Board Exam Desk

Chemistry Reviewer

Chemistry Licensure Examination | PRC | 120 original questions

2026 Edition | Updated November 2026

Original board-style practice questions with an answer key.

Practice questions

Inorganic Chemistry

1. Among the isoelectronic ions Na+, Mg2+, Al3+ and F-, which has the smallest ionic radius?

A. Mg2+
B. Na+
C. Al3+
D. F-

2. According to VSEPR theory, what is the molecular geometry of XeF4?

A. Seesaw
B. Tetrahedral
C. Square planar
D. Square pyramidal

3. How many unpaired electrons are present in a high-spin octahedral Fe3+ complex?

A. 5
B. 3
C. 1
D. 4

4. What is the oxidation state of chromium in potassium dichromate, K2Cr2O7?

A. +3
B. +6
C. +7
D. +12

5. What hybridization does the sulfur atom use in sulfur hexafluoride, SF6?

A. sp3d2
B. sp3d
C. sp3
D. dsp2

6. Ignoring pairing energy, what is the crystal field stabilization energy of a low-spin octahedral d6 ion?

A. -0.4 Δo
B. -1.2 Δo
C. -2.4 Δo
D. -1.8 Δo

7. Which of the following oxides is amphoteric, reacting with both strong acids and strong bases?

A. Na2O
B. Al2O3
C. SO3
D. CaO

8. Using molecular orbital theory, what is the bond order of the dioxygenyl cation, O2+?

A. 2.5
B. 2.0
C. 1.5
D. 3.0

9. Which of the following diatomic molecules is paramagnetic in its ground state?

A. O2
B. N2
C. F2
D. CO

10. What is the IUPAC name of the coordination compound [Co(NH3)5Cl]Cl2?

A. Pentaamminechloridocobalt(III) chloride
B. Pentaamminechloridocobalt(II) chloride
C. Chloridopentaamminecobalt(II) dichloride
D. Pentaamminecobalt(III) trichloride

11. How many geometric isomers does the square planar complex [Pt(NH3)2Cl2] have?

A. 1
B. 3
C. 4
D. 2

12. Which second-period element has the highest first ionization energy among B, C, N and O?

A. O
B. N
C. C
D. B

13. Based on the hard-soft acid-base principle, which metal ion forms the most stable complex with iodide ion?

A. Hg2+
B. Mg2+
C. Al3+
D. Na+

14. What mass of KClO3 (122.55 g/mol) must decompose to give 5.00 L of O2 measured at 0 °C and 101.325 kPa? (2KClO3 -> 2KCl + 3O2; molar volume 22.414 L/mol)

A. 27.3 g
B. 41.0 g
C. 9.11 g
D. 18.2 g

15. Which noble gas forms the largest number of well-characterized compounds, such as its fluorides and oxides?

A. Argon
B. Xenon
C. Neon
D. Helium

16. Lithium shows a diagonal relationship with which element, sharing properties such as forming a normal oxide and a nitride on heating in air?

A. Magnesium
B. Sodium
C. Beryllium
D. Aluminium

17. What is the spin-only magnetic moment of a complex ion containing three unpaired electrons?

A. 2.83 BM
B. 4.90 BM
C. 3.87 BM
D. 1.73 BM

18. Which of the following oxoacids of chlorine is the strongest acid in water?

A. HClO3
B. HClO2
C. HClO4
D. HClO

19. What is the coordination number of each Na+ ion in the rock-salt (NaCl) crystal structure?

A. 6
B. 4
C. 8
D. 12

20. Copper (63.546 g/mol) crystallizes in a face-centered cubic lattice with a unit-cell edge of 361.5 pm. What is its calculated density?

A. 4.47 g/cm3
B. 2.23 g/cm3
C. 17.9 g/cm3
D. 8.93 g/cm3

Organic Chemistry

21. What is the IUPAC name of (CH3)2CHCH2CH2OH?

A. 2-Methylbutan-4-ol
B. 3-Methylpentan-1-ol
C. 3-Methylbutan-1-ol
D. 2-Methylbutan-1-ol

22. What is the major organic product when propene reacts with HBr in the presence of a peroxide?

A. 2-Bromopropane
B. 1-Bromopropane
C. 1,2-Dibromopropane
D. Propan-2-ol

23. Acid-catalyzed hydration of 1-methylcyclohexene gives which major product?

A. 2-Methylcyclohexanol
B. Cyclohexylmethanol
C. 1-Methylcyclohexane-1,2-diol
D. 1-Methylcyclohexanol

24. Which alkyl bromide reacts fastest with sodium iodide in acetone by an SN2 mechanism?

A. CH3Br
B. CH3CH2Br
C. (CH3)2CHBr
D. (CH3)3CBr

25. How many stereoisomers exist for 2,3-dibromobutane?

A. 4
B. 3
C. 2
D. 1

26. Which of the following species is aromatic?

A. Cyclopentadienyl cation
B. Cyclopentadienyl anion
C. Cyclooctatetraene
D. Cyclohepta-1,3,5-triene

27. Nitration of toluene with a mixture of concentrated HNO3 and H2SO4 gives mainly which products?

A. Meta-nitrotoluene only
B. Ortho- and para-nitrotoluene
C. Nitrobenzene and methanol
D. Phenylnitromethane

28. Which reagent oxidizes a primary alcohol to an aldehyde without significant further oxidation to the carboxylic acid?

