CHAPTER 1

# FUNDAMENTAL CONCEPTS OF CHEMISTRY

## **CHAPTER STUDY OBJECTIVES**

1. ***Recognize elemental symbols and names of the elements, and name compounds from***

***molecular pictures.***

SKILLS TO MASTER: Recognizing elemental symbols and names of the elements; naming compounds from molecular pictures

KEY CONCEPTS: Properties of molecules (the microscopic level) translate into properties of materials (the macroscopic level).

2. ***Recognize the SI units commonly used in chemistry, and perform some common unit conversions.***

SKILLS TO MASTER: Working with unit conversions; determining the correct number of significant figures in the result of a calculation

KEY CONCEPTS: The correct conversion ratio leads to cancellation of unwanted units. Proper use of significant figures is important to tell the reader what the accuracy and precision of the measurement are.

3. ***Analyze and solve problems in a consistent, organized fashion.***

Solving Quantitative Problems

Step 1. Determine what is asked for.

Step 2. Visualize the problem.

Step 3. Organize the data.

Step 4. Identify a process to solve the problem.

Step 5. Manipulate the equations.

Step 6. Substitute and calculate.

Step 7. Does the result make sense?

4. ***Solve mass–number–molar mass-type problems.***

SKILLS TO MASTER: Determining elemental molar masses

KEY CONCEPTS: Chemical calculations are built around the mole. One mole is the number of atoms in exactly 12 g of the pure isotope carbon-12. The molar mass of any naturally occurring element is the sum of the contributions from its isotopes.

5. ***Perform mole–mass–number conversions.***

SKILLS TO MASTER: Drawing line structures of compounds; calculating molar masses of compounds

KEY CONCEPTS: A molecule is a combination of two or more atoms held together in a specific shape by attractive forces. The molar mass of a compound is found by adding together the molar masses of all of its elements, taking into account the number of moles of each element present. Molar masses are used to convert between moles of substance and mass.

6. ***Calculate concentrations of solutions and of diluted solutions.***

KEY CONCEPTS: Concentration is the amount of substance per unit volume of solution. Polyatomic ions remain intact when a salt dissolves in water. Diluting a solution decreases the concentrations of the solutes.

7. ***Balance chemical reactions.***

KEY CONCEPTS: Molecules of reagents react in whole number ratios to form products. The number of atoms of each element is conserved in any chemical reaction.

8. ***Calculate the amount of a product from the amounts of the reactants and a balanced chemical equation*.**

SKILLS TO MASTER: Using stoichiometric ratios

9. ***Calculate yields of chemical reactions.***

10. **Solve limiting-reagent-type problems.**

SKILLS TO MASTER: Constructing tables of amounts

KEY CONCEPTS: The limiting reactant is the one whose number of moles divided by its stoichiometric coefficient has the smallest value. The quantity of the limiting reactant determines how much products are formed.

**Multiple Choice QUESTIONS**

1. Which of the following is a microscopic property?

a) the colour of a substance

b) the density of a substance

c) the arrangement of atoms in the molecules making up the substance

d) the mass of a substance

e) the shape of the crystals in a solid substance

Answer: c

Difficulty: Easy

Learning Objective: Recognize elemental symbols and names of the elements, and name compounds from molecular pictures.

Section Reference: 1.1 Atoms, Molecules, and Compounds

2. What is the correct formula for molecular oxygen?

a) O

b) 2O

c) O2

d) O2

e) O3

Answer: c

Difficulty: Easy

Learning Objective: Recognize elemental symbols and names of the elements, and name compounds from molecular pictures.

Section Reference: 1.1 Atoms, Molecules, and Compounds

Use the following information for Questions 3–7.

3.785 L = 1 gallon; 2.2 lbs = 1 kg; *V* = πr3; 1 in = 2.54 cm; 1 mile = 1.609 km; 12 in = 1 ft; 1 yard = 3 ft; 1 gal = 3.785 L; ˚C = 5/9 (˚F – 32)

proton charge = +1.6022 x 10-19 C mass = 1.6726 x 10-27 kg

electron charge = -1.6022 x 10-19 C mass = 9.1094 x 10-31 kg

neutron charge = 0 mass = 1.6749 x 10-27 kg

3. Which of the following are valid conversions from cubic yards to mm3?

a) 

b) 

c) 

d) 

e) 

Answer: c

Difficulty: Medium

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

4. One less common temperature unit is the Rankine. This scale has the same magnitude degree increment as the Fahrenheit scale, but zero Rankine is the same as absolute zero, or 0 K. Absolute zero is –459.7° Fahrenheit. Which of the following are true?

a) Water freezes at 32 Rankine and boils at 212 Rankine.

b) Water freezes at 273 Rankine and boils at 373 Rankine.

c) Room temperature, 25°C, is 536.7 Rankine.

d) Room temperature, 25°C, is 563.7 Rankine.

e) Body temperature, 37°C, is 563.7 Rankine.

Answer: c

Difficulty: Hard

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

5. The distance between two atoms was determined to be 11.4 nm. What is this distance in centimetres?

a) 1.14 x 10-6 cm

b) 11. 4 x 107 cm

c) 114 cm

d) 0.000000114 cm

e) 1.14 x 10-11 cm

Answer: a

Difficulty: Easy

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

6. Four different target shooters fired five shots at targets and their results are shown below. Which of the following statements best describes the precision and accuracy of each “marksman”?

|  |  |
| --- | --- |
|  |  |
| A | B |
|  |  |
| C | D |

a) A is accurate and precise, C is inaccurate and precise.

b) B is imprecise and inaccurate, D is accurate and imprecise.

c) A and D have similar precision but A is more accurate.

d) C and D have similar accuracy, but D is more precise.

