Ch13 Rev. WS

13.4 In a solution of NaCl, the formation of $Na^+(aq)$ from the interaction between Na^+ particles and water molecules is called *hydration.*

13.5 A *saturated solution* of $CdCO_3$ forms when $CdCO_3(s)$ and dissolved $CdCO_3$ are in a state of dynamic equilibrium.

13.6 The solubility of $CdCO_3$ in water at 25°C is 4.48×10^{-4} g/mL. A 1-L solution that contains 3.0×10^{-2} g of dissolved $CdCO_3$ is *unsaturated;* one that contains 6.0×10^{-1} g of dissolved $CdCO_3$ is *supersaturated;* and one that contains 4.48×10^{-1} g of dissolved $CdCO_3$ is *saturated.*

13.7 We would expect water and crystal particles that are around 10,000 Å in size to form a *colloid.*

13.8 The *Tyndall effect* could be utilized to detect the presence of smoke in a darkened room.

13.9 If two solutions are connected by a semipermeable membrane and are isotonic, the solutions have the same *osmotic pressure.*

13.10 Two aqueous solutions, 0.1 *M* NaCl and 0.2 *M* NaCl, are separated by a semipermeable membrane that allows only water to pass through it. *Osmosis* occurs as water flows out of the 0.2 *M* NaCl solution through the semipermeable membrane into the 0.1 *M* NaCl solution.

13.11 An example of a *colligative property* is the observation that a 0.25 m $LaCl_3$ solution has a freezing point that is lower than that of pure water by an amount $(K_f)(0.25)$.

13.12 According to *Raoult's law,* the vapor-pressure lowering of a solvent over a solution is given by the product of the molarity of the solution and the vapor pressure of pure solvent.

13.13 According to *Henry's law,* doubling the partial pressure of a gas over a solvent in which it dissolves doubles the solubility of the gas in the solvent.

13.14 It is found that the vapor pressure of a solvent is directly dependent on its mole fraction. This suggests that it is an *ideal solution.*

13.15 A solution contains 0.30 mg of sodium ion per liter of solution: This corresponds to a concentration of sodium ion of 3.0 *ppm.*

13.16 *Crystallization* occurs more readily when a seed crystal is present.

13.17 The *molal boiling-point-elevation constant* for carbon tetrachloride is 2.53 °*C*/*m*. This means that 1 *m* nonvolatile solute particles in carbon tetrachloride will cause the solution to boil 2.53 °*C* higher than pure carbon tetrachloride.

13.18 In general, *molal freezing-point-depression constants* for solvents are smaller in magnitude than their molal boiling-point-elevation constants.

13.19 The presence of *ion pairs* in a solution will cause an increase in osmotic pressure.

13.20 CH_3Cl should have *hydrophilic* properties.

13.21 A $CH_3(CH_2)_{20}$–group in a molecule should cause the molecule to be *hydrophobic.*

Problems and Short-Answer Questions

13.22 A 0.500-L solution that contains 20.0 g of glucose has an osmotic pressure of 5.43 atm at 25°C. What is the molar mass of glucose?

13.23 Calculate the concentrations asked for in each problem.
(a) The molality of 142 g of Na_2CO_3 in 2.00 kg of water at 0°C (a saturated solution).
(b) The molality of 24.50 g of codeine, $C_{18}H_{21}NO_3$ in 150.5 g of ethanol, C_2H_5OH.
(c) The mole fraction of 32.3 g of NaCl in 265.0 g of H_2O.
(d) The percent-by-mass of HCl in a tile cleaner containing 140 g of HCl and 800 g of H_2O.

13.24 What volume of concentrated hydrochloric acid with a density of 1.19 g/mL and containing 37.2% by mass of HCl contains 150 g of HCl?

13.25 The freezing-point depressions for 0.01 *m* solutions of $Co(NH_3)_6Cl_3$, $MgSO_4$, NH_4Cl, and CH_3COOH are 0.0643°C, 0.0308°C, 0.0358°C, and 0.0193°C, respectively. K_f for H_2O is 1.86°C/*m*. Which compounds are strong electrolytes and which are weak? Which compound forms the greatest number of ions in a 0.01 *m* solution?