A. Hot acidic KMnO4
B. Jones reagent (CrO3, H2SO4, water)
C. Sodium borohydride
D. Pyridinium chlorochromate (PCC)

29. What is the degree of unsaturation (rings plus π bonds) of a compound with molecular formula C8H10O2?

A. 5
B. 3
C. 2
D. 4

30. What is the product of the base-catalyzed aldol addition of two molecules of ethanal, before any dehydration?

A. But-2-enal
B. 2-Hydroxybutanal
C. 3-Hydroxybutanal
D. Butane-1,3-diol

31. Which of the following compounds is the strongest acid?

A. Phenol
B. 4-Nitrophenol
C. 4-Methylphenol
D. Ethanol

32. Methylmagnesium bromide is added to propanone, followed by aqueous acid workup. What is the product?

A. Butan-2-ol
B. Propan-2-ol
C. 2-Methylpropan-1-ol
D. 2-Methylpropan-2-ol

33. What is the product of the Diels-Alder reaction between buta-1,3-diene and ethene?

A. Cyclohexa-1,3-diene
B. Hexa-1,5-diene
C. Cyclobutane
D. Cyclohexene

34. Treating 2-bromo-2-methylbutane with potassium tert-butoxide, a bulky base, gives which major alkene?

A. 2-Methylbut-1-ene
B. 2-Methylbut-2-ene
C. 3-Methylbut-1-ene
D. Pent-2-ene

35. Under the Cahn-Ingold-Prelog rules, which substituent has the highest priority?

A. -NH2
B. -COOH
C. -CH3
D. -OH

36. Ethanoic acid is heated with propan-1-ol and a little concentrated H2SO4. What is the organic product?

A. Ethyl propanoate
B. Propyl methanoate
C. Propyl ethanoate
D. Dipropyl ether

37. Which test gives a silver mirror with butanal but no reaction with butanone?

A. Iodoform test
B. Tollens' test
C. Lucas test
D. Bromine water test

38. A strong, sharp infrared absorption near 1715 cm^-1 most likely indicates which functional group?

A. An alcohol O-H
B. An alkyne C≡C
C. A ketone C=O
D. An amine N-H

39. How many distinct signals appear in the 1H NMR spectrum of ethyl ethanoate, CH3COOCH2CH3?

A. 2
B. 4
C. 3
D. 5

40. Complete combustion of 0.2500 g of a compound containing only C, H and O gives 0.4995 g CO2 and 0.2045 g H2O. What is its empirical formula?

A. CH2O
B. C3H6O
C. C2H4O
D. C2H6O

Analytical Chemistry

41. What is the pH of a 0.0250 M HCl solution?

A. 2.40
B. 1.40
C. 0.60
D. 1.60

42. What is the pH of a 0.100 M acetic acid solution? (Ka = 1.8 x 10^-5)

A. 1.00
B. 4.74
C. 3.87
D. 2.87

43. A buffer contains 0.20 M NH3 and 0.30 M NH4Cl. What is its pH at 25 °C? (Kb of NH3 = 1.8 x 10^-5)

A. 9.43
B. 4.92
C. 8.57
D. 9.08

44. A 25.00 mL portion of HCl requires 18.40 mL of 0.1050 M NaOH to reach the endpoint. What is the molarity of the HCl?

A. 0.07728 M
B. 0.1427 M
C. 0.04830 M
D. 0.1050 M

45. The molar solubility of Ag2CrO4 in pure water at a certain temperature is 6.5 x 10^-5 mol/L. What is its Ksp?

A. 2.7 x 10^-13
B. 1.1 x 10^-12
C. 4.2 x 10^-9
D. 8.5 x 10^-9

46. A 0.5000 g sample is treated so that all its sulfur precipitates as BaSO4 (233.38 g/mol), giving 0.3825 g of precipitate. What is the percentage of sulfur (32.06 g/mol)?

A. 76.50%
B. 21.02%
C. 10.51%
D. 5.25%

47. A solution has an absorbance of 0.450 in a 1.00 cm cell at a wavelength where its molar absorptivity is 1.5 x 10^4 L/(mol·cm). What is its concentration?

A. 6.75 x 10^3 M
B. 3.0 x 10^-5 M
C. 3.3 x 10^-4 M
D. 1.5 x 10^-5 M

48. A sample transmits 25.0% of the incident light at the analytical wavelength. What is its absorbance?

A. 0.602
B. 1.398
C. 0.250
D. 0.750

49. Which substance is commonly used as a primary standard for standardizing sodium hydroxide solutions?

A. Sodium carbonate
B. Hydrochloric acid
C. Potassium permanganate
D. Potassium hydrogen phthalate

50. Which indicator is most suitable for titrating acetic acid with sodium hydroxide?

A. Phenolphthalein
B. Methyl orange
C. Methyl red
D. Bromophenol blue

51. A 50.00 mL water sample requires 12.60 mL of 0.01000 M EDTA for titration of Ca2+ and Mg2+. What is the total hardness expressed as mg CaCO3 per liter? (CaCO3 = 100.09 g/mol)

A. 126 mg/L
B. 504 mg/L
C. 25.2 mg/L
D. 252 mg/L

52. What volume of 12.0 M HCl is needed to prepare 500.0 mL of 0.300 M HCl?

A. 20.0 mL
B. 7.20 mL
C. 40.0 mL
D. 12.5 mL

53. Five replicate analyses give 10.2, 10.5, 10.3, 10.6 and 10.4 mg/L. What is the sample standard deviation?

A. 0.14 mg/L
B. 0.16 mg/L
C. 0.40 mg/L
D. 0.025 mg/L

54. In the Volhard method for chloride, excess standard AgNO3 is back-titrated with thiocyanate. What serves as the indicator?