Answer: d

Difficulty: Easy

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

7. What is the answer, with the correct number of significant figures, for the following problem?

3.784 g + 56.3 g + 445.55 g =?

a) 505.634 g

b) 505.63 g

c) 505.6 g

d) 505 g

e) 506 g

Answer: c

Difficulty: Easy

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

Use the following information for Questions 8–11.

1 mole = 6.022 x1023 particles

8. If you had a 50 g sample of C, Al, Fe, Au, and Ti, you would have more atoms of which element?

a) C

b) Al

c) Fe

d) Au

e) Ti

Answer: a

Difficulty: Easy

Learning Objective: Solve mass–number–molar mass-type problems.

Section Reference: 1.4 Counting Atoms: The Mole

9. If you had a 5.0 g sample of Li, Na, K, Rb, and Cs, you would have more atoms of which element?

a) Li

b) Na

c) K

d) Rb

e) Cs

Answer: a

Difficulty: Easy

Learning Objective: Solve mass–number–molar mass-type problems.

Section Reference: 1.4 Counting Atoms: The Mole

10. How many atoms are present in 52.0 grams of iron?

a) 0.93 atoms

b) 5.61 x 1023

c) 5.61

d) 52

e) 1.20 x 1024

Answer: b

Difficulty: Easy

Learning Objective: Solve mass–number–molar mass-type problems.

Section Reference: 1.4 Counting Atoms: The Mole

11. Consider three mole samples of C, Al, Fe, Au, and Ti; which sample will have the greatest mass?

a) C

b) Al

c) Fe

d) Au

e) Ti

Answer: d

Difficulty: Easy

Learning Objective: Solve mass–number–molar mass-type problems.

Section Reference: 1.4 Counting Atoms: The Mole

12. How many moles of carbon are present in 20 grams of C3H8?

a) 0.40 moles C

b) 0.80 moles C

c) 1.40 moles C

d) 1.67 moles C

e) 3 moles C

Answer: c

Difficulty: Medium

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

13. The line structure is shown below for terephthalic acid, a starting material of Kevlar that is used in bullet proof vests:

terephthalic_acid

What is the correct molecular formula for this compound?

a) C6H6 O4

b) C8H2 O4

c) C8H6O4

d) C10H4O4

e) C12H6O4

Answer: c

Difficulty: Medium

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

14. Cumene is an important industrial chemical used in the manufacture of acetone and phenol. The line structure is shown below:

cumene

What is the correct molecular formula for cumene?

a) C8H12

b) C9H11

c) C9H12

d) C10H10

d) C9H16

Answer: c

Difficulty: Medium

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

15. Adipic acid, whose line structure is shown below, is used in the manufacture of nylon used in carpet fibre, among other things.

adipic_acid

What is the chemical formula for adipic acid?

a) C4H2O4

b) C6H2O4

c) C6H6O4

d) C6H8O4

e) C6H10O4

Answer: e

Difficulty: Easy

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

16. Calculate the molar mass of terephthalic acid, whose line structure appears below:

terephthalic_acid

a) 166.13 g/mole

b) 150.13 g/mole

c) 152.12 g/mole

d) 178.14 g/mole

e) 201.14 g/mole

Answer: a

Difficulty: Medium

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

17. Calculate the molar mass of ammonium phosphate, (NH4)3PO4.

a) 94.97 g/mole

b) 18.04 g/mole

c) 113.01 g/mole

d) 131.05 g/mole

e) 149.09 g/mole

Answer: e

Difficulty: Easy

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

18. Calculate the molar mass of potassium carbonate, K2CO3

a) 39.10 g/mole

b) 60.01 g/mole

c) 99.11 g/mole

d) 138.211 g/mole

e) 177.31 g/mole

Answer: d

Difficulty: Easy

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

19. Styrene is used in many plastic products and also in automobile tire rubber. The line structure is shown below:

styrene

How many hydrogen atoms are contained in 1.05 x 106 kg of styrene?

a) 4.86 x 1031

b) 6.07 x 1030

c) 1.01 x 107

d) 104

e) 7.71 x 1015

Answer: a

Difficulty: Medium

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

20. One litre of air contains about 1 x 10-2 moles of O2.What is the mass of O2 contained in a room 10 m long by 5 m wide by 3 m high?

a) 4.8 g

b) 50g

c) 52 kg

d) 48 kg

e) 1500 g

Answer: d

Difficulty: Medium

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

21. How many grams of AgNO3 need to be added to 400 ml of water to make a solution of 0.250 M concentration?

a) 1.70 g

b) 17.0 g

c) 4.25 g

d) 42.5 g

e) 68.0 g

Answer: b

Difficulty: Medium

Learning Objective: Calculate concentrations of solutions and of diluted solutions.

Section Reference: 1.6 Aqueous Solutions

22. Nitric acid is a corrosive acid capable of dissolving many metals, with the evolution of brown nitrogen dioxide gas as a byproduct. It is often sold as concentrated nitric acid which has [HNO3] = 16. *M*. A common concentration used in the laboratory is 6.0 *M* HNO3. If you need 20. L of 6.0 *M* HNO3, what volume of concentrated nitric acid is required?

a) 6.7 L

b) 7.5 mL

c) 0.75 L

d) 5.7 L

e) 7.5 L

Answer: e

Difficulty: Easy

Learning Objective: Calculate concentrations of solutions and of diluted solutions.

Section Reference: 1.6 Aqueous Solutions

23. Nitric acid, HNO3, is produced along with water by the reaction of oxygen, O2, with ammonia, NH3, and water, H2O, in a series of steps, with the unbalanced net reaction shown below.

