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TENTH EDITION

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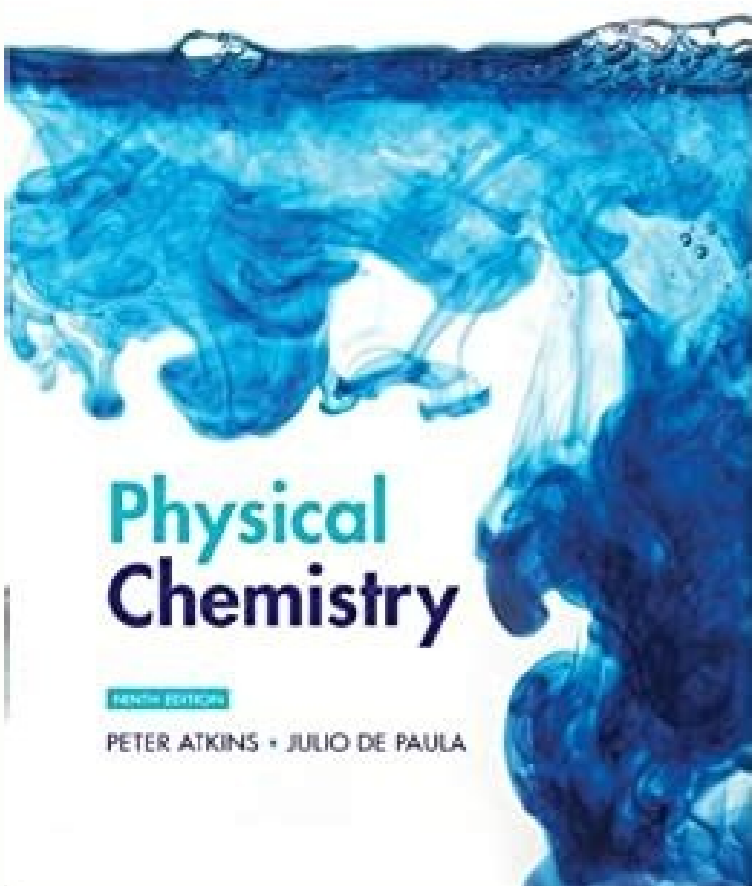
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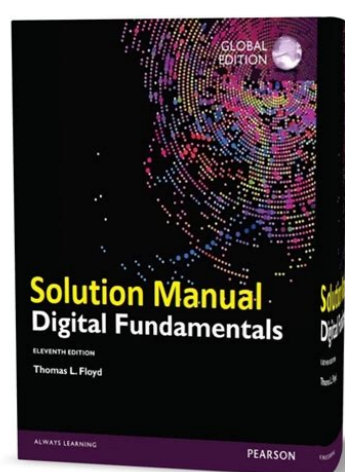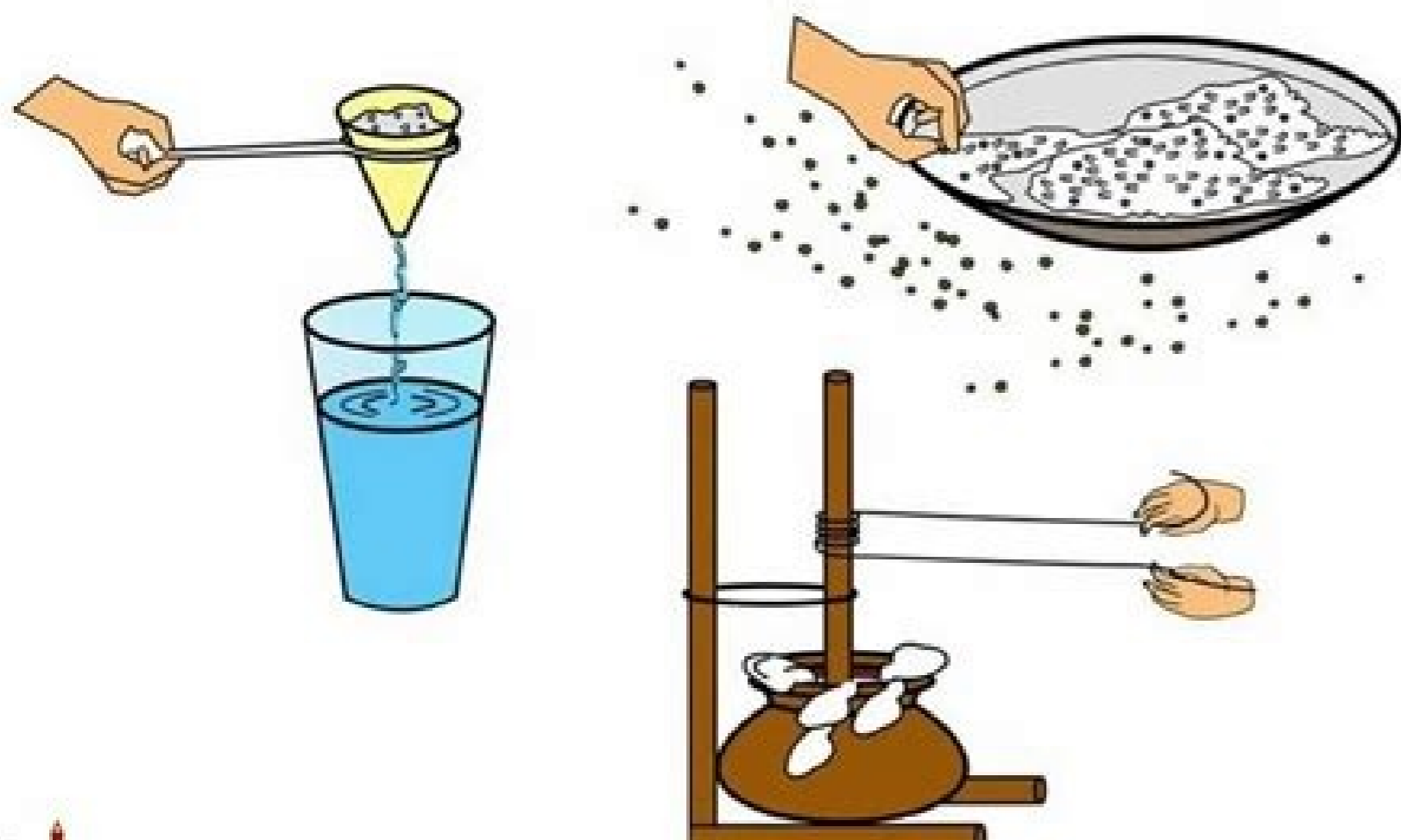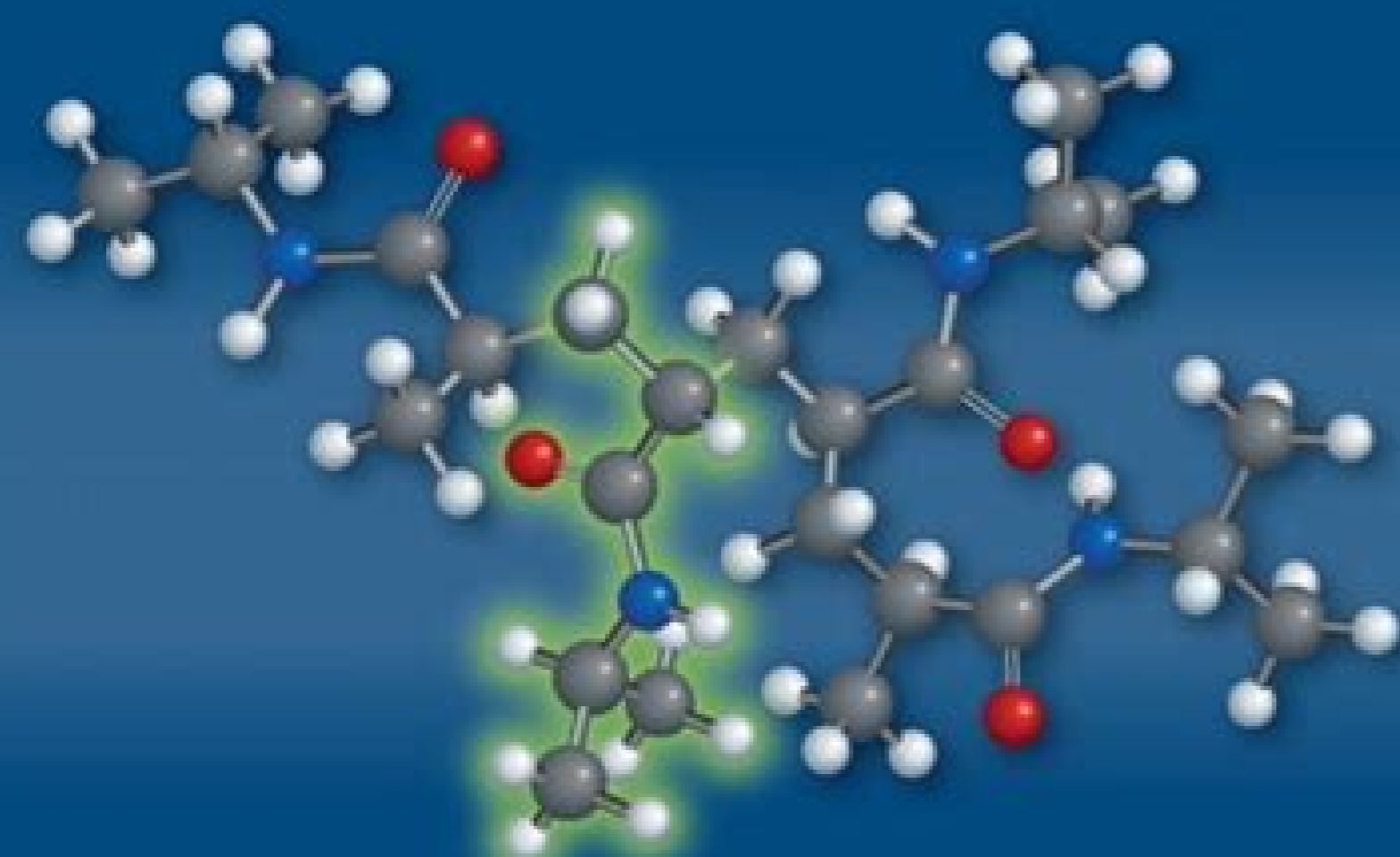
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COMPLETE SOLUTIONS MANUAL

GENERAL CHEMISTRY

PRINCIPLES AND MODERN APPLICATIONS

ELEVENTH EDITION

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solutions to b) exercises and even-numbered problems (instructor) answers to a) exercises and odd-numbered problems (student) PHYSICAL CHEMISTRY Thermodynamics, Structure, and Change Tenth Edition Peter Atkins | Julio de Paula Foundations A Matter Answers to discussion questions A.2 Metals conduct electricity, have luster, and they are malleable and ductile. Nonmetals do not conduct electricity and are neither malleable nor ductile. Metalloids typically have the appearance of metals but behave chemically like a nonmetal. 1 IA 1 H 1.008 3 Li 6.941 11 Na 22.99 19 K 39.10 37 Rb 85.47 55 Cs 132.9 87 Fr (223) 2 IIA 3 IIIB 4 IVB 5 VB 6 VIB 7 VIIB 8 9 10 VIIIB VIIIB VIIIB 11 IB 12 IIB 13 IIIA 14 IVA 15 VA 16 VIA 17 VIIA 5 B 10.81 13 Al 26.98 31 Ga 69.72 49 In 114.8 81 Tl 204.4 6 C 12.01 14 Si 28.09 32 Ge 72.59 50 Sn 