A. Chromate ion
B. Fluorescein
C. Starch
D. Iron(III) ion

55. Iron(II) in a dissolved ore sample requires 22.50 mL of 0.02000 M KMnO4 in acid solution. What mass of iron (55.845 g/mol) is present? (MnO4- + 5Fe2+ + 8H+ -> Mn2+ + 5Fe3+ + 4H2O)

A. 0.1257 g
B. 0.02513 g
C. 0.6284 g
D. 0.2513 g

56. Two chromatographic peaks have retention times of 5.20 and 5.80 min and baseline widths of 0.30 and 0.34 min. What is their resolution?

A. 0.94
B. 3.8
C. 1.9
D. 1.2

57. For the cell Zn | Zn2+ (0.010 M) || Cu2+ (1.0 M) | Cu at 25 °C, E°cell = 1.10 V. What is the cell potential?

A. 1.04 V
B. 1.22 V
C. 1.16 V
D. 0.98 V

58. Which gas chromatography detector is especially sensitive to halogenated compounds such as organochlorine pesticides?

A. Flame ionization detector
B. Electron capture detector
C. Thermal conductivity detector
D. Refractive index detector

59. What radiation source is normally used in flame atomic absorption spectrometry for determining a specific metal?

A. Deuterium lamp
B. Hollow cathode lamp
C. Tungsten filament lamp
D. Nernst glower

60. Concentrated hydrochloric acid is 37.0% HCl by mass and has a density of 1.18 g/mL. What is its molarity? (HCl = 36.46 g/mol)

A. 12.0 M
B. 10.1 M
C. 32.4 M
D. 1.01 M

Physical Chemistry

61. How many moles of an ideal gas occupy 10.0 L at 300 K and 200 kPa?

A. 0.0802 mol
B. 8.02 mol
C. 0.406 mol
D. 0.802 mol

62. Under identical conditions, how many times faster does H2 (2.016 g/mol) effuse than O2 (31.998 g/mol)?

A. 15.9
B. 1.99
C. 0.251
D. 3.98

63. A first-order reaction has a rate constant of 0.0231 min^-1. What is its half-life?

A. 43.3 min
B. 21.6 min
C. 30.0 min
D. 15.0 min

64. For a first-order process, what percentage of the reactant remains after four half-lives?

A. 6.25%
B. 12.5%
C. 25.0%
D. 3.13%

65. The rate constant of a reaction doubles when the temperature rises from 300 K to 310 K. What is the activation energy?

A. 5.76 kJ/mol
B. 53.6 kJ/mol
C. 23.3 kJ/mol
D. 124 kJ/mol

66. Given C(s) + O2(g) -> CO2(g), ∆H = -393.5 kJ, and CO(g) + 1/2 O2(g) -> CO2(g), ∆H = -283.0 kJ, what is ∆H for C(s) + 1/2 O2(g) -> CO(g)?

A. -110.5 kJ
B. -676.5 kJ
C. +110.5 kJ
D. -221.0 kJ

67. How much heat is needed to warm 250 g of liquid water from 20.0 °C to 80.0 °C? (c = 4.184 J/(g·K))

A. 83.7 kJ
B. 20.9 kJ
C. 62.8 kJ
D. 1.05 kJ

68. For a reaction, ∆H° = -92.2 kJ/mol and ∆S° = -198.7 J/(mol·K), both assumed constant. Above what temperature does the reaction become nonspontaneous?

A. 464 K
B. 0.464 K
C. 215 K
D. 298 K

69. A reaction has an equilibrium constant K = 1.0 x 10^5 at 298 K. What is its standard Gibbs energy change?

A. -12.4 kJ/mol
B. -28.5 kJ/mol
C. +28.5 kJ/mol
D. -2.85 kJ/mol

70. Estimate the freezing point depression of a 0.500 mol/kg aqueous NaCl solution, assuming complete dissociation. (Kf of water = 1.86 K·kg/mol)

A. 0.930 K
B. 3.72 K
C. 0.465 K
D. 1.86 K

71. What is the osmotic pressure of a 0.100 mol/L aqueous glucose solution at 298 K?

A. 2.48 kPa
B. 248 kPa
C. 24.8 kPa
D. 496 kPa

72. Pure water has a vapor pressure of 3.17 kPa at 25 °C. What is the vapor pressure of a solution in which the mole fraction of water is 0.900, assuming ideal behavior?

A. 2.85 kPa
B. 0.317 kPa
C. 3.52 kPa
D. 3.17 kPa

73. What are the SI-based units of the rate constant of a second-order reaction when concentration is in mol/L and time in seconds?

A. mol/(L·s)
B. L/(mol·s)
C. 1/s
D. L2/(mol2·s)

74. A reaction A -> products follows the rate law rate = -d[A]/dt = k[A]^2 with k = 0.50 L/(mol·s) and an initial concentration of A of 0.20 mol/L. What is its first half-life?

A. 1.4 s
B. 0.10 s
C. 10 s
D. 5.0 s

75. Water boils at 373.15 K under 101.325 kPa, and its enthalpy of vaporization is 40.7 kJ/mol. Using the Clausius-Clapeyron equation, estimate its vapor pressure at 353.15 K.

A. 213 kPa
B. 81.1 kPa
C. 48.2 kPa
D. 96.0 kPa

76. For N2(g) + 3H2(g) ■ 2NH3(g), ∆H° < 0, which change shifts the equilibrium toward ammonia?

A. Raising the temperature
B. Adding an inert gas at constant volume
C. Increasing the total pressure
D. Adding an iron catalyst

77. For H2(g) + I2(g) ■ 2HI(g), Kc = 49 at a certain temperature. If 1.00 mol/L each of H2 and I2 are mixed initially, what is [HI] at equilibrium?

