Note: There are 7 questions in this exam (check both sides of the sheet).
Fill in your answer in the blank space provided immediately following each question. Half a point will be subtracted every time you report a numerical result with an incorrect number of significant figures. A copy of the periodic table is attached. Good luck!

1. a. (4) What is the chemical formula of magnesium phosphate?

$Mg_3(PO_4)_2$

b. (4) What is the name of the compound $KClO_4$?

Potassium Perchlorate

c. (4) How many protons and electrons does the sodium ion have?

Na^+ : 11 protons, 10 electrons

d. (4) What is the molar mass of $PbCO_3$?

207.2+12.01+3*16.00= 267.2

e. (4) Give the name of the elements with the following atomic symbols:

Hg: **Mercury**

P: **Phosphorus**

F: **Fluorine**

Mn: **Manganese**

2. Write a balanced equation for each of the following reactions (it is not necessary to indicate the states of each substance):

a. (6) Burning butane in oxygen

$2\ C_4H_{10} + 13\ O_2 \rightarrow 8\ CO_2 + 10\ H_2O$

b. (6) Calcium Carbide (CaC_2) reacts with water to form an aqueous solution of calcium hydroxide and acetylene (C_2H_2)

$CaC_2 + 2\ H_2O \rightarrow Ca(OH)_2 + C_2H_2$

3. Balance the following chemical equations:

a. (6) $CH_4\,(g) + \mathbf{4}\ Br_2\,(g) \text{ -----> } CBr_4(l) + \mathbf{4}\ HBr\,(g)$

b. (6) $Cr(OH)_3\,(s) + \mathbf{3}\ HClO_4\,(aq) \text{ ---> } Cr(ClO_4)_3\,(aq) + \mathbf{3}\ H_2O\,(l)$

c. (6) $N_2O_5\,(g) + H_2O\,(l) \text{ -----> } \mathbf{2}\ HNO_3\ (aq)$

4. (10) Automotive air bags inflate when sodium azide rapidly decomposes:

$2\ NaN_3\,(s) \text{ -----> } 2\ Na\,(s) + 3N_2\,(g)$

a) (5) How many moles of N_2 are produced by the decomposition of 1.50 moles of NaN_3?

1.50 mol NaN_3 X (3 mol N_2) / (2 mol NaN_3) = 2.25 mol N_2

b) (5) How many grams of NaN_3 are required to form 5.00 g of nitrogen gas?

Molar mass NaN_3 = 22.99+3*14.01 = 65.02 g /mol

Molar mass N_2= 2*14.01 = 28.02 g /mol

5.00 g N_2 / (28.02 g N_2/ mol N_2) X (2 mol NaN_3 /3 mol N_2)
X 65.02 g NaN_3 / mol NaN_3 = 7.73 g NaN_3

5. (15) Vanillin, the dominant flavoring in vanilla, contains C, H, and O. When 1.050 g of this substance is completely combusted, 2.43 g of CO_2 and 0.500 g of H_2O are produced. What is the empirical formula of vanillin?

2.43 g CO2 X (12.01 g C/44.01 g CO2) = 0.663 g C

0.500 g H2O X (2*1.008 g H/ 18.02 g H2O) = 0.0559 g H

1.050 – 0.663 – 0.0559 = 0.331 g O

Convert to moles:
0.663/12.01 = 0.0552 mol C

0.0559/1.008 = 0.0555 mol H

0.331/ 16.00 = 0.0207 g O

Divide by the smallest (0.0207):
C: 0.0552/0.0207 = 2.66
H: 0.0555/0.0207= 2.68
O: 0.0207/0.0207= 1

To get whole numbers multiply all by 3. Empirical formula:

$C_8H_8O_3$

6. (15) When chlorine gas is bubbled into hot potassium hydroxide solution, it reacts according to the equation:

$3Cl_2$ (g) + 6KOH (aq) -→ 5 KCl (aq) + $KClO_3$ (aq) + $3H_2O$ (l)

A reacting mixture contains 6.00 mol of chlorine and 8.00 mol of potassium hydroxide.
a) (5) Find the limiting reactant

Cl_2:KOH = 6 / 8 > 3/6 => KOH is limiting reactant

b) (5) How many moles of $KClO_3$ will form and how many moles of excess reactant will remain?

8.00 mol KOH X (1 mol $KClO_3$ /6 mol KOH) = 1.33 mol $KClO_3$ will form

8.00 mol KOH X (3 mol Cl_2 /6 mol KOH) = 4.00 mol Cl_2 will react

6.00-4.00 = 2.00 mol Cl_2 will remain

c) (5) How many grams of KOH are needed to form 50.0 Kg of $KClO_3$?

molar mass of $KClO_3$ = 39.10 + 35.45 + 3*16.00 = 122.55 g/mol
molar mass of KOH: 39.10 + 16.00 + 1.008 = 56.11 g/mol

50.0 Kg $KClO_3$X 1000 g/Kg /122.55 (g /mol) = 408 mol $KClO_3$

408 mol $KClO_3$X (6 mol KOH/1 mol $KClO_3$) X 56.11 g/mol /(1000 g/Kg) = 137 Kg KOH

7. (10) Hydrogen chloride is prepared commercially by the reaction of sodium chloride with concentrated sulfuric acid:

$NaCl\ (s) + H_2SO_4\ (aq) \rightarrow NaHSO_4\ (s) + HCl\ (g)$

If the percent yield is 81.5%, how many grams of HCl will be obtained by treating 25.0 Kg of NaCl with excess sulfuric acid?

molar masses:
NaCl: 22.99+35.45 = 58.44 g/mol HCl: 35.45+1.008=36.46 g/mol

25.0 Kg X 1000 (g/Kg) / (58.44 g/mol) = 428 mol NaCl

theoretical yield: 428 mol NaCl X (1 mol HCL/1 mol NaCl)X 36.46 g/mol / (1000g/Kg) = 15.6 Kg HCl

actual yield= 15.6 Kg X 81.5% = 12.7 Kg