CHAPTER

12 Laboratory Calculations

contents

review questions

INSTRUCTIONS Each of the questions or incomplete statements that follows is comprised of four suggested responses. Select the *best* answer or completion statement in each case.*

1. What is the molarity of a solution that contains 18.7 g of KCl in 500 mL?
   A. 0.1
   B. 0.5
   C. 1.0
   D. 5.0

2. A calcium standard solution contains 10 mg/dL of calcium. What is its concentration in millimoles per liter?
   A. 2.5 mmol/L
   B. 5.0 mmol/L
   C. 7.5 mmol/L
   D. 10.0 mmol/L

3. How much NaCl is needed to prepare 100 mL of a standard solution of concentration 135 mEq/L of Na?
   A. 0.31 g
   B. 0.79 g
   C. 1.2 g
   D. 1.8 g

4. How much 95% alcohol is required to prepare 5 L of 70% alcohol?
   A. 2.4 L
   B. 3.5 L
   C. 3.7 L
   D. 4.4 L

5. A solution of NaOH is standardized by titration with 0.100 N HCl. A total of 10.0 mL of NaOH requires 11.25 mL of HCl. What is the normality of the NaOH solution?
   A. 0.100
   B. 0.112
   C. 0.113
   D. 1.125

*Note: A periodic table of the elements is located on p. 967.

6. How many milliliters of concentrated H_2SO_4 (sp. gr. = 1.84 g/mL; assay = 97%) are required to prepare 10 L of 0.1 N H_2SO_4?
   A. 1.84
   B. 9.20
   C. 27.5
   D. 54.4

7. How many grams of $CaCl_2 \cdot 2H_2O$ must be used to prepare 500 mL of 10% anhydrous $CaCl_2$?
   A. 33.1
   B. 41.3
   C. 50.0
   D. 66.2

8. What is the osmolality of a solution containing 5.85 g NaCl and 18 g glucose in 1 kg water?
   A. 0.2
   B. 0.3
   C. 0.6
   D. 0.9

9. Physiologic saline solution is 0.85% NaCl. What is its osmolarity?
   A. 0.15
   B. 0.29
   C. 0.85
   D. 8.5

10. Convert 70°F to degrees Celsius.
   A. 7°C
   B. 12°C
   C. 20°C
   D. 21°C

11. A 5 N solution is diluted 1:4. The resulting solution is diluted 4:15. What is the concentration in normality of the final solution?
   A. 0.25
   B. 0.33
   C. 2.5
   D. 3.0

12. A colorimetric method calls for the use of 0.1 mL of serum, 5 mL of reagents, and 4.9 mL of water. What is the dilution of the serum in the final solution?
   A. 1 to 5
   B. 1 to 10
   C. 1 to 50
   D. 1 to 100

13. A solution of a colored substance that is known to follow Beer's law has an absorbance of 0.085 when measured in a cell 1 cm in length. Calculate the absorbance for a solution of twice the concentration measured in the same cell.
   A. 0.042
   B. 0.085
   C. 0.170
   D. 5.90

14. In a spectrophotometric procedure that follows Beer's law, the absorbance of a standard solution of concentration 15 mg/dL is 0.50 in a 1-cm cell. The absorbance of the sample solution is 0.62. What is the concentration?
   A. 0.62 mg/mL
   B. 6.2 mol/L
   C. 12.1 mg/dL
   D. 18.6 mg/dL

15. A stock standard solution of urea contains 10 mg/mL of urea nitrogen. How much stock (in milliliters) is needed to prepare 200 mL of a working standard containing 20 mg/dL of urea nitrogen?
   A. 1
   B. 2
   C. 4
   D. 8

16. How many milliliters of a $50\%^{v/v}$ acetic acid solution are required to prepare 1 L of $5\%^{v/v}$ acetic acid?
A. 0.01
B. 0.10
C. 10
D. 100

17. How many grams of sulfosalicylic acid (mol wt = 254) are required to prepare 1 L of a $3\%^{w/v}$ solution?
A. 3.0
B. 7.6
C. 30
D. 254

18. A quantitative protein analysis is performed on an aliquot of a 24-hour urine specimen. The test indicates the presence of 1.2% protein. If a total urine volume of 2155 mL is collected, how many grams of protein are excreted in the 24-hour specimen?
A. 0.056
B. 2.6
C. 25.9
D. 258.6

19. How many grams of H_2SO_4 are required to prepare 750 mL of a 2 M solution?
A. 36.8
B. 73.5
C. 98
D. 147

20. How many grams of NaOH are required to prepare 4 L of a 2 N solution?
A. 40
B. 80
C. 160
D. 320

21. How many milliliters of glacial acetic acid (mol wt = 60; assay = 99.7%) are required to prepare 2 L of a $5\%^{v/v}$ solution?
A. 6
B. 10
C. 50
D. 100

22. How many grams of H_2SO_4 are required to prepare 6 L of a 5 N solution?
A. 245
B. 294
C. 490
D. 1470

23. How many grams of NaOH are required to prepare 2500 mL of a 4 M solution?
A. 40
B. 100
C. 160
D. 400

24. An isotonic saline solution contains $0.85\%^{w/v}$ NaCl. How many grams of NaCl are needed to prepare 5 L of this solution?
A. 4.25
B. 8.5
C. 42.5
D. 170

25. How many grams of NaOH are required to prepare 500 mL of a 0.02 N solution?
A. 0.4
B. 0.8
C. 4.0
D. 8.0

26. What is the normality of a $30\%^{w/v}$ H_2SO_4 solution?
A. 0.31
B. 0.61
C. 3.06
D. 6.12

27. A serum chloride concentration is 369 mg/dL. What is the concentration in milliequivalents per liter?
A. 5
B. 10
C. 36
D. 104

28. A serum calcium level is 8.6 mg/dL. What is the concentration in millimoles per liter?
A. 2.2
B. 2.5
C. 4.3
D. 8.6

29. How many milliliters of concentrated HNO_3 (sp. gr. = 1.42 g/mL; assay = 70%) are required to prepare 2 L of 0.15 N HNO_3?
A. 13.3
B. 19.0
C. 38.0
D. 189.9

30. With the use of concentrated HCl (sp. gr. = 1.19 g/mL; assay = 37.5%), 3 L of 0.50 N HCl are prepared. A total of 16 mL of 0.20 N NaOH is required to titrate 7 mL of the HCl solution, indicating a lower normality of the acid solution than desired. How many milliliters of concentrated HCl must be added to the acid solution to attain an accurate 0.50 N HCl solution?
A. 6.40
B. 10.53
C. 101.03
D. 105.33

31. A serum chloride concentration is 369 mg/dL. What is the concentration in millimoles per liter?
A. 5
B. 10
C. 36
D. 104

32. How many milliliters of a stock solution of 20% $^{w/v}$ NaOH are required to prepare 800 mL of a 2.5%$^{v/v}$ solution?
A. 20
B. 50
C. 100
D. 125

33. How many milliliters of a 40% $^{w/v}$ NaOH solution are required to prepare 1.5 L of 2 N NaOH?
A. 0.3
B. 3.0
C. 30
D. 300

34. How many grams of anhydrous sodium sulfate (mol wt = 142) are required to prepare 750 mL of a 23%$^{w/v}$ solution?
A. 2.3
B. 106.5
C. 172.5
D. 230

35. With the use of concentrated HCl, 2 L of 0.20 N HCl are prepared. On titration, it is determined that the normality is actually 0.208. To correct this error, how many milliliters of deionized water must be added to the solution (10 mL used in titration process) to make an accurate 0.20 N HCl solution?
A. 10.4
B. 76.5
C. 79.6
D. 80.0

36. A serum calcium level is 8.6 mg/dL. What is the concentration in milliequivalents per liter?
A. 2.2
B. 2.5
C. 4.3
D. 8.6

37. How many milliliters of a 5 N HCl solution are required to prepare 4 L of 10%$^{w/v}$ HCl?
A. 219
B. 292
C. 1460
D. 2192

38. A serum potassium level is 19.5 mg/dL. What is the concentration in milliequivalents per liter?
A. 0.5
B. 5.0
C. 10.0
D. 19.5

39. An analysis for sodium is performed on an aliquot of a 24-hour urine specimen. A sodium value of 122.5 mmol/L is read from the instrument. What is the amount of sodium in the 24-hour urine specimen if 1540 mL of urine are collected?
A. 79.5
B. 188.6
C. 1886.5
D. 18,865

40. With the use of concentrated HNO_3, 4 L of 0.50 N HNO_3 are prepared. On titration, it is determined that the normality is actually 0.513. To correct this error, how many milliliters of deionized water must be added to the remaining 3.975 L of solution to make an accurate 0.50 N HNO_3 solution?
A. 25.6
B. 100.7
C. 103.4
D. 104.0

41. What is the pH of a 0.2 N acetic acid solution that is 1% ionized?
A. 0.703
B. 1.699
C. 1.703
D. 2.699

42. What is the ionic strength of a 0.2 M Na_2SO_4 solution?
A. 0.4
B. 0.5
C. 0.6
D. 1.2

43. A 1.0 mg/dL bilirubin standard (purity = 99.0%; mol wt = 584) is prepared by dissolving it in chloroform at 25°C. Under these conditions, the molar absorptivity at 453 nm is 60,700. What is the expected absorbance of this standard solution?
A. 0.104
B. 0.607
C. 0.962
D. 1.039

44. An enzyme assay is performed at 37°C, and absorbance readings are taken each minute for a total of 4 minutes. Given the following information, what is the enzyme activity in units per liter at 37°C?