\_\_ NH3 + \_\_ O2 **** \_\_ HNO3 + \_\_H2O

If the coefficient of NH3 is 1 in the balanced chemical equation of the reaction, what is the coefficient on O2?

a) 2

b) 3

c) 4

d) 5

e) 6

Answer: a

Difficulty: Medium

Learning Objective: Balance chemical reactions.

Section Reference: 1.7 Writing Chemical Equations

24. Fertilizer is manufactured from, among other components, phosphoric acid, H3PO4, which, itself is primarily synthesized from fluorapetite, Ca5F(PO4)3 and sulphuric acid, H2SO4.

\_\_ H2SO4 + \_\_ Ca5F(PO4)3 **** \_\_ H3PO4 + \_\_ CaSO4 + \_\_ HF

If the coefficient of H2SO4 is 5 in the balanced chemical equation of the reaction, what is the coefficient of HF?

a) 1

b) 2

c) 3

d) 4

e) 5

Answer: a

Difficulty: Medium

Learning Objective: Balance chemical reactions.

Section Reference: 1.7 Writing Chemical Equations

25. Two important industrial chemicals, NaOH and chlorine, are produced from solutions of sodium chloride by the following reaction:

\_\_ NaCl + \_\_ H2O **** \_\_ NaOH + \_\_ Cl2 + \_\_ H2

If the coefficient of H2O is 2 in the balanced chemical equation of reaction, what is the coefficient of NaOH?

a) 1

b) 2

c) 3

d) 4

e) 5

Answer: b

Difficulty: Easy

Learning Objective: Balance chemical reactions.

Section Reference: 1.7 Writing Chemical Equations

26. A 1.345 g sample of solid residue from a hazardous waste dump is being analyzed for barium. The sample is dissolved and then sodium sulphate is added. The insoluble barium sulphate is dried, and a total of 73.8 mg of BaSO4 is collected. What percent of the sample is barium?

a) 0.323 % Ba

b) 2.33 % Ba

c) 3.23 % Ba

d) 4.02 % Ba

e) 5.23 % Ba

Answer: c

Difficulty: Medium

Learning Objective: Balance chemical reactions.

Section Reference: 1.7 Writing Chemical Equations

27. Sodium sulphate is used in detergents and can be synthesized by the following *unbalanced* reaction:

NaCl + H2SO4 **** Na2SO4 + HCl

How much sulphuric acid (in kg) would be required to consume 5.0 x 103 kg of NaCl?

a) 4.3 x 106 kg

b) 4.2 x103 kg

c) 4.4 x 104 kg

d) 5.0 x 106 kg

e) 8.7 x 104 kg

Answer: b

Difficulty: Hard

Learning Objective: Calculate the amount of a product from the amounts of the reactants and a balanced chemical reaction.

Section Reference: 1.8 The Stoichiometry of Chemical Reactions

Feedback: Student must balance reaction.

28. Aluminum sulphate is used in sand paper, among other uses. How many g of aluminum oxide dihydrate will be needed to produce 500 g of aluminum sulphate by the (unbalanced) reaction below?

Al2O3 •2H2O + H2SO4 **** Al2(SO4)3 + H2O

a) 1.46

b) 40.0

c) 202

d) 342

e) 500

Answer: c

Difficulty: Hard

Learning Objective: Calculate the amount of a product from the amounts of the reactants and a balanced chemical reaction.

Section Reference: 1.8 The Stoichiometry of Chemical Reactions

Feedback: Student must balance reaction.

29. The industrial synthesis of methanol, CH3OH, is catalyzed by metal oxides. Billions of kg are produced annually for use in polymers and fuel additives.

CO + 2 H2 **** CH3OH

How many kg of hydrogen will be required to produce 1.0 x 105 kg of methanol?

a) 3.1 x 106

b) 6.2 x 103

c) 6.2 x 106

d) 1.3 x 107

e) 1.3 x 104

Answer: e

Difficulty: Medium

Learning Objective: Calculate the amount of a product from the amounts of the reactants and a balanced chemical reaction.

Section Reference: 1.8 The Stoichiometry of Chemical Reactions

30. A way of generating dry O2 in the lab is to heat potassium chlorate. If you determined that 25 grams of O2 are needed, how much potassium chlorate do you need to start with?



a) 64 grams

b) 96 grams

c) 17 grams

d) 25 grams

e) 128 grams

Answer: a

Difficulty: Medium

Learning Objective: Calculate the amount of a product from the amounts of the reactants and a balanced chemical reaction.

Section Reference: 1.8 The Stoichiometry of Chemical Reactions

31. Urea is used as a source of nitrogen in fertilizer. The second step of the synthesis is heating the intermediate ammonium carbamate to produce urea shown in the equation below:

NH2CO2NH4 **** NH2(CO)NH2 + H2O

The reaction proceeds in 60% yield, on average, and the product is mixed with unreacted starting materials, which are readily separated from the product. They can then be recycled and undergo the process again. If one starts with 1 kg of ammonium carbamate, how many times will it have to be cycled through this reaction to give at least a 90% yield?

a) 2

b) 3

c) 4

d) 5

e) infinite number of times

Answer: b

Difficulty: Hard

Learning Objective: Calculate yields of chemical reactions.

Section Reference: 1.9 Yields of Chemical Reactions

32. How many kg of ethylene oxide is needed to produce 1.05 x 104 kg of ethylene glycol by the following reaction that proceeds in 95% yield?

eth_glycol_synth

a) 1.69 x 105

b) 1.78 x 105

c) 5.23 x 103

d) 7.45 x 103

e) 7.84 x103

Answer: e

Difficulty: Hard

Learning Objective: Calculate yields of chemical reactions.

