]$ decreases. There is no respiratory compensation for primary respiratory disorders. The patient is hyperventilating, which is the cause of the respiratory alkalosis. Appropriate renal compensation would be decreased reabsorption of HCO_3^-, which would cause his arterial $[HCO_3^-]$ to decrease and his blood pH to decrease (become more normal).

19. The answer is C [VII B, D 4; Table 5.6]. Both individuals will have hyperosmotic urine, a negative free-water clearance ($-C_{H_2O}$), a normal corticopapillary gradient, and high circulating levels of antidiuretic hormone (ADH). The person with water deprivation will have a high plasma osmolarity, and the person with syndrome of inappropriate antidiuretic hormone (SIADH) will have a low plasma osmolarity (because of dilution by the inappropriate water reabsorption).

20. The answer is B [Table 5.11]. Thiazide diuretics have a unique effect on the distal tubule; they increase Ca^{2+} reabsorption, thereby decreasing Ca^{2+} excretion and clearance. Because parathyroid hormone (PTH) increases Ca^{2+} reabsorption, the lack of PTH will cause an increase in Ca^{2+} clearance. Furosemide inhibits Na^+ reabsorption in the thick ascending limb, and extracellular fluid (ECF) volume expansion inhibits Na^+ reabsorption in the proximal tubule. At these sites, Ca^{2+} reabsorption is linked to Na^+ reabsorption, and Ca^{2+} clearance would be increased. Because Mg^{2+} competes with Ca^{2+} for reabsorption in the thick ascending limb, hypermagnesemia will cause increased Ca^{2+} clearance.

21. The answer is D [IX D 2; Table 5.8]. First, the acid–base disorder must be diagnosed. Alkaline pH, with increased HCO_3^- and increased Pco_2, is consistent with metabolic alkalosis with respiratory compensation. The low blood pressure and decreased turgor suggest extracellular fluid (ECF) volume contraction. The reduced $[H^+]$ in blood will cause intracellular H^+ to leave cells in exchange for extracellular K^+. The appropriate respiratory compensation is *hypoventilation*, which is responsible for the elevated Pco_2. H^+ excretion in urine will be decreased, so less titratable acid will be excreted. K^+ secretion by the distal tubules will be increased because aldosterone levels will be increased secondary to ECF volume contraction.

22. The answer is B [VII B; Figure 5.14]. This patient's plasma and urine osmolarity, taken together, are consistent with water deprivation. The plasma osmolarity is on the high side of normal, stimulating the posterior pituitary to secrete antidiuretic hormone (ADH). Secretion of ADH, in turn, acts on the collecting ducts to increase water reabsorption and produce hyperosmotic urine. Syndrome of inappropriate antidiuretic hormone (SIADH) would also produce hyperosmotic urine, but the plasma osmolarity would be lower than normal because of the excessive water retention. Central and nephrogenic diabetes insipidus and excessive water intake would all result in hyposmotic urine.

23. The answer is C [II B 2, 3]. Effective renal plasma flow (RPF) is calculated from the clearance of para-aminohippuric acid (PAH) [$C_{PAH} = U_{PAH} \times V/P_{PAH} = 600$ mL/min]. Renal blood flow (RBF) = RPF/1 − hematocrit = 1091 mL/min.

24. The answer is A [III D]. Para-aminohippuric acid (PAH) has the greatest clearance of all of the substances because it is both filtered and secreted. Inulin is only filtered. The other substances are filtered and subsequently reabsorbed; therefore, they will have clearances that are lower than the inulin clearance.

25. The answer is D [I C 2 f; Table 5.2]. By sweating and then replacing all volume by drinking H_2O, the woman has a *net loss of NaCl without a net loss of* H_2O. Therefore, her extracellular and plasma osmolarity will be decreased, and as a result, water will flow from extracellular fluid (ECF) to intracellular fluid (ICF). The intracellular osmolarity will also be decreased after the shift of water. Total body water (TBW) will be unchanged because the woman replaced all volume lost in sweat by drinking water. Hematocrit will be increased because of the shift of water from ECF to ICF and the shift of water into the red blood cells (RBCs), which causes their volume to increase.

26. The answer is A [Table 5.4]. Exercise causes a shift of K^+ from cells into blood. The result is hyperkalemia. Hyposmolarity, insulin, β-agonists, and alkalosis cause a shift of K^+ from blood into cells. The result is hypokalemia.

27. The answer is E [Table 5.9]. A cause of metabolic alkalosis is hyperaldosteronism; increased aldosterone levels cause increased H^+ secretion by the distal tubule and increased reabsorption of "new" HCO_3^-. Diarrhea causes loss of HCO_3^- from the gastrointestinal (GI) tract and acetazolamide causes loss of HCO_3^- in the urine, both resulting in hyperchloremic metabolic acidosis with normal anion gap. Ingestion of ethylene glycol and salicylate poisoning leads to metabolic acidosis with increased anion gap.

28. The answer is A [VI B; Table 5.7]. Parathyroid hormone (PTH) acts on the renal tubule by stimulating adenyl cyclase and generating cyclic adenosine monophosphate (cAMP). The major actions of the hormone are inhibition of phosphate reabsorption in the proximal tubule, stimulation of Ca^{2+} reabsorption in the distal tubule, and stimulation of 1,25-dihydroxycholecalciferol production. PTH does not alter the renal handling of K^+.