13.26 A 0.157 *M* NaCl solution is to be used to replace lost blood. The average osmotic pressure of blood is 7.7 atm at 25°C. Is the NaCl solution isotonic with blood?

13.27 When 20.00 g of sucrose is dissolved in 100.00 g of water at 20°C, a vapor-pressure lowering of 0.185 torr Hg is observed. The vapor pressure of pure H_2O at 20 °C is 17.54 torr. Determine the mass of 1 mole of sucrose from the vapor-pressure-lowering data.

13.28 Hydrophilic colloids do not settle out of solution as do dispersions of larger, visible particles. Why?

13.29 In each of the following pairs of substances, which substance will be more soluble in liquid NH_3?
(a) $NaCl(s)$ or $H_2(g)$
(b) $CCl_4(l)$ or $CH_3OH(l)$

13.30 Indicate whether each of the following processes proceeds with an increase or decrease in randomness (disorder):
(a) sublimation of solid CO_2;
(b) freezing of liquid ammonia;
(c) increasing the total pressure of $N_2(g)$ stored over water in a closed container.

13.31 Proteins are substances found in living cells. They are long molecules that include both nonpolar hydrocarbon segments and polar subunits. Proteins are flexible and can fold about themselves. If a protein is placed in water, in what way would you expect the protein to fold itself? (In other words, in what way are the polar and nonpolar segments arranged with respect to one another in the folded protein structure?)

13.32 A saturated solution of KBr in H_2O at 0°C has a molality of 0.4499. What is the solubility of KBr in H_2O in units of g KBr/100 mL of H_2O at 0°C? The density of H_2O at 0°C is 0.99988 g/mL.

Multiple-Choice Questions

13.33 What is the molality of ethylene glycol, $C_2H_4(OH)_2$, in a solution prepared by mixing 5.00 g of ethylene glycol in 125 g of water?
(a) 0.644
(b) 0.000644
(c) 0.619
(d) 0.000619
(e) none of these

13.34 What is the mole fraction of water in a solution prepared by mixing 12.5 g of H_2O with 220 g of acetone, C_3H_6O?

(a) 0.817
(b) 0.845
(c) 0.183
(d) 0.155
(e) none of these

13.35 In which of the following solvents would you expect the solubility of $CaCl_2$ to be greatest?

(a) CH_3OH
(b) C_6H_6 (benzene)
(c) CCl_4
(d) H_2O
(e) insufficient information to answer question

13.36 Given that $K_b = 2.53°C/m$ for benzene, which mass of acetone (CH_3COCH_3) must be dissolved in 200 g of benzene to raise the boiling point of benzene by 3.00 °C?

(a) 7.26 g
(b) 0.0726 g
(c) 2.56 g
(d) 0.138 g
(e) 13.8 g

13.37 The presence of a nonvolatile solute in a volatile solvent will result in which of the following?

(a) It will raise the freezing point and lower the vapor pressure and boiling point.
(b) It will lower the freezing point and raise the vapor pressure and boiling point.
(c) It will raise the freezing point, vapor pressure, and boiling point.
(d) It will lower the freezing point and vapor pressure and raise the boiling point.
(e) It will lower the boiling point and raise the freezing point and vapor pressure.

13.38 Which of the following substances might stabilize a colloidal suspension of oil in water?

(a) octane, C_8H_{18}
(b) sodium bicarbonate, $NaHCO_3$
(c) sodium stearate, $NaCO_2(CH_2)_{16}CH_3$
(d) HCl
(e) $CaCl_2$

13.39 Which of the following solutions has the largest osmotic pressure?

(a) 0.15 *M* NaCl
(b) 0.10 *M* $CaCl_2$
(c) 0.05 *M* $Ba(NO_3)_2$
(d) 0.05 *M* $Al(NO_3)_3$
(e) 0.20 *M* NH_3

13.40 When 0.200 g of a high-molecular-weight compound is dissolved in water to form 12.5 mL of solution at 25 °C, the osmotic pressure of the solution is found to be 1.10×10^{-3} atm. What is the molar mass of the compound?

