MULTIPLE CHOICE QUESTIONS TEST WITH A SINGLE CORRECT ANSWER
(Select just one answer A, B, C or D)

The Periodic table with the needed data is given on the last page of the test

1. For each process described below, state whether the material being discussed is most likely a mixture or a compound, and state whether the process is a chemical change or a physical change.

I. The products of distillation of an orange liquid are a yellow liquid and a red solid.

II. A colorless, crystalline solid is decomposed, giving a pale yellow-green gas and a soft, shiny metal.

III. A cup of tea becomes sweeter as sugar is added to it.

A. I mixture, physical change, II and III compounds, chemical changes.

B. I and III mixtures, physical changes, II compound, chemical change.

C. II mixture, physical change, I and III compounds, chemical changes.

D. I and III mixtures, physical changes, II mixture, chemical change.

2. Serotonin ($C_{10}H_{12}N_2O$; $M_r = 176$) is a compound that transfers nerve impulses in the brain and muscles. A sample of spinal fluid from a volunteer in a study was found to contain serotonin with concentration of 1,5 ng/L. How many molecules of serotonin are there in one milliliter of the spinal fluid?

A. $5.13 \cdot 10^9$ B. $9.03 \cdot 10^{11}$

C. $5.13 \cdot 10^{27}$ D. $9.03 \cdot 10^{29}$

3. Which of the following statements best explains the law of conservation of mass?

A. 100 g of water is heated to give steam.

B. A sample of N_2 gas is heated at constant pressure without any change of mass.

C. 12 g of carbon combines with 32 g of oxygen to form 44 g of CO_2.

D. 10 g of carbon is heated in vacuum without any change in mass.

4. What is the mass fraction of oxygen in $Zn(BrO_3)_2$?

A. 24.83 % B. 39.00 %

C. 29.89 % D. 39.79 %

5. Which pair of ions have the same electronic configuration?

A. Cr^{3+}, Fe^{3+} B. Fe^{3+}, Mn^{2+}

C. Fe^{3+}, Co^{3+} D. Sc^{3+}, Cr^{3+}

6. An element E has the electron configuration [Kr]$5s^2 4d^{10} 5p^2$. The formula for the fluoride of E is most likely:

A. EF B. EF_2

C. EF_4 D. EF_6

7. The atomic numbers of three elements X, Y and Z are a, a+1 и a+2, where Z is an alkali metal. In a compound of X and Z, the type of bonding is:

A. hydrogen bond.
B. metallic bond.
C. covalent bond.
D. ionic bond.

8. Which of the following compounds/ions exhibit both ionic and covalent bonding?

A. $BaCO_3$ B. $MgCl_2$

C. BaO D. SO_4^{2-}

9. The stoichiometric coefficients of the participants in the reaction described by the equation $Al_2(CO_3)_3 + H_3PO_4 = AlPO_4 + CO_2 + H_2O$ are (left to right)

A. 2,4,4,6,3 B. 1,2,2,3,3

C. 2,2,4,3,3 D. 3,2,6,3,1

10. In a reaction, 34.0 g of chromium(III) oxide reacts with 12.1 g of aluminum to produce chromium and aluminum oxide. If 23.3 g of chromium is obtained, what mass of aluminum oxide is produced?

A. 64.6 g B. 11.4 g
C. 46.6 g D. 22.8 g

11. How many moles of NaOH should be mixed with 1 mol H_3PO_4 to form sodium dihydrogen phosphate, without any of the reactants being in excess?

A. 0.5 mol NaOH and 1 mol H_3PO_4
B. 1 mol NaOH and 1 mol H_3PO_4.
C. 2 mol NaOH and 1 mol H_3PO_4.
D. 3 mol NaOH and 1 mol H_3PO_4.