A. 0.778 mol/L
B. 1.56 mol/L
C. 1.75 mol/L
D. 0.875 mol/L

78. For N2O4(g) ■ 2NO2(g), Kc = 4.6 x 10^-3 at 298 K. What is Kp in bar units? (R = 0.08314 L·bar/(mol·K))

A. 1.9 x 10^-4
B. 4.6 x 10^-3
C. 2.8
D. 0.11

79. What is the energy of one photon of light with a wavelength of 500 nm? (h = 6.626 x 10^-34 J·s, c = 2.998 x 10^8 m/s)

A. 3.31 x 10^-40 J
B. 1.99 x 10^-25 J
C. 7.95 x 10^-19 J
D. 3.97 x 10^-19 J

80. A current of 2.00 A passes through aqueous CuSO4 for 30.0 min. What mass of copper (63.546 g/mol) is deposited at the cathode? (F = 96 485 C/mol)

A. 2.37 g
B. 1.19 g
C. 0.593 g
D. 0.0395 g

Biochemistry

81. Which of the standard amino acids found in proteins is achiral?

A. Alanine
B. Glycine
C. Serine
D. Proline

82. The covalent bond that joins the carboxyl group of one amino acid to the amino group of the next in a protein is a(n):

A. Glycosidic bond
B. Peptide (amide) bond
C. Phosphodiester bond
D. Ester bond

83. Alanine has pKa values of 2.34 (alpha-carboxyl) and 9.69 (alpha-amino). What is its isoelectric point?

A. 7.35
B. 12.03
C. 4.68
D. 6.02

84. An enzyme has Vmax = 120 μmol/min and Km = 2.0 mM. What is the initial velocity when the substrate concentration is 6.0 mM?

A. 90 μmol/min
B. 30 μmol/min
C. 60 μmol/min
D. 40 μmol/min

85. How does a purely competitive inhibitor change the kinetic parameters of an enzyme?

A. Km unchanged; Vmax decreases
B. Both Km and Vmax decrease
C. Apparent Km increases; Vmax unchanged
D. Apparent Km decreases; Vmax increases

86. Sucrose consists of glucose and fructose joined by which glycosidic linkage?

A. α(1→2)β
B. β(1→4)
C. α(1→4)
D. α(1→6)

87. In a Lineweaver-Burk (double-reciprocal) plot, the intercept on the horizontal 1/[S] axis equals:

A. -1/Km
B. 1/Vmax
C. Km/Vmax
D. -Vmax

88. How many hydrogen bonds connect a guanine-cytosine base pair in double-stranded DNA?

A. 2
B. 1
C. 3
D. 4

89. A sample of double-stranded DNA contains 22% adenine. What percentage of its bases are cytosine?

A. 28%
B. 22%
C. 56%
D. 44%

90. What is the net yield of ATP from glycolysis when one glucose molecule is converted to two pyruvate molecules?

A. 4 ATP
B. 36 ATP
C. 2 ATP
D. 1 ATP

91. Which enzyme catalyzes the main committed, regulated step of glycolysis?

A. Hexokinase
B. Aldolase
C. Enolase
D. Phosphofructokinase-1

92. Which of the following fatty acids is saturated?

A. Palmitic acid
B. Oleic acid
C. Linoleic acid
D. Arachidonic acid

93. The alpha helix of a protein is stabilized mainly by hydrogen bonds between which groups?

A. Backbone C=O and N-H groups
B. Side-chain carboxyl groups
C. Cysteine sulfur atoms
D. Phosphate groups

94. When a protein is denatured by moderate heat, which level of structure normally remains intact?

A. Secondary structure
B. Primary structure
C. Tertiary structure
D. Quaternary structure

95. Which coenzyme is derived from the vitamin niacin?

A. FAD
B. Coenzyme A
C. NAD+
D. Thiamine pyrophosphate

96. How many acetyl-CoA molecules are produced by complete beta-oxidation of one palmitoyl-CoA (C16)?

A. 7
B. 16
C. 4
D. 8

97. What class of lipid forms the basic bilayer structure of biological cell membranes?

A. Triacylglycerols
B. Waxes
C. Carotenoids
D. Phospholipids

98. Which of the following disaccharides is a non-reducing sugar?

A. Sucrose
B. Maltose
C. Lactose
D. Cellobiose

99. In mammals, the urea cycle takes place mainly in which organ?

A. Kidney
B. Pancreas
C. Skeletal muscle
D. Liver

100. An enzyme preparation containing 1.5 mg of protein converts 30 μmol of substrate per minute under standard assay conditions. What is its specific activity?

A. 45 U/mg
B. 0.050 U/mg
C. 20 U/mg
D. 30 U/mg

Chemical Technology

101. In the Haber-Bosch synthesis of ammonia, what material serves as the main catalyst?

A. Promoted iron
B. Vanadium(V) oxide
C. Platinum-rhodium gauze
D. Raney nickel

102. In the contact process for sulfuric acid, which catalyst oxidizes SO2 to SO3?

A. Promoted iron
B. Nickel
C. Zeolite
D. Vanadium(V) oxide

103. The Ostwald process catalytically oxidizes ammonia over platinum-rhodium gauze to ultimately produce which chemical?