Absorbance (*A*) Readings	**Method Information**
0.204 *A* at 1 minute	Reagent volume = 3.0 mL
0.406 *A* at 2 minutes	Sample volume = 200 μL
0.610 *A* at 3 minutes	Light path = 1 cm
0.813 *A* at 4 minutes	$\varepsilon_{340\ nm}$ of NADH = 6.22×10^3

A. 490
B. 522
C. 525
D. 1307

45. A patient weighs 175.5 pounds. What is the patient's weight expressed in kilograms?
   A. 8.0
   B. 38.6
   C. 79.8
   D. 87.8

46. Convert 30°C to degrees Fahrenheit.
   A. 4°F
   B. 10°F
   C. 49°F
   D. 86°F

47. A curie (Ci) is the quantity of radioactive material that exhibits
   A. 3.7×10^4 dps
   B. 3.7×10^7 dps
   C. 3.7×10^{10} dps
   D. 3.7×10^{10} dpm

48. Each radionuclide has a unique half-life associated with it. Assuming an initial activity of 100%, through how many half-life periods must a nuclide pass to bring its activity down to less than 1%?
   A. 3
   B. 7
   C. 10
   D. 100

49. ^{125}I has a half-life of 60 days. At the end of 180 days, what percent of activity would remain?
   A. 12.5
   B. 25.0
   C. 33.3
   D. 50.0

50. How many grams of NaOH are required to prepare 500 mL of a NaOH solution with a pH of 12?
   A. 0.02
   B. 0.2
   C. 0.4
   D. 2.0

51. What is the relative centrifugal force ($\times g$) of a centrifuge operating at 2500 rpm with a radius of 10 cm?
   A. 625
   B. 699
   C. 1250
   D. 6988

52. A 10-mL class A volumetric flask has an accuracy of ±0.2%. Express the ±0.2% tolerance in terms of milliliters.
   A. ±0.002
   B. ±0.01
   C. ±0.02
   D. ±0.04

53. A sample of deionized water is found to contain a lead concentration of 0.01 ppm. What is the equivalent concentration expressed as milligrams per deciliter?
   A. 0.01
   B. 0.001
   C. 0.0001
   D. 0.00001

54. Because of a malfunction, a spectrophotometer is able to show only the percent transmittance (%*T*) readings on its digital display. Convert 68.0%*T* to its corresponding absorbance.
   A. 0.109
   B. 0.168
   C. 0.320
   D. 0.495

55. Which of the following correctly states the conditions required in using a colorimetric method based on Beer's law?
   A. Incident radiation should be monochromatic.
   B. Absorption of light by the solvent must be insignificant in comparison with absorption by the solute (the analyte).
   C. The solution must be sufficiently dilute to provide a linear relation between absorption and concentration.
   D. All the above

56. When one of two variable quantities changes as a result of a change in the other, the result is frequently presented in the form of a graph. Which of the following descriptions of a graph is correct?
   A. The *x*-axis is usually used to plot the independent variable.
   B. Different scales may be used for each of the two axes.
   C. Semilog paper uses a logarithmic scale for one axis and a linear, or Cartesian, scale for the other axis.
   D. All the above

57. Primary standards used for analytical work should have what property?
   A. The substance must be available in a form not less than 99.95% pure.
   B. It should not be hygroscopic.
   C. It must be a stable substance that can be dried, preferably at 104–110°C.
   D. All the above

58. Which of the following weighs the least?
   A. 0.1 ng
   B. 0.01 g
   C. 1.0 mg
   D. 1000 pg

59. The OH^- concentration of a solution is 1×10^{-6}. What is the pH of this solution?
   A. 0.6
   B. 6
   C. 8
   D. 14

60. What amount of NaCl (mol wt $=$ 58.5) is needed to obtain 50 mg Cl?
   A. 19.6 mg
   B. 30.3 mg
   C. 50.0 mg
   D. 82.4 mg

PERIODIC TABLE OF THE ELEMENTS

Main groups | Transition metals | Main groups

	1A[a] 1	2A 2	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1	1 **H** 1.00794																	2 **He** 4.002602
2	3 **Li** 6.941	4 **Be** 9.012182											5 **B** 10.811	6 **C** 12.0107	7 **N** 14.00674	8 **O** 15.9994	9 **F** 18.998403	10 **Ne** 20.1797
3	11 **Na** 22.989770	12 **Mg** 24.3050											13 **Al** 26.981538	14 **Si** 28.0855	15 **P** 30.973762	16 **S** 32.066	17 **Cl** 35.4527	18 **Ar** 39.948
4	19 **K** 39.0983	20 **Ca** 40.078	21 **Sc** 44.95591	22 **Ti** 47.867	23 **V** 50.9415	24 **Cr** 51.9961	25 **Mn** 54.938049	26 **Fe** 55.845	27 **Co** 58.933200	28 **Ni** 58.6934	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.92160	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
5	37 **Rb** 85.4678	38 **Sr** 87.62	39 **Y** 88.90585	40 **Zr** 91.224	41 **Nb** 92.90638	42 **Mo** 95.94	43 **Tc** [98]	44 **Ru** 101.07	45 **Rh** 102.90550	46 **Pd** 106.42	47 **Ag** 107.8682	48 **Cd** 112.411	49 **In** 114.818	50 **Sn** 118.710	51 **Sb** 121.760	52 **Te** 127.60	53 **I** 126.90447	54 **Xe** 131.29
6	55 **Cs** 132.90545	56 **Ba** 137.327	57 ***La** 138.9055	72 **Hf** 178.49	73 **Ta** 180.9479	74 **W** 183.84	75 **Re** 186.207	76 **Os** 190.23	77 **Ir** 192.217	78 **Pt** 195.078	79 **Au** 196.96655	80 **Hg** 200.59	81 **Tl** 204.3833	82 **Pb** 207.2	83 **Bi** 208.98038	84 **Po** [210]	85 **At** [210]	86 **Rn** [222]
7	87 **Fr** [223]	88 **Ra** [226]	89 **†Ac** [227]	104 **Rf** [261]	105 **Db** [262]	106 **Sg** [266]	107 **Bh** [264]	108 **Hs** [265]	109 **Mt** [268]	110 [269]	111 [272]	112 [277]	113	114 [285]	115	116 [289]	117	118 [293]

*Lanthanide series	58 **Ce** 140.116	59 **Pr** 140.90765	60 **Nd** 144.24	61 **Pm** [145]	62 **Sm** 150.36	63 **Eu** 151.964	64 **Gd** 157.25	65 **Tb** 158.92534	66 **Dy** 162.50	67 **Ho** 164.93032	68 **Er** 167.26	69 **Tm** 168.93421	70 **Yb** 173.04	71 **Lu** 174.967
†Actinide series	90 **Th** 232.0381	91 **Pa** 231.03588	92 **U** 238.0289	93 **Np** [237]	94 **Pu** [244]	95 **Am** [243]	96 **Cm** [247]	97 **Bk** [247]	98 **Cf** [251]	99 **Es** [252]	100 **Fm** [257]	101 **Md** [258]	102 **No** [259]	103 **Lr** [262]

[a] The labels on top (1A, 2A, etc.) are common American usage. The labels below these (1, 2, etc.) are those recommended by the International Union of Pure and Applied Chemistry.

The names and symbols for elements 110 and above have not yet been decided.

