

Assignment – NCHE111 – May 2023

Combination of Study Units 2, 3, 4 and 5

Due date: Monday 22 May 2023 by 13:00 or earlier.**TOTAAL: / TOTAL: 32 PUNTE. / 32 MARKS****Groeplid 1: / Group member 1:**

Voorletters: <i>Initials:</i>		Van: <i>Surname:</i>	MEMO
Studentennummer: <i>Student number:</i>		Handtekening: <i>Signature:</i>	

Groeplid 2: / Group member 2:

Voorletters: <i>Initials:</i>		Van: <i>Surname:</i>	MEMO
Studentennummer: <i>Student number:</i>		Handtekening: <i>Signature:</i>	

Groeplid 3: / Group member 3:

Voorletters: <i>Initials:</i>		Van: <i>Surname:</i>	MEMO
Studentennummer: <i>Student number:</i>		Handtekening: <i>Signature:</i>	

Groeplid 4: / Group member 4:

Voorletters: <i>Initials:</i>		Van: <i>Surname:</i>	MEMO
Studentennummer: <i>Student number:</i>		Handtekening: <i>Signature:</i>	

INSTRUCTIONS:

- You may do the assignment alone **OR** the assignment may also be done in groups of two but no more than FOUR students. You decide for yourself who will work together. If you decide to work as a group, you choose a group leader who will coordinate the times that you will get together to work on the assignment. Everybody in the group gets the same mark for the assignment. Make sure that everybody in your group participates. Everybody in the group must work together on ALL THE QUESTIONS. This means that you may not divide the questions between the group members. One of the purposes of the assignment is also to initiate collaboration and conversation about chemistry with your peers. So, chat with each other about potential solutions to the problems and try to get to the answers together – learn from each other!!!
- **Hand in one assignment answer sheet as a group.** Make sure that the full initials, surnames, student numbers and signatures of everybody that collaborated in your group are clearly indicated on the answer sheet. The answer sheet **MUST** be answered in the spaces provided and **in pen**. **NO** answer sheets that are answered in pencil will be marked and groups that answer in pencil will receive zero for this assignment. **No excuses will be accepted later.**
- Make photocopies for yourself of the completed assignment which you can store and then hand in an original hardcopy of the completed assignment at my office before 13:00 on Monday 22 May 2023. There will be a box outside my office where you can hand in the assignment. My office number is F208, Building G1. It is on the top floor of the Chemistry Building. My name is on the door.
- **You may use literature or the internet for some of the questions. Not all data are provided, and the missing data must be sourced from the literature or the web.**
- Please staple all your pages together. DO NOT hand in loose pages. I will accept no responsibility for pages that are lost.
- Do not email me your completed assignment and expect me to print it out and staple it together.

Good luck!

Dr Colin

Vraag 1. / Question 1.

[4 marks]

Hoeveel mol KOH is nodig om met al die SO₂ te reageer wat geproduseer is deur die oksidasie van 0.450 mol yster(IV)sulfied? / How many moles of KOH are required to react with all the SO₂ produced by the oxidation of 0.450 moles of iron(IV) sulfide?

Step 1:
Write a balanced reaction equation for the oxidation of iron(IV) sulfide.

$$4 \text{FeS}_2 + 11 \text{O}_2 \rightarrow 2 \text{Fe}_2\text{O}_3 + 8 \text{SO}_2$$

↓
You have
0.450 mol

The mol ratio between FeS₂ : SO₂
4 : 8
or 1 : 2

∴ (0.450 mol) × 2 = 0.90 mol SO₂ will form

Then Step 2:
Write a balanced reaction equation for the reaction of SO₂ with KOH

$$\text{SO}_2 + 2 \text{KOH} \rightarrow \text{K}_2\text{SO}_3 + \text{H}_2\text{O}$$

The mol ratio of SO₂ : KOH
1 : 2

∴ Mol amount of KOH required to react with all the SO₂ produced by the oxidation of 0.450 mol FeS₂
= (0.90 mol) × 2 = 1.80 mol of KOH

Vraag 2. / Question 2.