Section Reference: 1.9 Yields of Chemical Reactions

33. A way of generating dry O2 in the lab is to heat potassium chlorate. If you determined that 25 grams of O2 are needed, how much potassium chlorate do you need to start with if there is only a 60% yield?



a) 64 grams

b) 96 grams

c) 17 grams

d) 25 grams

e) 106 grams

Answer: e

Difficulty: Hard

Learning Objective: Calculate yields of chemical reactions.

Section Reference: 1.9 Yields of Chemical Reactions

34. Hydrazine (N2H4) is made by the reaction of ammonia (NH3) with hypochlorite (OCl-). Given the following equation 420 kg of ammonia is reacted with excess hypochlorite to generate 315 kg of hydrazine. What is the percent yield for this unbalanced reaction?

NH3 + OCl- **** N2H4 + Cl- + H2O

a) 75.0 %

b) 79.7 %

c) 150 %

d) 20.3 %

e) 66.7 %

Answer: b

Difficulty: Hard

Learning Objective: Calculate yields of chemical reactions.

Section Reference: 1.9 Yields of Chemical Reactions

Feedback: Student must balance reaction.

35. Adiponitrile is produced by the reaction of HCN and butadiene:

adiponitrile_prep

If 450 kg of butadiene and 400 kg of HCN were to react to completion, what is the maximum amount of adiponitrile that would be produced?

a) 450 kg

b) 8.32 x 103 moles

c) 1.48 x 103 moles

d) 800 kg

e) 900 kg

Answer: d

Difficulty: Hard

Learning Objective: Solve limiting-reagent-type problems.

Section Reference: 1.10 The Limiting Reactant

36. Aluminum sulphate is used in finishing paper, among other uses. If 500 kg of aluminum oxide dihydrate react completely with 1500 kg of 90% by mass aqueous H2SO4, how many kg of aluminum sulphate can be produced?

Al2O3 •2H2O + 3H2SO4 **** Al2(SO4)3 + 5H2O

a) 1.24 x 103 kg

b) 1.35 x 103 kg

c) 1.57 x103 kg

d) 3.62 x103 kg

e) 4.59 x103 kg

Answer: a

Difficulty: Hard

Learning Objective: Solve limiting-reagent-type problems.

Section Reference: 1.10 The Limiting Reactant

37. Thermite is a reaction that was once used to weld railroads together as shown below. A 48.0 g sample of Al(s) was reacted with 99.0 g of Fe2O3 according to the equation below. What could be the theoretical yield of Fe(s) in grams?

2 Al(s) + Fe2O3(s) **** Al2O3(s) + 2 Fe(s)

a) 52.5 g

b) 99.3 g

c) 69.2 g

d) 48.0 g

e) 175 g

Answer: c

Difficulty: Hard

Learning Objective: Solve limiting-reagent-type problems.

Section Reference: 1.10 The Limiting Reactant

38. Potassium permanganate reacts with hydrochloric acid to give chlorine gas according to unbalanced chemical reaction shown below. If 34.2 g of KMnO4 were mixed with 0.990 moles of HCl, how many moles of chlorine gas could be produced?

KMnO4 + HCl **** MnCl2 + KCl + Cl2(g) + H2O

a) 0.541 moles

b) 0.850 moles

c) 0.309 moles

d) 0.989 moles

e) 0.354 moles

Answer: c

Difficulty: Hard

Learning Objective: Solve limiting-reagent-type problems.

Section Reference: 1.10 The Limiting Reactant

Feedback: Student must balance reaction.

**ESSAY QUESTIONS**

39. What are the symbols for the following elements?

sulphur, fluorine, titanium, potassium, zinc

Answer: sulphur (S); fluorine (F); titanium (Ti); potassium (K); zinc (Zn)

Difficulty: Easy

Learning Objective: Recognize elemental symbols and names of the elements, and name compounds from molecular pictures.

Section Reference: 1.1 Atoms, Molecules, and Compounds

40. What are the names of the elements with the following symbols?

Cr, Na, Cl, Be, He

Answer: Cr (chromium); Na (sodium); Cl (chlorine); Be (beryllium); He (helium)

Difficulty: Easy

Learning Objective: Recognize elemental symbols and names of the elements, and name compounds from molecular pictures.

Section Reference: 1.1 Atoms, Molecules, and Compounds

41. What are the names of the elements with the following symbols?

Mn, Mg, Md, Rn, Ra

Answer: Mn (maganese); Mg (magnesium); Md (mendelevium); Rn (radon); Ra (radium)

Difficulty: Easy

Learning Objective: Recognize elemental symbols and names of the elements, and name compounds from molecular pictures.

Section Reference: 1.1 Atoms, Molecules, and Compounds

42. Write formulas of the compounds whose molecular pictures are shown below (unlabelled atoms are carbon).











Answer: C2H4O; CO; N2; C2H2; F2

Difficulty: Easy

Learning Objective: Recognize elemental symbols and names of the elements, and name compounds from molecular pictures.

Section Reference: 1.1 Atoms, Molecules, and Compounds

43. Determine the formula of a compound whose molecules each contain two atoms of carbon, two atoms of oxygen and six atoms of hydrogen.

Answer: C2H6O2

Difficulty: Easy

Learning Objective: Recognize elemental symbols and names of the elements, and name compounds from molecular pictures.

Section Reference: 1.1 Atoms, Molecules, and Compounds

44. Name three macroscopic properties of orange juice.

Answer: orange colour, density near 1 g/mL, slightly sour taste, pulp, smell, etc.

Difficulty: Easy

Learning Objective: Recognize elemental symbols and names of the elements, and name compounds from molecular pictures.