Atomic weights in brackets are the masses of the longest-lived or most important isotope of radioactive elements.

Further information is available at http://www.shef.ac.uk/chemistry/web-elements/

The production of elements 116 and 118 was reported in May 1999 by scientists at Lawrence Berkeley National Laboratory.

answers & rationales

1.

B. A simple and universally applicable method for solving laboratory calculation problems is to read the problem with three questions in mind:

1. What am I given?
2. What do I want?
3. What is the relation between no. 1 and no. 2?

Given: the concentration of a solution in terms of grams per 500 mL

Want: the concentration in terms of molarity (M)

Relation: molarity = moles per liter

Calculation: A molar solution is one that contains 1 gram molecular weight (usually called 1 mol) of solute per liter of solution. The gram molecular weight is the sum of the atomic weights. A table of atomic weights is used to determine that the gram molecular weight of KCl = 39 + 35.5 = 74.5 g. Express the concentration of the given solution (18.7 g/500 mL) in terms of grams per liter for easy comparison with molarity (moles per liter).

$$18.7\ \text{g}/500\ \text{mL} = 18.7\ \text{g}/0.5\ \text{L} = 37.4\ \text{g/L}$$

$$\text{moles} = \frac{\text{grams}}{\text{gram molecular weight}}$$

$$= \frac{37.4}{74.5} = 0.50$$

$$0.50\ \text{mol/L} = 0.50\ \text{M}$$

A solution that contains 18.7 g KCl/500 mL is 0.50 M KCl.

2.

A. To convert 10 mg of calcium per deciliter to millimoles per liter, proceed as follows. Calculate the milligrams of calcium per liter.

$$10\ \text{mg Ca/dL} = 10\ \text{mg/dL} \times 10\ \text{dL/L}$$

$$= 100\ \text{mg Ca/L}$$

Calculate the weight of 1 mmol of calcium.

Mol wt of Ca = 40 g/mol = 40,000 mg/mol
Thus, 1 mmol Ca = 40 mg Ca.

Then convert 100 mg Ca to mmol Ca:

$$\frac{100\ \text{mg/L}}{40\ \text{mg/mmol}} = 2.5\ \text{mmol Ca/L}$$

Therefore, a concentration of 10 mg Ca/dL = 2.5 mmol Ca/L.

3.

B. To calculate how much NaCl is needed to prepare 100 mL of a standard solution of concentration 135 mEq/L of Na, first consider how many equivalents of Na are present in a mole of NaCl. Find the molecular weight of NaCl. Note that the concentration is expressed in milliequivalents *per liter* (mEq/L), but the desired volume is 100 mL.

Calculation: Because sodium has a valence of 1, one mole of NaCl contains 1 Eq of Na. Molecular weight of NaCl = 23 + 35.5 = 58.5 g. It follows that if 1 Eq of Na is present in 58.5 g NaCl, then 1 mEq of Na is present in 0.0585 g NaCl. There are 135 mEq of Na present in 135 × 0.0585 = 7.90 g NaCl. Therefore, a concentration of 135 mEq/L = 7.90 g NaCl/L.

Let X equal the weight of NaCl in 100 mL of the desired solution. Then

$$\frac{X}{100\text{ mL}} = \frac{7.90\text{ g}}{1000\text{ mL}}$$

$$X = \frac{7.90\text{ g} \times 100\text{ mL}}{1000\text{ mL}} = 0.790\text{ g NaCl}$$

4.

C. Problems requiring the conversion of one concentration to another are conveniently solved by applying the formula

$$C_1 \times V_1 = C_2 \times V_2$$

where C_1 and V_1 are the concentration and volume of the starting solution; C_2 and V_2 are the concentration and volume of the final solution. Thus to prepare 5 L of 70% alcohol from 95% alcohol, let C_1 and V_1 refer to the 95% alcohol, and let C_2 and V_2 refer to the 70% alcohol.

$$95\% \times V_1 = 70\% \times 5\text{ L}$$

$$V_1 = \frac{70 \times 5\text{ L}}{95} = 3.7\text{ L}$$

5.

B. To solve questions involving standardization of an acid or a base by titration, bear in mind that at the endpoint of the titration, the number of equivalents of acid used will be the same as the number of equivalents of base used. Therefore, the following formula applies:

$$C_1 \times V_1 = C_2 \times V_2$$

where C_1 and V_1 are the concentration and volume of HCl needed to neutralize the NaOH solution. The equation is set up below.

$$(0.100\text{ N HCl})\ (11.25\text{ mL}) = C_2\ (10.0\text{ mL})$$

$$C_2 = \frac{11.25 \times 0.100\text{ N}}{10.0} = 0.112\text{ N}$$

6.

C. To calculate how many milliliters of concentrated H_2SO_4 (sp. gr. = 1.84 g/mL, assay = 97%) are required to prepare 10 L of 0.1 N H_2SO_4, first calculate the concentration of the concentrated sulfuric acid in terms of normality. Because the specific gravity is the weight of 1 mL, it follows that 1 mL of concentrated sulfuric acid weighs 1.84 grams. The assay is 97%; that is, 97% of the 1.84 g is H_2SO_4. Therefore, 1 mL of concentrated sulfuric acid contains

$$\frac{97}{100} \times 1.84 \text{ g } H_2SO_4 = 1.78 \text{ g } H_2SO_4$$

and 1 L of concentrated sulfuric acid contains 1780 g H_2SO_4. To convert this concentration (1780 g/L) to normality, recall that a normal solution contains 1 gram equivalent weight per liter. A gram equivalent weight (g Eq wt) is the weight that will combine with or replace 1 g of hydrogen. Because H_2SO_4 has two replaceable hydrogens, the

$$\text{g Eq wt of } H_2SO_4 = \frac{\text{mol wt}}{2} = \frac{98}{2} = 49 \text{ g}$$

Therefore, the concentrated sulfuric acid, which is 1780 g/L, contains

$$\frac{1780 \text{ g/L}}{49 \text{ Eq/L}} = 36.3 \text{ Eq/L}$$

Hence its concentration is 36.3 N.

Now the question becomes: How many milliliters of 36.3 N H_2SO_4 are required to prepare 10 L of 0.1 N H_2SO_4? Using the relation $N_1 \times V_1 = N_2 \times V_2$, let N_1 and V_1 be the concentration and volume of the concentrated H_2SO_4 and let N_2 and V_2 be the concentration and volume of the 0.1 N H_2SO_4.

$$N_1 \times V_1 = N_2 \times V_2$$

$$36.3 \text{ N} \times V_1 = 0.1 \text{ N} \times 10 \text{ L}$$

$$V_1 = \frac{0.1 \times 10 \text{ L}}{36.3} = 0.0275 \text{ L} = 27.5 \text{ mL}$$

Therefore, 27.5 mL of concentrated H_2SO_4 are required to prepare 10 L of 0.1 N H_2SO_4.

7.

D. The problem requires the preparation of 500 mL of 10%$^{w/v}$ $CaCl_2$ with the use of the hydrate $CaCl_2 \cdot 2H_2O$. First calculate how much $CaCl_2$ is needed: 500 mL of 10% $^{w/v}$ $CaCl_2$ contains

$$500 \text{ mL} \times \frac{10 \text{ g}}{100 \text{ mL}} = 50 \text{ g } CaCl_2$$

Then calculate how much $CaCl_2$ is present in $CaCl_2 \cdot 2H_2O$ by comparing molecular weights:

$$\text{mol wt of } CaCl_2 = 40 + 71 = 111 \text{ g}$$

$$\text{mol wt of } CaCl_2 \cdot 2H_2O = 40 + 71 + 4 + 32 = 147 \text{ g}$$

There are 111 g of $CaCl_2$ present in 147 g $CaCl_2 \cdot 2H_2O$; 50 g of $CaCl_2$ are present in

$$\frac{147}{111} \times 50 = 66.2 \text{ g } CaCl_2 \cdot 2H_2O$$

As an alternate method, let X = grams $CaCl_2 \cdot 2H_2O$ needed.

$$\frac{111}{147} = \frac{50}{X}$$

$$X = \frac{147 \times 50}{111} = 66.2 \text{ g}$$

Therefore, a total of 66.2 g $CaCl_2 \cdot 2H_2O$ are needed to prepare 500 mL of 10% $^{w/v}$ $CaCl_2$.

8.