A. Ammonium nitrate
B. Urea
C. Hydrazine
D. Nitric acid

104. The Solvay (ammonia-soda) process is used industrially to manufacture which compound?

A. Sodium hydroxide
B. Sodium chloride
C. Sodium carbonate
D. Sodium sulfate

105. Electrolysis of concentrated aqueous NaCl in a membrane cell yields which set of products?

A. Na metal and Cl2
B. O2, H2 and NaCl
C. Cl2, H2 and NaOH
D. HCl, O2 and Na2O

106. Alkaline hydrolysis (saponification) of a triglyceride fat with NaOH produces glycerol and:

A. Free fatty acids and NaCl
B. Fatty alcohols
C. Sodium salts of fatty acids
D. Methyl esters of fatty acids

107. Liquid vegetable oils are converted into solid fats for margarine by which process?

A. Saponification with NaOH
B. Catalytic hydrogenation over nickel
C. Transesterification with methanol
D. Fractional distillation

108. What are the principal raw materials for manufacturing Portland cement clinker?

A. Sand and soda ash
B. Limestone and clay
C. Gypsum and coal
D. Bauxite and cryolite

109. Which chemical is widely used as a coagulant to remove suspended particles in municipal water treatment?

A. Aluminium sulfate
B. Sodium chloride
C. Calcium hypochlorite
D. Activated carbon

110. Temporary hardness of water, which can be removed by boiling, is caused mainly by dissolved:

A. Calcium and magnesium sulfates
B. Sodium chloride
C. Calcium and magnesium hydrogen carbonates
D. Calcium and magnesium chlorides

111. A plant converts 1000 kg of N2 into 950 kg of NH3. What is the percentage yield? (N2 = 28.014 g/mol, NH3 = 17.031 g/mol)

A. 78.1%
B. 95.0%
C. 39.1%
D. 64.0%

112. Coal containing 2.50% sulfur by mass is burned completely. What mass of SO2 forms per 1000 kg of coal? (S = 32.06 g/mol, SO2 = 64.06 g/mol)

A. 25.0 kg
B. 50.0 kg
C. 12.5 kg
D. 75.0 kg

113. Polyvinyl chloride (PVC) is produced by addition polymerization of which monomer?

A. Chloroprene
B. Chloromethane
C. 1,2-Dichloroethane
D. Chloroethene

114. Nylon-6,6 is made by condensation polymerization of hexane-1,6-diamine with which compound?

A. Terephthalic acid
B. Caprolactam
C. Hexanedioic acid
D. Ethylene glycol

115. In the octane rating scale for gasoline, which compound is assigned an octane number of 100?

A. n-Heptane
B. 2,2,4-Trimethylpentane
C. n-Octane
D. Toluene

116. What is the theoretical mass of ethanol obtainable by fermenting 1.00 kg of glucose? (C6H12O6 -> 2C2H5OH + 2CO2; glucose = 180.16 g/mol, ethanol = 46.07 g/mol)

A. 256 g
B. 1022 g
C. 511 g
D. 489 g

117. What is the major chemical constituent of ordinary soda-lime glass?

A. Calcium carbonate
B. Silicon dioxide
C. Sodium chloride
D. Aluminium oxide

118. The kraft process for chemical pulping of wood uses a cooking liquor containing:

A. Sulfuric acid and calcium sulfite
B. Hydrogen peroxide and ozone
C. Sodium chloride and chlorine
D. Sodium hydroxide and sodium sulfide

119. What mass of $Ca(OH)_2$ (74.09 g/mol) is needed to neutralize 2.00 kg of H_2SO_4 (98.08 g/mol) in an acidic waste stream?

A. 2.65 kg
B. 1.51 kg
C. 0.755 kg
D. 3.02 kg

120. What is the mass percentage of nitrogen in urea, $CO(NH_2)_2$ (60.06 g/mol)?

A. 46.6%
B. 23.3%
C. 31.8%
D. 53.3%

Answer key

Chemistry

1. C. Al3+

All four have 10 electrons; Al3+ has the most protons (13) pulling on them, so it is the smallest.

2. C. Square planar

Xe has 4 bonding pairs and 2 lone pairs (octahedral electron geometry); the lone pairs sit trans, giving a square planar shape.

3. A. 5

Fe3+ is d5; in a weak field each of the five d orbitals is singly occupied before pairing, giving 5 unpaired electrons.

4. B. +6

2(+1) + 2x + 7(-2) = 0 gives 2x = 12, so each Cr is +6.

5. A. sp3d2

Six bonding pairs and no lone pairs on S require six hybrid orbitals arranged octahedrally, described as sp3d2.

6. C. -2.4 ∆o

Low-spin d6 is t2g6 eg0: 6 x (-0.4 ∆o) = -2.4 ∆o.

7. B. Al2O3

Aluminium oxide dissolves in acids to give Al3+ and in strong bases to give aluminate; the others are purely basic or acidic.

8. A. 2.5

O2+ has 10 bonding and 5 antibonding valence electrons: (10 - 5)/2 = 2.5.

9. A. O2

O2 has two unpaired electrons in degenerate π* orbitals; N2, F2 and CO have all electrons paired.

10. A. Pentaamminechloridocobalt(III) chloride

Ligands are listed alphabetically (ammine before chlorido); charge balance with two outer Cl- gives Co(+3).

11. D. 2

The two Cl ligands can be adjacent (cis) or opposite (trans), giving two geometric isomers.

12. B. N

Nitrogen's half-filled 2p subshell is especially stable; oxygen's fourth 2p electron is paired and easier to remove.

13. A. Hg2+

I- is a soft base and pairs best with the soft, polarizable Hg2+; the other ions are hard acids.

14. D. 18.2 g

n(O2) = 5.00/22.414 = 0.2231 mol; n(KClO3) = 0.2231 x 2/3 = 0.1487 mol; 0.1487 x 122.55 = 18.2 g.

15. B. Xenon

Xenon's large size and relatively low ionization energy allow it to form stable compounds such as XeF2, XeF4 and XeO3.

16. A. Magnesium

Li and Mg have similar charge-to-radius ratios, so both burn to give normal oxides and react with N2 to form nitrides.