(a) 3.56×10^5 g
(b) 3.56×10^4 g
(c) 2.98×10^4 g
(d) 2.98×10^3 g
(e) 3.00×10^4 g

ch 21 Rev WS

would be expected to cause similar biological damage in humans.

21.4 The nuclear mass of $^{59}_{27}Co$ is 58.91837 amu. From the mass of a proton and neutron given in section 21.6 of the text, you can calculate the *mass defect* of $^{59}_{27}C$ to be –0.55538 amu.

21.5 *Alpha particles* are identical to helium-4 atoms.

21.6 The symbol for a *beta particle* is $^{0}_{-1}e$.

21.7 Ten *curies* of radioactivity is equivalent to 3.7×10^{11} nuclear disintegrations per second.

21.8 An example of a *fission* process is the reaction

$$^{1}_{0}n + ^{235}_{92}U \longrightarrow ^{103}_{42}Mo + ^{131}_{50}Sn + 2^{1}_{0}n$$

21.9 An example of a *fusion reaction* is

$$3^{4}_{2}He \longrightarrow ^{12}_{6}C + \text{energy}$$

21.10 *Gamma radiation* is a type of electromagnetic radiation similar to X rays.

21.11 The symbol for a *positron*, $^{0}_{1}e$, tells us that it is a particle with a charge equivalent in magnitude but opposite in sign to that possessed by an electron.

21.12 An example of a *nuclear transmutation* reaction is $^{98}_{42}Mo + ^{2}_{1}H \longrightarrow ^{99}_{43}Tc + ^{1}_{0}n$.

21.13 *Radioisotopes* undergo first-order nuclear decay processes.

21.14 A nuclear reactor uses a controlled *chain reaction* to produce usable energy.

21.15 16.28 kg of $^{239}_{94}Pu$ is the amount of $^{239}_{94}Pu$ required to maintain a chain reaction initially involving $^{239}_{94}Pu$ reacting with neutrons in a particular nuclear reactor. This quantity of $^{239}_{94}Pu$ is its *critical mass* under these conditions.

21.16 From the information given in problem 21.15, we know that 18 kg of $^{239}_{94}Pu$ is *subcritical* and 10 kg of $^{239}_{94}Pu$ is *supercritical.*

21.17 An example of a *nucleon* is an electron in an atom.

21.18 A nucleus containing a *magic number* of nucleons, such as 18 protons, is likely to be radioactive.

21.19 The *radioactive series* for ^{238}U involves 14 decay steps leading to a stable ^{206}Pb.

21.20 There are many *nuclear disintegration series* that occur in nature.

21.21 *Particle accelerators* involve shooting particles into a vacuum in the presence of alternating electrical or magnetic fields.

21.22 The *transuranium elements* occur immediately following uranium in the periodic table.

21.23 In a typical *Geiger counter,* gamma rays enter a tube through a thin window and ionize a gas.

21.24 A *scintillation counter* is an instrument used to detect radiation by fluorescence.

21.25 A *radiotracer* used to study reactions of carbon-based compounds is carbon-12.

21.26 Low temperatures can be used to induce *thermonuclear reactions.*

21.27 *Somatic radiation damage* is exemplified by Leukemia.

21.28 *Genetic damage* is short term in nature.

21.29 The SI unit of radioactivity is the *becquerel,* which is equivalent to one curie.

21.30 If a nucleus emits radiation only with the input of energy, it is said to be *radioactive.*

21.31 The *half-life* of strontium-90 is 29 years. This means that in three half-lives 10.0 g of it decays to 3.3 grams (1/3 of original mass).

21.32 A *radionuclide* is a nucleus that is radioactive and has a specified number of protons and neutrons.

21.33 The neutral OH molecule is unstable and is an example of a *free radical* because it possesses one unpaired electron.