118.7 82 Pb 207.2 7 N 14.01 15 P 30.97 33 As 74.92 51 Sb 121.8 83 Bi 209.0 8 O 16.00 16 S 32.07 34 Se 78.96 52 Te 127.6 84 Po (209) 9 F 19.00 17 Cl 35.45 35 Br 79.90 53 I 126.9 85 Periodic Table of the Elements 4 Be 9.012 12 Mg 24.31 20 Ca 40.08 38 Sr 87.62 56 Ba 137.3 88 Ra 226 21 Sc 44.96 39 Y 88.91 57 La 138.9 89 Ac (227) 22 Ti 47.88 40 Zr 91.22 72 Hf 178.5 23 V 50.94 41 Nb 92.91 73 Ta 180.9 24 Cr 52.00 42 Mo 95.94 74 W 183.9 25 Mn 54.94 43 Tc (98) 75 Re 186.2 26 Fe 55.85 44 Ru 101.1 76 Os 190.2 27 Co 58.93 45 Rh 102.9 77 Ir 192.2 58 Ce 140.1 90 Th 232.0 59 Pr 140.9 91 Pa (231) 60 Nd 144.2 92 U 238.0 61 Pm 145 93 Np 237 62 Sm 150.4 94 Pu (244) 28 Ni 58.69 46 Pd 106.4 78 Pt 195.1 63 Eu 152.0 95 Am (243) 29 Cu 63.55 47 Ag 107.9 79 Au 197.0 64 Gd 157.3 96 Cm (247) 30 Zn 65.38 48 Cd 112.4 80 Hg 200.6 65 Tb 158.9 97 Bk (247) 18 VIIIA 2 He 4.003 10 Ne 20.18 18 Ar 39.95 36 Kr 83.80 54 Xe 131.3 86 Rn (222) 66 Dy 162.5 98 Cf (251) Transition metals Lanthanoids Actinoids 1 IA 1 H 1.008 3 Li 6.941 11 Na 22.99 19 K 39.10 37 Rb 85.47 55 2 IIA 3 IIIB 4 IVB 5 VB 6 VIB 7 VIIB 8 9 10 VIIIB VIIIB VIIIB 11 IB 12 IIB Periodic Table of the Elements 4 Be 9.012 12 Mg 24.31 20 Ca 40.08 38 Sr 87.62 56 21 Sc 44.96 39 Y 88.91 57 22 Ti 47.88 40 Zr 91.22 72 23 V 50.94 41 Nb 92.91 73 24 Cr 52.00 42 Mo 95.94 74 25 Mn 54.94 43 Tc (98) 75 26 Fe 55.85 44 Ru 101.1 76 27 Co 