Matter and Measurement

1. Ethylene glycol (antifreeze) has a density of 1.11g/cm^3 .
   a. What is the mass in g of 417 mL of this liquid?

   b. What is the volume in L of 4.1 kg of this liquid?

Atoms and Elements

2. Write isotopic symbols for each of the following isotopes:
   a. The sodium isotope with 12 neutrons
   b. The oxygen isotope with 8 neutrons

3. Determine the number of protons and electrons in each of the following ions.
   a. Ni^{2+} b. S^{2-}

4. Rubidium has two naturally occurring isotopes with the following masses and natural abundances.

Isotope	Mass (amu)	Abundance (%)
Rb-85	84.9118	72.15
Rb-87	86.9092	27.85

Calculate the atomic mass of rubidium.

ACS Question 1: In what respect does an atom of Magnesium, Mg, differ from a magnesium ion, Mg^{2+}?

   a. The ion has an inert gas electron configuration, the atom does not.
   b. The positive charge on the nucleus of the ion is two units greater than the nuclear charge on the atom.
   c. The ion has two more protons than the atom.
   d. The ion has two more planetary electrons than the atom.

Naming

5. Name each of the following:
   a. $PbCl_4$ b. $Ba(OH)_2$ c. $CoSO_4 \cdot 7H_2O$

   d. NI_3 e. I_2O_5 f. HI g. HNO_3

6. Write a formula for each of the following:
   a. potassium hydrogen carbonate b. lead (II) chromate

   c. iron (II) phosphate d. sulfuric acid

   e. hydrofluoric acid f. disulfur tetrafluoride g. dichlorine monoxide

Chemical Reactions and Quantities

7. The empirical formula and molar mass of several compounds are listed below. Find the molecular formula of each compound.
   a. C_6H_7N, 186.24 g/mol b. CCl, 284.77 g/mol

8. How many aluminum atoms are in a can with a mass of 15.3g of Al?

9. Calculate the mass percent of Fluorine in $C_2Cl_4F_2$

10. Balance the following equation: $C_4H_{10}(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$

11. To obtain iron from iron ore the following reaction is used:

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$$

From experiment, we observed the 153g of $Fe_2O_3(s)$ combined with 96.2g of CO (g) produced 88.3 g of Fe. Find the limiting reactant, theoretical yield and percent yield.

12. Calculate the mass of NaCl in a 60mL sample of a 1.7 M NaCl solution

13. Determine the concentration of Cl^- in a .25M aqueous solution of $AlCl_3$.

14. To what volume should you dilute 50 mL of 12M HCl to obtain a 6.5M solution of HCl?

Gases

15. A cylinder contains 28.5L of oxygen gas at a pressure of 1.8 atm and a temperature of 298 K. How much gas (moles) is in the cylinder?

16. A gas mixture contains 1.25 g N_2 and 0.85 g O_2 in a 1.55 L container at 18^o C. Calculate the mole fraction and partial pressure of each component in the gas mixture.

17. CH_3OH can be synthesized by the following reaction:

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(g)$$

What volume of H_2 gas, measured at 748mmHg and 86^o C, is required to synthesize 25.8 g of CH_3OH?

ACS Question 2: Which is true about equal volumes of CH_4 and O_2 gasses at 20°C and 1 atm of pressure?

a. The CH_4 sample has a mass that is one half that of the O_2 sample.
b. The number of O_2 molecules is twice as large as the number of CH_4 molecules.
c. The average kinetic energy of the O_2 molecules is on-half that of the CH_4 molecules.
d. The average velocity of the O_2 molecules is one-half that of the CH_4 molecules.

Thermochemistry

18. A 3.21 g of Aluminum block initially at 22 C$^\circ$ absorbs 859 J of heat. What is the final temperature of the Aluminum block? Specific heat of Al is .903 J/g•$^\circ$C

19. The combustion of toluene has ΔH_{rxn} of $-3.91 * 10^3$ kJ/mol. When 1.55g of toluene (C_7H_8) undergoes combustion in a bomb calorimeter, the temperature rises from 19 C° to 35 C°. Find the heat capacity of the bomb calorimeter.