12. Saccharin ($C_7H_5NO_3S$, M_r = 183.18) is used as an artificial sweetener and is present in the form of tablets containing a filler besides saccharin. An analyst, in order to determine the total saccharin content of the tablets, analyzed ten tablets with a total mass of 0.5894 g. The tablets were first dissolved in water, then they were oxidized to convert all sulfur to sulfate anions, and finally an excess of barium chloride solution was added. The mass of barium sulfate obtained (M_r = 233.38) was 0.5032 g. What is the average mass of saccharin in one tablet?

A. 503.2 mg B. 50.32 mg
C. 394.9 mg D. 39.49 mg

13. Aluminum oxide is produced by direct reaction of Al (s) and O_2 (g). How many moles of aluminum are needed to obtain 3.70 mol of aluminum oxide?

A. 7.40 mol B. 3.70 mol
C. 2.00 mol D. 1.85 mol

14. The salt denoted by X in the following diagram is:

Salt X + NaOH $\xrightarrow{\text{heating}}$ Y (g) + H_2O

Salt X $\longrightarrow$ positive test with brown ring (in the presence of $FeSO_4$ and concentrated H_2SO_4)

A. KNO_3 B. KNO_2
C. NH_4NO_3 D. NH_4Cl

15. A student had three test tubes labeled A, B and C and each tube had to be tested for a presence of certain type of anion. In which of the offered answers can all of the listed anions be identified by a silver nitrate solution?

A. SO_3^{2-}, SO_4^{2-}, I^-
B. PO_4^{3-}, NO_3^-, I^-
C. CO_3^{2-}, NO_3^-, SO_4^{2-}
D. No combination can be identified only by the addition of a solution of $AgNO_3$.

PROBLEMS:

Put the calculations and the answer to the problem at the designated place!

The Periodic table with the needed data is given on the last page of the test.

1. (**Total 4p**) Write the chemical formulas or names of the following compounds:

Chemical formula	Name
HIO_3	iodic acid
$Pb(ClO_2)_2$	lead(II) chlorite
N_2O_3	dinitrogen trioxide
Cl_2O_7	dichlorine heptoxide
Na_3AsO_4	sodium arsenate
$KHSO_3$	potassium bisulfite
$CrNH_4(SO_4)_2 \cdot 12H_2O$	ammonium chromium(III) sulfate dodecahydrate
$SbCl_5$	antimony pentachloride

2. (**Total 4**p) A sample of 5 g of a technical iron(II) sulphide FeS, containing 5 % (mass fraction) metallic iron reacted with hydrochloric acid.

A. Write the equations of the reactions that occur.

$Fe + 2HCl \rightleftharpoons FeCl_2 + H_2$

$FeS + 2HCl \rightleftharpoons FeCl_2 + H_2S$

B. Calculate the volume of the gaseous products separately at standard conditions.

Solution:

$$n(\mathrm{Fe}) = \frac{m(\mathrm{Fe})}{M(\mathrm{Fe})} = \frac{0{,}25\ \mathrm{g}}{55{,}85\ \mathrm{g/mol}} = 4{,}48 \cdot 10^{-3}\ \mathrm{mol}$$

$$n(\mathrm{FeS}) = \frac{m(\mathrm{FeS})}{M(\mathrm{FeS})} = \frac{4{,}75\ \mathrm{g}}{87{,}91\ \mathrm{g/mol}} = 5{,}40 \cdot 10^{-2}\ \mathrm{mol}$$

$$V(\mathrm{H_2}) = n(\mathrm{H_2}) \cdot V_0 = 4{,}48 \cdot 10^{-3}\ \mathrm{mol} \cdot 22{,}4\ \mathrm{dm^3/mol} = 0{,}1\ \mathrm{dm^3}$$

$$V(\mathrm{H_2S}) = n(\mathrm{H_2S}) \cdot V_0 = 5{,}40 \cdot 10^{-2}\ \mathrm{mol} \cdot 22{,}4\ \mathrm{dm^3/mol} = 1{,}21\ \mathrm{dm^3}$$