17. C. 3.87 BM

μ = sqrt(n(n + 2)) = sqrt(3 x 5) = sqrt(15) = 3.87 Bohr magnetons.

18. C. HClO4

More terminal oxygens on Cl spread the negative charge of the conjugate base, so HClO4 ionizes most completely.

19. A. 6

In the rock-salt lattice each Na+ sits in an octahedral hole surrounded by six Cl- ions, and vice versa.

20. D. 8.93 g/cm3

An fcc cell holds 4 atoms: d = 4(63.546)/[(6.022 x 10^23)(3.615 x 10^-8 cm)^3] = 254.18/28.45 = 8.93 g/cm3.

21. C. 3-Methylbutan-1-ol

The longest chain containing the OH carbon has four carbons; numbering from the OH end puts the methyl on C3.

22. B. 1-Bromopropane

Peroxides start a radical chain in which Br adds to the terminal carbon to give the more stable secondary radical, so the anti-Markovnikov product forms.

23. D. 1-Methylcyclohexanol

Protonation gives the tertiary carbocation at C1, which water attacks (Markovnikov addition).

24. A. CH3Br

SN2 rates fall with steric hindrance at the reacting carbon: methyl > primary > secondary >> tertiary.

25. B. 3

Two stereocenters would allow 4, but the (2R,3S) form is a meso compound identical to (2S,3R), leaving 3.

26. B. Cyclopentadienyl anion

The cyclopentadienyl anion is cyclic, planar and fully conjugated with 6 π electrons, satisfying Hückel's 4n + 2 rule.

27. B. Ortho- and para-nitrotoluene

The methyl group is an activating ortho/para director because it stabilizes the arenium ion intermediates for those positions.

28. D. Pyridinium chlorochromate (PCC)

PCC in an anhydrous solvent stops at the aldehyde; aqueous chromic acid and permanganate continue to the acid, and NaBH4 is a reducing agent.

29. D. 4

DoU = (2C + 2 - H)/2 = (16 + 2 - 10)/2 = 4; oxygen does not affect the count.

30. C. 3-Hydroxybutanal

The enolate of one ethanal attacks the carbonyl carbon of another, giving CH3CH(OH)CH2CHO (3-hydroxybutanal).

31. B. 4-Nitrophenol

The nitro group withdraws electron density by resonance and induction, stabilizing the phenoxide ion more than in the other compounds.

32. D. 2-Methylpropan-2-ol

The methyl carbanion adds to the ketone carbonyl, and protonation gives the tertiary alcohol (CH3)3COH.

33. D. Cyclohexene

The [4+2] cycloaddition forms two new σ bonds and a six-membered ring with one remaining C=C bond.

34. A. 2-Methylbut-1-ene

A bulky base removes the more accessible primary hydrogen, favoring the less substituted (Hofmann) alkene.

35. D. -OH

Priority is set by the atomic number of the attached atom: O (8) > N (7) > C (6); -COOH is attached through carbon.

36. C. Propyl ethanoate

In Fischer esterification the acid supplies the acyl part (ethanoate) and the alcohol supplies the alkyl part (propyl).

37. B. Tollens' test

Tollens' reagent (ammoniacal Ag+) oxidizes aldehydes and is reduced to metallic silver; simple ketones are not oxidized.

38. C. A ketone C=O

Saturated ketone carbonyl stretches appear near 1715 cm^-1; O-H and N-H absorb above 3200 cm^-1, and C≡C near 2100-2260 cm^-1.

39. C. 3

There are three proton environments: the acetyl CH3 (singlet), the OCH2 (quartet) and the ethyl CH3 (triplet).

40. C. C2H4O

C: 0.4995/44.009 = 0.01135 mol (0.1363 g); H: 2(0.2045/18.015) = 0.02270 mol (0.0229 g); O: 0.0908 g = 0.00568 mol; ratio 2 : 4 : 1.

41. D. 1.60

HCl ionizes completely, so [H+] = 0.0250 M and pH = -log(0.0250) = 1.60.

42. D. 2.87

[H+] ≈ sqrt(Ka x C) = sqrt(1.8 x 10^-6) = 1.34 x 10^-3 M, so pH = 2.87.

43. D. 9.08

pOH = pKb + log([NH4+]/[NH3]) = 4.74 + log(1.5) = 4.92; pH = 14.00 - 4.92 = 9.08.

44. A. 0.07728 M

Moles NaOH = 0.01840 L x 0.1050 M = 1.932 x 10^-3 mol = moles HCl; 1.932 x 10^-3/0.02500 L = 0.07728 M.

45. B. 1.1 x 10^-12

Ag2CrO4 -> 2Ag+ + CrO4^2-: Ksp = (2s)^2(s) = 4s^3 = 4(6.5 x 10^-5)^3 = 1.1 x 10^-12.

46. C. 10.51%

Mass S = 0.3825 x (32.06/233.38) = 0.05255 g; 0.05255/0.5000 x 100 = 10.51%.

47. B. 3.0 x 10^-5 M

By Beer's law, c = A/(εb) = 0.450/(1.5 x 10^4 x 1.00) = 3.0 x 10^-5 mol/L.

48. A. 0.602

A = -log T = -log(0.250) = 0.602.

49. D. Potassium hydrogen phthalate

KHP is a stable, non-hygroscopic, high-purity monoprotic acid with a large molar mass, ideal for weighing out NaOH standards.

50. A. Phenolphthalein

The equivalence point of a weak acid-strong base titration is basic (around pH 8-9), within phenolphthalein's transition range.

51. D. 252 mg/L

Moles EDTA = 1.260 x 10^-4 = moles CaCO3 equivalent = 12.61 mg; 12.61 mg/0.05000 L = 252 mg/L.