Section Reference: 1.1 Atoms, Molecules, and Compounds

45. Plastics are one class of a type of very large molecules called polymers. They are built from smaller building blocks, such as propene. Propene has three carbon atoms and six hydrogen atoms. What is its chemical formula?

Answer: C3H6

Difficulty: Easy

Learning Objective: Recognize elemental symbols and names of the elements, and name compounds from molecular pictures.

Section Reference: 1.1 Atoms, Molecules, and Compounds

46. What are two microscopic properties of a substance?

Answer: atoms’ connectivity, distance between atoms, angles between three atoms, etc.

Difficulty: Easy

Learning Objective: Recognize elemental symbols and names of the elements, and name compounds from molecular pictures.

Section Reference: 1.1 Atoms, Molecules, and Compounds

Use the following information for Questions 47–61.

3.785 L = 1 gallon; 2.2 lbs = 1 kg; *V* = πr3; 1 in = 2.54 cm; 1 mile = 1.609 km; 12 in = 1 ft; 1 yard = 3 ft; 1 gal = 3.785 L; ˚C = 5/9 (˚F – 32)

proton charge = +1.6022 x 10-19 C mass = 1.6726 x 10-27 kg

electron charge = -1.6022 x 10-19 C mass = 9.1094 x 10-31 kg

neutron charge = 0 mass = 1.6749 x 10-27 kg

47. The drive to San Francisco from Los Angeles along the coastal route is 450 miles. What is the distance from Los Angeles to San Francisco expressed in SI units using scientific notation?

Answer: 7.24 x105 m

Difficulty: Easy

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

48. What is the volume in SI units of a swimming pool that is 4.5 feet deep by 5 yards wide and 25 yards long?

Answer: 1.4 x102 m3

Difficulty: Medium

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

49. You fill your car up in Jamaica and it takes 42.3 L of gasoline. How many gallons is this amount?

Answer: 11.2 gallons

Difficulty: Easy

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

50. Gold has a density of 19.282 g/cm3. What is the mass (in kg) of a sphere of solid gold with a radius of 6.0 cm? (The volume of a sphere is *V* = πr3 where *r* is the radius.)

Answer: 17.4 kg

Difficulty: Easy

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

51. What is the temperature of liquid nitrogen in ˚F, if the nitrogen is currently at –195.8 ˚C?

Answer: –320.4 ˚F

Difficulty: Medium

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

52. A flask with a mass of 160.342 g is filled with 22° C water. The mass of the flask filled with water is found to be 310.5 g. Given that the density of water at 22°C is 0.99780 g/cm3, what is the volume of the flask?

Answer: 150.5 mL

Difficulty: Easy

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

53. Fill in the missing quantity:

|  |  |  |
| --- | --- | --- |
| **Measurement** | **Number of Significant Figures** | **Number Expressed in Scientific Notation** |
| 0.46433 kg | *(5)\** | 4.6433 x 10-1 kg |
| 356.001 m | *(6)\** | (*3.56001 x 102 m*)\* |
| 0.000432 L | 3 | *(4.32 x 10-4 L)\** |
| \_\_\_\_\_\_ g | *(6)\** | 1.00101 x 104 g |

Answer: 100,101 g

Difficulty: Medium

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

54. When you fill up your car in a country in Europe, your credit card is charged $25.45 for 32.3 L of gasoline. What is the price of gasoline in dollars per gallon?

Answer: $2.98/gallon

Difficulty: Easy

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

55. Rhodium metal recently was selling for $105.15 per gram. What is the price for a pound of rhodium metal in dollars?

Answer: $4.7738 x 104

Difficulty: Easy

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

56. It has been said that 3.0 kg of plutonium is enough to make an atomic bomb. If you were working security at an airport, just how large of a metallic object would you be looking for? That is, determine the diameter (in cm) of a sphere of plutonium that has a mass of 3.0 kg. (the density of plutonium is 19.84 g/cm3)

Answer: 6.6 cm

Difficulty: Easy

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

57. You are asked to administer 4.9 g of an injectable solution which contains 0.23 % of a lifesaving drug by mass. The syringe has graduations of 0.1 mL. If the density of the solution is 1.13 g/mL, how many mL should you inject?

Answer: 4.3 mL

Difficulty: Medium

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

58. Ethyl ether has a density of 0.7138 g/ml. How many litres will be needed to obtain 500 grams of ethyl ether for a reaction?

Answer: 700 ml = 0.700 L

Difficulty: Easy

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

59. The density of mercury is 13.6 g/ml and the density of water is 1.00 g/ml. How many meters high would a column of water need to be, to be equal in mass to a column of mercury 750 mm high? (assume the columns of liquid have the same diameter)

Answer: 13.6 x 750 = 10,200 mm = 10.2 meters for water

Difficulty: Medium

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

60. What is the difference in mass between 1.000 x 1015 protons and the same number of neutrons? What is the electrical charge (in coulombs) carried by this number of protons?

Answer: 2.32 x 10-12 kg, 1.60 x 10-4 coul

Difficulty: Easy

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

61. What is the mass of 1.000 x 1015 electrons? What is the electrical charge (in coulombs) carried by this number of electrons?

Answer: 9.11 x 10-16 kg, –1.60 x 10-4 coul

Difficulty: Easy

Learning Objective: Recognize the SI units commonly used in chemistry, and perform some common unit conversions.

Section Reference: 1.2 Measurements in Chemistry

Use the following information for Questions 62–67.

1 mole = 6.022 x1023 particles

62. Which would have a greater mass: 1.25 mole sample of lead or 11.25 mole sample of aluminum?

Answer: aluminum

Difficulty: Easy

Learning Objective: Solve mass–number–molar mass-type problems.