58.93 45 Rh 102.9 77 28 Ni 58.69 46 Pd 106.4 78 29 Cu 63.55 47 Ag 107.9 79 30 Zn 65.38 48 Cd 112.4 80 VIIIA 2 He 4.003 10 Ne 20.18 18 Ar 39.95 36 Kr 83.80 54 Xe 131.3 86 Cs 132.9 87 Fr (223) Ba 137.3 88 Ra 226 La 138.9 89 Ac (227) Hf 178.5 Ta 180.9 W 183.9 Re 186.2 Os 190.2 Ir 192.2 58 Ce 140.1 90 Th 232.0 59 Pr 140.9 91 Pa (231) 60 Nd 144.2 92 U 238.0 61 Pm 145 93 Np 237 62 Sm 150.4 94 Pu (244) 95 Am 150.4 94 Pu (244) Pt 195.1 63 Eu 152.0 95 Am (243) Au 197.0 64 Gd 157.3 96 Cm (247) Hg 200.6 65 Tb 158.9 97 Bk (247) Tl 204.4 Pb 207.2 Bi 209.0 Po (209) At (210) Rn (222) 66 Dy 162.5 98 Cf (251) A.4 Valence-shell electron pair repulsion theory (VSEPR theory) predicts molecular shape with the concept that regions of high electron density (as represented by single bonds, multiple bonds, and lone pair) take up orientations around the central atom that maximize their separation. The resulting positions of attached atoms (not lone pairs) are used to classify the shape of the molecule. When the central atom has two or more lone pair, the molecular geometry must minimize repulsion between the relatively diffuse orbitals of the lone pair. Furthermore, it is assumed that the repulsion between a lone pair and a bonding pair is stronger than the repulsion between two bonding pair, thereby, making bond angles smaller than the idealized bond angles that appear