B. *Given:* weights of NaCl and glucose dissolved in 1 kg of water
Want: osmolality of solution
Relation: osmolality = moles per kilogram of solvent times the number of particles into which solute molecules dissociate
Calculation: Express the amount of each solute in terms of moles (grams per molecular weight)

$$5.85 \text{ g NaCl} = \frac{5.85 \text{ g}}{58.5 \text{ g/mol}} = 0.1 \text{ mol NaCl}$$

$$18 \text{ g glucose} = \frac{18 \text{ g}}{180 \text{ g/mol}} = 0.1 \text{ mol glucose}$$

Consider the dissociation of each solute.

$$0.1 \text{ mol NaCl} \rightarrow 0.1 \text{ mol Na}^+ + 0.1 \text{ mol Cl}^-$$

Glucose does not dissociate appreciably.

Number of Osmols =

$$\begin{aligned} 0.1 \times 2 &= 0.2 \text{ osmol NaCl} \\ &+ \underline{0.1} \text{ osmol glucose} \\ \text{Total } &0.3 \text{ osmol in 1 kg } H_2O \\ &= 0.3 \text{ osmolal} \end{aligned}$$

9.

B. *Given:* concentration in grams per deciliter: 0.85% NaCl = 0.85 g/dL
Want: concentration in osmolarity
Relation: osmolarity = moles per liter times the number of particles into which the solute dissociates
Calculation: molecular weight of NaCl = 23 + 35.5 = 58.5 g/mol
In dilute solution, NaCl is assumed to be fully dissociated; therefore, each molecule of NaCl will produce two particles, a sodium ion and a chloride ion.

Osmolarity =
mol/L × No. of particles/dissociate molecule

$$= \frac{\text{g}}{\text{mol wt}} / \text{L} \times \text{No. of particles/dissociate molecule}$$

Convert to grams per liter:

$$0.85 \text{ g/dL} \times 10 \text{ dL/L} = 8.5 \text{ g/L}$$

$$\text{Osmolarity} = \frac{8.5 \text{ g/L}}{58.5 \text{ g/mol}} \times 2 = 0.29 \text{ osmol/L}$$

10.

D. To convert 70°F to degrees Celsius, compare the size of Fahrenheit and Celsius degrees. There are 212 − 32 = 180 Fahrenheit degrees between the boiling point and the freezing point of water, respectively. There are 100 − 0 = 100 Celsius degrees between the boiling point and the freezing point of water, respectively. Therefore, 180 Fahrenheit degrees equal 100 Celsius degrees. From the relationship

$$\frac{°C - 0}{°F - 32} = \frac{100}{180} = \frac{5}{9}$$

two formulas may be derived:

$$°F = \left(°C \times \frac{9}{5}\right) + 32$$

and

$$°C = (°F - 32) \times \frac{5}{9}$$

Thus using the relationship

$$1°F = \frac{100}{180} = \frac{5°C}{9}$$

it follows that

$$\begin{aligned} 70°F &= 70 - 32 \\ &= 38°F \text{ degrees above freezing} \\ &= 38 \times \frac{5°C}{9} \text{ degrees above freezing} \\ &= 21°C \end{aligned}$$

11.

B. When more than one dilution is carried out on a sample, the final concentration is the initial concentration multiplied by each dilution expressed as a fraction. If a 5 N solution is diluted 1:4 and then further 4:15, the final concentration is:

$$5\ N \times \frac{1}{4} \times \frac{4}{15} = 0.33\ N$$

The same principle applies in testing a specimen that is too concentrated to fall within the range of the test procedure. The specimen is diluted, the test repeated, and the result multiplied by the reciprocal of the dilution. Thus, if the specimen had to be diluted 1:10 (1/10) to fall within the range of the test procedure, the result would be multiplied by 10 (10/1) to give the correct value.

12.

D. To find the dilution of serum in a mixture, calculate the total volume. The total volume equals 0.1 mL serum + 5 mL reagents + 4.9 mL water = 10 mL. Therefore, the dilution of serum is 0.1 mL to 10 mL, or 0.1:10. Because dilutions are usually expressed as 1 to some number, multiply both the serum volume (0.1) and the total volume (10) by a common factor of 10. Thus, the 0.1:10 serum dilution may be expressed as 1:100.

13.

C. Beer's law states that $A = abc$; where A = absorbance, a = absorptivity, b = light path in cm, and c = concentration of the absorbing compound. If a and b are constant, then A is directly proportional to c. Therefore, if c is doubled, then A also is doubled:

$$0.085\ A \times 2 = 0.170\ A$$

14.

D. In any given photometric procedure, the length of the light path (= width of the cuvet) and the absorptivity of the analyte are constant. Hence, if the procedure follows Beer's law, absorbance (A) is proportional to the concentration (C). This can be expressed as a ratio:

$$C_{\text{unknown}}/C_{\text{standard}} = A_{\text{unknown}}/A_{\text{standard}}$$

$$C_u = \frac{A_u}{A_s} \times C_s$$

$$\frac{0.62}{0.50} \times 15 \text{ mg/dL} = 18.6 \text{ mg/dL}$$

15.

C. Problems requiring the conversion of one concentration to another can use the following formula:

$$C_1 \times V_1 = C_2 \times V_2$$

where C_1 and V_1 are the concentration and volume of the stock solution. C_2 and V_2 are the concentration and volume of the final solution. The units of concentration must be the same; therefore, first convert 20 mg/dL to 0.2 mg/mL before solving the equation.

$$(10 \text{ mg/mL})\ V_1 = (0.2 \text{ mg/mL})\ (200 \text{ mL})$$

$$V_1 = \frac{0.2 \times 200 \text{ mL}}{10} = 4 \text{ mL}$$

16.

D. When starting with a percent solution, one may prepare a percent solution of a lesser concentration by using the following formula:

$$V_1 \times \%_1 = V_2 \times \%_2$$

Substitute the given information of the problem in the preceding formula:

$$1000 \text{ mL} \times 5\% = V_2 \times 50\%$$

$$\frac{1000 \text{ mL} \times 5}{50} = V_2$$

$$100 \text{ mL} = V_2$$

Therefore, 100 mL of a $50\%^{v/v}$ acetic acid solution are required to prepare 1 L of $5\%^{v/v}$ acetic acid. Add 100 mL of 50% acetic acid to the solvent, diluting with solvent to a final volume of 1 L.

17.

C. Percent solution refers to a specific number of parts per hundred. The term "parts" refers to the weight of a solute in grams or the volume of liquid in milliliters. The term "hundred" refers to the final volume of 100 mL of solution or 100 g of solution. Thus percent solutions may be expressed as weight per volume (w/v), weight per weight (w/w), or volume per volume (v/v). Preparation of a weight per volume solution may be done as follows: $3\%^{w/v}$ sulfosalicylic acid = 3 g/dL (remember that 100 mL is equivalent to 1 dL). To find the number of grams needed to prepare 1 L, multiply by the required volume in deciliters as follows: 3 g/dL × 10 dL/L × 1 L = 30 g. To prepare 1 L of a $3\%^{w/v}$ sulfosalicylic acid solution, dissolve 30 g of sulfosalicylic acid in deionized water (solvent) and dilute to a final volume of 1 L using a volumetric flask.

18.

C. The urine sample contained 1.2% protein, which is equivalent to 1.2 g of protein per deciliter. Because the total urine volume is given in milliliters, it is necessary to express the volume in deciliters so that the units of measurement correspond. This may be done by dividing the 24-hour volume in milliliters by 100, because there are 100 mL in each deciliter. The amount of protein excreted in the 24-hour urine specimen may now be calculated.

$$\frac{\text{Protein conc. in g/dL} \times \text{urine volume in mL/24 hr}}{100\ \text{mL/dL}} = \text{g/24 hr}$$

$$\frac{1.2\ \text{g/dL} \times 2155\ \text{mL/24 hr}}{100\ \text{mL/dL}} = 25.9\ \text{g/24 hr}$$

19.

D. A 1 molar solution contains 1 mole or 1 g molecular weight of a solute in 1 L of solution. One gram molecular weight of H_2SO_4 consists of 98 g. Thus 1 L of a 1 M solution contains 98 g of H_2SO_4, and a 2 M solution contains twice this amount or 196 g of H_2SO_4 per liter.

$$1\ \text{M}\ H_2SO_4 = 98\ \text{g/L}$$
$$2\ \text{M}\ H_2SO_4 = 2 \times 98\ \text{g/L} = 196\ \text{g/L}$$

Thus to find the number of grams needed to prepare only 750 mL of a 2 M H_2SO_4 solution, multiply by the required volume expressed in liters as follows:

$$196\ \text{g/L} \times \frac{750\ \text{mL}}{1000\ \text{mL/L}} = 147\ \text{g}$$

Therefore, 147 g of H_2SO_4 are needed to prepare 750 mL of a 2 M H_2SO_4 solution.