52. D. 12.5 mL

C1V1 = C2V2: V1 = (0.300 M x 500.0 mL)/12.0 M = 12.5 mL.

53. B. 0.16 mg/L

Mean = 10.4; sum of squared deviations = 0.10; s = sqrt(0.10/(5 - 1)) = 0.158 ≈ 0.16 mg/L.

54. D. Iron(III) ion

After the excess Ag+ is consumed, the first excess SCN- forms red FeSCN2+ with the Fe3+ indicator.

55. A. 0.1257 g

Moles MnO4- = 4.500 x 10^-4; moles Fe2+ = 5 x 4.500 x 10^-4 = 2.250 x 10^-3; mass = 2.250 x 10^-3 x 55.845 = 0.1257 g.

56. C. 1.9

Rs = 2(tB - tA)/(wA + wB) = 2(0.60)/(0.64) = 1.88 ≈ 1.9.

57. C. 1.16 V

E = E° - (0.05916/2) log([Zn2+]/[Cu2+]) = 1.10 - 0.02958 x (-2) = 1.16 V.

58. B. Electron capture detector

Electronegative halogens capture electrons emitted by the ECD's radioactive source, lowering the standing current strongly.

59. B. Hollow cathode lamp

A hollow cathode lamp made of the analyte element emits narrow lines that match that element's absorption lines.

60. A. 12.0 M

One liter has 1180 g of solution x 0.370 = 436.6 g HCl; 436.6/36.46 = 11.97 ≈ 12.0 mol/L.

61. D. 0.802 mol

n = PV/RT = (2.00 x 10^5 Pa)(1.00 x 10^-2 m3)/(8.314 x 300) = 0.802 mol.

62. D. 3.98

By Graham's law, rate ratio = sqrt(31.998/2.016) = sqrt(15.87) = 3.98.

63. C. 30.0 min

t1/2 = ln 2/k = 0.693/0.0231 min^-1 = 30.0 min.

64. A. 6.25%

Each half-life halves the amount: (1/2)^4 = 1/16 = 6.25%.

65. B. 53.6 kJ/mol

Ea = R ln(k2/k1)/(1/T1 - 1/T2) = 8.314(0.6931)/(1.075 x 10^-4 K^-1) = 5.36 x 10^4 J/mol.

66. A. -110.5 kJ

By Hess's law, subtract the second equation from the first: -393.5 - (-283.0) = -110.5 kJ.

67. C. 62.8 kJ

q = mcΔT = 250 g x 4.184 J/(g·K) x 60.0 K = 6.28 x 10^4 J = 62.8 kJ.

68. A. 464 K

ΔG = 0 when T = ΔH/ΔS = (-92 200 J/mol)/(-198.7 J/(mol·K)) = 464 K; above this, the -TΔS term makes ΔG positive.

69. B. -28.5 kJ/mol

ΔG° = -RT ln K = -(8.314)(298)(11.51) = -2.85 x 10^4 J/mol.

70. D. 1.86 K

ΔTf = iKf m = 2 x 1.86 x 0.500 = 1.86 K, since NaCl gives two ions.

71. B. 248 kPa

π = cRT = (100 mol/m3)(8.314 J/(mol·K))(298 K) = 2.48 x 10^5 Pa = 248 kPa; glucose does not dissociate.

72. A. 2.85 kPa

By Raoult's law, P = x(solvent) P° = 0.900 x 3.17 kPa = 2.85 kPa.

73. B. L/(mol·s)

For rate = k[A]^2, k = (mol/(L·s))/(mol/L)^2 = L/(mol·s).

74. C. 10 s

For second-order kinetics t1/2 = 1/(k[A]0) = 1/(0.50 x 0.20) = 10 s; 1.4 s would be the first-order formula ln 2/k.

75. C. 48.2 kPa

ln(P2/101.325) = -(40 700/8.314)(1/353.15 - 1/373.15) = -0.743; P2 = 101.325 x 0.476 = 48.2 kPa.

76. C. Increasing the total pressure

Higher pressure favors the side with fewer gas moles (2 vs 4); heating favors the endothermic reverse, and catalysts or inert gas at constant volume do not shift it.

77. B. 1.56 mol/L

(2x)^2/(1 - x)^2 = 49 gives 2x/(1 - x) = 7, so x = 0.778 and [HI] = 2x = 1.56 mol/L.

78. D. 0.11

Kp = Kc(RT)^Δn with Δn = 1: 4.6 x 10^-3 x (0.08314 x 298) = 4.6 x 10^-3 x 24.8 = 0.11.

79. D. 3.97 x 10^-19 J

E = hc/λ = (6.626 x 10^-34)(2.998 x 10^8)/(5.00 x 10^-7 m) = 3.97 x 10^-19 J.

80. B. 1.19 g

Q = 2.00 x 1800 = 3600 C; moles e- = 0.03731; Cu2+ needs 2 e-, so 0.01866 mol x 63.546 = 1.19 g.

81. B. Glycine

Glycine's side chain is a hydrogen atom, so its alpha carbon carries two identical substituents and is not a stereocenter.

82. B. Peptide (amide) bond

Condensation of -COOH with -NH2 releases water and forms an amide linkage, called a peptide bond in proteins.

83. D. 6.02

For an amino acid with a non-ionizable side chain, pI = (2.34 + 9.69)/2 = 6.02.

84. A. 90 μmol/min

v = Vmax[S]/(Km + [S]) = 120 x 6.0/(2.0 + 6.0) = 90 μmol/min.

85. C. Apparent Km increases; Vmax unchanged

A competitive inhibitor competes for the active site, so more substrate is needed for half-maximal rate, but high [S] still reaches Vmax.