in the absence of a lone pair. Solutions to exercises A.1(b) Example (i) Group 3 (ii) Group 5 (iii) Group 13 Element Sc, scandium V, vanadium Ga, gallium Ground-state Electronic Configuration [Ar]3d14s2 [Ar]3d34s2 [Ar]3d104s24p1 A.2(b) (i) chemical formula and name: CaH2, hydride ions: Ca2+ and H– oxidation numbers of the elements: calcium, +2; hydrogen, –1 (ii) chemical formula and name: CaC2, calcium carbide ions: Ca2+ and C22– (a polyatomic ion) oxidation numbers of the elements: calcium, +2; carbon, –1 (iii) chemical formula and name: LiN3, lithium azide ions: Li+ and N3– (a polyatomic ion) oxidation numbers of the elements: lithium, +1; nitrogen, –⅓ A.3(b) (i) Ammonia, NH3, illustrates a molecule with one lone pair on the central atom. H N H H (ii) Water, H2O, illustrates a molecule with two lone pairs on the central atom. H O H (iii) The hydrogen fluoride molecule, HF, illustrates a molecule with three lone pairs on the central atom. Xenon difluoride has three lone pairs on both the central atom and the two peripheral atoms. H F F Xe F A.4(b) (i) Ozone, O3. Formal charges (shown in circles) may be indicated. O O O (ii) O O F ClF3+ Cl O F F (iii) azide anion, N3– N N N A.5(b) The central atoms in XeF4, PCl5, SF4, and SF6 are hypervalent. A.6(b) Molecular and polyatomic ion shapes and

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