A Data Sheet with useful information is at the end.

1. (4) Write the molecular formula next to the names of the following compounds:

Ammonia	**NH_3**
Ethane	**C_2H_6**
Calcium Carbonate	**$CaCO_3$**
Potassium Perchlorate	**$KClO_4$**

2. (8) Balance the following chemical equations:

2 Fe_2O_3 + **3** C → **4** Fe + **3** CO_2

C_3H_8 + **5** O_2 → **3** CO_2 + **4** H_2O

2 $AgNO_3$ + $CaCl_2$ → $Ca(NO_3)_2$ + **2** AgCl

2 $NaHCO_3$ + H_2SO_4 → Na_2SO_4 + **2** CO_2 + **2** H_2O

3. (8) Copper dissolves in dilute nitric acid according to the equation:

$$3\ Cu\ (s) + 8\ HNO_3\ (aq) \rightarrow 3\ Cu(NO_3)_2\ (aq) + 2\ NO\ (g) + 4\ H_2O$$

How many grams of nitric acid are required to dissolve 11.45 g of Cu according to this equation?

Molar masses: Cu: 63.55 g/mol HNO_3: 1.008 + 14.01 + 3X16.00 = 63.02 g/mol

11.45 g/ 63.55 (g/mol) = 0.1802 mol Cu X 8/3 = 0.4805 mol HNO_3 X 63.02 g/mol = 30.28 g

4. (8) Chlorine dioxide has been used as a disinfectant in air-conditioning systems. It reacts with water according to the equation:

$$6\ ClO_2 + 3\ H_2O \rightarrow 5\ HClO_3 + HCl$$

142.0 g of ClO_2 are mixed with 38.0 g of H_2O.

a) (4) Which is the limiting reactant

Molar masses: ClO_2: 35.45+2*16.00= 67.45 g/mol H_2O: 18.02 g/mol
142.0 g/67.45 (g/mol) = 2.105 mol ClO_2
38.0 g/18.02 (g/mol) = 2.11 mol H_2O

2.105/2.11 < 6/3 => ClO_2 is limiting

b) (4) How many g of the excess reactant will remain if the reaction goes to completion?

2.105 mol ClO_2 will react with 2.105 X 3/6 = 1.053 mol H_2O

2.11 – 1.053 = 1.06 mol H_2O will remain X 18.02 g/mol = 19.1 g H_2O

5. (8) How many mL of O_2 measured at 27 ºC and 654 torr are needed to react completely with 16.8 mL of CH_4 measured at 35 ºC and 725 torr?

$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

$n_{CH4} = P_{CH4}\ X\ V_{CH4} / (RXT_{CH4})$

$n_{O2} = 2\ X\ n_{CH4}$

$V_{O2} = n_{O2}\ RXT_{O2} / P_{O2} = 2\ X\ P_{CH4}\ X\ V_{CH4} / (RXT_{CH4})\ X\ RXT_{O2} / P_{O2} =$

2 X (725 torr/654 torr) X (16.8 mL) X (273 + 27 K) / (273 + 35 K) = 36.3 mL

6. (8) The thermochemical equation for the combustion of acetylene is:

$2\ C_2H_2\ (g) + 5\ O_2\ (g) \rightarrow 4\ CO_2\ (g) + 2\ H_2O\ (l) \qquad \Delta H^o = -2599.3\ kJ$

Use this equation and data from your data sheet to calculate the enthalpy of formation of acetylene gas.

ΔH^o = (ΔH_f of products) – (ΔH_f of reactants) =>

-2599.3 = 4X(-393.5) + 2 X (-285.9) – 2 ΔH_f (acet) => ΔH_f (acet) = 226.8 kJ /mol

7. (4) Calculate the percentage composition by mass for $CaSO_4$.

Molar mass = 40.08 + 32.07 + 4 X 16.00 = 136.15 g/mol

Ca: 40.08 / 136.15 X 100% = 29.44 %

S: 32.07 / 136.15 X 100% = 23.55 %

O: 4X16.00/ 136.15 X 100% = 47.01 %

8. (4) Calculate the energy in joules of a photon of green light having a wavelength of 560 nm.