86. A. α(1→2)β

C1 of α-glucose is bonded to C2 of β-fructose; because both anomeric carbons are tied up, sucrose is non-reducing.

87. A. -1/Km

1/v = (Km/Vmax)(1/[S]) + 1/Vmax; setting 1/v = 0 gives 1/[S] = -1/Km.

88. C. 3

G-C pairs form three hydrogen bonds, whereas A-T pairs form two, which is why GC-rich DNA melts at higher temperature.

89. A. 28%

By Chargaff's rules A = T = 22%, so G + C = 56% and C = 28%.

90. C. 2 ATP

Four ATP are made by substrate-level phosphorylation, but two are consumed in the priming steps, for a net of 2.

91. D. Phosphofructokinase-1

PFK-1 catalyzes the irreversible phosphorylation of fructose 6-phosphate and is allosterically controlled by ATP, AMP and citrate.

92. A. Palmitic acid

Palmitic acid (C16:0) has no C=C double bonds; oleic, linoleic and arachidonic acids have one, two and four respectively.

93. A. Backbone C=O and N-H groups

Each backbone C=O hydrogen-bonds to the N-H four residues further along the chain.

94. B. Primary structure

Denaturation disrupts noncovalent interactions but does not hydrolyze the covalent peptide bonds that define the amino acid sequence.

95. C. NAD+

Niacin (nicotinic acid) provides the nicotinamide ring of NAD+ and NADP+; FAD comes from riboflavin, CoA from pantothenate.

96. D. 8

Seven cycles of beta-oxidation cleave the 16-carbon chain into eight two-carbon acetyl-CoA units.

97. D. Phospholipids

Phospholipids are amphipathic, with polar heads facing water and nonpolar tails facing each other, which drives bilayer formation.

98. A. Sucrose

In sucrose both anomeric carbons are in the glycosidic bond, so there is no free hemiacetal to reduce Benedict's reagent.

99. D. Liver

Hepatocytes contain the full set of urea cycle enzymes, split between mitochondria and cytosol; the kidneys excrete the urea.

100. C. 20 U/mg

Specific activity = activity/protein = 30 μmol/min ÷ 1.5 mg = 20 μmol/(min·mg), i.e., 20 U/mg.

101. A. Promoted iron

Iron promoted with oxides such as K2O and Al2O3 catalyzes the reaction N2 + 3H2 -> 2NH3.

102. D. Vanadium(V) oxide

V2O5 catalyzes 2SO2 + O2 -> 2SO3, and the SO3 is then absorbed in concentrated H2SO4.

103. D. Nitric acid

NH3 is oxidized to NO, which forms NO2 and is absorbed in water to give HNO3.

104. C. Sodium carbonate

Brine, ammonia and CO2 give NaHCO3, which is heated (calcined) to Na2CO3.

105. C. Cl2, H2 and NaOH

Chloride is oxidized to Cl2 at the anode, water is reduced to H2 and OH- at the cathode, and Na+ migrates through the membrane to form NaOH.

106. C. Sodium salts of fatty acids

Each ester bond is cleaved by OH-, giving the sodium carboxylate soaps and the triol glycerol.

107. B. Catalytic hydrogenation over nickel

H2 adds across the C=C bonds of the unsaturated fatty acid chains, raising the melting point.

108. B. Limestone and clay

Limestone supplies CaO and clay or shale supplies SiO2, Al2O3 and Fe2O3; gypsum is only ground in afterwards.

109. A. Aluminium sulfate

Alum hydrolyzes to gelatinous Al(OH)3 flocs that trap colloidal particles, which then settle out.

110. C. Calcium and magnesium hydrogen carbonates

On boiling, Ca(HCO3)2 decomposes to insoluble CaCO3, CO2 and water; sulfates and chlorides cause permanent hardness.

111. A. 78.1%

Theoretical NH3 = 1000 x (2 x 17.031/28.014) = 1216 kg; yield = 950/1216 x 100 = 78.1%.

112. B. 50.0 kg

Sulfur = 25.0 kg; SO2 = 25.0 x (64.06/32.06) = 50.0 kg.

113. D. Chloroethene

Chloroethene (vinyl chloride, CH2=CHCl) polymerizes to -(CH2-CHCl)n-.

114. C. Hexanedioic acid

Hexanedioic (adipic) acid and the six-carbon diamine form amide links; the two 6s refer to the carbon counts of each monomer.

115. B. 2,2,4-Trimethylpentane

Isooctane (2,2,4-trimethylpentane) resists knocking and defines 100, while n-heptane defines 0.

116. C. 511 g

Moles glucose = 1000/180.16 = 5.551; ethanol = 2 x 5.551 x 46.07 = 511 g.

117. B. Silicon dioxide

Soda-lime glass is roughly 70% SiO2, with Na2O and CaO added to lower the melting point and improve durability.

118. D. Sodium hydroxide and sodium sulfide

Kraft white liquor (NaOH + Na2S) dissolves lignin and frees the cellulose fibers.

119. B. 1.51 kg

H2SO4 + Ca(OH)2 -> CaSO4 + 2H2O (1:1); 2000/98.08 = 20.39 mol x 74.09 g/mol = 1.51 kg.

120. A. 46.6%

Urea contains two N atoms: 2 x 14.007/60.06 x 100 = 46.6%.

Topics to review

- Stoichiometry and chemical equilibrium
- Organic reactions and structure
- Instrumental analysis and calibration
- Laboratory safety, quality control and reporting

Online question banks and study resources

Chemist - Pass Harbor (Question bank)

Chemical technician - Pass Harbor (Question bank)

Official PRC board information

Current PRC exam programs

Independent study material prepared by Board Exam Desk.