20. Identify each of the following processes as endothermic or exothermic and indicate the sign of ΔH.
    i. Sweat evaporating from skin
    ii. An ice cube melting
    iii. Water freezing in the freezer
    iv. Wood burning in a fire
    v. Nail polish remover quickly evaporating after it is accidentally spilled on the skin

21. What mass of butane, in grams, is necessary to produce 1.5 x 10^3 kJ of heat? What mass of CO_2 is produced?
    $C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2 + 5H_20$, ΔH_{rxn}= -2658kJ

22. Calculate the ΔH_{rxn} for the following reaction using ΔH°_{rxn}'s:

    $CH_4(g) + 4Cl_2(g) \rightarrow CCl_4(g) + 4HCl(g)$

	ΔH°_{rxn} (kJ)
$C(s) + 2H_2(g) \rightarrow CH_4(g)$	76.4
$C(s) + 2Cl_2(g) \rightarrow CCl_4(g)$	-95.7
$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$	.92.3

23. Use standard enthalpies of formation to calculate ΔH_{rxn} for the following reaction:

$$N_2O_4(g) + 4H_2(g) \rightarrow N_2(g) + 4H_2O(g)$$

Is the reaction exothermic or endothermic?

	ΔH_f° (kJ/mol)
$N_2O_4(g)$	11.1
$H_2(g)$	0
$N_2(g)$	0
$H_2O(g)$	241.8

Quantum Mechanical Model of the Atom

24. What are the quantum numbers and names of the orbitals in the n = 3 principal level?

25. Consider the following types of electromagnetic radiation: gamma rays, radio waves, microwaves, and visible light. Arrange them in order of:

i. Increasing frequency
ii. Decreasing energy per photon
iii. Decreasing wavelength

26. Determine the wavelength of the light absorbed when an electron in a hydrogen atom makes a transition from an orbital in n=2 to an orbital in n=7 ($E= 2.18\times10^{-18}\ J(1/n^2)$ $h = -6.63\times10^{-34} j\bullet s$ $c=3.00\times10^{8}$ m/sec

ACS Question 3: Which set of quantum numbers is correct and consistent with n=4?

a. l = 3 ml = -3 ms= +½ b. l = 4 ml = +2 ms= -½
c. l = 2 ml = +3 ms= +½ d. l = 3 ml = -3 ms= +1

Periodic Trends

27. Write the electron configuration and identify the number of valence electrons and the number of core electrons for the following elements: Also indicate if they are paramagnetic or diamagnetic.

i. Cl
ii. O
iii. Ca
iv. Al

28. Arrange the following elements in order of increasing metallic character, Ionization energy, and atomic radius:

i. Fr
ii. Sb
iii. In
iv. S
v. Ba
vi. Se

29. Choose the element with more negative (more exothermic) electron affinity from each of the flowing pairs:
    i. Mg or S
    ii. K or Cs
    iii. Si or P
    iv. Ga or Br
    v. Li or F

Chemical Bonding: Lewis Dot Structures

30. Write the Lewis structure for the following molecules or ions:
    i. N_2H_2
    ii. C_2H_4
    iii. H_3COCH_3
    iv. CN^-
    v. OH^-
    vi. NO_2^-

31. Consider the following trend in the lattice energies of the alkaline earth metal oxides and explain this trend:

Metal Oxide	Lattice Energy (kJ/mol)
MgO	-3795
CaO	-3414
SrO	-3217
BaO	-3029

32. Determine whether a bond between each of the following pairs of atoms would be pure covalent, polar covalent, or ionic.
    a. Br and Br b. C and Cl c. Sr and O
33. Write a Lewis structure for each of the following ions. Include resonance structures if necessary and assign formal charges to all atoms. If necessary, expand the octet on the central atom to lower formal charge.