[4 marks]

Bereken die molaliteit van 'n oplossing wat bestaan uit 1.88 mL koolstoftetrachloried in 75.0 mL chloroform as oplosmiddel. / Calculate the molality of a solution consisting of 1.88 mL of carbon tetrachloride in 75.0 mL of chloroform as solvent.

Answer.

You will need the densities of both the solute and the solvent to calculate the masses and mole amounts. Carbon tetrachloride is CCl_4 with a density = 1.59 g/mL and chloroform is CHCl_3 with a density = 1.49 g/mL.

Remember that molality is:

$$m = \frac{\text{mol of solute}}{\text{mass of solvent in kg}}$$

① Calculate the mass of the solute which is carbon tetrachloride - CCl_4 from the density:

Density of CCl_4 = 1.59 g/mL
Volume of CCl_4 = 1.88 mL

$$\therefore m_{\text{CCl}_4} = d \times V = (1.59 \text{ g/mL})(1.88 \text{ mL})$$

$$\checkmark = 2.989 \text{ g of CCl}_4 \rightarrow$$

② Calculate the mole amount of the solute:

$$n_{\text{CCl}_4} = \frac{m}{M} = \frac{2.989 \text{ g}}{153.8 \text{ g/mol}}$$

$$\checkmark = 0.01943 \text{ mol CCl}_4 \rightarrow$$

or: $1.943 \times 10^{-2} \text{ mol} \rightarrow$

③ Calculate the mass of the solvent which is chloroform - CHCl_3 from the density:

$$m_{\text{CHCl}_3} = d \times V = (1.49 \text{ g mL}^{-1})(75.0 \text{ mL})$$

$$= 111.75 \text{ g CHCl}_3$$

$$\checkmark = 0.11175 \text{ kg CHCl}_3 \rightarrow$$

④ Molality = $\frac{\text{mol of solute}}{\text{mass of solvent in kg}} = \frac{0.01943 \text{ mol}}{0.11175 \text{ kg}}$

$$\checkmark = 0.174 \text{ mol/kg} \rightarrow$$

Vraag 3. / Question 3.**[4 marks]**

Geewe die volgende data: / Given the following data:

(i)	$\text{Ca(s)} + 2\text{C(grafite)} \rightarrow \text{CaC}_2\text{(s)}$	$\Delta H = -62.8 \text{ kJ}$
(ii)	$\text{Ca(s)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{CaO(s)}$	$\Delta H = -635.5 \text{ kJ}$
(iii)	$\text{CaO(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Ca(OH)}_2\text{(aq)}$	$\Delta H = -653.1 \text{ kJ}$
(iv)	$\text{C}_2\text{H}_2\text{(g)} + 5/2\text{O}_2\text{(g)} \rightarrow 2\text{CO}_2\text{(g)} + \text{H}_2\text{O(l)}$	$\Delta H = -1300.0 \text{ kJ}$
(v)	$\text{C(grafite)} + \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)}$	$\Delta H = -393.5 \text{ kJ}$

Bereken ΔH vir die volgende reaksie, deur van Hess se wet en manipulasie van die geewe reaksies gebruik te maak. / Calculate ΔH for the following reaction by using Hess's law and manipulating the given reactions:



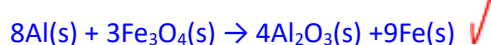
(i)	Reverse $\text{CaC}_2\text{(s)} \rightarrow \text{Ca(s)} + 2\text{C(grafite)}$	$\Delta H = +62.8 \text{ kJ}$	<input checked="" type="checkbox"/>
(ii)	$\text{Ca(s)} + \frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{CaO(s)}$	$\Delta H = -635.5 \text{ kJ}$	
(iii)	$\text{CaO(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Ca(OH)}_2\text{(aq)}$	$\Delta H = -653.1 \text{ kJ}$	
(iv)	Reverse $2\text{CO}_2\text{(g)} + \text{H}_2\text{O(l)} \rightarrow \text{C}_2\text{H}_2\text{(g)} + 5/2\text{O}_2\text{(g)}$	$\Delta H = +1300.0 \text{ kJ}$	<input checked="" type="checkbox"/>
(v)	(x2) $2\text{C(grafite)} + 2\text{O}_2\text{(g)} \rightarrow 2\text{CO}_2\text{(g)}$	$\Delta H = 2(-393.5 \text{ kJ})$	<input checked="" type="checkbox"/>
		$\Delta H = -712.5 \text{ kJ}$	<input checked="" type="checkbox"/>