20.

D. A one normal (1 N) solution contains 1 g equivalent weight of a solute in 1 L of solution. For a base, the equivalent weight is defined as that weight which combines with 1.008 g of replaceable hydrogen. One gram equivalent weight of NaOH consists of 40 g. Thus 1 L of a 1 N solution contains 40 g of NaOH, and a 2 N solution contains twice this amount or 80 g of NaOH per liter.

$$1\ \text{N NaOH} = 40\ \text{g/L}$$
$$2\ \text{N NaOH} = 2 \times 40\ \text{g/L} = 80\ \text{g/L}$$

Thus to find the number of grams needed to prepare 4 L of a 2 N NaOH solution, multiply by the required volume as follows: $80\ \text{g/L} \times 4\ \text{L} = 320\ \text{g}$. Therefore, 320 g of NaOH are needed to prepare 4 L of a 2 N NaOH solution. Prepare this solution by dissolving the 320 g of solute in solvent and bring to a final volume of 4 L.

21.

D. "Percent solution" refers to a specific number of *parts per hundred.* For a volume per volume solution, measure the volume of liquid solute required in milliliters and add solvent to a final volume of 100 mL of solution. Preparation of a $5\%^{v/v}$ CH_3COOH solution may be done as follows: 5% glacial acetic acid = 5 mL/dL (remember, 100 mL is equivalent to 1 dL). Thus to find the number of milliliters needed to prepare 2 L of 5% CH_3COOH, multiply by the required volume in deciliters as follows: $5\ \text{mL/dL} \times 10\ \text{dL/L} \times 2\ \text{L} = 100\ \text{mL}$. Thus to prepare 2 L of a 5% acetic acid solution, add 100 mL of glacial acetic acid to deionized water (remember—always add acid to water) and dilute using a volumetric flask to a final volume of 2 L.

22.

D. A 1 normal (1 N) solution contains 1 g equivalent weight of a solute in 1 L of solution. For an acid, the equivalent weight is defined as that weight which is equivalent to 1.008 g of replaceable hydrogen. The gram equivalent weight may be determined by dividing the gram molecular weight by the positive valence. One equivalent weight of H_2SO_4 equals 49 g, because the molecular weight of 98 g divided by the positive valence 2 is 49 g. Thus 1 L of a 1 N solution contains 49 g of H_2SO_4, and a 5 N solution contains five times this amount or 245 g of H_2SO_4 per liter.

$$1\ \text{N}\ H_2SO_4 = 49\ \text{g/L}$$
$$5\ \text{N}\ H_2SO_4 = 5 \times 49\ \text{g/L} = 245\ \text{g/L}$$

Thus to find the number of grams needed to prepare 6 L of a 5 N H_2SO_4 solution, multiply by the required volume as follows: 245 g/L × 6 L = 1470 g. Therefore, 1470 g of H_2SO_4 are needed to prepare 6 L of a 5 N H_2SO_4 solution.

23.

D. A 1 molar solution contains 1 mol or 1 gram molecular weight of a solute in 1 L of solution. One gram molecular weight of NaOH consists of 40 g. Thus 1 L of a 1 M solution contains 40 g of NaOH, and a 4 M solution contains four times this amount or 160 g of NaOH per liter.

$$1\ \text{M NaOH} = 40\ \text{g/L}$$
$$4\ \text{M NaOH} = 4 \times 40\ \text{g/L} = 160\ \text{g/L}$$

Thus to find the number of grams needed to prepare 2500 mL of a 4 M NaOH solution, multiply by the required volume expressed in liters as follows:

$$160\ \text{g/L} \times \frac{2500\ \text{mL}}{1000\ \text{mL/L}} = 400\ \text{g}$$

Therefore, 400 g of NaOH are needed to prepare 2500 mL (2.5 L) of a 4 M NaOH solution.

24.

C. A weight per volume percent solution contains a specific number of grams (equivalent to the percent indicated) of solute per 100 mL (equivalent to 1 dL) of solution. An $0.85\%^{w/v}$ isotonic saline solution contains 0.85 g of NaCl per 100 mL of solution. To find the number of grams needed to prepare 5 L of solution, multiply by the required volume in deciliters as follows: 0.85 g/dL × 5 L × 10 dL/L = 42.5 g NaCl. Using a volumetric flask, prepare 5 L of an $0.85\%^{w/v}$ NaCl solution by dissolving 42.5 g of NaCl in deionized water and diluting to a final volume of 5 L.

25.

A. A 1 normal solution contains 1 g equivalent weight of a solute in 1 L of solution. One equivalent weight of NaOH contains 40 g; thus, a 0.02 N solution contains one-fiftieth of this amount, or 0.8 g of NaOH per liter.

$$1\ \text{N NaOH} = 40\ \text{g/L}$$
$$0.02\ \text{N NaOH} = 0.02 \times 40\ \text{g/L} = 0.8\ \text{g/L}$$

Thus to find the number of grams needed to prepare 500 mL (0.5 L) of a 0.02 N NaOH solution, multiply by the required volume as follows: 0.8 g/L × 0.5 L = 0.4 g or 400 mg. Therefore, 0.4 g (or 400 mg) of NaOH are needed to prepare 500 mL of a 0.02 N NaOH solution.

26.

D. When starting with a 30% $^{w/v}$ H_2SO_4 solution, the normality of the solution may be calculated by employing the following steps:

1. Determine the molecular weight of H_2SO_4: mol wt = 98 g.
2. Find the g/Eq in 1 L of 1 N H_2SO_4 solution: 98 g/L ÷ 2 Eq/L = 49 g/Eq = 49 g/L.
3. Find the corresponding percent of a 1 N H_2SO_4 solution: 49 g/L ÷ 10 dL/L = 4.9 g/dL = 4.9% $^{w/v}$ H_2SO_4.
4. Find the normality of the 30% H_2SO_4 solution. Divide the stated percent by the percent of the 1 N H_2SO_4 solution: 30% ÷ 4.9% = 6.12 N H_2SO_4.

27.

D. To convert 369 mg/dL of chloride to milliequivalents per liter, use the following formula:

$$\frac{\text{mg/dL} \times 10 \times \text{valence}}{\text{atomic mass}} = \text{mEq/L}$$

For the problem presented, let 10 represent the number of deciliters per liter; 35.5 is the atomic mass of chloride, and 1 is the valence of chloride:

$$\frac{369\ \text{mg/dL} \times 10 \times 1}{35.5} = 104\ \text{mEq/L}$$

28.

A. To convert 8.6 mg/dL of calcium to millimoles per liter, the following formula may be used:

$$\frac{\text{mg/L}}{\text{molecular mass}} = \text{mmol/L}$$

For the problem presented:

$$\frac{8.6\ \text{mg/dL} \times 10\ \text{dL/L}}{40} = 2.15\ \text{mmol/L}$$

The calculated value of 2.15 mmol/L rounded to the nearest tenth gives the answer 2.2 mmol/L.

29.

B. When starting with a concentrated HNO_3 solution, a 0.15 normal solution may be prepared by employing the following steps:

A. Calculate the normality of the concentrated HNO_3 solution.

1. Multiply the specific gravity (expressed as grams per milliliter) by the assay (expressed as percent by weight) to find the number of grams per milliliter:

$$1.42\ \text{g/mL} \times 0.70 = 0.994\ \text{g/mL}$$

2. To find the number of grams per liter, multiply by 1000 mL/L:

$$0.994\ \text{g/mL} \times 1000\ \text{mL/L} = 994\ \text{g/L}$$

3. To find the normality (equivalents per liter) of the concentrated HNO_3, divide the grams per liter by the equivalent weight of HNO_3:

$$\begin{aligned} 1\ \text{N}\ HNO_3 &= 63\ \text{g/Eq} \\ 994\ \text{g/L} \div 63\ \text{g/Eq} &= 15.8\ \text{Eq/L} \\ &= 15.8\ \text{N}\ HNO_3 \end{aligned}$$

B. Calculate the number of milliliters of concentrated HNO_3 needed to prepare 2 L of 0.15 N HNO_3 using the formula $V_1 \times N_1 = V_2 \times N_2$.

$$\begin{aligned} 2000\ \text{mL} \times 0.15\ \text{N} &= V_2 \times 15.8\ \text{N} \\ \frac{2000\ \text{mL} \times 0.15}{15.8} &= V_2 \\ 19.0\ \text{mL} &= V_2 \end{aligned}$$

Thus 2 L of 0.15 N HNO_3 are prepared by diluting 19.0 mL of concentrated HNO_3 to a final volume of 2000 mL.