a. PO_4^{3-} b. CN^- c. SO_3^{2-} d. ClO_2^-

34. Hydrogenation reactions are used to add hydrogen across double bonds in hydrocarbons and other organic compounds. Use average bond energies to calculate ΔH_{rxn} for the following hydrogenation reaction:

$$H_2C = CH_{2\,(g)} + H_{2\,(g)} \rightarrow H_3C - CH_{3\,(g)}$$

	Bond Energies (kJ/mol)
C-H	414
C-C	347
C=C	611

ACS Question 4: The molecule :Ö=C=N̈-H has been detected in gas clouds between stars. The predicted C-N-H bond angle is about:

a. 90° b. 109° c. 120° d. 180°

Chemical Bonding: Molecular Shapes, Valence Bond Theory, and Molecular Orbital Theory

35. Determine the electron geometry, molecular geometry, and idealized bond angles for each of the following molecules. In which cases do you expect deviations from the idealized bond angle?

a. PF_3 b. SBr_2 c. $CHCl_3$ d. CS_2

36. Determine whether each of the following molecules is polar or nonpolar.

a. ClO_3^{--} b. SCl_2 c. SCl_4 d. $BrCl_5$

37. The valence electron configurations of several atoms are shown below. How many bonds can each atom make without hybridization?

a. Be $2s^2$

b. P $3s^23p^3$

c. F $2s^22p^5$

38. For each of the following compounds, draw an appropriate Lewis structure, determine the geometry using VSEPR theory, determine whether the molecule is polar, identify the hybridization of all interior atoms.

    a. COF_2 (carbon is the central atom)

    b. S_2Cl_2 (ClSSCl)

    c. SF_4

Answers:

1. a. 463g b. 3.7 L
2. a. $^{23}_{11}Na$ b. $^{16}_{8}O$
3. a. 28^1_1p and 26e$^-$ b. 16^1_1p and 18 e$^-$
4. 85.47 amu, mass spectrum will have a peak at 86.91amu and another peak about 2.5 times larger at 84.91amu

ACS Question 1: A

5. a. lead(IV) chloride b. barium hydroxide c. Cobalt(II) sulfate · heptahydrate d. nitrogen triiodide e. diiodine pentoxide f. hydroiodic acid g. nitric acid
6. a. $KHCO_3$ b. $PbCrO_4$ c. $Fe_3(PO_4)_2$ d. H_2SO_4 e. HF f. S_2F_4 g. Cl_2O
7. a.$C_{12}H_{14}N_2$ b. C_6Cl_6
8. $3.41 * 10^{23} atoms$
9. 18.6%
10. $2\ C_4H_{10}(g) + 13\ O_2(g) \rightarrow 8\ CO_2(g) + 10H_2O(g)$
11. Fe_2O_3, 107g, 82.5%
12. 5.96g
13. 0.75M
14. 92ml
15. 2.1 mol
16. $X_{N_2} = 0.627, X_{O_2} = 0.373, P_{N_2} = 0.687\ atm, P_{O_2} = 0.409\ atm$
17. 48.2

ACS Question 2: a.

18. 318° C
19. 4.11 kJ/ C°
20. As follows
    i. Endothermic; positive ΔH
    ii. Endothermic; positive ΔH
    iii. Exothermic; negative ΔH
    iv. Exothermic; negative ΔH
    v. Endothermic; positive ΔH
21. 33g C_4H_{10}; 99g CO_2
22. -354.9kJ
23. -976 kJ, exothermic
24. n=3; l=0,1,2, (s,p,d) ;m_l=-2,-1,0,1,2;m_s= -$\frac{1}{2}$,$\frac{1}{2}$
25. As follows:
    i. Radio waves, Microwaves, Visible Light, Gamma Rays
    ii. Gamma Rays, Visible Light, Microwaves, Radio waves
    iii. Radio waves, Microwaves, Visible Light, Gamma Rays
26. 397nm

ACS Question 3: a.