$E = hv = h\,c/\lambda = 6.626 \times 10^{-34}$ Js X 2.9979×10^{8} m/s / 560×10^{-9} m =

0.0355×10^{-17} J

9. (4) Write an abbreviated (noble gas core) electron configuration for the following:

Zn **[Ar] $4s^2$ $3d^{10}$**

O^{2-} **[Ne]**

In **[Kr] $5s^2$ $4d^{10}5p^1$**

Ni^{2+} **[Ar] $3d^8$**

10. (4) (a) (2) Circle the larger atom in each pair:

i) **Na** or Si

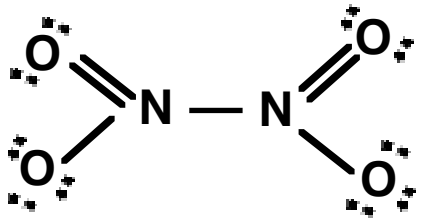
ii) P or **Sb**

(b) (2) Circle the atom with the larger ionization energy in each pair:

i) B or **O**

ii) **Cl** or As

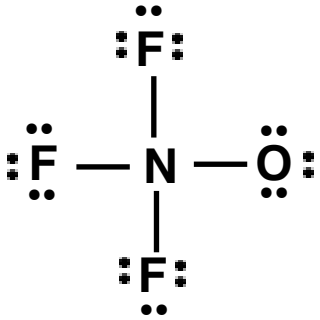
11. (10) (a) Draw all possible resonance structures for dinitrogen tetroxide (the two nitrogens are bonded to each other and two oxygens are bonded to each N). What is the nature of the NO and NN bonds (single, double, etc)?



There are three more structures like this with the double bonds on different oxygens.

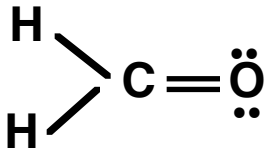
NN is a single bond and the NO bonds are between single and double (bond order 1.5)

12. (5) Assign formal charges to each atom in the following Lewis structure:



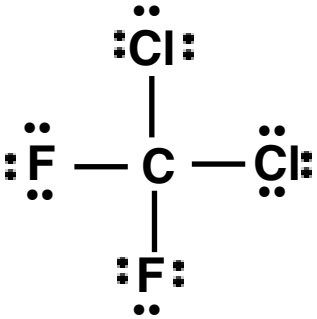
N : +1 F: 0 O : -1

13. (8) Use Lewis structures and the VSEPR method to predict the molecular geometry and the bond angles of formaldehyde (CH_2O). What is the hybridization of the C atom?



molecular geometry: trigonal planar
Bond angles ~ 120°. The HCO angles are slightly larger than 120°.
Hybridization of C: sp2

14. (5) Using the VSEPR method and your knowledge about electronegativity and bond polarity, predict whether the molecule CCl_2F_2 is polar or nonpolar.



Tetrahedral geometry. F is more electronegative than Cl, so the bond dipole moments do not cancel out and the molecule is polar.

15. (5) Assign oxidation numbers to each element in the following compounds:

a) NaOCl **Na +1, O -2, Cl +1**

b) MnO_4^{2-} **O -2, Mn +6**

c) $TiCl_4$ **Ti +4, Cl -1**

d) SO_3^{2-} **O -2, S +4**

e) NO^+ **O -2, N +3**

16. (7) In a titration, 23.25 mL of 0.105 M NaOH was needed to react with 21.45 mL of H_2SO_4 solution. What is the molarity of the acid?

$2\ NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2\ H_2O$

23.25×10^{-3} L X 0.105 mol/ L = 2.44×10^{-3} mol NaOH

This reacts with $2.44 \times 10^{-3} / 2 = 1.22 \times 10^{-3}$ mol H_2SO_4

Molarity = 1.22×10^{-3} mol / 21.45×10^{-3} L = 0.0569 M

DATA SHEET

Speed of light : 2.9979 X 10^{8} m/s

Planck's constant : 6.626 X 10^{-34} Js

E_n = -2.179 X 10^{-18} J/n^2

Mass of a proton: 1.67262 X 10^{-24} g

Mass of an electron: 9.10939 X 10^{-28} g

R= 0.082058 L atm / (mol K) = 62.364 L torr / (mol K) = 8.3145 J / (mol K)

Substance	ΔH_f^o, kJ/mol
NH_3 (g)	-46.11
H_2O (g)	-241.8
H_2O (l)	-285.9
NH_4Cl (s)	-314.4
HCl (g)	-92.31
C_2H_4 (g)	52.26
C_2H_6 (g)	-84.68
CO_2 (g)	-393.5
O_2 (g)	0