Vraag 4. / Question 4.**[6 marks]**

Bepaal die hitte wat vrygestel of geabsorbeer word wanneer 12.5 g Al met 26.5 g $\text{Fe}_3\text{O}_4\text{(s)}$ reageer. (Wenk: Daar is drie stappe vir hierdie problem. 1.) Gebalanseerde vergelyking en identifiseer die beperkende reagens. 2.) Bereken $\Delta H_{\text{reaksie}}$ vanuit vormingsentalpieë en 3.) Berekening van die hitte wat afgegee is deur die komplette omskakeling van die beperkende reagens.)

Determine the heat released or absorbed when 12.5g Al reacts with 26.5g $\text{Fe}_3\text{O}_4\text{(s)}$.

(Hint: There are three tasks to this problem. 1.) Balanced Equation and Identifying Limiting Reagent, 2.) Calculating $\Delta H_{\text{reaction}}$ from enthalpies of formation and 3.) Calculating the heat given off by the complete consumption of the limiting reagent.)

Step 1:

$$n_{\text{Al}} = 12.5\text{g} / 27 \text{ g}\cdot\text{mol}^{-1} = \underline{0.463 \text{ mol Al}} \quad \checkmark$$

$$n_{\text{Fe}_3\text{O}_4} = 26.5 \text{ g} / 231.54 \text{ g}\cdot\text{mol}^{-1} = \underline{0.114 \text{ mol Fe}_3\text{O}_4}$$

Mol ration between Al : Fe₃O₄ = 8 : 3

So, for 0.463 mols of Al you will need $[(0.463)3] / 8 = 0.174$ mol of Fe₃O₄. You only have 0.114 mol of Fe₃O₄ – **this means that Fe₃O₄ is the limiting reagent.**

Step 2:

Standard Thermodynamic Quantities we obtain the enthalpies of formation

$$\Delta H_f^\circ (\text{Fe}_3\text{O}_4) = - 1118.4 \text{ kJ/mol}$$

$$\Delta H_f^\circ (\text{Al}_2\text{O}_3) = - 1675.7 \text{ kJ/mol}$$

$$\Delta H_f^\circ (\text{Al}) = 0 \text{ kJ/mol}$$

$$\Delta H_f^\circ (\text{Fe}) = 0 \text{ kJ/mol}$$

Using

$$\Delta H_{\text{reaction}} = [\sum \Delta H_f^\circ (\text{products})] - [\sum \Delta H_f^\circ (\text{reactants})]$$

gives

$$\Delta H_{\text{reaction}} = [4(-1675.7) + 9(0)] - [8(0) - 3(-1118.4)] = \underline{-3363.6 \text{ kJ for the reaction}}$$

Step 3:

Base heat released on complete consumption of the limiting reagent.

You do not have 3 mol of Fe₃O₄. You only have 0.114 mol of Fe₃O₄.

$$\text{So, } (-3363 \text{ kJ} / 3 \text{ mol Fe}_3\text{O}_4) = - 1121.2 \text{ kJ/mol Fe}_3\text{O}_4.$$

Then 0.114 mol(-1121.2 kJ/mol) = **- 127.82 kJ of heat will be given of** when 0.114 mol of Fe₃O₄ reacts with enough Al.

Vraag 5. / Question 5.

[4 marks]

Gekonsentreerde swaelsuur (98.12 g.mol⁻¹) het 'n digtheid van 1.5 g/cm³ en is 60% H₂SO₄ per massa.

Die res is water. Hoeveel H⁺ ione is daar in 'n 45 mL gekonsentreerde swaelsuurooplossing?