30.

B. Because titration reveals that the normality of the HCl solution is lower than the desired normality of 0.50 N, it is apparent that concentrated HCl must be added. Use the following formula to determine the actual normality of the acid solution:

$$V_1 \times N_1 = V_2 \times N_2$$

where V_1 = 7 mL of the HCl solution, N_1 = actual normality of the HCl solution, V_2 = 16 mL of the 0.20 N NaOH solution, and N_2 = 0.20 N NaOH solution.

1. Find the actual normality of the acid solution:

$$7\text{ mL} \times N_1 = 16\text{ mL} \times 0.20\text{ N}$$

$$N_1 = \frac{16\text{ mL} \times 0.20}{7\text{ mL}}$$

$$N_1 = 0.457 \text{ actual N of HCl solution}$$

2. Find the number of milliequivalents per milliliter lacking in the initial HCl solution: 0.500 mEq/mL – 0.457 mEq/mL = 0.043 mEq/mL lacking.
3. Find the number of milliliters of the initial HCl solution remaining: 3000 mL – 7 mL = 2993 mL remaining.
4. Find the number of milliequivalents of HCl that must be added to the remaining solution: 2993 mL × 0.043 mEq/mL = 128.7 mEq required.
5. Find the number of grams per milliliter of HCl in concentrated HCl: 1.19 g/mL (sp. gr.) × 0.375 (assay) = 0.446 g HCl/mL of concentrated acid. It follows that there are 446 g HCl/L.
6. Find the normality of concentrated HCl (Eq wt = 36.5 g): 446 g/L ÷ 36.5 g/Eq = 12.22 Eq/L, or 12.22 N, or 12.22 mEq/mL.
7. Find the number of milliliters of concentrated HCl that must be added:

$$\frac{128.7\text{ (mEq required)}}{12.22\text{ (mEq/mL in conc. HCl)}} = 10.53\text{ mL}$$

Thus, 10.53 mL of concentrated HCl must be added to the remaining volume of 2993 mL for a total volume of 3003.53 mL to prepare an accurate 0.50 N HCl solution.

31.

D. When the concentrations of the four serum electrolytes—sodium, potassium, chloride, and carbon dioxide—are expressed, the preferred terminology is an expression of the unit designation as millimoles per liter (mmol/L). To convert from milligrams per deciliter to millimoles per liter, the following formula may be used:

$$\frac{\text{mg/L}}{\text{molecular mass}} = \text{mmol/L}$$

$$\frac{369\text{ mg/dL} \times 10\text{ dL/L}}{35.5} = 104\text{ mmol/L}$$

32.

C. When a dilute solution is prepared from a concentrated solution, the following equation may be used:

$$V_1 \times C_1(\%) = V_2 \times C_2(\%)$$

For the stated problem let V_1 = milliliters of the 20% NaOH solution, C_1 = the 20% NaOH solution, V_2 = 800 mL of the desired 2.5% solution, and C_2 = the 2.5% NaOH solution. Using this information in the above equation:

$$V_1 \times 20\% = 800\text{ mL} \times 2.5\%$$

$$V_1 = \frac{800\text{ mL} \times 2.5\%}{20\%}$$

$$V_1 = 100\text{ mL}$$

Thus, 100 mL of the 20%$^{w/v}$ NaOH solution are required to prepare a total volume of 800 mL of 2.5%$^{v/v}$ NaOH. This may be done by diluting 100 mL of 20% NaOH to a final volume of 800 mL.

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33.

D. When one starts with a percent solution, a normal solution may be prepared by employing the following steps.

A. Calculate the normality of the 40%$^{w/v}$ NaOH solution.

1. Find the number of grams in 1 equivalent weight of a 1 N NaOH solution:

$$1 \text{ N NaOH} = 40 \text{ g/Eq} = 40 \text{ g/L}$$

2. Find the grams per liter in the 40%$^{w/v}$ NaOH solution:

$$40 \text{ g/100 mL} \times 1000 \text{ mL/L} = 400 \text{ g/L}$$

3. Find the normality of the 40% NaOH solution by dividing the number of grams per liter in the 40% NaOH solution by the equivalent weight of NaOH:

$$400 \text{ g/L} \div 40 \text{ g/Eq} = 10 \text{ Eq/L}$$
$$= 10 \text{ N NaOH}$$

B. Calculate the number of milliliters of 40%$^{w/v}$ NaOH needed to prepare 1.5 L of 2 N NaOH using the formula:

$$V_1 \times N_1 = V_2 \times N_2$$
$$1500 \text{ mL} \times 2 \text{ N} = V_2 \times 10 \text{ N}$$
$$\frac{1500 \text{ mL} \times 2}{10} = V_2$$
$$300 \text{ mL} = V_2$$

Therefore, 300 mL of 40%$^{w/v}$ NaOH are required to prepare 1.5 L of 2 N NaOH. Add 300 mL of 40% NaOH to the solvent, diluting with solvent to a final volume of 1.5 L.

34.

C. A weight per volume percent solution contains a specific number of grams of solute per 100 mL of solution. Preparation of a 23%$^{w/v}$ Na_2SO_4 solution may be done as follows: 23%$^{w/v}$ Na_2SO_4 = 23 g/dL. Thus to find the number of grams needed to prepare 750 mL, multiply by the required volume in deciliters, as follows:

$$23 \text{ g/dL} \times 10 \text{ dL/L} \times \frac{750 \text{ mL}}{1000 \text{ mL/L}} = 172.5 \text{ g}$$

To prepare 750 mL of a 23%$^{w/v}$ Na_2SO_4 solution, dissolve 172.5 g of Na_2SO_4 in solvent and dilute to a final volume of 750 mL.

35.

C. Because the normality of the HCl solution is greater than the desired normality, this problem can be considered similar to that of preparing a dilute solution from a concentrated solution. Thus the following equation may be used to determine the new total volume required, and indirectly the amount of deionized water that must be added to the remaining volume, to achieve the desired normality:

$$V_1 \times N_1 = V_2 \times N_2$$

where V_1 = mL of the desired 0.20 N HCl solution, N_1 = 0.20 N HCl solution, V_2 = 1990 mL remaining of the 0.208 N HCl solution, and N_2 = 0.208 N HCl solution. Using this information in the above equation:

$$V_1 \times 0.20 \text{ N} = 1990 \text{ mL} \times 0.208 \text{ N}$$
$$V_1 = \frac{1990 \text{ mL} \times 0.208 \text{ N}}{0.20 \text{ N}}$$
$$V_1 = 2069.6 \text{ mL}$$

Thus a new total volume of 2069.6 mL is required to make an accurate 0.20 N HCl solution. To determine the amount of deionized water that must be added to the remaining 1990 mL volume, find the difference between the new total volume and the remaining volume: 2069.6 mL – 1990 mL = 79.6 mL of deionized water that must be added to the remaining volume of solution.

36.

C. To convert milligrams per deciliter to milliequivalents per liter, use the following formula:

$$\frac{\text{mg/dL} \times 10 \times \text{valence}}{\text{atomic mass}} = \text{mEq/L}$$

For the problem presented, let 10 represent the number of deciliters per liter; 40 is the atomic mass of calcium, and 2 is the valence of calcium.

$$\frac{8.6 \text{ mg/dL} \times 10 \times 2}{40} = 4.3 \text{ mEq/L}$$

37.

D. When one starts with a 5 N HCl solution, 4 L of a $10\%^{w/v}$ HCl solution may be prepared by employing the following steps:

A. Calculate the normality of the $10\%^{w/v}$ HCl solution.
   1. Find the number of grams in 1 equivalent weight of a 1 N HCl solution:
      1 N HCl = 36.5 g/Eq.
   2. Find the number of grams per liter in the $10\%^{w/v}$ HCl solution:
      $10\%^{w/v}$ HCl = 10 g/dL = 100 g/L.
   3. Find the normality of the $10\%^{w/v}$ HCl solution. Divide the number of grams per liter in the 10% solution by the equivalent weight of HCl:
      100 g/L ÷ 36.5 g/Eq = 2.74 N HCl.