Section Reference: 1.4 Counting Atoms: The Mole

63. Which would have a greater mass: a 1.75 mole sample of tin or a 5.25 mole sample of aluminum?

Answer: tin

Difficulty: Easy

Learning Objective: Solve mass–number–molar mass-type problems.

Section Reference: 1.4 Counting Atoms: The Mole

64. Which would have a greater mass: a 2.37 mole sample of potassium or a 3.72 mole sample of magnesium?

Answer: potassium

Difficulty: Easy

Learning Objective: Solve mass–number–molar mass-type problems.

Section Reference: 1.4 Counting Atoms: The Mole

65. Naturally occurring platinum has several different isotopes, 190Pt (0.0127%; 189.960 amu); 192Pt (0.78 %; 191.9614 amu); 194Pt (32.9%; 193.9628 amu), 195Pt (33.8 %; 194.9648 amu); 196Pt (25.3 %; 195.9650 amu) and 198Pt (7.21 %; 197.9675 amu). What is the molar mass of naturally occurring platinum?

Answer: 195.1 g/mole

Difficulty: Medium

Learning Objective: Solve mass–number–molar mass-type problems.

Section Reference: 1.4 Counting Atoms: The Mole

66. The density of a particular 300 cm3 graphite sample is 2.16 g cm-3; how many atoms are contained in the sample?

Answer: 3.25x1025

Difficulty: Medium

Learning Objective: Solve mass–number–molar mass-type problems.

Section Reference: 1.4 Counting Atoms: The Mole

67. What volume is occupied by an iron sample containing 7.2 x 1025 atoms if the density of the sample is 7.87 g cm3?

Answer: 850 cm3

Difficulty: Medium

Learning Objective: Solve mass–number–molar mass-type problems.

Section Reference: 1.4 Counting Atoms: The Mole

68. Calculate the number of moles of carbon atoms and moles of sulphur atoms in 50.0 g of CS2.

Answer: 0.657 moles C, 1.31 moles S

Difficulty: Easy

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

69. Draw a ball and stick model of 1,6-hexanediamine, a starting material for nylon. The line structure is shown below:

hexane_diamine

Answer:



Difficulty: Easy

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

70. Determine the molecular formula and draw the line structure for 2-bromobutane.

Answer:

C4H9Br; 

Difficulty: Easy

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

71. Determine the molecular formula and draw the line structure of 2-bromo-3-pentanol.

Answer:

C5H11OBr; 

Difficulty: Easy

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

72. Determine the chemical formula from the line structure for methyl methacrylate.



Answer: C5H8O2

Difficulty: Medium

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

73. Write the chemical formula for ethylene oxide, a starting material for ethylene glycol and a disinfectant. The ball and stick formula is shown below:

from from ethyleneoxide

Answer: C2H4O

Difficulty: Easy

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

74. Write the chemical formula for ethylene glycol, which is the primary component in automotive coolant.

from from ethyleneglycol

Answer: C2H6O2

Difficulty: Easy

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

75. Draw the line structure of 2-propanol.

Answer:

isopropanol

Difficulty: Easy

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

76. The 380 pages of a textbook are 3.33 cm in height. What would be the height of an Avogadro’s number of pages in km?

Answer: 5.3 x 1016 km; one light year is about 9.5 x 1013 km

Difficulty: Easy

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

77. Sulphuric acid, H2SO4 is one of the more important industrial chemicals. How many moles of sulphuric acid are present in 1.0 x 109 kg?

Answer: 1.02 x 1010 mole

Difficulty: Easy

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

78. Which is greater: the number of molecules of C6H6 in 1.0 x10-6 g or the number of moles of C6H6 in 1.05 x 1010 kg?

Answer: number of molecules of C6H6 in 1.0 x10-6g

Difficulty: Medium

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

79. A 0.52 kg bowl is known to be 35% silver and 64% gold by mass. How many atoms of silver are contained in this bowl?

Answer: 1.01 x 1024 atoms Ag

Difficulty: Medium

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

80. What mass of calcium citrate, Ca3(C6O7H5)2 will have the same amount of calcium as 1.00 g of calcium carbonate?

Answer: 1.66 g

Difficulty: Medium

Learning Objective: Perform mole–mass–number conversions.

Section Reference: 1.5 Amounts of Compounds

81. A solution is prepared by the addition of 18.0 g fructose, C6H12O6, to water, allowing it to dissolve and then adding more water until the total volume is 0.350 L. What is the molarity of fructose in the solution?

Answer: 0.286 M

Difficulty: Medium

Learning Objective: Calculate concentrations of solutions and of diluted solutions.

Section Reference: 1.6 Aqueous Solutions

82. How many moles of Sr2+ ions and Cl– ions are contained in 51.5 mL of 0.23 *M* SrCl2?

Answer: 1.18 x 10-2 mol Sr2 and 2.37 x 10-2 mol Cl–.)

Difficulty: Medium

Learning Objective: Calculate concentrations of solutions and of diluted solutions.

Section Reference: 1.6 Aqueous Solutions

83. How many mL of 0.75 *M* NaCl would be required to prepare 1.5 L of 2.0 x 10-3 *M* NaCl?

Answer: 4.0 mL of 0.75 *M* NaCl

Difficulty: Easy

Learning Objective: Calculate concentrations of solutions and of diluted solutions.

Section Reference: 1.6 Aqueous Solutions

84. What mass of NaCl is required to prepare 1.5 L of 2.0 x 10-3 *M* NaCl?

Answer: 1.8x10-1 g

Difficulty: Easy

Learning Objective: Calculate concentrations of solutions and of diluted solutions.