Concentrated sulphuric acid (98.12 g.mol⁻¹) has a density of 1.5 g/cm³ and is 60% H₂SO₄ per mass. The rest is water. How many H⁺ ions are there in a 45 mL concentrated sulphuric acid solution?

$$m = d \times V = (1.5 \text{ g.cm}^{-3})(45 \text{ mL}) = 67.5 \text{ g}$$

$$(67.5\text{g})0.60 = \underline{40.5 \text{ g H}_2\text{SO}_4}$$

$$\text{Mol amount of H}_2\text{SO}_4 = m/M = 40.5 \text{ g} / 98.12 \text{ g.mol}^{-1} = \underline{0.413 \text{ mol H}_2\text{SO}_4}$$

$$\text{Mol H}^+ \text{ ions} = (0.413 \text{ mol})2 = \underline{0.826 \text{ mol H}^+ \text{ ions}}$$

Amount of H⁺ ions = mol H⁺ ions × avogadro's number

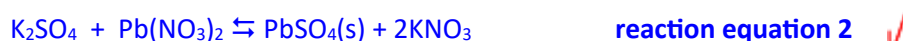
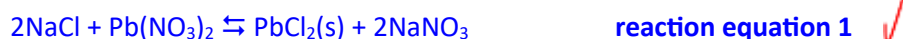
$$= (0.826 \text{ mol})(6.02 \times 10^{23}) = \underline{4.97 \times 10^{23} \text{ H}^+ \text{ ions}}$$

Vraag 6. / Question 6.

[10 marks]

'n Monster van 10.00 g wat bestaan uit 'n mengsel van natriumchloried en kaliumsulfaat word opgelos in water. Hierdie waterige oplossing reageer met oormaat lood(II)nitraat om 21.75 g vastestof te vorm. Bepaal die massa persentasie van die natriumchloried in die oorspronklike mengsel.

A 10.00 g sample consisting of a mixture of sodium chloride and potassium sulfate is dissolved in water. This aqueous mixture then reacts with excess aqueous lead(II) nitrate to form 21.75 g of solid. Determine the mass percent of sodium chloride in the original mixture.



For the mixture before dissolving in water and adding the lead(II) nitrate:

The mass of NaCl = x gram and the mass of K₂SO₄ = y gram.

$$X \text{ g of NaCl} + y \text{ g of K}_2\text{SO}_4 = 10 \text{ gram}$$

$$(m = n \times M) \quad \text{So, } x(58.45 \text{ g/mol}) + y(174.2 \text{ g/mol}) = 10 \text{ g} \quad \text{Mathematical equation 1}$$

For the solution after dissolving and adding the lead(II) nitrate:

$$(x/2) \text{ g of PbCl}_2(\text{s}) + y \text{ g of PbSO}_4(\text{s}) = 21.75 \text{ gram}$$

$$(m = n \times M) \quad \text{So, } (x/2)(278.1 \text{ g/mol}) + y(303.2 \text{ g/mol}) = 21.75 \text{ g} \quad \text{Mathematical equation 2}$$

Therefore:

$$\text{From mathematical equation 1:} \quad X = (10 - 174.2y) / 58.45 \text{ and}$$

$$\text{From mathematical equation 2:} \quad X = 2(21.75 - 303.2y) / 278.1$$

Then solve for y:

$$(10 - 174.2y) / 58.45 = 2(21.75 - 303.2y) / 278.1$$

$$4.7579(10 - 174.2y) = 2(21.75 - 303.2y)$$

$$47.579 - 43.50 = 828.828y - 606.40y$$

$$4.079 = 222.428y$$

$$y = 4.079 / 222.428 = 0.01834 \text{ mol} \quad \checkmark$$

$$\text{Thus } x = (10 - 174.2\{0.01834\}) / 58.45 = (10 - 3.195) / 58.45 = \underline{0.11643 \text{ mol}} \quad \checkmark$$

$$\text{Mass NaCl} = nM = 0.11643 \times 58.45 = \underline{6.805 \text{ g NaCl in the original mixture.}} \quad \checkmark$$

$$\text{Mass\% NaCl} = (6.805/10) \times 100 = \underline{68.05\% \text{ NaCl in original mixture}} \quad \checkmark$$

Test:

$$x\text{NaCl} + y\text{K}_2\text{SO}_4 = 10 \text{ gram}$$

$$x(58.45 \text{ g/mol}) + y(174.2 \text{ g/mol}) = 10 \text{ g}$$

$$(0.11643 \times 58.45) + (0.01834 \times 174.2) = 10 \text{ g}$$

$$6.805 + 3.195 = 10 \text{ gram}$$