B. Calculate the number of milliliters of 5 N HCl needed to prepare 4 L of $10\%^{w/v}$ HCl using the following formula:

$$V_1 \times N_1 = V_2 \times N_2$$
$$4000 \text{ mL} \times 2.74 \text{ N} = V_2 \times 5 \text{ N}$$
$$\frac{4000 \text{ mL} \times 2.74 \text{ N}}{5 \text{ N}} = V_2$$
$$2192 \text{ mL} = V_2$$

Therefore, 2192 mL of 5 N HCl are required to prepare 4 L of $10\%^{w/v}$ HCl. Add 2192 mL of 5 N HCl to the solvent, diluting with solvent to a final volume of 4 L.

38.

B. To convert milligrams per deciliter to milliequivalents per liter, use the following formula:

$$\frac{\text{mg/dL} \times 10 \times \text{valence}}{\text{atomic mass}} = \text{mEq/L}$$

For the problem presented, let 10 represent the number of deciliters per liter; 39 is the atomic mass of potassium, and 1 is the valence of potassium.

$$\frac{19.5 \text{ mg/dL} \times 10 \times 1}{39} = 5.0 \text{ mEq/L}$$

39.

B. The urine sample contained 122.5 mmol/L of sodium. Because the total urine volume is given in milliliters, it is necessary to express the volume in liters so that the units of measurement correspond. This may be done by dividing the 24-hour volume in milliliters by 1000, because each liter has 1000 mL. The amount of sodium excreted in the 24-hour urine specimen may now be calculated.

$$\frac{\text{Sodium mmol/L} \times \text{urine volume mL/24 hr}}{1000 \text{ mL/L}} = \text{mmol/24 hr}$$

$$\frac{122.5 \text{ mmol/L} \times 1540 \text{ mL/24 hr}}{1000 \text{ mL/L}}$$

$$= 188.6 \text{ mmol/24 hr}$$

40.

C. Because titration reveals that the normality of the HNO_3 solution is higher than the desired normality, it is apparent that the solution needs to be diluted. The following equation may be used to determine the new total volume required, and indirectly the amount of deionized water that must be added to the remaining volume to make the desired normality:

$$V_1 \times N_1 = V_2 \times N_2$$

where V_1 = milliliters of the desired 0.50 N HNO_3 solution, N_1 = 0.50 N HNO_3 solution, V_2 = 3975 mL remaining of the 0.513 N HNO_3 solution, and N_2 = 0.513 N HNO_3 solution. Using this information in the above equation:

$$V_1 \times 0.50\text{ N} = 3975\text{ mL} \times 0.513\text{ N}$$

$$V_1 = \frac{3975\text{ mL} \times 0.513\text{ N}}{0.50\text{ N}}$$

$$V_1 = 4078.4\text{ mL}$$

Thus, a new total volume of 4078.4 mL is required to make an accurate 0.50 N HNO_3 solution. To determine the amount of deionized water that must be added to the remaining 3975 mL volume, find the difference between the new total volume and the remaining volume:

4078.4 mL − 3975 mL = 103.4 mL of deionized water that must be added to the remaining volume of solution.

41.

D. The degree to which an acid solution dissociates determines the hydrogen ion concentration and thus the strength of the acid solution. Because the dissociation of acetic acid is only 1%, it is considered a weak acid. To calculate the pH of a 0.2 N acetic acid solution that is 1% ionized, proceed as follows:

1. Find the hydrogen ion concentration with the following formula:

$$[H^+] = \text{N} \times \%\text{ ionized}$$

$$[H^+] = 0.2 \times 0.01 = 0.002\text{ g H}^+/\text{L}$$

2. Find the pH of this solution with the following formula:

$$\text{pH} = \log\frac{1}{[H^+]}$$

$$\text{pH} = \log\frac{1}{0.002}$$

$$\text{pH} = 2.699$$

42.

C. A solution of Na_2SO_4 dissociates into two Na^+ ions and one SO_4^{2-} ion. The ionic strength is governed by the concentration (moles per liter) of each ion present in solution and the ionic charges associated with each ion. To calculate the ionic strength, derive half the sum for all ions present when the concentration of each ion present is multiplied by its valence squared. For a 0.2 M Na_2SO_4 solution, proceed as follows:

$$\text{Ionic strength} = \frac{\left[0.2 \times 2 \times (1)^2\right] + \left[0.2 \times (2)^2\right]}{2}$$

$$\text{Ionic strength} = 0.6$$

43.

D. The equation $A = abc$, where A represents the absorbance of a substance at a specified wavelength, a represents the absorptivity, b represents the length of the light path in centimeters, and c represents the concentration of the absorbing compound, is commonly referred to as Beer's law. When a 1-cm light path is used and the concentration is expressed in moles per liter, the constant a is replaced by the symbol ε (epsilon), which is referred to as the molar absorptivity. The molar absorptivity is generally defined as the absorbance determined, at a specified wavelength using a 1-cm light path, for a 1 M solution of a pure substance. The equation becomes $A = \varepsilon bc$. Use this formula to determine the absorbance of the 1.0 mg/dL (0.01 g/L) bilirubin standard solution. The molecular weight of bilirubin is 584 and ε is 60,700 at 453 nm using a 1-cm light path.

$$A = \varepsilon bc$$
$$A = (60{,}700)\ (1)\ (0.01 \div 584)$$
$$A = 1.039$$

Thus, a 1 mg/dL bilirubin standard solution should have an absorbance reading of 1.039.

44.

B. Over the years, numerous units have been used to express enzyme activity, including the Bodansky unit, the Gutman-Gutman unit, and the Bowers-McComb unit. The introduction of the international unit (IU or U) brought a common unit of comparison to enzyme assays. The International Unit is defined as the amount of enzyme activity that converts 1 μmol of substrate in 1 minute under standard conditions. The following formula is used to calculate enzyme activity.

$$\frac{\Delta A/\text{min} \times 1000 \times TV \times 1000 \times Tf}{6.22 \times 10^3 \times LP \times SV} = \text{U/L}$$

where ΔA/min is the average absorbance change per minute and 1000 converts milliliters to liters; TV is the total reaction volume and 1000 converts millimoles to micromoles; Tf is the temperature factor (1.0 at 37°C); 6.22×10^3 is the molar absorptivity of reduced nicotinamide-adenine dinucleotide (NADH) at 340 nm; LP is the light path in centimeters and SV is the sample volume. For the problem presented, determine the average ΔA/min and then substitute the given information into the equation.

Absorbance (A) Readings	ΔA/min	Average ΔA/min
0.204 A at 1 min		
	0.202	
0.406 A at 2 min		
	0.204	0.203
0.610 A at 3 min		
	0.203	
0.813 A at 4 min		

$$\frac{0.203\ \Delta A/\text{min} \times 1000 \times 3.2\ \text{mL} \times 1000 \times 1}{6.22 \times 10^3 \times 1.0 \times 0.2\ \text{mL}} = 522\ \text{U/L}$$

45.

C. A kilogram is approximately equal to 2.2 pounds. A weight expressed in pounds may be converted to kilograms by dividing the weight in pounds by the conversion factor 2.2 as follows:

$$175.5 \text{ lb} \div 2.2 \text{ lb/kg} = 79.8 \text{ kg}$$

46.

D. When converting Celsius to Fahrenheit degrees, remember that 1°C equals 9/5°F. Thus multiplying the temperature in degrees Celsius by 9/5 is necessary to express the temperature in the degrees Fahrenheit unit, and the addition of 32 allows for adjustment to the Fahrenheit scale's zero point. To convert 30°C to degrees Fahrenheit, the following formula may be used:

$$°F = (°C \times 9/5) + 32$$
$$°F = (30 \times 9/5) + 32$$
$$°F = 86$$

47.

C. Unlike most units of measurement used in chemistry, the curie (Ci) is a unit of measure for radioactivity that is independent of weight. The curie is defined as the quantity of radioactive material that exhibits 3.7×10^{10} disintegrations per second (dps). Other terms frequently used refer to units of radioactivity of smaller dimensions than the curie. These are the millicurie (mCi), which exhibits 3.7×10^7 dps, and the microcurie (μCi), which exhibits 3.7×10^4 dps.

48.