Section Reference: 1.6 Aqueous Solutions

85. What volume of 2.0 M NaCl solution must be added to 100 ml of 1.0 M KCl to prepare a solution having total chloride concentration of 1.5 M?

Answer: 100 ml

Difficulty: Medium

Learning Objective: Calculate concentrations of solutions and of diluted solutions.

Section Reference: 1.6 Aqueous Solutions

86. What volume of 1.0 M NaCl solution must be added to 100 ml of 2.5 M KCl to prepare a solution having total chloride concentration of 1.5 M?

Answer: 200 ml

Difficulty: Medium

Learning Objective: Calculate concentrations of solutions and of diluted solutions.

Section Reference: 1.6 Aqueous Solutions

87. What volume of 1.0 M NaCl solution must be added to 100 ml of 1.25 M CaCl2 to prepare a solution having total chloride concentration of 1.5 M?

Answer: 200 ml

Difficulty: Medium

Learning Objective: Calculate concentrations of solutions and of diluted solutions.

Section Reference: 1.6 Aqueous Solutions

88. What volume of 1.0 M MgBr2 solution must be added to 100 ml of 1.25 M KBr to prepare a solution having total chloride concentration of 1.5 M?

Answer: 50 ml

Difficulty: Medium

Learning Objective: Calculate concentrations of solutions and of diluted solutions.

Section Reference: 1.6 Aqueous Solutions

89. Balance the following chemical reaction, which illustrates the synthesis of an important industrial chemical:

\_\_ NH3 + \_\_ CO2 **** \_\_ NH2(CO)NH2 + \_\_ H2O

Answer: 2 NH3 + CO2 **** NH2(CO)NH2 + H2O

Difficulty: Easy

Learning Objective: Balance chemical reactions.

Section Reference: 1.7 Writing Chemical Equations

90. Balance the following chemical reaction, which illustrates the synthesis of an important industrial chemical:

\_\_ NaCl (*s*) + \_\_ H2SO4 (*aq*) **** \_\_ Na2SO4 (*s*) + \_\_ HCl (*g*)

Answer: 2 NaCl (*s*) + H2SO4 (*aq*) **** Na2SO4 (*s*) + HCl (*g*)

Difficulty: Easy

Learning Objective: Balance chemical reactions.

Section Reference: 1.7 Writing Chemical Equations

91. Balance the following chemical reaction, which illustrates the synthesis of an important industrial chemical:

\_\_ Al2O3 •2H2O (*s*) + \_\_ H2SO4 (*aq*) **** \_\_ Al2(SO4)3 (*s*) + \_\_ H2O (*l*)

Answer: Al2O3 •2H2O (*s*) + 3 H2SO4(*aq*) **** Al2(SO4)3 (*s*) + 5 H2O

Difficulty: Medium

Learning Objective: Balance chemical reactions.

Section Reference: 1.7 Writing Chemical Equations

92. Methanol, CH3OH, is produced as the sole product by the catalytic combination of hydrogen and carbon monoxide. Write the balanced chemical equation for this process.

Answer: CO + 2 H2 **** CH3OH

Difficulty: Medium

Learning Objective: Balance chemical reactions.

Section Reference: 1.7 Writing Chemical Equations

93. Gasoline is a mixture of hydrocarbons and is consumed via a combustion reaction. Hexane, C6H14, is one of the main components of gasoline and the following equation demonstrates its combustion. Balance the equation.

\_\_ C6H14 + \_\_ O2 **** \_\_ CO2 + \_\_ H2O

Answer: 2 C6H14 + 19 O2 **** 12 CO2 + 14 H2O

Difficulty: Medium

Learning Objective: Balance chemical reactions.

Section Reference: 1.7 Writing Chemical Equations

94. A 1.23 g sample which contains gold, silver and metal oxides is treated with concentrated HNO3 which dissolves all the metals and metal oxides with the exception of the gold. The mass of yellow metal remaining is 7.4 x 10-2 g. The solution is then treated with aqueous sodium chloride which precipitates AgCl and nothing else. A total of 0.196 g of AgCl is obtained. What is the percent gold and silver in this ore?

Answer: 6.0% Au; 12.0% Ag

Difficulty: Hard

Learning Objective: Balance chemical reactions.

Section Reference: 1.7 Writing Chemical Equations

95. Urea is used as a source of nitrogen in fertilizer. How many kg ammonia would be needed to produce 1.0 x 104 kg of urea by the *unbalanced* reaction shown below?

NH3 + CO2 **** NH2(CO)NH2 + H2O

Answer: 5.7 x 103 kg

Difficulty: Hard

Learning Objective: Calculate the amount of a product from the amounts of the reactants and a balanced chemical reaction.

Section Reference: 1.8 The Stoichiometry of Chemical Reactions

Feedback: Student must balance reaction.

96. Millions of tons of phosphoric acid are manufactured by the treatment of Ca5F(PO4)3 with 55% by mass H2SO4 in water (density = 1.993 g/mL). How many L of this sulphuric acid solution are required to synthesize 1.0 x 106 kg of H3PO4 by the following unbalanced reaction?

H2SO4 + Ca5F(PO4)3 **** H3PO4 + CaSO4 + HF

Answer: 1.5 x 106 L

Difficulty: Hard

Learning Objective: Calculate the amount of a product from the amounts of the reactants and a balanced chemical reaction.

Section Reference: 1.8 The Stoichiometry of Chemical Reactions

Feedback: Student must balance reaction.

97. The following reaction describes the chemistry of the “chlor-alkalai” process, the production of chlorine and sodium hydroxide:

2 NaCl + 2 H2O **** 2 NaOH + Cl2 + H2

Determine how many kg of Cl2 you will obtain for every kg of NaOH produced.