C. Calculate the volume fraction (as a percentage) of each gaseous product separately in the gas mixture!

Solution:

$$\varphi(H_2) = \frac{0{,}1\ dm^3}{1{,}31\ dm^3} \cdot 100 = 7{,}63\%$$

$$\varphi(H_2S) = \frac{1{,}21\ dm^3}{1{,}31\ dm^3} \cdot 100 = 92{,}37\%$$

3. (**Total 7p**) An ionic compound MX_3 is prepared according to the following **unbalanced** chemical equation:

$$M + X_2 \rightarrow MX_3$$

A sample (0.105 g) of X_2 contains $8.92 \cdot 10^{20}$ molecules. The compound MX_3 contains 54.47 % X by mass.

A. Determine the identities of M and X.

Solution:

$m(X_2) = 0{,}105$ g; $N(X_2) = 8{,}92 \cdot 10^{20}$ molecules; $w(X) = 54{,}47$ %

$$n(X_2) = \frac{N}{N_A} = \frac{8{,}92 \cdot 10^{20}}{6{,}022 \cdot 10^{23}/\text{mol}} = 1{,}48 \cdot 10^{-3}\ \text{mol}$$

$$n(X_2) = \frac{m(X_2)}{M(X_2)} \Rightarrow M(X_2) = \frac{m(X_2)}{n(X_2)} = \frac{0{,}105\text{g}}{1{,}48 \cdot 10^{-3}\ \text{mol}} = 70{,}95\ \text{g/mol}$$

$A_r(X) = 35{,}48 \Rightarrow X = Cl$

$3X \cong MX_3$

$$w(X) = \frac{3 \cdot M(X)}{M(MX_3)} \cdot 100 \Rightarrow M(X) = \frac{3 \cdot M(X)}{W(MX_3)} \cdot 100 = \frac{3 \cdot 35{,}48\ \text{g/mol}}{54{,}47} \cdot 100 = 195{,}4\ \text{g/mol}$$

$$M_r(MX_3) = A_r(M) + 3A_r(X) \quad \Rightarrow \quad A_r(M) = M_r(MX_3) - 3A_r(X) = 195{,}4 - 3 \cdot 35{,}48 = 88{,}96$$

M=Y (Yttrium)

B. Name the compound MX_3.

yttrium(III) chloride

C. Starting with 1.00 g of M and 1.00 g of X_2, what mass of MX_3 can be prepared?

Solution:

$2M + 3X_2 \rightarrow 2MX_3$

$$n_0(M) = \frac{m(M)}{M(M)} = \frac{1{,}00\ \text{g}}{88{,}96\ \text{g/mol}} = 1{,}124 \cdot 10^{-2}\ \text{mol}$$

$$n_0(X_2) = \frac{m(X_2)}{M(X_2)} = \frac{1{,}00\ \text{g}}{70{,}96\ \text{g/mol}} = 1{,}409 \cdot 10^{-2}\ \text{mol}$$

$$\frac{n(M)}{n(X_2)} = \frac{2}{3}$$

$$n(M) = \frac{2}{3} \cdot n(X_2) = \frac{2}{3} \cdot 1{,}409 \cdot 10^{-2}\ \text{mol} = 9{,}39 \cdot 10^{-3}\ \text{mol}$$

M is excess reagent, X_2 is limiting reagent

$$n(MX_3) = \frac{2}{3} \cdot n(X_2) = \frac{2}{3} \cdot 1{,}409 \cdot 10^{-2}\ \text{mol} = 9{,}39 \cdot 10^{-3}\ \text{mol}$$

$$m(MX_3) = \frac{2}{3} \cdot n(X_2) \cdot M(MX_3) = \frac{2}{3} \cdot 1{,}409 \cdot 10^{-2}\ \text{mol} \cdot 195{,}4\ \text{g/mol} = 1{,}835\ \text{g}$$

1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 181.0	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.0	89 **Ac** 227.0	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Ds** (281)	111 **Uuu** (272)	112 **Uub** (285)	113 **Uut** (284)	114 **Uuq** (289)	115 **Uup** (288)			

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)