B. Each radionuclide has a unique half-life associated with it: ^{14}C = 5730 years; ^{3}H = 12.3 years; ^{125}I = 60 days; and ^{131}I = 8.1 days. Because half-life refers to the percent of activity remaining after a specified time, it will be necessary for all radionuclides to pass through seven half-life periods in order to reduce the initial activity of 100% to less than 1%. The following example expresses this phenomenon:

$$A_n = A_0(\tfrac{1}{2})^7$$
$$A_7 = 100(\tfrac{1}{2})^7$$
$$A_7 = 0.78\%$$

49.

A. The term "half-life" refers to the time required for the activity of a known amount of radioactive material to decrease to half of the initial activity. In a radioimmunoassay (RIA), this loss of activity is critical to the sensitivity of the assay. As activity decreases with time, the sensitivity of the assay will also decrease. In the problem presented, assume 100% activity originally. Because ^{125}I has a half-life of 60 days, the lapse of 180 days represents three half-life periods (3 $t\tfrac{1}{2}$), 180 days ÷ 60 days/$t\tfrac{1}{2}$ = 3 $t\tfrac{1}{2}$. Use the following formula, where A_n is the activity at the specified number of half-life periods. A_0 is the initial activity, and n is the number of half-life periods.

$$A_n = A_0(\tfrac{1}{2})^n$$
$$A_3 = 100(\tfrac{1}{2})^3$$
$$A_3 = 12.5\%$$

Therefore, 12.5% of the initial activity remains at the end of 3 $t\tfrac{1}{2}$.

50.

B. For a strong base such as NaOH, dissociation into Na^+ and OH^- is complete. Thus in terms of molarity, the concentration of sodium ions equals the concentration of hydroxyl ions, which in turn equals the molar concentration of NaOH originally present. Proceed with the problem for a solution of NaOH with a pH of 12 by finding the molar concentration of the hydroxyl ions.

$$\begin{aligned} \text{pH} + \text{pOH} &= 14 \\ 12 + \text{pOH} &= 14 \\ \text{pOH} &= 2 \\ \text{pOH} &= -\log[\text{OH}^-] \\ 2 &= -\log[\text{OH}^-] \\ [\text{OH}^-] &= 1 \times 10^{-2} = 0.01 \text{ mol/L} \end{aligned}$$

Because 0.01 mol/L is the molar concentration of hydroxyl ions, it follows that the molar concentration of NaOH is 0.01 mol/L. The following formula is used to find the number of grams required to prepare a 0.01 M NaOH solution (molecular weight of NaOH = 40).

$$\begin{aligned} \frac{\text{g/L}}{\text{mol wt}} &= \text{M} \\ \frac{X}{40} &= 0.01 \\ X &= 0.4 \text{ g/L} = 0.2 \text{ g/500 mL} \end{aligned}$$

Thus, 0.2 g of NaOH is required to prepare 500 mL of a solution of NaOH with a pH of 12.

51.

B. By use of centrifugal force, a centrifuge effects the separation of substances of different densities. The most common use of a centrifuge in the clinical laboratory is the separation of serum or plasma from the blood cells. The use of the proper amount of centrifugal force with serum separator tubes is especially important. In order for a thixotropic, silicone gel to form a barrier between the serum and the cell clot, it is critical that the tube be centrifuged for a specified time and with the specified centrifugal force. The following formula is used to calculate the relative centrifugal force (RCF) in terms of gravities (g), where 1.118×10^{-5} represents a constant, r represents the rotating radius in centimeters, and rpm represents the rotating speed in revolutions per minute:

$$\begin{aligned} \text{RCF} &= 1.118 \times 10^{-5} \times \text{r} \times (\text{rpm})^2 \\ &= 1.118 \times 10^{-5} \times 10 \times (2500)^2 \\ &= 698.75 \\ \text{RCF} &= 699 \times g \end{aligned}$$

52.

C. Class A volumetric flasks are calibrated at 20°C. Glassware that is designated as class A must meet the requirements of the National Institute of Standards and Technology. The College of American Pathologists (CAP) requires that CAP-approved clinical laboratories use only class A glassware. A 10 mL class A volumetric flask that is accurate to ±0.2% has a tolerance of ±0.02 mL; 10 mL × 0.2% = 0.02 mL = ±0.02 mL. Thus the capacity of a 10 mL flask is within the range of 9.98 to 10.02 mL.

53.

B. The term "parts per million" (ppm) is a unit of concentration that describes the number of parts of a substance that are contained in 1 million parts of the solution. "Parts per million" refers to the number of grams of a substance in 1 million grams of solution. To convert from parts per million to concentration, the following formula is used:

$$\frac{g}{X\ mL} \times 1{,}000{,}000 = ppm$$

In referring to parts per million, it is important to remember that the unit of measure may vary (e.g., milligrams, micrograms, or nanograms), provided that the relationship of some number of parts in 1 million parts is maintained. Therefore, it follows that to convert 0.01 ppm to mg/dL:

$$\frac{mg}{X\ mL} \times 1000 = ppm$$

$$\frac{mg}{100} \times 1000 = 0.01$$

$$mg = \frac{0.01}{1000} \times 100$$

$$mg = 0.001$$

Thus 0.01 ppm of lead is equivalent to 0.001 mg/dL or 0.001 mg/100 mL.

54.

B. To convert 68.0 $\%T$ to absorbance (A), use the following formula:

$$A = -\log T = \log\frac{1}{T} = \log\frac{100\%}{\%T}$$

$$A = \log 100 - \log \%T$$

$$A = 2 - \log \%T$$

$$A = 2 - \log 68$$

$$A = 2 - 1.832 = 0.168$$

After determining absorbance values, they may be used in the Beer's law equation, $A = abc$, to determine concentration values. Absorbance and percent transmittance values may both be used to construct standard curves to determine concentration values of unknown samples.

55.

D. Spectrophotometric analysis is based on Beer's law, which states that under appropriate conditions the concentration of a colored substance in solution is directly proportional to the amount of light absorbed and inversely proportional to the logarithm of the transmitted light. The narrower the band of wavelengths of light used, the more closely is Beer's law followed. Because Beer's law applies only to absorption of light by the analyte, absorption by any other substance, such as the solvent, would make the law inapplicable. Beer's law is applicable only to dilute solutions. Fluorescing compounds would add light to the system. A chemical reaction would change the concentration of the analyte. In either case, Beer's law would be inapplicable.

56.

D. When one of the two variable quantities changes as a result of changing the other, the result is frequently presented in the form of a graph. It is essential that the scale chosen for each axis of the graph be used consistently. For example, when using Cartesian graph paper where both axes are linear to plot spectrophotometric data (concentration versus absorbance), if 1 cm represents a concentration of 10 mg/dL on the ordinate or horizontal x-axis, 1 cm cannot represent 100 mg/dL toward the end of the scale. Similarly, for the abscissa or vertical y-axis a uniform scale must be used (e.g., 1 cm represents 0.1 absorbance units), but it need not be, and generally it is not, the same as the scale used for the horizontal axis, as illustrated by this example.

57.

D. Primary standards are substances that react quantitatively with other analytes. The caliber of the analysis depends on the caliber of the primary standard. It is therefore essential that the primary standard available be at least 99.95% pure. The primary standard must not be hygroscopic to avoid errors in weighing caused by absorption of water. For accurate weighing, the primary standard must be dry. Dryness is obtained in an oven at a temperature slightly above the boiling point of water. Hence the primary standard must be stable at 110°C. Because the primary standard should have a large equivalent weight and hence a large molecular weight, a relatively large amount will be needed to react with the analyte. The error inherent in weighing very small quantities is thereby avoided.

58.

A. To solve this problem, all the values must be converted to a common unit. In metric measurement the gram is the primary unit for weight. The value 0.1 ng is equal to 1×10^{-10} g, which is the lightest weight given. The gram relationships for the other values stated are 0.01 g $= 1 \times 10^{-2}$ g, 1.0 mg $= 1 \times 10^{-3}$ g, and 1000 pg $= 1 \times 10^{-9}$ g.

59.

C. A solution with an OH^- concentration of 1×10^{-6} has a pOH of 6. The pH + pOH = 14; therefore the pH is 8. The H^+ concentration of pure water is 10^{-7} and has a pH of 7.

60.

D. The molecular weight of NaCl is 58.5 and the atomic weight of Cl is 35.5. To change 50 mg Cl into an equivalent amount of NaCl, the answer must be greater than the amount of Cl. The solution follows:

$$50 \text{ mg Cl} \times \frac{58.5 \text{ mg NaCl}}{35.5 \text{ mg Cl}} = 82.4 \text{ mg NaCl}$$

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