Answer: 0.887 kg

Difficulty: Medium

Learning Objective: Calculate the amount of a product from the amounts of the reactants and a balanced chemical reaction.

Section Reference: 1.8 The Stoichiometry of Chemical Reactions

98. Nitric acid is an important chemical, being used in diverse applications from fertilizer to explosives. The net reaction for its production is shown in the following unbalanced equation:

NH3 + 2 O2 **** HNO3 + H2O

About 7.7 billion kg of nitric acid is produced annually in the United States. How many kg of ammonia will be required to produce this amount?

Answer: 2.1 x 109 kg

Difficulty: Medium

Learning Objective: Calculate the amount of a product from the amounts of the reactants and a balanced chemical reaction.

Section Reference: 1.8 The Stoichiometry of Chemical Reactions

99. Ethylene glycol is used in automotive antifreeze and in polymers such as Dacron and other polyesters. It is produced by the hydration of ethylene oxide as shown below:

eth_glycol_synth

How much ethylene glycol can be produced from 5.02 x 104 g of ethylene oxide?

Answer: 7.07 x 104 g

Difficulty: Hard

Learning Objective: Calculate the amount of a product from the amounts of the reactants and a balanced chemical reaction.

Section Reference: 1.8 The Stoichiometry of Chemical Reactions

100. An important reactant in the production of nylon is adiponitrile, the product of addition of HCN and butadiene, the reaction shown below.



If one obtains 4.50 x 105 kg of adiponitrile from the reaction of 2.50 x 105 kg of butadiene with excess HCN, what is the % yield of the reaction?

Answer: 90%

Difficulty: Hard

Learning Objective: Calculate yields of chemical reactions.

Section Reference: 1.9 Yields of Chemical Reactions

101. Acetone, most generally known as a component of fingernail polish remover, can be manufactured by the following reaction, the *dehydrogenation* of isopropanol:

acetone_synth

Catalyzed by either zinc oxide or copper/zinc metal, the reaction gives an 80% yield of product. How much isopropanol is needed to prepare 9.5 x 104 kg of acetone?

Answer: 1.23 x 105 kg of isopropanol

Difficulty: Hard

Learning Objective: Calculate yields of chemical reactions.

Section Reference: 1.9 Yields of Chemical Reactions

102. The following unbalanced reaction summarizes the “wet process” for the synthesis of phosphoric acid.

H2SO4 + Ca5F(PO4)3 **** H3PO4 + CaSO4 + HF

If treatment of 5.0 x 103 kg of Ca5F(PO4)3 with excess sulphuric acid gives 2.72 x 103 kg of phosphoric acid, what is the % yield of the process?

Answer: 93%

Difficulty: Hard

Learning Objective: Calculate yields of chemical reactions.

Section Reference: 1.9 Yields of Chemical Reactions

Feedback: Student must balance reaction.

103. When 500 ml of 0.75 M AgNO3 solution is reacted with 250 ml of 2.3 M KCl, a white AgCl precipitate forms.

AgNO3(aq) + KCl(aq) **** AgCl(s) + KNO3(aq)

What mass of precipitate is recovered?

Answer: 54 g

Difficulty: Easy

Learning Objective: Solve limiting-reagent-type problems.

Section Reference: 1.10 The Limiting Reactant

104. When 500 ml of 1.75 M AgNO3 solution is reacted with 150 ml of 2.3 M CaCl2, a white AgCl precipitate forms.

AgNO3(aq) + KCl(aq) **** AgCl(s) + KNO3(aq)

What mass of precipitate is recovered?

Answer: 99 g

Difficulty: Medium

Learning Objective: Solve limiting-reagent-type problems.

Section Reference: 1.10 The Limiting Reactant

105. How many sandwiches can be made from a dozen buns, 2 lbs of bacon (1lb = 24 slices), 1 jar of pickles (= 41 pickles), and a 2 jars of olives (1 jar = 20 spoonfuls) if each sandwich requires 5 slices of bacon, 3 pickle slices, 2 spoonfuls of olives and 1 bun?

Answer: 9 sandwiches

Difficulty: Easy

Learning Objective: Solve limiting-reagent-type problems.

Section Reference: 1.10 The Limiting Reactant

106. Quicklime, CaO, is converted to slaked lime, calcium hydroxide, by reaction with water:

CaO(*s*) + H2O(*l*) **** Ca(OH)2 (*s*)

If 5.10 kg of CaO is allowed to react with 2.0 kg of H2O, what is the maximum amount of Ca(OH)2 that can be produced?

Answer: 6.74 kg

Difficulty: Medium

Learning Objective: Solve limiting-reagent-type problems.

Section Reference: 1.10 The Limiting Reactant

107. Sulphur hexafluoride, a very good electrical insulator, is prepared by the unbalanced reaction of sulphur with elemental fluorine:

S (*s*) + F2 (*g*) **** SF6 (*g*)

How many kg of SF6 could be produced from the reaction of 1.50 x 102 kg of S with 6.50 x 102 kg of F2?

Answer: 6.84 x 102 kg

Difficulty: Hard

Learning Objective: Solve limiting-reagent-type problems.

Section Reference: 1.10 The Limiting Reactant

Feedback: Student must balance reaction.

108. Hydrogen cyanide, HCN, is manufactured by the following reaction:

2 NH3(*g*) + 3 O2 (*g*) + 2 CH4 (*g***) ** 2 HCN (*g*) + 6 H2O (*g*)

If 250.0 kg each of NH3, O2 and CH4 react, what would be the theoretical yield in kg of HCN?

Answer: 140.6 kg

Difficulty: Hard

Learning Objective: Solve limiting-reagent-type problems.

Section Reference: 1.10 The Limiting Reactant

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