29. The answer is C [IV C 3 b; V B 4 b]. Hypertension, hypokalemia, metabolic alkalosis, elevated serum aldosterone, and decreased plasma renin activity are all consistent with a primary hyperaldosteronism (e.g., Conn syndrome). High levels of aldosterone cause increased Na^+ reabsorption (leading to increased blood pressure), increased K^+ secretion (leading to hypokalemia), and increased H^+ secretion (leading to metabolic alkalosis). In Conn syndrome, the increased blood pressure causes an increase in renal perfusion pressure, which inhibits renin secretion. Neither Cushing syndrome nor Cushing disease is a possible cause of this patient's hypertension because serum cortisol and adrenocorticotropic hormone (ACTH) levels are normal. Renal artery stenosis causes hypertension that is characterized by increased plasma renin activity. Pheochromocytoma is ruled out by the normal urinary excretion of vanillylmandelic acid (VMA).

30. The answer is D [IX D 3; Tables 5.8 and 5.9]. The history strongly suggests chronic obstructive pulmonary disease (COPD) as a cause of respiratory acidosis. Because of the COPD, the ventilation rate is decreased and CO_2 is retained. The $[H^+]$ and $[HCO_3^-]$ are increased by mass action. The $[HCO_3^-]$ is further increased by renal compensation for respiratory acidosis (increased HCO_3^- reabsorption by the kidney is facilitated by the high Pco_2).

31. The answer is B [IX D 4; Table 5.8]. The blood values in respiratory alkalosis show decreased Pco_2 (the cause) and decreased $[H^+]$ and $[HCO_3^-]$ by mass action. The $[HCO_3^-]$ is further decreased by renal compensation for chronic respiratory alkalosis (decreased HCO_3^- reabsorption).

32. The answer is E [IX D 1; Tables 5.8 and 5.9]. In patients who have chronic renal failure and ingest normal amounts of protein, fixed acids will be produced from the catabolism of protein. Because the failing kidney does not produce enough NH_4^+ to excrete all of the fixed acid, metabolic acidosis (with respiratory compensation) results.

33. The answer is E [IX D 1; Tables 5.8 and 5.9]. Untreated diabetes mellitus results in the production of keto acids, which are fixed acids that cause metabolic acidosis. Urinary excretion of NH_4^+ is increased in this patient because an adaptive increase in renal NH_3 synthesis has occurred in response to the metabolic acidosis.

34. The answer is A [IX D 2; Tables 5.8 and 5.9]. The history of vomiting (in the absence of any other information) indicates loss of gastric H^+ and, as a result, metabolic alkalosis (with respiratory compensation).

35. The answer is E [V B 4]. K^+ is secreted by the late distal tubule and collecting ducts. Because this secretion is affected by dietary K^+, a person who is on a high-K^+ diet can secrete more K^+ into the urine than was originally filtered. At all of the other nephron sites, the amount of K^+ in the tubular fluid is either equal to the amount filtered (site *A*) or less than the amount filtered (because K^+ is reabsorbed in the proximal tubule and the loop of Henle).

36. The answer is D [VII B 3; Figure 5.16]. A person who is deprived of water will have high circulating levels of antidiuretic hormone (ADH). The tubular fluid/plasma (TF/P) osmolarity is 1.0 throughout the proximal tubule, regardless of ADH status. In antidiuresis, TF/P osmolarity is greater than 1.0 at site *C* because of equilibration of the tubular fluid with the large corticopapillary osmotic gradient. At site *E*, TF/P osmolarity is greater than 1.0 because of water reabsorption out of the collecting ducts and equilibration with the corticopapillary gradient. At site *D*, the tubular fluid is diluted because NaCl is reabsorbed in the thick ascending limb without water, making TF/P osmolarity less than 1.0.

37. The answer is E [IV A 2]. Because inulin, once filtered, is neither reabsorbed nor secreted, its concentration in tubular fluid reflects the amount of water remaining in the tubule. In antidiuresis, water is reabsorbed throughout the nephron (except in the thick ascending limb and cortical diluting segment). Thus, inulin concentration in the tubular fluid progressively rises along the nephron as water is reabsorbed, and will be highest in the final urine.

38. The answer is A [IVA 2]. The tubular fluid inulin concentration depends on the amount of water present. As water reabsorption occurs along the nephron, the inulin concentration progressively increases. Thus, the tubular fluid inulin concentration is lowest in Bowman space, prior to any water reabsorption.

39. The answer is A [IV C 1 a]. Glucose is extensively reabsorbed in the early proximal tubule by the Na^+–glucose cotransporter. The glucose concentration in tubular fluid is highest in Bowman space before any reabsorption has occurred.

40. The answer is C [IV A 2]. Once inulin is filtered, it is neither reabsorbed nor secreted. Thus, 100% of the filtered inulin remains in tubular fluid at each nephron site and in the final urine.

41. The answer is A [IV C 1 a]. Alanine, like glucose, is avidly reabsorbed in the early proximal tubule by a Na^+–amino acid cotransporter. Thus, the percentage of the filtered load of alanine remaining in the tubular fluid declines rapidly along the proximal tubule as alanine is reabsorbed into the blood.

42. The answer is D [III C; IVA 3]. Para-aminohippuric acid (PAH) is an organic acid that is filtered and subsequently secreted by the proximal tubule. The secretion process adds PAH to the tubular fluid; therefore, the amount that is present at the end of the proximal tubule is greater than the amount that was present in Bowman space.

43. The answer is B [III E]. Alkalinization of the urine converts more salicylic acid to its A^- form. The A^- form is charged and cannot back-diffuse from urine to blood. Therefore, it is trapped in the urine and excreted.