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Problems and Short-Answer Questions

21.34 Write balanced nuclear equations for the following nuclear transformations:

(a) niobium-99 undergoes beta decay
(b) chromium-48 undergoes electron capture
(c) calcium-39 undergoes positron emission
(d) carbon-16 undergoes neutron emission
(e) gadolinium-148 undergoes alpha emission

21.35 Supply the missing subatomic particle, energy form, or nuclide in the following induced nuclear reactions:

(a) $-$_____$(^{3}_{1}H, n)^{4}_{2}He$
(b) $^{253}_{99}Es$ (_____, n)$^{256}_{101}Mv$
(c) $^{81}_{35}Br$ (γ, n) $-$_____

21.36 One theory of stellar evolution has $^{16}_{8}O$ forming by the reaction of helium-4 and carbon-12 in the core of a sun at very high temperatures.

(a) Write the nuclear equation describing this nuclear reaction.
(b) Is this a fission or fusion reaction?

21.37 Calculate the energy associated with the reaction you wrote for problem 21.36. Does the result of your energy calculation support this particular stellar-evolution theory? Required atomic mass (amu) are: $^{4}_{2}He$, 4.00260; $^{12}_{6}C$, 12.00000; $^{16}_{8}O$, 15.99491.

21.38 In 1990, you and your friends barbecue hamburgers using charcoal that was made recently from freshly cut wood. Later you bury some unburned charcoal in the ground. Suppose that many years later an archeologist digs up your charcoal and by experimental methods finds that it has a ^{14}C:^{12}C ratio only 30 percent of the ^{14}C:^{12}C ratio in charcoal made from a recently cut tree. Assuming that the ^{14}C:^{12}C ratio does not change in the atmosphere, approximately how far in the future will the archeologist have found the buried charcoal? The half-life of ^{14}C is 5730 years.

21.39 What type of decay process would you expect for unstable heavy nuclei with too many protons and neutrons?

21.40 $^{75}_{33}As$ reacts with $^{4}_{2}He$ to form a nuclide and one neutron. The product nuclide undergoes positron emission. What is the final nuclide formed in this two-step disintegration series?

21.41 Why is the rem considered a more accurate measure of biological damage than the rad?

21.42 How much radioactivity, in curies, does 1 μg of Ra-226 produce? What is this in units of disintegrations per second?

21.43 A small amount of Pb-212, in the form of the 2+ ion, is injected into a saturated solution of $PbCl_2$ that is in contact with the solid salt. A short time later some of the Pb-212 is found in solid $PbCl_2$ in the saturated solution. What does this information tell you about the nature of the equilibrium between solid $PbCl_2$ and its dissolved ions?

Multiple-Choice Questions

21.44 How many protons, neutrons, and electrons does a $^{7}_{3}Li$ atom contain?

(a) 7p, 3n, 4e
(b) 4p, 3n, 7e
(c) 3p, 3n, 4e
(d) 4p, 3n, 3e
(e) 3p, 4n, 3e

21.45 How is the mass defect for a nucleus calculated?

(a) Atomic weight of the element minus mass number;
(b) atomic weight of the element minus mass of nucleons;
(c) nuclear mass minus mass number;
(d) nuclear mass minus mass of nucleons;
(e) none of the above.

21.46 Which of the following particles cannot be accelerated in a cyclotron?

(a) Alpha;
(b) beta;
(c) proton;
(d) neutron;
(e) positron.

21.47 How is the presence of radioactivity detected in a scintillation counter?

(a) by fluorescence of ZnS upon interaction with radiation
(b) by interaction of the radiation with a photographic plate
(c) by ionization of a gas
(d) by precipitation of a radioactive substance
(e) by gas chromatography techniques

21.48 What is the missing particle or energy in the reaction $^{209}_{83}Bi + {}^{2}_{1}H \longrightarrow {}^{210}_{84}Po +$ _____

(a) $^{0}_{-1}e$
(b) $^{0}_{1}e$
(c) $^{1}_{0}n$
(d) α
(e) $^{4}_{2}He$

21.49 What is the binding energy of $^{35}_{17}Cl$, given that the atomic mass equals 34.95953 amu?

(a) 4.77232×10^{-11} J
(b) 4.77232×10^{-10} J
(c) 5.27231×10^{-11} J