27. As follows:
    i. $1s^2 2s^2 2p^6 3s^2 3p^5$ or [Ne] $3s^2 3p^5$ paramagnetic
    Valence = 7, Core = 10
    ii. $1s^2 2s^2 2p^4$ or [He] $2s^2 2p^4$ paramagnetic
    Valence = 6, Core = 2
    iii. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ or [Ar]$4s^2$ diamagnetic
    Valence = 2, Core = 18
    iv. $1s^2 2s^2 2p^6 3s^2 3p^1$ or [Ne] $3s^2 3p^1$ paramagnetic
    Valence = 3, Core = 10

28. As follows:
    i. Metallic Character: S, Se, Sb, In, Ba, Fr
    ii. Ionization Energy: Fr, Ba, In, Sb, Se, S
    iii. S, Se, Sb, In, Ba, Fr
29. As follows:
    i. S
    ii. K
    iii. Si
    iv. Br
    v. F
30. As follows:

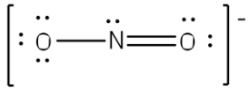
i. $H - \ddot{N} = \ddot{N} - H$

ii. $H_2 - C = C - H_2$ (Written in shorthand)

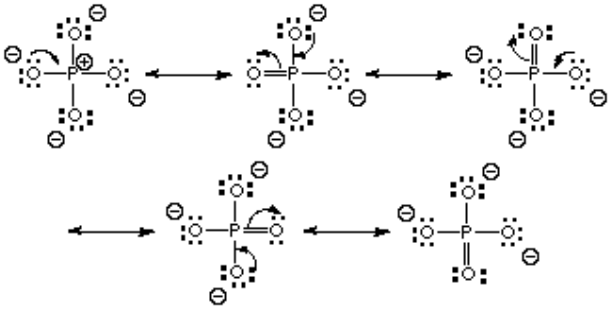
iii. $H_3 - C - \ddot{O} - C - H_3$ (Written in shorthand)

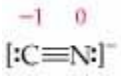
iv. $[\ddot{C} \equiv \ddot{N}]^-$

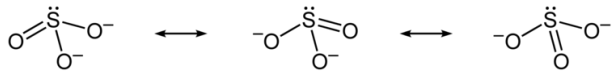
v. $\left[:\ddot{O} - H \right]^-$

vi. 

31. As the size of the alkaline earth metal ions increases, so does the distance between the metal cations and oxygen anions. Therefore, the magnitude of the lattice energy decreases accordingly because the potential energy decreases as the distance increases.
32. A. Pure covalent. B. polar covalent. C. ionic bond
33. Structures here from page A-23 question 31
    Phosphorous is a third-row element, so it can expand its octet to contain ten valence electrons. The oxygen atoms can each loan a lone pair to the phosphorus, so several resonance structures result.



b. 

c. 

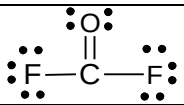
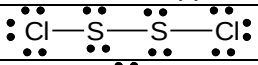
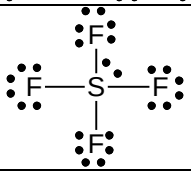
d. $\left[:\ddot{O} - \ddot{Cl} - \ddot{O}: \right]^-$

34. -128kJ

ACS Question 4: c

35. a. e^- geometry: tetrahedral molecular geometry: trigonal pyramidal idealized bond angle: 109.5˚, deviation
    b. e^- geometry: tetrahedral molecular geometry: bent idealized bond angle: 109.5˚, deviation
    c. e^- geometry: tetrahedral molecular geometry: tetrahedral idealized bond angle: 109.5˚, deviation (due to large size of Cl compatred to H)
    d. e^- geometry: linear idealized bond angle: 180˚
36. a. polar b. polar c. polar d. polar
37. a. 0 b. 3 c. 1

38.

	Lewis Structure	Geometry	Polar?	Hybridization
a.		Trigonal planar	Polar	Carbon: sp^2
b.		bent	Polar	Sulfur: sp^3
c.		Seesaw	polar	Sulfur: sp^3d